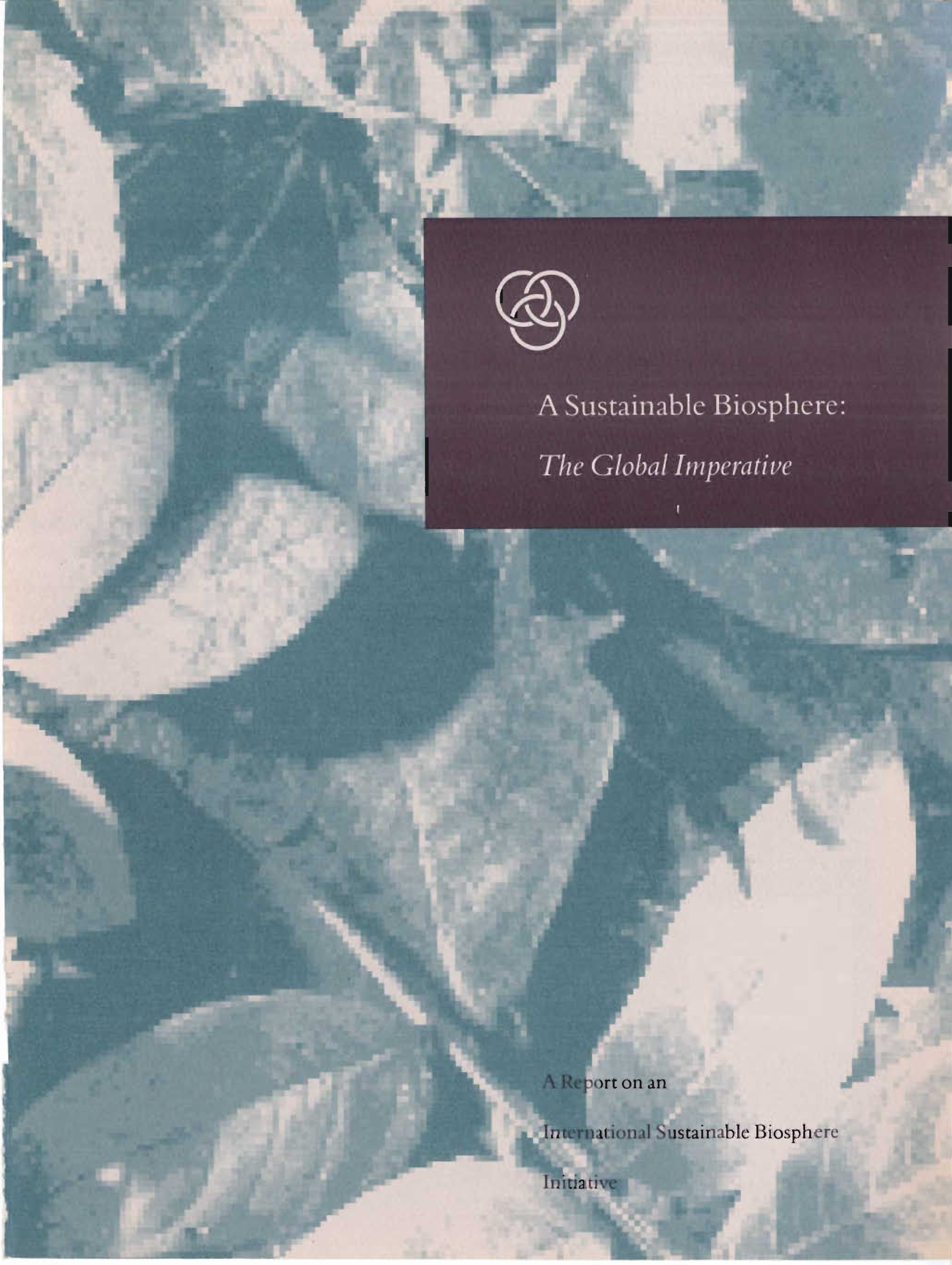

A Sustainable Biosphere:

The Global Imperative

A Report on an

International Sustainable Biosphere

Initiative

Ecology International 1991: 20

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A Sustainable Biosphere

Reports from the International Sustainable Biosphere Initiative Workshop
and from the Ecological Society of America

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Preface

Throughout the world there is an increasing awareness that environmental problems resulting from human activities threaten the future of this planet and its biosphere. The deteriorating state of our global environment and the increasing demands for resources by the growing human population have led to concern about the sustainability of the Earth's life support systems. It is becoming recognized that there is an urgent need to ameliorate environmental deterioration and to enhance the capacity of the planet to sustain the needs of the world's population.

