

*Ecology has a major responsibility in solving environmental problems. In Mexico, scientific institutions need to contribute more to the practical use of their research findings, especially with regard to the rural management of ecosystems. Based on the framework of the Ecological Information System, two surveys were conducted among ecologists and nongovernmental organizations in Mexico. It was found that ecology has a great deal to contribute to environmental problem solving and that nongovernmental organizations function as links between science and rural producers, such as agriculturists, cattle ranchers, forest extractors, hunters, gatherers, and fishermen, although these interactions should be strengthened. Suggestions are made for the design of new forms of communicating science within scientific institutions that contribute to the utilization of scientific results.*

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## ***Communication and Utilization of Science in Developing Countries***

*The Case of Mexican Ecology*

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*Ecology is the study of the relationships between living organisms and their physical environment (Begon, Harper, and Townsend 1986). Its principal aim is to explain how nature works. However, ecological science has acquired an increasing social relevance because of its role in providing information for the management of ecosystems and their resources by human groups. Ecological science is now recognized to be an important basis on which decisions*

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*Author's Note:* This study received financial support from the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, as well as from the Universidad Nacional Autónoma de México, through a doctoral scholarship. I am very grateful to the scientists and members of nongovernmental organizations who agreed to participate in the study. I also thank the anonymous reviewers for their valuable comments. Address correspondence to Alicia Castillo, Departamento de Ecología de los Recursos Naturales, Instituto de Ecología, Universidad Nacional Autónoma de México, Apartado Postal 27-3 (Xangari), Morelia, Michoacán, Mexico; phone: +52-43 20-0517, ext. 42532; fax: +52-43 28 0554; e-mail: castillo@oikos.unam.mx.

Science Communication, Vol. 22 No. 1, September 2000 46-72  
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should be made with regard to Earth's resources and life support systems (Ehrlich 1989). This has given ecology a role in social politics, since it is recognized that nature cannot be studied separately from society and from human beings, and that ecological problems predominantly constitute social problems.

Within the international community of ecological scientists, there exists a concern about the extent of applicability of ecological science—that is, its utilization in solving practical problems related to the management of ecosystems and their resources. Questions have been raised about the real impact of ecological science on management practice or policy (Ecological Applications 1993; Ludwig, Hilborn, and Walters 1993; Pienkowsky and Watkinson 1996). On the other hand, all around the world environmental problems such as deforestation, loss of biodiversity, and pollution continue to increase at alarming rates regardless of the number of investigations reflected in the also-increasing number of journals and publications on ecological matters. This accumulation of scientific knowledge and its poor utilization in the solution of problems suggest that ecological science has not been successful in accomplishing its social role.

Some authors have suggested that science needs to be integrated with other sources of information (Costanza 1993; Holling 1993). It is proposed that for a more fruitful participation of ecological science in environmental problem solving, new forms of ecological inquiry should be developed that analyze issues from a systems perspective, including the interactions of social systems with natural systems (Holling, Berkes, and Folke 1998). In the particular context of developing countries also, traditional or indigenous knowledge with regard to the environment generated by rural societies is known to play a relevant role in the formulation of appropriate strategies for managing and conserving ecosystems and their resources (DeWalt 1994; Gadgil, Berkes, and Folke 1993; Maundu 1995; Toledo 1992). Ecology, therefore, needs to become an interdisciplinary science capable of collaborating with the social sciences and other knowledge systems (Daily and Ehrlich 1999).

### *Ecology in Mexico*

The roots of Mexican ecological research can be found in the works of natural historians of the last century, which described Mexico's diverse habitats. However, the rise of modern ecological science began only during the decades of the 1940s and 1950s (Soberón 1995). This contrasts with the scientific societies of ecologists in Europe and the United States, which were

established in 1913 (the British Ecological Society) and 1915 (the Ecological Society of America), respectively. Currently, only five institutions and no more than fifteen other small research groups can be identified that are dedicated to ecological research in Mexico. Estimates of the total number of ecologists is about 350, which represents 0.37 ecologists per 100,000 inhabitants (Instituto Nacional de Estadística, Geografía e Informática 2000), and there is no scientific society congregating them (Castillo and Toledo 2000). In contrast, the Ecological Society of America registers 7,600 members, approximately 2 to 3 ecologists per 100,000 inhabitants in the United States (Ecological Society of America 2000; Population Reference Bureau 2000).

Despite the small size of the community, ecologists in Mexico have been centrally involved in the formulation of the current environmental policy and have contributed significantly to the understanding of the diverse ecosystems of the country. This is of great importance, since Mexico is considered to be a "megadiverse" country along with Brazil, Colombia, the Democratic Republic of Congo (former Zaire), Madagascar, Indonesia, and Australia. More than half of the world's biological diversity is concentrated in these countries (Mittermeier, Robles-Gil, and Mittermeier 1997).

Mexico confronts serious processes of environmental deterioration, including high rates of deforestation and soil erosion, water depletion, overexploitation of plant and animal species, and loss of genetic resources, to mention some of the most important. The current ecological crisis demands, therefore, the wider participation of the science of ecology and related disciplines in the search for alternative ways to manage the country's natural heritage. Ecologists, and particularly their institutions, should strive to promote more productive interactions between their activities and those of the social sectors responsible for the ways in which the environment is used. In this way, it is important to recognize that in countries such as Mexico and in most of the developing world, natural resources are used, managed, and conserved by rural producers: a complex array of agriculturists, cattle ranchers, forest extractors, hunters, gatherers, and fishermen (Toledo 1997). A main characteristic of these groups is that their livelihoods depend directly on the appropriation of ecosystems, and in most developing countries these rural producers are poor.

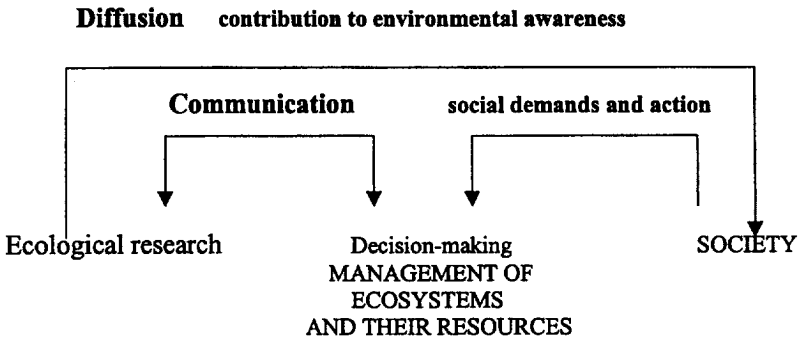
### *Communication of Ecological Information*

Communication can be used as an instrument for inducing change (Röling 1990), especially in the ways in which societies interact with their environments. Through the use of communication, it is possible to mobilize people in

order to make demands or to change their behavior, to help them to acquire skills, or to create and strengthen organizations. Long and Long (1992) even suggest that through communication interventions, knowledge can be negotiated and created by groups of actors who have different social (and knowledge) systems.

