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H.J. RES. 589—INTERNATIONAL BIOLOGICAL PROGRAM

GOVERNMENT

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HEARINGS
BEFORE THE
SUBCOMMITTEE ON
SCIENCE, RESEARCH, AND DEVELOPMENT
OF THE
COMMITTEE ON
SCIENCE AND ASTRONAUTICS
U.S. HOUSE OF REPRESENTATIVES
NINETY-FIRST CONGRESS
FIRST SESSION

MAY 6 AND 7, 1969

[No. 6]

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CHAPTER I

The first chapter of the book is devoted to a general survey of the subject. It begins with a definition of the term "philosophy" and then proceeds to a discussion of the various branches of the subject. The author then discusses the history of philosophy, from the ancient Greeks to the modern era. He then discusses the various schools of thought, such as Platonism, Aristotelism, and Stoicism. The chapter concludes with a discussion of the relationship between philosophy and other sciences, such as mathematics and natural science.

INTERNATIONAL BIOLOGICAL PROGRAM

TUESDAY, MAY 6, 1969

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10 a.m., in room 2325, Rayburn House Office Building, Hon. Emilio Q. Daddario (chairman of the subcommittee), presiding.

Mr. DADDARIO. This meeting will come to order. Today we open our third set of hearings on the International Biological Program.

In 1967, this subcommittee inquired into the substantive aspects of the IBP over a period of 4 months and subsequently issued a comprehensive report, outlining certain needs and problems connected with the program.

A year ago this month, we held additional hearings with particular attention being devoted to methods of implementing the IBP.

The hearings today are designed to discuss a resolution supporting the IBP which has resulted from the earlier labors of this subcommittee. We believe they will be profitable and will help provide us with legislation we can take to the House in the near future.

The resolution before us is House Joint Resolution 589, which Chairman Miller and I introduced March 25, 1969. Identical resolutions by Mr. Fulton and Mr. Podell have also been introduced and are before the committee.

(The resolution referred to follows:)

[H.J. Res. 589, 91st Cong., first sess.]

JOINT RESOLUTION Expressing the support of the Congress, and urging the support of Federal departments and agencies as well as other persons and organizations, both public and private, for the international biological program

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) the Congress hereby finds and declares that the international biological program, which was established under the auspices of the International Council of Scientific Unions and the International Union of Biological Sciences and is sponsored in the United States by the National Academy of Sciences and the National Academy of Engineering, deals with one of the most crucial situations to face this or any other civilization—the immediate or near potential of mankind to damage, possibly beyond repair, the earth's ecological system on which all life depends. The Congress further finds and declares that the international biological program provides an immediate and effective means available of meeting this situation, through its stated objectives of increased study and research related to biological productivity and human welfare in a changing world environment.

(b) The Congress therefore commends and endorses the international biological program and expresses its support of the United States National Committee and the Interagency Coordinating Committee, which together have the responsibility for planning, coordinating, and carrying out the program in the United States.

(c) In view of the urgency of the problem, the Congress finds and declares that the provision by the United States of adequate financial and other support for the international biological program is a matter of first priority.

SEC. 2. (a) The Congress calls upon all Federal departments and agencies and other persons and organizations, both public and private, to support and cooperate fully with the international biological program and the activities and goals of the United States National Committee and the Interagency Coordinating Committee.

(b) For this purpose, the Congress authorizes and requests all Federal departments and agencies having functions or objectives which coincide with or are related to those of the international biological program to obligate or make appropriate transfers of funds to the program from moneys available for such functions or objectives and provide such other support as may be appropriate.

Mr. DADDARIO. As we begin this inquiry, let me repeat a few thoughts I voiced in the House when the resolution was introduced:

The IBP is not just another Government venture, and it is not some abstract international dream. It is a very real, planned, and coordinated effort to establish an ecological base for the management of our environment and for the prevention of the deterioration which is threatening our entire planet. It may be one of the most crucial programs, in spite of its mild-sounding title, to evolve in our time.

Since last summer when the Subcommittee on Science, Research and Development completed its hearings and review on the status of the IBP a great deal has transpired to justify our original enthusiasm and to eliminate those reservations we had concerning the organization and management of such a complex program.

However, since World War II we have left ecology—the only scientific discipline which specializes in the total environment—to its own devices in a market in which it could not possibly compete. As a result, a science which might have matured to meet our problem solving needs in environmental matters has fallen behind the bold advances in many other areas of American science.

It is the problem solving—the utilitarian and practical aspects of conservation and its management—which is the motivation for the IBP, rather than the usual emphasis on sentiment and esthetics. This pragmatic approach has led ecological practitioners in the United States and in some 70 other nations to undertake the complex task of planning and designing a research program which will produce the manpower, skills, and theory essential to the management of our environmental resources.