The concept of sustainability implies the use of ecological systems in a manner that satisfies current needs without compromising the needs or options of future generations. We will increasingly require the application of ecological knowledge if we are to achieve such sustainability. For example, decisions concerning the use of resources cannot be made effectively without a fundamental understanding of the ways in which the natural systems of Earth are affected by human activities. Researchers, especially ecologists, can and must contribute to establishing the scientific basis for sustaining a high quality of life on Earth.

Driven by these concerns for integrating ecological science into the wise management of the Earth's resources, the Ecological Society of America proposed the *Sustainable Biosphere Initiative* (SBI), an ecological research agenda for the 1990s. This agenda was developed further in a workshop in Cuernavaca, Mexico, in which ecologists from fourteen countries recommended the establishment of a cooperative program, the *International Sustainable Biosphere Initiative* (ISBI).

Much interest, and much discussion, has resulted in the development of these two documents. Both call for an interdisciplinary approach to facilitate the sharing of knowledge and skills. Neither individual scientists nor national organizations can address the challenge of sustainability on their own. The problems are not just scientific, but include peoples' value systems and expectations, education and judgment. The sustainability of our biosphere requires the integration of social, physical and biological sciences. Ecologists must be joined by policy makers, resource managers and society at large.

INTECOL is pleased to publish the ISBI report, *A Sustainable Biosphere: The Global Imperative,* in this special issue of *Ecology International* and to introduce the ISBI together with the SBI to ecologists all over the world. The message that they contain is an important step for the professional ecological community and places a high priority on research directed to the understanding of environmental issues. INTECOL is dedicated to promoting, developing and communicating the science of ecology and to applying ecological principles to global needs through international cooperation.

INTECOL endorses all efforts to develop, and to implement, such initiatives for global cooperative programs combining research, education and environmental decision-making. It is our hope that these documents will spur attention, imagination, scientific investigation and action to achieve general environmental sustainability.

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President of INTECOL

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Secretary-General of INTECOL

A SUSTAINABLE BIOSPHERE: THE GLOBAL IMPERATIVE

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A SUSTAINABLE BIOSPHERE: THE GLOBAL IMPERATIVE

1. INTRODUCTION

There is wide agreement among scientists that the future of planet Earth is at risk. Environmental problems resulting from human activities threaten the sustainability of global life-support systems. The present generation is the first in the history of humankind with the power to totally destroy life on earth. It is also the last generation with the option to reverse trends in environmental degradation and transform the world to a healthy, sustainable state. However, the information and understanding needed by decision makers to address the situation is wholly inadequate.

Researchers, and especially ecologists, can and must contribute to establishing the scientific basis for attaining a higher quality of life on Earth. Higher quality of life includes sustainability, equity and coexistence with other species and components of our heritage, in a biologically and culturally diverse world. Activities initiated in pursuit of an improved quality of life, through the production of food, fibre, shelter, consumer goods, recreation, and so forth, frequently lead to unintended results (Fig. 1). These negative consequences of humanity's activities all relate to the functioning of ecological systems, and require knowledge and understanding of such processes in natural and transformed environments as keys to their solution.