Within the ecological scientific community, communication frequently has been recognized as a factor that plays an important role in the utilization of research findings. The Committee on the Applications of Ecological Theory to Environmental Problems (1986) stated that the poor applicability of ecological science is "partly a result of the failure of academic ecologists to attempt to determine where and how their knowledge might be applied and of a lack of communication among generators and users of new knowledge" (p. vi). The Sustainable Biosphere Initiative (Lubchenco et al. 1991, 373), considered to be a key document among ecologists for the setting of research priorities in order to conserve Earth's resources, placed ecological research within an "acquisition, dissemination, and utilization" context in which communication plays an important role. This report, nevertheless, only acknowledges the need to improve communication but does not develop these ideas further. More recent reports have recognized that an interactive, reciprocal, and ongoing communication among ecologists, the public, and decision makers can enhance effective conservation practices (Christensen et al. 1996; Mangel et al. 1996). More recently, Norton (1998) has suggested that the poor capacity of ecologists to communicate with decision makers may be due to their reluctance to mix value-laden issues with scientific study.

In Mexico, science communication efforts have been predominantly concerned with the diffusion of scientific concepts, findings, and methods, with the purpose of including science in Mexican culture (Sánchez 1998). In relation to ecology, the task has been directed toward raising the awareness of environmental issues among populations, within an environmental education perspective (González Gaudiano 1999). Less consideration has been given to communicating science for its practical use. In the context of countries such as Mexico, ecological science certainly does need to contribute to the diffusion of ecological knowledge and ideas to raise people's awareness. This increased awareness can lead to social participation in environmental projects, or to political actions that influence decisionmaking processes at different levels. Nevertheless, it is also necessary to communicate information through a two-way process of exchange that contributes more directly to the solution of problems, in particular those with regard to the management of ecosystems. Through processes of communication, the research carried out in scientific institutions can be linked to the work of people directly involved in the appropriation of natural resources through activities such as

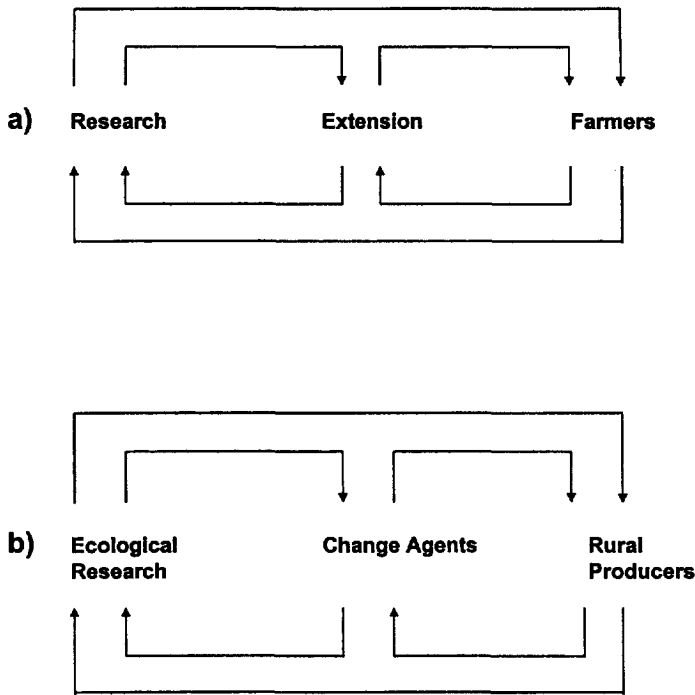


**Figure 1: Processes of Diffusion and Communication of Ecological Information in Relation to the Management of Ecosystems and Their Resources**

agriculture, forestry, and fishing. Figure 1 shows the relationships between these two forms of disseminating scientific knowledge.

### ***The Ecological Information System: Communication for Utilization***

To examine the relationship between what is produced in ecological science and potential users of this knowledge, an information system approach (Röling 1990) is used. This approach allows one to understand the way in which people and institutions generate information, use information sources, process and transform information, and use knowledge in practical situations. It has been developed mainly within the agricultural disciplines as a response to a mode of work in which scientists decided research priorities and generated technologies, which were then transmitted by extension agents to farmers for their use. The failure of many programs based on such a one-way model of communication (Wellard 1993) and the study of the interactions between the knowledge systems of scientists and farmers (Chambers, Pacey, and Thrupp 1993; Okali, Sumberg, and Farrington 1994; Scoones and Thompson 1994) changed the views with regard to the roles of agricultural research, extension, and farmers in the promotion of agricultural development. As a response, the model of an Agricultural Information System was developed (Röling 1990; Röling and Engel 1991; Van den Ban and Hawkins 1996). In this model, two-way forms of communication (see Figure 2a) link research, extension, and farmers. The model is useful for examining the roles



**Figure 2: (a) Agricultural Information System and (b) Ecological Information System. The Arrows Indicate Flows of Information between the Sectors**

of research and extension in order to improve the synergistic functioning of the system to underpin knowledge utilization by agricultural producers (Röling 1990).

Based on this approach, a model called the Ecological Information System (EIS) has been proposed as a conceptual framework for ecological science in countries such as Mexico (Castillo 2000). The system is composed of (1) a research sector that includes institutions and people engaged in ecological research, (2) a change agent sector that considers those groups working in rural communities that are promoting sustainable forms of managing natural resources (Beal 1981), and (3) a rural producer sector, mainly composed of peasants, which corresponds to the main users of the information in the system and includes those individuals and organizations that depend directly on the appropriation of natural resources. Currently, nongovernmental organizations (NGOs) are playing a crucial role as change agents in developing

countries. In the Latin American region, for instance, NGOs are actively searching for new kinds of agricultural development and strategies for managing natural resources based on local participation, skills, and resources, which enhance productivity while conserving the resource base (Altieri and Masera 1993).

A diagram of the EIS is presented in Figure 2b, where the three sectors are shown linked by arrows representing the flows of information between the sectors. The model emphasizes the need for an exchange of information between the participants and opens up the possibility of social encounters for the joint creation of new knowledge (Long and Long 1992). Thus, the EIS can provide ecological science with an integrative framework that allows its interaction with those social sectors in need of scientific information for the solution of specific problems. Effective communication among the sectors is the key factor that would facilitate the interaction between the generation of scientific information and the rural management of natural resources.

As a first approximation to the study of the EIS, and to examine the interactions between the sectors, this research work asks the following questions: How do ecologists in Mexico see the utility of ecological knowledge? How do they evaluate the importance of communicating their findings to different sectors of society? How much do ecologists collaborate with other sectors of society including rural producers? Do NGOs in Mexico (as change agents within the EIS) function as links between the research and rural producer sectors? Elucidation of these questions can then be used to construct proposals for the communication and public utilization of ecology toward the solution of environmental problems.