We have no responsible policy choice other than to respond favorably to the needs of the ecological sciences. Our immediate opportunity is the International Biological Program which we have requested American biologists to design and promulgate. Thus we intend and expect, by means of this resolution, that Federal agencies which conduct relevant scientific work will support the IBP to the extent that meets the needs of the U.S. projects under that program.

A final word.

Last week, in response to a request I had made following the 1968 Joint House-Senate Colloquium on the Environment, I received a very significant "coordinated statement" from the members of the Committee on Environmental Quality of the Federal Council on Science and Technology.

Coming as it does from representatives of all Federal agencies concerned—even though it is not an official Government position—this

statement may well serve as a landmark for the establishment of a national environmental policy. It is perhaps the most cogent pronouncement of its kind to date.

I shall have more to say about this statement in the near future when it is transmitted to the Congress.

Meanwhile, let me simply say that special emphasis is given by this statement to "the international spread of environmental problems which calls for positive action on an international scale." It further recommends "the development of international arrangements to coordinate existing or initiate new programs . . . on a continuing or regularized basis."

The implications for the IBP, I think, are obvious, and it gives us an opportunity to look forward with even greater optimism for the support of such activities.

Witnesses this morning on the resolution before us are Dr. Frank Blair, chairman of the U.S. national committee of the IBP, and Dr. Harve Carlson, who is the chairman of the Federal Interagency Coordinating Committee on the IBP.

We are pleased to have both of you here, and would appreciate it if you would both come forward, and we will start with Dr. Blair. As I understand it, Dr. Blair also has Dr. Smith and Dr. Milan with him, and I would appreciate it if those gentlemen would come to the table, and if some of you will pull up a chair.

Dr. CARLSON. Mr. Chairman, may I use some of my colleagues?

Mr. DADDARIO. Certainly. If there is room for them there.

STATEMENT OF DR. W. FRANK BLAIR, CHAIRMAN, U.S. NATIONAL COMMITTEE FOR THE IBP, ACCOMPANIED BY DR. FRED SMITH, UNIVERSITY OF MICHIGAN, AND DR. F. A. MILAN, UNIVERSITY OF WISCONSIN

Dr. BLAIR. Mr. Chairman, it is a pleasure to be here before this subcommittee to talk again about the IBP. I would like to express the appreciation of our U.S. national committee to your subcommittee and to Mr. Miller chairman of the parent committee for the interest you have had in the IBP, and for the very excellent scrutiny you have given our program. We feel that this has been of great assistance in the development of our program to where it is today.

I have a prepared statement which I would like to submit for the record, and I would like to refer to some of the high points of this statement rather than read the rather lengthy statement.

(The following is the prepared statement of Dr. W. Frank Blair.)

PREPARED STATEMENT OF DR. W. FRANK BLAIR, PROFESSOR OF ZOOLOGY, UNIVERSITY OF TEXAS; CHAIRMAN, U.S. NATIONAL COMMITTEE FOR THE IBP

Mr. Chairman, members of the Subcommittee, thank you for your invitation to discuss again with you the U.S. participation in the International Biological Program and for the opportunity of stating my support of House Joint Resolution 589—which you and Mr. Miller introduced.

Section 2 of that Resolution calls upon Federal agencies and other persons and organizations, both public and private, to support and cooperate with the program; and authorizes and requests those Federal agencies having functions or objectives which coincide with or are related to those of the program, to

obligate or make appropriate transfers of funds from moneys available for such functions, and to provide other support as appropriate.

This identical resolution, S.J. Res. 89, has been introduced in the Senate by Mr. Muskie and several co-signers. The convictions of several members of both the House and Senate that U.S. participation in the IBP should be supported is most encouraging.

I believe that I can best comment on this resolution by briefly describing:

1. Our program planning.
2. The current status of the substantive elements of the program.
3. My impressions of where US/IBP objectives coincide with or are related to those of the Federal agencies.

4. Some details illustrating the internationality of elements of our program.

On 27 March I described to your Subcommittee the general budget plans as I understand them for a "line item" in the FY 70 Budget of the National Science Foundation of \$5 million for the US/IBP. This amount is for support of a U.S. program of \$15 million. The Foundation has indicated in its special study that it expects the additional \$10 million by either interagency transfer or direct funding by the most concerned agencies. It seems, therefore, that the Foundation's FY 70 budget planning for IBP and the wording of Section 2 of H.J. Res. 589 are parallel and mutually supporting. And if enacted by the Congress and strongly applied by the Executive Branch, my previous recommendations to you—"I believe that a way must be found that will allow NSF vigorously to fulfill its role as coordinating agency in providing adequate funds, or securing them by interagency transfer, to permit the Integrated Research Programs of the US/IBP to become fully operational"—will have been implemented.