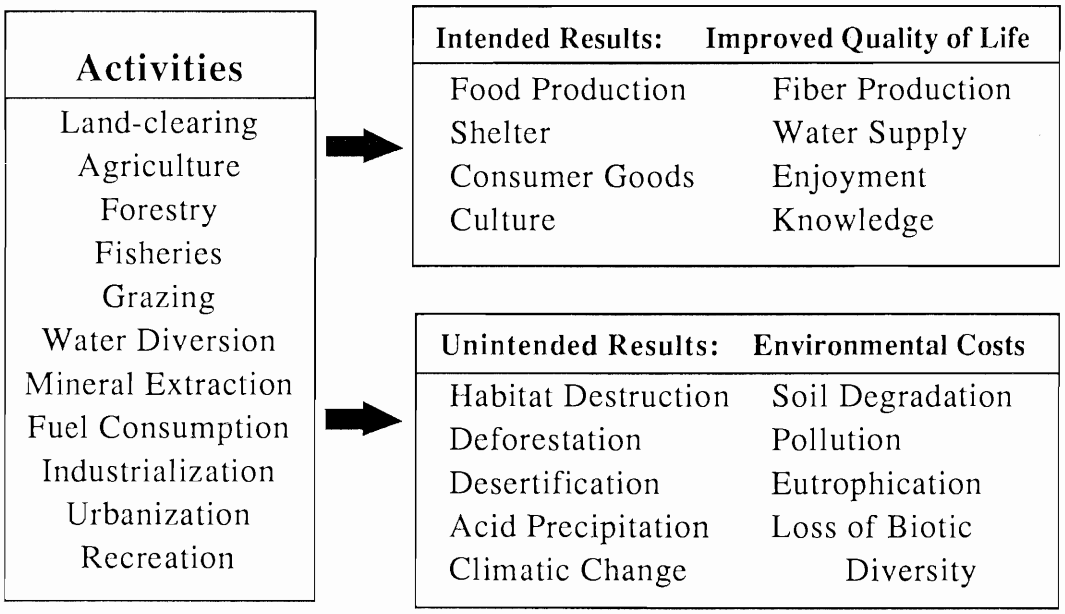

FIGURE 1: Human activities affecting the sustainability of the biosphere (After Lubchenco *et al.* 1991). Ecological knowledge applied in management systems would reduce the incidence of negative, unintended results while continuing to provide the positive, intended results.

In response to this challenge, the Ecological Society of America proposed the *Sustainable Biosphere Initiative,* an ecological research agenda for the 1990s (Lubchenco *et al.* 1991; Risser *et al.* 1991). This proposal was taken further by a workshop held in Cuernavaca, Mexico, in June 1991. The workshop, attended by ecologists from fourteen countries around the globe, recommended the establishment of a cooperative program, the *International Sustainable Biosphere Initiative* (ISBI), with the central goal to:

> "facilitate the acquisition, dissemination, and utilization of ecological knowledge to ensure the sustainability of the biosphere."

The concept of sustainability (Table 1) implies the use of ecological systems (the biosphere) in a

TABLE 1: The guiding principles of ecologically sustainable resource management (Adapted after Hare *et al.* 1990).

Inter-generational equity: providing for today while retaining resources and options for tomorrow.
Conservation of cultural and biological diversity and ecological integrity.
Constant natural capital and 'sustainable income'.
Anticipatory and precautionary policy approach to resource use, erring on the side of caution.
Limits on natural resource use within the capacity of the environment to supply renewable resources and assimilate wastes.
Qualitative rather than quantitative development of human well-being.
Pricing of environmental values and natural resources to cover full environmental and social costs.
Global rather than regional or national perspective of environmental issues.
Efficiency of resource use by all societies.
Strong community participation in policy and practice in the process of transition to an ecologically sustainable society.

manner that satisfies current needs without compromising the needs or options of future generations. There are clearly trade-offs between meeting current needs and maintaining a diversity of options for the future. Achieving a better understanding of these trade-offs is one of the fundamental challenges of the ISBI.

2. APPROACH AND COMPONENTS OF THE PROGRAM

The dimension of the environmental crisis facing planet Earth is such that neither individual scientists nor national organizations can address the challenge on their own. The problems are not only scientific, but include people's value systems and expectations, education and judgment. Entirely new ways of organizing research projects and implementing their findings will be needed because the sustainability of ecosystems involves the actions of many management agencies and because it requires the integration of social, physical and biological sciences. Ecologists must be joined by policy makers, resource managers, and society at large if the ISBI is to mobilize the intellectual and logistic resources needed to achieve its goal.

The ISBI recognizes the striking dichotomy between the industrialized and the less developed countries in terms of their population and economic dynamics and the consequences of these asymmetries in resource use and abuse. Solving the problems of excessive and often wasteful use of fossil fuels, the production of toxic wastes and the exploitation of tropical forest resources by the First World economies will require a suite of ecological studies that will differ in scale and application from those addressing the problems of desertification, sedimentation, sanitation and malnutrition experienced by the Third World. The ISBI must therefore respond to a wider range of needs than any previous program of its kind. It must also link the actions of global decision-makers with those of rural peasants.

The interdisciplinary approach adopted by the ISBI will facilitate the sharing of knowledge and skills and their implementation through interactions among the three components of the program - research, education, and environmental decision-making (Fig. 2).