### *Method: Exploration of the EIS*

Two surveys were conducted with members of the research and the change agent sectors as a way to examine their interactions in the context of the EIS.

#### *Survey of Ecologists*

The survey was conducted in 1995 with ecologists from the two main institutions of ecological research in Mexico. These were the Institute of Ecology of the National Autonomous University of Mexico (IE-UNAM) and the Institute of Ecology A.C. (IE-AC) of the National Council of Science and Technology (Piñero 1994). It is estimated that these two institutions currently employ nearly 50 percent of the research ecologists of the whole country

**TABLE 1**  
**Two Main Ecological Research Institutions in Mexico**

<i>Institution</i>	<i>Year Founded</i>	<i>Aims (as stated in the institution's official documents)</i>	<i>Areas of Research</i>
Instituto de Ecología A.C.	1975	Generation of scientific and technological knowledge in the areas of ecology, biosystematics, and use and conservation of natural resources, linking activities to the environmental problems found at the national level	Vegetation and flora; ecology and animal behavior
Instituto de Ecología UNAM	1987	To generate ecological information of high quality; to develop qualified personnel in ecology; to provide access to the information generated to individuals and institutions involved in environmental management	Applied ecology; evolutionary ecology; functional ecology

(Castillo and Toledo 2000). At the time of the study, 100 researchers in the two institutions were estimated to be working on ecological issues. Table 1 presents some features of these institutions, including their main areas of expertise. Questionnaires were distributed to all of these ecologists, and fifty-six were completed and returned. The information collected was related to the actual and potential use of the information they produce, their perception of traditional systems of knowledge, their interaction with the rural producers and NGOs (as change agents) sectors, and their participation in interdisciplinary work. Another subject was related to the communication of scientific findings. The questionnaire included eleven closed-ended and two open-ended questions (presented in Table 2 and Appendix A).

### *Survey of NGOs*

This survey was carried out as a mail survey with a self-completion questionnaire (Cohen and Mannion 1993). In 1995, a total of 387 questionnaires were sent to NGOs throughout the country that were self-described as being involved in activities that promote alternative forms of managing natural resources through environmental education and related activities that involve the communication of scientific information. These NGOs were identified from two directories of environmental organizations in Mexico (Ordoñez, Miramontes, and García-Barrios 1993; Secretaría de Desarrollo Social

**TABLE 2**  
**Ecologists' Responses to the Survey Questions (*N* = 56) (percentages)**

<i>Question</i>	<i>A Lot</i>	<i>Little</i>	<i>None</i>	<i>Varies</i>	<i>No Answer</i>
1. To what extent do you consider that the knowledge generated in ecology is useful in the solution of environmental problems?	70	27	0		3
2. To what extent do you consider that the knowledge generated in ecology in Mexico has been used to solve environmental problems?	2	86	9		3
3. To what extent does your research group consider the possibility of finding solutions to problems when projects are planned and specific objectives are decided?	36	39	5	18	2
4. To what extent would you be willing to participate in projects that seek applications for the knowledge that is generated within your research group?	77	21	0		2
5. To what extent do you collaborate with the following disciplines in research projects?					
Natural scientists	91	7	0		
Social scientists	9	37	52		
Communicators and educators	9	30	57		
6. To what extent do you receive requests for information from nongovernmental organizations (NGOs)?	13	41	41		5
7. To what extent do you collaborate with NGOs in research projects?	13	23	57		7
8. To what extent do you consider that traditional knowledge can be used in the formulation of proposals for the management of natural resources?	79	14	0		7
9. To what extent do you interact with local people in the locations where you carry out your fieldwork?	46	38	11	5	
10. To what extent do you use information given by local people in your research?	36	48	12	4	

1993). Throughout a period of nine months, a total of fifty-seven organizations returned the questionnaires. The information collected was related to such things as the context in which the groups work and the professions and occupations represented by the personnel within the organizations. The main body of the questionnaire was related to the interactions between these organizations and the research sector. The questionnaire included six closed-ended and three open-ended questions (see Appendix B).

## ***Results: A First Approximation to the EIS***

### ***Ecologists' Perceptions and Interactions***

In relation to the uses of ecological information for the solution of environmental problems (see question 1 in Table 2), most scientists agreed that ecology has a great deal to contribute to the solution of problems. None of the scientists thought that ecology had no useful purpose. However, with regard to Mexican ecology (question 2), the great majority of ecologists said that little of the information produced in the country had been used in the solution of environmental problems. In two open-ended questions (a and b in Appendix A), ecologists were asked to identify three areas in which the knowledge they generate could be used and also to give an example of how the knowledge generated within their work group had been used to solve a practical problem. Of the fifty-six scientists surveyed, fifty-five provided examples of potential uses. The complete list of examples they suggested (see Table 3) includes specific practices ranging from those that could be used at the level of a rural community to those more broadly related to the management of natural resources.

In relation to examples of actual practical use of the information generated, 60 percent of scientists outlined a specific action they had contributed. Interventions in the design of protected areas, as well as projects involving environmental planning, were common. Participation in environmental legislation and work related to the use of particular resources were also mentioned. About 30 percent of researchers admitted that until now, no practical use had been made of the information they had generated. In two cases, respondents were not sure whether their information had been used. One of these scientists said that although she did not know whether the information generated about a palm species was used by palm extractors, results were published in the journal *Ecological Applications* and, therefore, made a contribution to the application of information. With regard to the design of research (question 3 in Table 2), opinions among ecologists seem to be equally divided between those who said a great deal of thought about the possibility of finding solutions to problems is taken into account when designing projects and those who said that little such consideration is taken into account (see Table 2). Some scientists also admitted that this consideration varies depending on particular projects. In some cases this was considered to be an important factor, whereas in others the main objective was far removed from practical considerations. Finally, in relation to scientists' disposition to work

**TABLE 3**  
**Areas Suggested by Ecologists in Which**  
**the Knowledge They Generate Could Be Used**

<i>Micro Level</i>	<i>Macro Level</i>	<i>Environmental Conservation</i>
Biological control of pests	Environmental planning	Detection of areas of high biodiversity value
Design and management of agro-ecosystems	Environmental impact assessments	Site selection and design of protected areas
Control of soil erosion	Management of water resources	Management of species in danger
Breeding and artificial selection of plants	Uses of plants using ethnobotanical data	Management of exotic species
Production of seeds and fruits	Design of criteria for sustainability	Effects of human activities on ecosystems
Management of crop species	Design of genetic resource banks	Succession and environmental restoration
Sustainable extraction of useful plants	Management of forest areas	
Extraction and cultivation of animal species	Management of touristic coastal areas	
Restoration of eroded and degraded areas		

NOTE: Micro-level suggestions are for actions that could be implemented at the rural community level, macro-level suggestions are for actions that could be implemented at regional levels, and environmental conservation suggestions are for actions concerning protected areas.

on applied projects (question 4), most said they would be very willing to participate in such efforts.