The following table summarizes firm plans for submission of Integrated Research Program proposals. It constitutes a sound and reasonable basis for IBP budget planning for FY 70.

IRP	To be submitted	Amounts (millions)
ENVIRONMENT COMPONENT		
Analysis of ecosystems	4th quarter, fiscal year 1969	\$0.275
Grasslands	do	2.209
Deciduous forests	3d quarter, fiscal year 1970	2.275
Desert	4th quarter, fiscal year 1969	1.700
Coniferous forest	3d quarter, fiscal year 1970	.900
Tropical	do	.080
Tundra	2d quarter, fiscal year 1970	.200
Convergent/divergent evolution (including Hawaii)	4th quarter, fiscal year 1969 and 1st quarter, fiscal year 1970	1.100
Aerobiology	1st quarter, fiscal year 1970	.500
Marine mammals ¹	do	.175
Biological control ²	do	.500
Conservation of genetic materials ³	do	.077
Biogeography of the sea ⁴	4th quarter, fiscal year 1970	.300
Phenology	2d quarter, fiscal year 1970	.280
Physiology of colonizing species	1st quarter, fiscal year 1970	.400
Upwelling	3d quarter, fiscal year 1970	.125
HUMAN ADAPTABILITY COMPONENT		
Urban and migrant peoples ⁵	do	2.610
American Indians ⁶	1st quarter, fiscal year 1970	.240
Nutrition ⁷	do	.290
Eskimos	Continuation	.200
High altitude people ⁸	4th quarter, fiscal year 1969 and 1st quarter, fiscal year 1970	.600
Chronobiology ⁹	2d quarter, fiscal year 1970	.200
Total		15.236

¹ Marine mammals is now identified as a "potential IRP" and the USEC/IBP has encourage the originator to fully develop the program. A draft proposal has been submitted. Funding needs and approximate date for proposal submission have been verified.

² Biological control is now identified as a "potential IRP" and the USEC/IBP has encouraged the originator to fully develop the program. Proposal has been submitted. Funding needs and approximate date for proposal submission have been verified.

³ Above notes also apply to conservation of genetic materials. This proposal will originate from ARS-USDA, and a draft has been submitted. It will involve both in-house and non-Government effort. It is not budgeted in ARS. It was identified by SCIBP circa 1964 as an essential IBP effort. With USEC/IBP endorsement proposal will seek support either by inter-agency transfer from NSF to USDA, or by reprogramming within USDA.

⁴ Central program proposal on biogeography of the sea has been shelved (rejected) by NSF. There is a high probability that a program proposal on estuarine ecosystem analysis will develop under the guidance of PROCOM. If this reoriented IRP develops, projects now identified with biogeography of the sea may be subsumed under the reoriented IRP.

⁵ Central program proposal for urban and migrant peoples is not yet satisfactorily developed. Research projects in this program are developing; e.g., the Holmes County project is supported at \$180,000 per year, the Chicago proposal now under review in HEW requests approximately \$100,000 for fiscal year 1970. The Miami River project will request approximately \$600,000 for fiscal year 1970. Plans are underway for central program coordination and synthesis. These plans should produce a central proposal by the 3d quarter of fiscal year 1970.

⁶ The current IBP identified portion of the AEC-supported research on genetics of American Indians is \$150,000 per year in a total AEC program of \$358,000 in fiscal year 1969. The total IBP effort required on this IRP is \$390,000 for fiscal year 1970. The originator will request \$240,000 additional for fiscal year 1970. Request will be addressed to AEC and will suggest that AEC seek interagency transfer from NSF since this latter amount is not budgeted in AEC.

⁷ The fiscal year 1970 amount shown on the nutrition IRP assumes that the \$40,000 initiating proposal will be funded in fiscal year 1969. The \$299,000 fiscal year 1970 program includes continuation of the central coordination at \$40,000 per year plus \$250,000 of new research.

⁸ The high altitude IRP proposes coordination at no cost between principal investigators at Pennsylvania State University, University of Colorado, and University of Wisconsin. The Pennsylvania State proposal at approximately \$200,000 will be submitted during the last quarter of fiscal year 1969. The University of Wisconsin proposal was submitted to NSF approximately 4 months ago. The University of Colorado proposal will be submitted during the 1st quarter of fiscal year 1970.