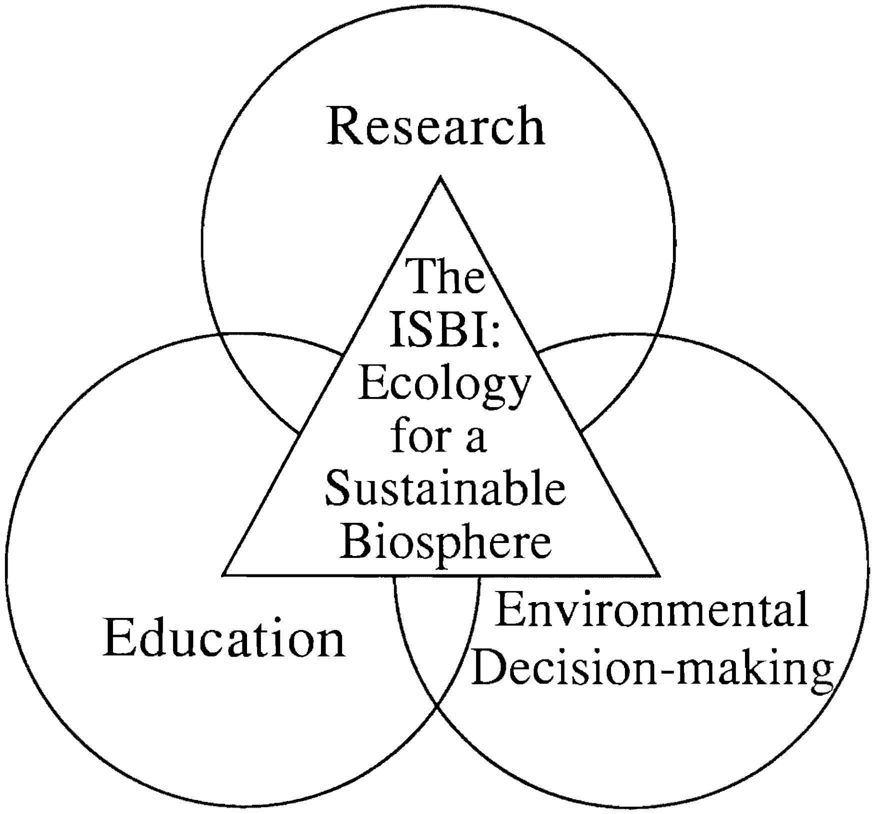

FIGURE 2: Interdisciplinary interactions called for by the International Sustainable Biosphere Initiative (ISBI) (After Lubchenco *et al.* 1991)

2.1 **Research:** The lessons learnt from previous international research programs indicate that the ISBI should include the following elements in its strategic approach:

- An operational research program, setting short-, medium- and long-term goals must be formulated to guide the program and against which to evaluate its progress;
- A cornerstone of the ISBI should be investigator-initiated, peer-reviewed research within agreed research agendas or programs;
- Participation in international programs such as the ISBI provides an invaluable source of inspiration to researchers working in industrialized countries, and particularly to researchers in often isolated, rural communities of less developed countries where the need for such stimulation is greatest;
- The ISBI research program must complement and be recognized by other international scientific endeavours, such as the International Geosphere-Biosphere Program, the Man and the Biosphere Program, and the Biodiversity Strategy and Action Plan;
- Participation in the program should range from the contributions of creative, individual scientists to major interdisciplinary team efforts;
- In view of the urgency and importance of these problems, and the limited resources currently available for environmental research, scientists must set rigorous criteria for the selection of priorities, otherwise such decisions might be taken by others; and
- Innovative funding strategies need to be developed to satisfy the demands of this global, interdisciplinary project.

2.2 **Education:** If changes in the current environmental situation are to be produced, it is essential that all people are made aware of the unique position that humanity occupies at this moment in history. It is evident that sustained resource use is neither an obvious nor an intuitive perception amongst most communities. The ISBI emphasizes the importance not only of transferring ecological information to the public, but also of demonstrating the benefits of ecologically sound practices to both industrial and peasant societies. Active participation of communities in the research programs, and in the implementation of lessons learnt, is essential in the education and training component of ISBI.

The ISBI proposes to develop strong links with the media, with opinion formers and with educators. The ISBI will require increased participation by ecologists in formal and non-formal education and training programs, most especially in less developed countries.