Summarizing the perceptions of ecologists, it appears that they acknowledge the potential contribution of ecology to solve environmental problems. They accepted, however, that little of the knowledge generated in Mexico had been used. Most ecologists claimed to be willing to participate in practical projects and seemed to have clear ideas with regard to the use of the knowledge they generate.

Concerning the participation of ecologists in interdisciplinary work, results showed that ecologists mainly collaborate with other natural scientists (question 5 in Table 2). In relation to the interaction between ecologists and NGOs as change agents (question 6), about 80 percent of ecologists acknowledged that they had received few or no information requests from NGOs. Also, when asked about the extent of collaboration with this type of organization (question 7), more than half of the ecologists stated that this did not occur. From the point of view of scientists, therefore, it seems that little interaction occurs between ecologists and NGOs in Mexico.

When analyzing the interaction between ecologists and members of rural communities, an important aspect concerns the role of traditional systems of knowledge on the environment—that is, those bodies of information generated by rural communities. Ecologists were asked about the value and the possible use of this knowledge (question 8 in Table 2). The great majority of respondents agreed that traditional knowledge could make a valuable contribution when developing recommendations. Another area of interest was the interactions of ecologists with rural populations, especially in the locations where the ecologists carry out fieldwork (question 9). Special focus was on the transmission of information between the two sectors. Almost half the scientists said that they interacted a great deal with local people, and about 40 percent said that this interaction was minimal. With regard to the interactions with rural organizations, half the scientists claimed to know social organizations, and the other half admitted that they were not in contact with any such local groups. Results also showed that almost 40 percent of the scientists claimed to use a great deal of information given to them by rural people in their research (question 10). In contrast, almost 50 percent of scientists said they use this type of information only a little. In summary, it is notable that most ecologists recognized the importance of traditional systems of knowledge in searching for sustainable ways of managing natural resources. Many ecologists also claimed to interact with local people in their fieldwork locations and to use information given by local people in their research.

With regard to the communication of science, ecologists were questioned about the media used to communicate their research findings to different sectors, including other scientists (see question c in Appendix A). The results show a notable difference in the emphasis given by scientists to communication with peers compared with efforts made to address other sectors of society (Table 4).

### *NGOs as a Link between Sectors*

A primary matter of interest about the organizations surveyed is their location. The fifty-seven organizations were from twenty-four states (of a total of thirty-one) and Mexico City, where eleven of the fifty-seven organizations were based. There was only one international environmental NGO in the sample (the Mexican representative of the U.S. World Wildlife Fund). With regard to whether the organizations mainly work in rural or urban settings (question 1 in Appendix B), the results show that 30 percent work exclusively in rural areas, 23 percent solely in urban localities, and 47 percent in both rural and urban contexts. This shows that nearly 80 percent of the NGOs surveyed work in rural settings. When asked about the professions and

occupations represented within these organizations (question 2), the results showed a high proportion of biologists working in 65 percent of the organizations. Social scientists were less well represented, working in less than 40 percent of the total number of organizations. More significantly, perhaps, is the presence of educators and communicators, who were employed in more than 40 percent of the total number of organizations. In relation to the rural producers, there is a notable representation of peasants in 40 percent of all organizations, and this was almost 60 percent for the organizations that work only at the rural level.

One of the most important aspects that the survey addressed was the sources of information used by NGOs. Organizations were asked to indicate whether the organization carries out its own research, uses information from research institutions, and uses information from publications (question 3 in Appendix B). The results show that 49 percent of the organizations carry out their own research, 47 percent use scientific institutions as sources of information, and 51 percent use publications. In general terms, 80 percent of the organizations used scientific sources of information for their work. The following results relate to the types of sources of information the organizations reportedly used.

#### *Research Carried Out by NGOs*

Table 4 shows the results related to the different areas in which NGOs carried out research (question 4 in Appendix B). The differences in the amount of research NGOs conduct between those areas of the natural sciences (the first seven areas in Table 5) and the social sciences are apparent. When asked in an open-ended question about the constraints in carrying out their own research (question 5), most organizations reported that obtaining funding was the main problem.

#### *Research Institutions as Sources of Information*

In an open-ended question, NGOs were asked for examples of up to three research institutions that had given them information (question 6 in Appendix B). Of the twenty-seven organizations that claimed to use these institutions as sources of information, twenty-five gave examples of research centers, universities, international research organizations, or NGOs that carry out research. When asked how an organization perceived its relationship with the scientists working for the research institutions from which they were

**TABLE 4**  
**Different Types of Communication Used by Ecologists**  
**to Transmit the Information They Generate**

% Classes of Publications	% Scientists Publishing in Each Class		
	Scientific Communications	Reports	Public Communications
0	0	32	7
1-25	4	55	64
26-50	16	5	25
51-75	30	2	0
76-100	46	2	0

NOTE: Scientific communications included refereed publications, attendance at conferences, and contributions to scientific books. Reports were considered those communications prepared in response to requests for particular sectors of society (e.g., government). Articles in magazines, public lectures, and contributions in newspapers or television and radio programs were considered as communications for the public understanding of science. It is important to note that nearly 80 percent of the ecologists surveyed said that more than half of their various communications were of a scientific type. In contrast, reports accounted for less than 25 percent of scientists' communications for more than 80 percent of the researchers. In the case of public communications, about 90 percent of the ecologists estimated that these constituted less than 50 percent of all their communications.

**TABLE 5**  
**Areas of Research Carried Out by Nongovernmental Organizations**

Area	%
Ecology	50
Flora and fauna	61
Environmental planning	57
Environmental assessment	50
Agronomy	36
Forestry	46
Fisheries	18
Sociology and anthropology	29
Economy	21

NOTE:  $N = 28$ . An organization may carry out more than one type of research.

receiving information (question 7), most organizations (63 percent) evaluated that relationship as good, since the institutions gave them the information needed. Only two organizations reported that research institutions participated with them in the generation of the information needed.

TABLE 6  
**Scientific Publications Used by Nongovernmental Organizations**

<i>National Publications</i>	%	<i>International Publications</i>	%
<i>Acta Botánica</i>	31	<i>Biological Conservation</i>	21
<i>Acta Zoológica</i>	34	<i>Conservation Biology</i>	21
<i>Antropológicas</i>	21	<i>Ecological Applications</i>	7
<i>Biotecnología</i>	17	<i>Ecological Economics</i>	14
<i>Boletín de la Sociedad Botánica</i>	21	<i>Ecology</i>	28
<i>Ciencia</i>	17	<i>Environmental Science and Technology</i>	17
<i>Ciencia y Desarrollo</i>	76	<i>Forest Ecology and Management</i>	10
<i>Etnoecológica</i>	17	<i>Human Ecology</i>	14
		<i>Journal of Applied Ecology</i>	10
		<i>Journal of Ecology</i>	17
		<i>Natural Resources Journal</i>	10

NOTE:  $N = 29$ . An organization may use more than one publication as a source of information.