⁹ Chronobiology has been identified by the USEC/IBP as a "potential IRP" and the originator has been encouraged to develop and submit this IRP proposal first to the USEC/IBP for internal evaluation and then to NSF for support. The funds required and time of submission have been verified.

I think that we should note that "Analysis of Ecosystems" alone will request \$7.4 million in FY 70. Dr. Smith, who is here with me, will comment later concerning his budget planning for this IRP, and will submit for the record his progress report on this Integrated Research Program.

Likewise I think we should note that the total "Environmental Component" of our program is approximately \$11.0 million and that the "Human Adaptability Component" is approximately \$4.1 million. This, in my opinion, constitutes a reasonable balance at this time. The table represents "new money" requirements throughout.

In addressing the complexities of interagency transfers in support of IBP, I would like to use one IBP-IRP as an example—"Population Genetics of American Indians." This program is historically rooted in an AEC program, "Area

Program in Population Genetics," and had its beginnings in genetic studies undertaken in Japan in the area of Hiroshima and Nagasaki following World War II. Dr. James V. Neel has been a principal investigator from the beginning. Studies of primitive South American Indians offers unique opportunities for further investigations of genetic principles and these studies are of interest to AEC. AEC currently supports the Population Genetics program at \$358,000 this year. The American Indian portion is estimated at \$150,000.

Dr. Neel's proposal for FY 70 will be addressed to AEC and will request \$598,000 of which \$390,000 will be identified with IBP. If we assume that AEC will continue the IBP level of effort of \$150,000 then "new money" requirements for this IRP will be \$240,000.

Dr. Neel has provided an advance copy of his proposal to me. It has not yet cleared various administrative and management levels at the University of Michigan nor in the AEC. Likewise it has not yet undergone an internal IBP review. Nevertheless I would like to quote four paragraphs of his proposal:

"The portion of this Program that deals with the American Indian has been designated as one of the thirteen Integrated Research Projects of the United States contribution to the International Biological Program. One of the two principal themes of the IBP is the subject of human adaptability; the American Indian offers a rapidly vanishing opportunity to obtain insight into both the genetic and physiological adaptations of man during the pre- or early-agriculture period of his evolution. In this IBP-effort, we are fortunate in having very able colleagues in Venezuela (Layrisse, Arends) and Brazil (Salzano).

"With the completion of the work on inbreeding effects, and the near completion of the Tecumseh analysis, a larger proportion of the total effort of this program will be directed towards the IBP. The total budget for the current year is \$358,306 (direct costs: \$250,879; indirect costs \$107,427), of which we have estimated for the purposes of the U.S. National Committee for IBP, that \$150,000 supports in one way or the other the work on the American Indian.

"It is our understanding that the National Science Foundation, as the officially designated lead agency for the IBP, may receive a line item appropriation for the support of IBP. It is our further understanding that the "new money" aspects of the Program on the American Indian are eligible for consideration for support from that line item if in fact it is appropriated. It is for this reason that we have attempted at the outset to place the Indian portion of this Program in perspective. We will not (unless otherwise directed) make any direct approach to the NSF, in the expectation that should after appropriate review our program be judged meritorious and worthy of the expanded support, AEC will inform us concerning the appropriate administrative procedures.

"It will be noted that we now propose a budget for next year (direct costs) of \$434,166; and for the following year, \$587,785. A tentative budget has not previously been submitted for 1971-1972—it is now set at \$602,330. If this program is to be successful, we need assurance of forward support for at least two years, so that we can make the necessary recruitments to temporary positions."

Thus we see the complexities of interagency funding. If you would like the advance copy of this proposal I would be pleased to leave it for your analysis. I think that these genetic studies of Human Adaptability are essential to the US/IBP and that we should find a method of support. The USEC/IPB is in no position to say that this support should be totally from AEC or partially from NSF or if an interagency transfer should be considered and in what direction. I commend this proposal to your examination since the early pages establish the IRP base, and the latter half provides a detailed progress report.

So far we have discussed budget planning for FY 70 and complexities of interagency funding. I would like now to summarize the status of current and past support.

The following table lists IRPs supported in FY 68 and FY 69 and the agencies providing support. In the column headed "Origin" we attempt to differentiate between research on IRPs (1) that existed prior to IBP and (2) that was initiated because of IBP. Likewise in the subtotals under FY 68 and FY 69 we differentiate between these amounts. These subtotals provide some indication of funds preprogrammed within agency budgets as distinguished from reprogrammed funds made available because of IBP. All may be said to be mission funds; and may be said to directly support IBP-IRPs. On 27 March I stated to you that funds allocated in FY 69 for IBP approached the lower limit recommended by your subcommittee. This table shows \$3.8 million granted in FY 69 in support of IBP-IRPs of which \$1.3 million was granted as a result of IBP initiation.