The best strategies will vary among countries and will require imagination. However, some possible approaches include:

- Publish articles and books explaining to the general public, in easily digestible terms, the discipline of ecology and how it is already contributing to the solution of perceived important problems;
- Assist school authorities at all levels of education in the creation of suitable ecologically oriented teaching programs;
- Contribute to the development of interdisciplinary environmental post graduate courses for engineers, economists, and business managers;
- Consider conferring a professional title that will convey some of the expertise of ecology into management and policy design; and
- Stimulate the emergence of a new breed of research ecologists with training that includes not only the natural sciences but also the social sciences.

2.3 **Environmental decision-making:** The ISBI will have to overcome existing attitudes that frequently do not perceive ecologists as offering solutions to problems relating to the quality of life. Ecologists will have to break away from the intellectual and professional traditions that have constrained their involvement in social, economic and political matters. The ISBI recognizes that basic research, executed through the intellectual curiosity of individual scientists, must provide the information on which wise environmental decisions depend. The knowledge generated by such studies must be incorporated into policy on and management of natural resources. The development and application of decision support systems based on the findings of the ISBI will be an integral and ongoing component of the program, drawing on advances in geographic information systems, environmental data bases, monitoring systems and other developments in information technology. Effective communication and implementation of the knowledge gained through the program will be the key to the ISBI's success. It is thus imperative that the research results of the ISBI permit sound generalizations and interpretation.

3. RESEARCH PRIORITIES

To achieve sustainable use of the biosphere, we need to make rapid progress in three facets of sustainability: diversity and sustainability; sustainability in a changing biosphere; and in the human dimensions of sustainability. First, we must accelerate ecological research in those areas most directly related to the maintenance of the functional basis of ecosystems upon which the sustainability of our biosphere depends. Second, this research must be carried out against the background of global change. There are well established international efforts in this area and here we describe those sections most relevant to achieving global sustainability. Third, sustainability is a human-centered concept and can only be achieved with the willingness and cooperation of many culturally diverse human societies. Here we again emphasize the need for a closer link between ecologists and our colleagues in the social sciences and describe some topics of common interest.

The tenet behind all these proposals is that basic research is the foundation on which informed environmental decisions must rely: the greater the applied needs, the more important becomes basic research. We do not have the time nor resources to tackle each problem with narrowly based investigation. Our research program must encompass the entire biosphere, but it must also be related to the scale at which management decisions are made. Thus, most projects will be based on particular ecosystems or local communities. However, it is essential that comparative and regional studies are undertaken, eventually leading to a global viewpoint.

We also emphasize that urban-industrial ecosystems require special attention since these house the majority of human populations, they are the main sources of pollution, they are dependent on energy and many have material inputs for their continuation and become unstable because of unconstrained growth. In the following research themes, we urge ecologists to investigate the complex inter-relationships between urban, agricultural, forest and natural terrestrial and aquatic ecosystems which together make up the cultural landscapes within the biosphere.

3.1 DIVERSITY AND SUSTAINABILITY

As ecosystems come under increasing use, it is particularly important to understand how they respond to different classes of disturbances, how simplifying ecosystems changes their functional properties, and how ecosystem diversity might be maintained in the face of increasing disturbance.

3.1.1 Ecosystem Responses to Disturbance

Goal: To develop a functional classification of ecosystems according to their response characteristics to disturbance. This knowledge will be the basis for a theory of ecosystem management.

1) How do different ecosystems respond to natural and anthropogenic disturbance?

2) What are the interactive effects of perturbations on ecosystem behavior?

3.1.2 Consequences of Simplification

The vegetational cover of a huge proportion of the Earth's land surface is becoming ever more simplified. Earth is losing species, losing genetic variation within species, and losing spatial heterogeneity in the disturbance of life-forms and community-types.

Goal: To understand the relationship between biodiversity and ecosystem behavior.

1) What are the relationships between system complexity and stability (in various senses), especially in systems composed of minimal numbers of species, genotypes, life-forms and spatial units?

2) How many life-forms and species, what degree of genetic variation in each species, and how much spatial heterogeneity in community structure, are needed to maintain and/or reconstruct self-maintaining ecosystems in the face of changing conditions?

3) What is the resistance of crops and simplified natural systems to pathogens and pests as a function of genetic diversity and a changing environment?

4) How does energy input relate to the stability and management of systems of varying complexity?