#### *Publications as Sources of Information*

With the purpose of evaluating the extent to which NGOs were in contact with and used the kinds of publications in which ecologists communicate their findings, NGOs were asked to select from a list of publications those that they used in their work (question 8 in Appendix B). The list was obtained through a review of articles published between 1991 and 1993 by scientists of the IE-UNAM. The objective of the question was to explore the extent to which NGOs had access to the main channels of communication used by ecologists in Mexico. The list of publications was divided into national and international journals, and results are given in Table 6.

The importance of the publication *Ciencia y Desarrollo* (Science and Development) is notable, since nearly 80 percent of the total number of organizations surveyed used this publication. Although it is a refereed journal, published by the Mexican National Council of Science and Technology, *Ciencia y Desarrollo* also functions as a publication for the public understanding of science. It is widely distributed throughout the country, where it is available in bookshops and supermarkets. The use by NGOs of international scientific journals, however, appears to be insignificant. When organizations were asked in an open-ended question which scientific journals they used most often (question 9 in Appendix B), *Ciencia y Desarrollo* again appeared to be especially important. Organizations also referred to publications of international organizations such as the World Resources Institute.

## ***Discussion: Toward the Public Utilization of Ecological Science***

### ***Generalization of Findings***

In relation to a maximum estimation of 300 Mexican ecologists in 1995 (based on unpublished reports), the survey sample of researchers represents the opinions of nearly 19 percent of these Mexican ecologists. On the other hand, the NGOs surveyed represent approximately 15 percent of the Mexican NGOs that worked in environmental education activities at the time of the study. It should be noted, however, that in Mexico people develop NGOs as a way of creating self-employment, especially professionals who find it difficult to obtain a post within government or academic institutions. As a result, new NGOs are frequently created, and although some do not function actively, they remain in existence on paper. It could also be the case that organizations claim to be carrying out environmental education activities, through which funds can be obtained. Taking all this into consideration, the figure of 387 organizations reporting that environmental education is part of their work should be viewed with some caution. It should also be mentioned that more than half of the organizations responding to the survey in 1995 appear in the 1999 Mexican directory of environmental organizations (Fondo Mexicano para la Conservación de la Naturaleza 1999). Thus, although the results given here should be considered as tentative, these findings offer some insights about how NGOs view their work and about their role as links between science and such sectors as rural producers.

### ***Science for Sustainable Development***

There was general agreement among Mexican ecologists that ecology has a great deal to contribute to the solution of problems, although little ecological information has been used to date. Ecologists expect that strategies and specific technologies for the management of natural resources can be developed from the background explanations they provide about the structure and functioning of ecosystems.

Some factors could explain the scant use of ecological information for the solution of problems in Mexico. One is the recent origin of ecological science, since only during the past three decades has an important body of ecological researchers been formed. Although the number of scientists and institutions continues to increase, the community of ecologists is still small for the

number of tasks they are expected to fulfill. These tasks include research, undergraduate to postgraduate teaching, participation in environmental problem solving, and promotion of public awareness and understanding of environmental problems. The way in which the science is developing, however, does not facilitate the accomplishment of all these relevant activities.

Science in peripheral countries such as Mexico (where science was introduced from Europe during the colonization process) follows the patterns established in central countries (mainly in Europe and the United States), and ecology is not an exception. Through the control of the main channels of scientific communication, central countries establish research topics, methodologies, and approaches for the different disciplines (López 1997). Many ecologists in Mexico were trained in Europe and the United States, and when they return to the country, they frequently continue to work along the lines of their supervisors. They also reproduce their ethos or "scientific ideology" (Lomnitz and Fortes 1981), which is the set of beliefs and values with regard to the nature and purpose of science. This makes difficult the establishment of scientific institutions linked with local contexts, needs, and cultures. It is necessary, therefore, that Mexican ecologists recognize the importance of investigating issues that are relevant to the society in which they live rather than pursue topics set by central scientific trends. This would mean the establishment of ecological science in such a way that the development of Mexican ecology would emanate from and be directed toward the solution of the country's specific problems (Sarmiento 1990).

Another related factor in the minimal use of ecological information is that ecologists communicate almost exclusively with their peer colleagues. The major cause of this is the system of academic rewards. Scientists in Mexico are constrained by the process of evaluation, either at their home institutions or by the National System of Researchers. This is a system that awards fellowships administered by the Ministry of Education to productive scientists. Awards are periodically reviewed and currently constitute an important proportion of the salary of scientists. The main products expected from scientists are scientific articles published in international refereed journals. At the institutional level, the same scheme is followed. Therefore, scientists understand the application of ecology to be merely the publication of results in applied journals, as was the case with an ecologist in this study. Thus, "applied" ecology is what journals such as *Ecological Application* and the *Journal of Applied Ecology* publish, regardless of the final real-world consequence of an investigation (as demonstrated also by Pienkowsky and Watkinson 1996). What is needed in applied science is reward systems to be developed that recognize other indicators of scientific performance apart from production of peer-reviewed papers. As has been shown in Castillo and Toledo (2000),

applied ecologists in Mexico are receiving fewer economic incentives than scientists involved in basic science, although their work addresses some of the country's most important problems.

### *Ecologists' Interactions with Other Sectors*

Ecologists have little contact with members of NGOs. This is a result, perhaps, of the way in which scientists work—that is, being interested primarily in publishing scientific articles. Institutions do not value the collaboration of scientists with nonacademic sectors such as NGOs, which constitute a barrier to possible interactions. It remains up to the individual interest of a researcher to establish relationships with the different types of organizations that are involved in environmental problem solving. NGOs, nevertheless, are a relevant part of these relationships. Their role as a link between science and other social sectors is discussed in the following section.

With regard to the relationship with the rural producer sector, ecologists admitted that traditional systems of knowledge could be useful in the design of sustainable strategies for managing natural resources. Results from the survey of ecologists also suggest that interactions between ecologists and local people are not uncommon. Researchers claimed to be using information provided by local people in their projects. Although the precise nature of the information they are using remains unknown, it might be the case that this information is related more to such matters as specific queries by scientists about the location of research sites, or about the presence of particular plants or animals in a given area. Although this information is used in research projects, it does not modify the direction of a project. The project itself remains under the control of each particular scientist. When also considering the way in which science works, the most probable situation is that although rural people do provide information to ecologists, they do not influence in any significant way the work of scientists. Within the framework of the EIS, however, the research sector would require a two-way communication with rural producers that allows the feedback of information from them. As the literature on knowledge dissemination and utilization has suggested, there is a need to involve user audiences in the research process, from the setting of agendas to the final stages of writing up findings and recommendations. Structuring activities around issues identified as important by users themselves, and helping users to reflect on their own preconceived ideas and concerns, is also recognized as relevant (National Center for the Dissemination of Disability Research 1998). With regard to the EIS, it is through the permanent exchange of information between the sectors, and the acknowledgment

of the role of users of information, that the system may function synergistically and an effective utilization of science be promoted.