3.1.3 The Nature and Maintenance of Diverse Systems

At the opposite end of the spectrum of complexity from human dominated, highly simplified systems, are those containing species-rich, near-natural communities. In this case the concern is to assess and maintain the genotypes, species and community diversity in these diminishing and increasingly isolated areas.

Goal: To document and understand the mechanisms maintaining complex systems.

1) What is the biology and distribution of organisms and systems in areas of high complexity?

2) What rules govern dispersal and gene flow at coarse scales on which to base recommendations on reserve design?

3) What are the origins and processes of maintenance of high diversity systems?

3.2 SUSTAINABILITY IN A CHANGING ATMOSPHERE

Developing a sustainable biosphere is an enormous challenge in the face of the ever increasing demands on the earth's natural resources. A major complication in developing plans for maintaining a sustainable biosphere is the fact that the status of our natural resources is not only changing as a result of direct human impacts, such as land use, erosion, sedimentation, and pollution, but is also being changed due to indirect effects of human activity leading to changes in the composition of the atmosphere and, most likely, to climate change itself. Thus, documenting, understanding and predicting the trajectories of global change, and their impacts on natural systems, is crucial for developing plans for a sustainable biosphere.

The following research questions are given by way of example only and indicate that new information is needed to answer problems related to global change that include studies at levels from responses of individuals to those of entire regions.

3.2.1 The State of the Biosphere

Goal: To document the present state of the Earth's biotic systems and the factors controlling the rate and direction of change.

1) How can we monitor the status of the Earth's biotic resources through time?

2) What are the climatic controls on the growth of organisms at regional scales, and of interactive controlling elements including salinity, pollutants, CO_2, and so forth, and how can these be quantified?

3.2.2 Responses and Feedbacks of Biotic Systems to Change

Goal: To develop the information needed to access the responses and feedbacks of biotic systems to global change.

1) What are the responses of organisms and whole ecosystems to multiple stress factors, including UVB, enhanced CO_2, elevated temperature, climate change and pollutants, and how will these responses influence atmospheric projections?

2) How will the controls of the distribution, abundance, and productivity of organisms be altered in the context of a rapidly changing environment?

3) What are the effects of ecosystem degradation or eutrophication in the past and present, and how can this knowledge guide habitat management and restoration measures?

3.2.3 Synthesis and Modelling

Goal: To develop approaches for synthesizing information from various disciplines and taken at different scales in order to understand the functioning of the Earth system.

1) What new approaches are available to improve the linkage of information from various scales of research (for example, ecosystem change models linked with global circulation models)?

2) What methods can be used to interpret patterns at broad scales (e.g., remote sensing) in terms of processes operating at finer scales?

3) What new approaches can be used for integrating information from the level of the individual organism with that of the ecosystem?

3.3 HUMAN DIMENSIONS OF SUSTAINABILITY

Ecologists and social scientists have traditionally worked separately, using dissimilar approaches to the same or related problems. Achieving sustainability of the biosphere will call upon these separate disciplines to integrate their approaches in a complementary manner. The following themes and research questions are some examples where the links between the natural and the social sciences are particularly evident.

3.3.1 Human Population and Perceived Resources

Goal: To understand the relationships between the human population and renewable resources.

1) What are the local, regional and global population growth trends, and how do they relate to perceived resource availability?

2) What are the cultural constraints on how people perceive environmental degradation? How does community participation in sustainability planning influence perceptions of the rate and direction of environmental change/degradation?

3) How is human regional migration related to perceptions of trends in environmental quality/degradation?

4) How can traditional knowledge and established production systems be incorporated into strategies for sustained development?

3.3.2 Human Values and Beliefs and Resource Degradation

Goal: To understand the role of various beliefs and value systems in generating differences in the dynamics of resource depletion or resource conservation at the local and regional levels.

1) How do local and regional values and belief systems constrain or promote the degradation of natural resources?

2) How can traditional values be incorporated into strategies for maintenance of biological diversity?

3.3.3 Cultural Styles and Environmental Change

Goal: To understand how various life styles and socio-economic regimes are related to ecological impacts.

1) What is the relationship between equity of resource access/allocation and the sustainable use of natural resources?

2) What are the relative environmental impacts of different human life styles?

3) What are the ecological consequences of alternative industrial technologies?