### *NGOs as a Link between Science and Rural Communities*

Environmental NGOs are widely acknowledged to promote changes with regard to the ways in which human societies relate to the natural systems surrounding them (Edwards and Hulme 1992). A relevant role played by NGOs is that of functioning as a link between the rural sectors (for whom many NGOs implement projects) and other sectors of society, such as with governmental institutions that remain largely responsible for providing crucial services like health and education. Due to their involvement at the grassroots level, NGOs also have been able to link the systems of knowledge of local communities with those of outside agencies, most significantly research institutions. In the area of agricultural development, for example, NGOs have facilitated the integration of community knowledge into research as a way of encouraging the development of technologies based on local resources and knowledge (Wellard 1993). This function, however, is not free of obstacles and limitations. Studies carried out in Africa have shown the importance of establishing cooperation between NGOs and research institutions, although they reveal the existence of psychological, institutional, and organizational factors that prevent the existence of effective interactions (Bara Gueye 1992; Lindskog and Mando 1992).

With regard to current findings, a first conspicuous aspect is the large proportion of NGOs that claimed to be carrying out their own research. This research was related particularly to the natural sciences in areas associated with ecological science. This finding is perhaps explained to a large extent by the strong representation of biologists within these organizations. This factor may have important implications, since NGOs might perceive the nature of environmental problems as primarily biological. Related also to the presence of people with scientific backgrounds on the staff of NGOs is the important use of scientific sources of information. With regard to the use of publications, the importance of the journal *Ciencia y Desarrollo* should be emphasized. This journal certainly provides an important forum for the dissemination of the research carried out in the country. However, when six annual unpublished reports of the IE-UNAM were reviewed as part of this study, the average number of articles published by this institution in *Ciencia y Desarrollo* was between one and two per year. This may be an indicator of the poor communication between what is produced in ecological research in the country and the NGO sector.

The limited use of international scientific journals by NGOs may be due to the high cost of subscriptions, but perhaps more important it is because these publications do not address the needs of NGOs. Although this type of source provides important scientific information, research results cannot easily be used to solve the practical problems with which NGOs have to contend. It should also be mentioned that most of these publications are in a foreign language, usually English, which can act as an obstacle in the communication process.

In relation to the interactions with research institutions, results indicate that NGOs make use of these institutions and that they value them. However, the fact that only two organizations reported that research institutions had participated with them in generating information suggests the link is weak; hence, cooperative partnerships occur rarely.

It is evident that in the work carried out by NGOs, science—through its institutions, actors, and outcomes—has a part to play. Not only do NGOs have personnel with scientific backgrounds, they also use scientific sources of information. On the other hand, it can be interpreted from the results of this study that the link with the Mexican scientific community (in particular in the area of ecological science) is not strong. NGOs do not usually consider research findings produced by Mexican ecologists, and neither institutions nor scientists consider the requirements of NGOs when designing their research. There is a need to strengthen the links between NGOs and the scientific institutions involved in ecological research in the country. NGOs have a potential role to play in the communication between Mexican ecological science and rural producers, and both types of organizations should be more open to interaction and collaboration.

### *The EIS as a Conceptual Framework*

The model of the EIS has proven useful in the identification of actors within each sector and as a framework for the examination of communication interactions between them. In this study, it is suggested that ecologists and their institutions acknowledge the relevance of collaborating with sectors such as rural producers and NGOs. The EIS model can guide the direction of applied ecological research in developing countries where rural production plays a relevant part in ecological management. In Mexico, for example, about 30,000 peasant communities manage an area of 100 million hectares, corresponding to 60 percent of the country's productive lands. Also, 7,000 to 9,000 rural communities manage 70 percent of Mexican forests (Bray 1995). It is through rural activities such as agriculture, forestry, and fishing that societies in developing countries obtain much of the resources they need, which

can then be used to obtain products and services for human consumption. Rural management of ecosystems is the first step in the exchange between society and nature (Toledo 1998).

The proposed EIS allows the integration of ecological science with the realities of the rural producers, who constitute the main managers of terrestrial, marine, and freshwater ecosystems in developing countries (Toledo 1997). In addition, the EIS can function as a framework for enhancing the use of both traditional knowledge and scientific information for the solution of problems. Within the context of the EIS, two experiences have been analyzed in Mexico of scientific research groups whose work is aimed at finding sustainable ways of managing ecosystems and their resources. The analysis included an examination of communication interactions between the three sectors forming the EIS. Results revealed the importance of promoting the feedback of information from rural producers and change agents to the research sector and the incorporation of this information into the research process. The creation of linkage systems that facilitate the connection between the generation and utilization of scientific information was also supported (Castillo 2000). It is important to mention the need for further studies of the EIS from the perspective of rural producers to address questions such as how peasants perceive the role of ecology and what are the best ways for them to come in contact with scientific knowledge.

### ***Recommendations: The Social Responsibility of Scientific Institutions***

For the more efficient interaction between the sectors forming the EIS, institutions of ecological research should start improving access to the information they generate by creating mechanisms that put this information into more usable forms and communicating it to different social sectors. As stated in the Sustainable Biosphere Initiative, it is necessary to develop "new institutional structures" that help to link ecological information with decisionmaking (Lubchenco et al. 1991). It is recommended that special units be created as an integral part of institutions, with the principal aim of promoting and establishing connections between science (its institutions, actors, and products) and different sectors of society. Teams forming these units would play the role of change agents working in collaboration with change agents in rural and nongovernmental organizations.

These new units within scientific institutions could rely on the work of science communicators. In Mexico, although there has been a growing movement promoting the public understanding of science, professionals dedicated

to this field have not yet been widely accepted, or even recognized, by the scientific community. Their work is still regarded as having less value than research, and within the evaluation systems their curricula simply do not measure up. These communicators, however, have an enormous potential role to play not only in the promotion of public understanding of science but also in its public utilization. Apart from working on the dissemination of research findings and scientific basic principles, another relevant task for the science communicators would be that of transforming scientific information to suit the needs of different social sectors. As has been mentioned throughout this article, a relevant sector to target is rural producers.

Communicators should assist rural people and other sectors involved in environmental management to request information from researchers and to influence the type of research carried out. In this way, users of information could be incorporated into the research process, setting the basis for a "participatory ecology" that has been strongly advocated (Holling, Berkes, and Folke 1998). The accomplishment of these functions would place scientific activity within a "knowledge perspective" that integrates the processes of knowledge generation, communication, and utilization within the same framework (Beal, Dissanayake, and Konoshima 1986). There are examples of experiences in Mexico following these initiatives. At the Colegio de la Frontera Sur, based in the southern border of Mexico, there is a Linkage with Social Sectors program in which a team of twelve "linkage technicians" plan, design, and implement projects related to agriculture, health, women's participation in rural development, and biodiversity conservation (Ecofronteras 1999). In these projects, the communication of researchers with rural communities and the utilization of scientific findings are promoted in order to develop better technologies for the sustainable management of natural resources and more suitable rural development strategies.

Finally, another important task is that of increasing and improving the existence of publications for the public understanding and utilization of science in Mexico. There is a considerable need for publications written in Spanish that disseminate what Mexican scientists are finding in relation to the national environment. This should be an important aspect of the work to be developed by research institutions and governmental agencies responsible for research and development. The scientific reward systems must begin to acknowledge the relevance of this task and place value on these types of publications. Mexican researchers and communicators could devote time to the production of scientific publications. Academic institutions involved in ecological research could then better contribute to the search for strategies that allow for the maintenance of Mexico's natural systems and the sustainable livelihood of its society.

**Appendix A**  
**Questions Used in the Survey of Ecologists**

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a. Could you suggest three areas in which the knowledge generated by your research group could be applied?

- i. \_\_\_\_\_
- ii. \_\_\_\_\_
- iii. \_\_\_\_\_

b. Could you give an example of how the knowledge generated by your research group has been used to solve a practical problem?

c. Could you estimate the proportion of use (giving percentages) of the different types of media that you use to communicate the knowledge you generate to other sectors (including other scientists)?

- \_\_\_ % refereed journals (international and national)
  - \_\_\_ % scientific meetings (conferences)
  - \_\_\_ % reports
  - \_\_\_ % scientific books (or chapters)
  - \_\_\_ % books (or chapters) for public understanding of science
  - \_\_\_ % articles for public understanding of science
  - \_\_\_ % newspapers
  - \_\_\_ % television and radio
  - \_\_\_ % others (specify)
- 

**Appendix B**  
**Questionnaire Used in the Survey of Nongovernmental Organizations**

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1. In what type of location does your organization carry out its work?

- |       |       |
|-------|-------|
| Rural | Urban |
|-------|-------|

2. What professions and/or occupations are represented in your organization?

- |             |                 |                       |
|-------------|-----------------|-----------------------|
| Biologists  | Sociologists    | Agricultural peasants |
| Chemists    | Anthropologists | Cattle raisers        |
| Physicists  | Psychologists   | Forestry workers      |
| Geographers | Educators       | Fishermen             |
| Agronomists | Communicators   | Miners                |

3. From where does your organization obtain the scientific information that it needs to support its projects?

- The organization carries out its own research
- From research institutions
- From publications

**Section A**

4. What kind of research is carried out by your organization?

Ecology	Forestry
Flora and fauna	Fisheries
Environmental planning	Sociology and anthropology
Environmental impact assessment	Economy
Agronomy	

5. Are there any barriers in carrying out these activities? \_\_\_\_\_

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**Section B**

6. Please mention up to three research institutions that have provided information to your organization: \_\_\_\_\_

7. How does your organization perceive its relationship with scientists of the above institutions?

Very good, since they participate with you in the generation of the information that is needed

Good, since they give you the information you need

Regular, since they simply give you references related to the information you need

Poor, since you simply have access to their libraries

**Section C**

8. Of the following publications, please indicate those that your organization uses:

National	International
<i>Acta Botánica</i>	<i>Biological Conservation</i>
<i>Acta Zoológica</i>	<i>Conservation Biology</i>
<i>Antropológicas</i>	<i>Ecological Applications</i>
<i>Biotecnología</i>	<i>Ecological Economics</i>
<i>Boletín de la Sociedad Botánica</i>	<i>Ecology</i>
<i>Ciencia</i>	<i>Environmental Science and Technology</i>
<i>Ciencia y Desarrollo</i>	<i>Forest Ecology and Management</i>
<i>Etnoecológica</i>	<i>Human Ecology</i>
	<i>Journal of Applied Ecology</i>
	<i>Journal of Ecology</i>
	<i>Natural Resources Journal</i>

9. Please mention up to three scientific journals or magazines used constantly by your organization: \_\_\_\_\_

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## References

- Altieri, M. A., and O. Masera. 1993. Sustainable rural development in Latin America: Building from the bottom-up. *Ecological Economics* 7:93-121.
- Bara Gueye, M. 1992. Co-operation between Senegalese non-governmental organizations and national research structures: Constraints and perspectives. International Institute for Environment and Development Paper no. 37.
- Beal, G. M. 1981. The change agent and change-agent roles. In *Extension education and rural development*, edited by B. R. Crouch and S. Chamala, 109-21. New York: John Wiley & Sons.
- Beal, G. M., W. Dissanayake, and S. Konoshima, eds. 1986. *Knowledge generation, exchange and utilization*. Boulder, CO: Westview Press.
- Begon, M., J. L. Harper, and C. R. Townsend. 1986. *Ecology: Individuals, populations and communities*. Sunderland, MA: Sinauer Associates Inc.
- Bray, D. 1995. Peasant organization and the permanent reconstruction of nature. *Journal of Environment and Development* 4:185-204.
- Castillo, A. 2000. The ecological information system: Analyzing the communication and utilization of scientific information in Mexico. *Environmental Management* 25:383-92.
- Castillo, A., and V. M. Toledo. 2000. Applying ecology in the Third World: The case of Mexico. *BioScience* 50:66-76.
- Chambers, R., A. Pacey, and L. A. Thrupp, eds. 1993. *Farmer first: Farmer innovation and agricultural research*. London: Intermediate Technology.
- Christensen, N. L., A. N. Bartuska, J. H. Brown, S. Carpenter, C. D'Antonio, R. Francis, J. F. Franklin, J. A. MacMahon, R. F. Noss, D. J. Parsons, C. H. Peterson, M. G. Turner, and R. G. Woodmansee. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management. *Ecological Applications* 6:665-91.
- Cohen, L., and L. Mannion. 1993. *Research methods in education*. London: Routledge.
- Committee on the Applications of Ecological Theory to Environmental Problems. 1986. *Ecological knowledge and environmental problem-solving: Concepts and case studies*. Washington, DC: National Academy Press.
- Costanza, R. 1993. Developing ecological research that is relevant for achieving sustainability. *Ecological Applications* 3:579-81.
- Daily, G. C., and P. R. Ehrlich. 1999. Managing Earth's ecosystems: An interdisciplinary challenge. *Ecosystems* 2:277-80.
- DeWalt, B. R. 1994. Using indigenous knowledge to improve agriculture and natural resources management. *Human Organization* 53:123-42.
- Ecofronteras. 1999. La vinculación académica en el sureste de México. *Gaceta Ecosur* 9:2-29.
- Ecological Applications. 1993. Forum science and sustainability. *Ecological Applications* 3:545-89.
- Ecological Society of America. 2000. *The ecological society of America membership*. Available from <http://esa.sdsc.edu>
- Edwards, M., and D. Hulme. 1992. *Making a difference: NGOs and development in a changing world*. London: Earthscan.
- Ehrlich, P. R. 1989. Discussion: Ecology and resource management—Is ecological theory any good in practice? In *Perspectives in ecological theory*, edited by J. Roughgarden, R. M. May, and S. A. Levin, 306-18. Princeton, NJ: Princeton University Press.
- Fondo Mexicano para la Conservación de la Naturaleza. 1999. *Directorio Mexicano de la Conservación 1999*. Mexico City: Fondo Mexicano para la Conservación de la Naturaleza.