The results from these research themes will contribute to decision making about the multiple use of our resources. Multiple use of ecosystems has long been the norm in human societies. However, in the past, usage patterns tended to evolve over a longer period of time and impacts were of lower intensity. Thus, decisions were often reversible and often did not limit the options of future generations. Now, impacts are greater in intensity and area, and organizational structures often make it more difficult to achieve consensus on usage patterns. Thus, there is a need for new decision support systems. These systems must bring together information on physical, biological and socio-economic domains. The information should be broadly based, quickly available, readily assimilable and presented in a form that allows the consequences of alternative scenarios to be assessed.

Ultimately, we must address the question of most fundamental importance: that of the Earth's human population supporting capacity. This must be accepted as a valid and urgent research priority. We note that it is a complex question and that it must be evaluated in terms of differing socio-economic scenarios, implied living standards, and potential per-capita material and energy use scenarios. Some consideration may be focused on levels of agricultural inputs, alternate uses of potentially productive land, industrial inputs, and energy subsidies and fluxes. Research must be undertaken and it must be multidisciplinary and multinational in its context.

TABLE 2: International Organizations and Institutions currently involved in projects that relate to ISBI objectives.

International Council of Scientific Unions (ICSU)
- International Geosphere - Biosphere Programme (IGBP)
- Scientific Committee on Problems of the Environment (SCOPE)
- International Union of Biological Sciences (IUBS)
- Tropical Soil Biology and Fertility program (TSBF)

United Nations Educational, Scientific and Cultural Organization (UNESCO)
- Man and the Biosphere program (MAB)
- International Hydrological Program (IHP)

International Union for the Conservation of Nature and Natural Resources (IUCN)
- World Conservation Monitoring Centre (WCMC)

United Nations Environmental Program (UNEP)
- Global Environmental Monitoring System (GEMS)

Food and Agricultural Organization (FAO)

World Health Organization (WHO)

World Meteorological Organization (WMO)

World Resources Institute (WRI)
- Biodiversity Strategy and Action Plan (BSAP)

4. ORGANIZATION

The Cuernavaca meeting recommended the development of an ISBI program, ideally under the auspices of the International Council of Scientific Unions (ICSU). The ISBI would not subsume any existing ICSU activity, but rather develop synergistic interactions with the many similar programs within ICSU and other international ventures (Table 2). At an early stage, these interrelations would need to be structured within a formal proposal. ISBI would direct its energies to:

1) Stimulate the curiosity of individual scientists and research groups to study sustainability questions;

2) Reinforce the participation of local communities in sustainability projects which demonstrate benefits; and

3) Mobilize ecologists throughout the world to join a series of 'flagship' projects initiated and funded through ISBI.

In order to implement the workshop proposal, an interim Steering Committee was appointed, with the mandate:

1) To edit and publish the Cuernavaca workshop proceedings. To interact closely with INTECOL in the distribution of the proceedings to the ecological community at large.

2) To promote the inclusion of the workshop's findings in material currently being prepared for the ASCEND 91 meeting, to be convened by ICSU in Austria in November 1991, as a submission to UNCED.

3) To prepare and to submit to the next General Assembly of the ICSU Scientific Committee on Problems of the Environment (SCOPE), to be convened in Spain in January 1992, a proposal for a project directed at producing a global synthesis of the conceptual and practical considerations relevant to attaining a sustainable biosphere.

4) To attend to any other matters pertaining to the successful launch of the International Sustainable Biosphere Initiative.

The members of the interim Steering Committee are Brian Huntley (Convener) (South Africa), Eduardo Fuentes (Chile), Wolfgang Haber (Germany), Jane Lubchenco (United States), Valeri Neronov (USSR), Ian Noble (Australia), and P.S. Ramakrisnan (India).

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Hare, W.L., J.P. Marlowe, M.L. Rae, F. Gray, R. Humphries, and R. Ledgar, 1990. Ecologically Sustainable Development. Australian Conservation Foundation, Fitzroy, Victoria.

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.

Risser, P.G., J. Lubchenco and S.A. Levin, 1991. Biological Research Priorities: A Sustainable Biosphere. *Bioscience:* in press.

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The three interlocking rings of the Borromean Knot symbolize the triad of interdependent concerns of the Sustainable Biosphere Initiative. These concerns are for global change, biological diversity and sustainable ecological systems. Breaking any of the three links in the Borromean Knot disengages the remaining rings. The integrity of the whole requires the integrity of each part.

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