- Gadgil, M., F. Berkes, and C. Folke. 1993. Indigenous knowledge for biodiversity conservation. *Ambio* 22:151-56.
- González Gaudiano, E. 1999. Otra lectura a la historia de la educación ambiental en América Latina y el Caribe. *Tópicos en Educación Ambiental* 1:9-26.
- Holling, C. S. 1993. Investing research for sustainability. *Ecological Applications* 3:552-55.
- Holling, C. S., F. Berkes, and C. Folke. 1998. Science, sustainability and resource management. In *Linking social and ecological systems*, edited by F. Berkes and C. Folke, 342-62. Cambridge: Cambridge University Press.
- Instituto Nacional de Estadística, Geografía e Informática. 2000. *Estadísticas sociodemográficas*. Available from <http://www.inegi.gob.mx>
- Lindskog, P., and A. Mando. 1992. The relationship between research institutes and NGOs in the field of soil and water conservation in Burkina Faso. International Institute for Environment and Development Paper no. 39.
- Lomnitz, L., and J. Fortes. 1981. Ideología científica y difusión de la ciencia. In *La divulgación de la ciencia*, edited by L. Estrada, 9-26. Mexico City: Universidad Nacional Autónoma de México.
- Long, N., and A. Long. 1992. *Battlefields of knowledge: The interlocking of theory and practice in social research and development*. London: Routledge.
- López, C. 1997. Towards reframing the center-periphery problem. Paper presented at the International Society for the History, Philosophy and Social Studies of Biology International Meeting, July, Seattle, Washington.
- Lubchenco, J., A. M. Olson, L. B. Brubaker, S. R. Carpenter, M. M. Holland, S. P. Hubbell, S. A. Levin, J. A. MacMahon, P. A. Matson, J. M. Melillo, H. A. Mooney, C. H. Peterson, H. R. Pulliam, L. A. Real, P. J. Regal, and P. G. Risser. 1991. The sustainable biosphere initiative: An ecological research agenda. *Ecology* 72:371-412.
- Ludwig, D., R. Hilborn, and C. Walters. 1993. Uncertainty, resource exploitation, and conservation: Lessons from history. *Science* 260:17, 36.
- Mangel et al. 1996. Principles for the conservation of wild living resources. *Ecological Applications* 6:338-62.
- Maundu, P. 1995. Methodology for collecting and sharing indigenous knowledge: A case study. *Indigenous Knowledge and Development Monitor* 3:3-5.
- Mittermeier, R. A., P. Robles-Gil, and C. G. Mittermeier. 1997. *Megadiversidad: Los Países Biológicamente más Ricos del Mundo*. Mexico City: CEMEX.
- National Center for the Dissemination of Disability Research. 1998. *Review of the literature on dissemination and knowledge utilization*. Available from <http://www.ncddr.org>
- Norton, B. G. 1998. Improving ecological communication: The role of ecologists in environmental policy formation. *Ecological Applications* 8:350-64.
- Okali, C., J. Sumberg, and J. Farrington. 1994. *Farmer participatory research: Rhetoric and reality*. London: Intermediate Technology.
- Ordoñez, M. J., B. Miramontes, and R. García-Barrios. 1993. *Directorio de organizaciones de manejo, protección y conservación ambiental en México*. Mexico City: Centro de Investigaciones y Docencia Economicas.
- Pienkowski, M., and A. R. Watkinson. 1996. The application of ecology. *Journal of Applied Ecology* 33:1-4.
- Piñero, D. 1994. *La ecología, las ciencias ambientales y la situación ambiental en México*. Mexico City: Consejo Consultivo de Ciencias de la Presidencia de la República.
- Population Reference Bureau. 2000. *1999 world population data sheet*. Available from <http://www.prb.org>

- Röling, N. 1990. *Extension science information systems in agricultural development*. Cambridge: Cambridge University Press.
- Röling, N., and P.G.H. Engel. 1991. The development of the concept of agricultural knowledge information system (AKIS): Implications for extension. In *Agricultural extension: World-wide institutional evolution and forces of change*, edited by W. M. Rivera and D. J. Gustafson, 125-37. Amsterdam: Elsevier Science.
- Sánchez, M.A.M. 1998. *La divulgación de la ciencia como literatura*. Mexico City: Universidad Nacional Autónoma de México.
- Sarmiento, G. 1990. Sobre los idiomas de la ciencia en América Latina y otros comentarios metacientíficos. *Interciencia* 15:42-45.
- Scoones, I., and J. Thompson. 1994. *Beyond farmer first: Rural peoples' knowledge, agricultural research and extension practice*. London: Intermediate Technology.
- Secretaría de Desarrollo Social. 1993. *Directorio verde: Organismos no-gubernamentales*. Mexico City: Instituto Nacional de Ecología, Secretaría de Desarrollo Social.
- Soberón, J. 1995. Algunas ideas sobre el desarrollo y las perspectivas de la ecología en México. *Ciencia* 46:5-8.
- Toledo, V. M. 1992. What is ethnoecology? Origins, scope and implications of a rising discipline. *Etnoecologica* 1:5-21.
- . 1997. Sustainable development at the village community level: A Third World perspective. In *Environmental sustainability: Practical global applications*, edited by F. Smith, 233-50. Boca Raton, FL: St. Lucia Press.
- . 1998. Estudiar lo rural desde una perspectiva interdisciplinaria: El enfoque ecológico-sociológico. In *Globalización, crisis y desarrollo rural en América Latina*, edited by E. Valdivia. Texcoco, México: Colegio de Posgraduados/Universidad Autónoma de Chapingo.
- Van den Ban, A. W., and H. S. Hawkins. 1996. *Agricultural extension*. Oxford: Blackwell Science.
- Wellard, K. 1993. Linking local knowledge systems and agricultural research: The role of NGOs. In *Cultivating knowledge*, edited by W. De Boef, K. Amanor, K. Wellard, and A. Bebbington, 136-42. London: Intermediate Technology.

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