MAJOR INTERNATIONAL BIOLOGICAL PROGRAM STUDIES SUPPORTED

[In thousands of dollars]

Major study	Supported by	Origin	Granted, fiscal year 1968	Granted, fiscal year 1969	Requested, fiscal year 1969— pending
Environment:					
Analysis of ecosystems.....	NSF.....	IBP.....	\$ 224.3		
Grasslands.....	NSF, AEC, USDA.....	IBP.....	\$ 400.0	451.0	\$ 2,209
Desert.....	NSF.....	IBP.....		20.2	
Deciduous forest.....		IBP.....			\$ 230
Coniferous forest.....	NSF.....	IBP.....		\$ 30.0	\$ 31
Convergent/divergent evolution.....	NSF, HEW, USAF.....	Pre-IBP and IBP.....	162.5	105.2	
Aerobiology.....	NSF.....	IBP.....		126.1	
Biogeology of the sea.....	NSF, USDI, SI.....	Pre-IBP and IBP.....	50.0	51.7	\$ 66
Upwelling ecosystems.....	NSF.....	IBP.....		171.5	
Human adaptability:					
Intensive study of Eskimos.....	HEW, SI, USAF, Wenner-Gren.....	IBP.....	40.6	\$ 312.5	
Migrant peoples:					
Chicago.....		IBP.....			\$ 99
Mississippi.....	HEW.....	IBP.....		180.5	
Biology of human populations at high altitude.....		IBP.....			\$ 140
Population genetics of American Indian.....	AEC.....	Pre-IBP and IBP.....	150.0	150.0	\$ 358 \$ 240
Nutrition:					
Central.....	Army, USDA, AID, HEW.....	IBP.....			\$ 39
Research.....	Universities and private sources.....	Pre-IBP.....	3,452.0	2,203.0	
Subtotal IBP originated.....			689.1	1,437.7	3,054
Subtotal pre-IBP.....			3,790.3	2,503.2	358
Total.....			4,479.4	3,940.9	3,412

¹ 2 years.² 7 months.³ National Science Foundation (NSF).⁴ 3 years.⁵ Department of Health, Education, and Welfare (HEW).

Atomic Energy Commission (AEC).

The table also shows the variety of agencies *now* funding IBP-IRPs. Since all grants were made in support of agency missions, it seems unlikely that any agency would willingly transfer funds to NSF. I personally hope that other agencies will internally establish IBP line items. I believe that if this is done, budget planning will be more visible, and the identity of IBP-IRP's with agency missions will be more clearly understood. I think that the only fiscal alternative to multiple line items is to increase the NSF line item to \$15 million. If the latter is done we would expect transfers from NSF to other agencies totaling approximately \$10 million in FY 70. It seems clear that the Present \$5 million line item will quickly be absorbed in on-going agency programs—even though those programs had an IBP genesis.

Concerning agency functions and objectives that coincide with or are related to those of the IBP—some indications of these relationships are shown in the preceding table. Following is a listing of IBP-IRPs, and some agencies that I believe should be interested in each:

IRP	Agencies
Environment:	
Analysis of Ecosystems-----	NSF, USDA, AEC, USDI, NASA.
Convergent/Divergent Evolution (including Hawaii).	NSF, Smithsonian, USDI, USAF, NASA, State.
Aerobiology -----	NSF, USDA, HEW, USDI, AEC, USDC-ESSA, DOD.
Marine Mammals-----	NSF, USDI, State, Smithsonian.
Biological Control-----	NSF, USDA, USDI, HEW, State-AID, DOD.
Conservation of Genetic Material--	NSF, USDA, State-AID, NASA, AEC.
Biogeography of the Sea-----	NSF, USDI, Smithsonian.
Phenology -----	NSF, USDA, USDI, AEC, NASA.
Physiology of Colonizing Species---	NSF, USDA, Smithsonian, HEW.
Biological Production in Upwelling Ecosystems.	NSF, USDI, NASA, Navy, AEC, Smith- sonian.
Human Adaptability:	
Biology of Urban and Migrant Peo- ples.	HEW, USDA, NSF, HUD, Transporta- tion, USDC.
Population Genetics of the Ameri- can Indian.	AEC, HEW, NSF, USDI.
Nutritional Adaptation to the En- vironment -----	HEW, USDA, NSF, HUD, State-AID, DOD.
International Study of Eskimos----	HEW, DOD, NSF, Smithsonian, USDI, AEC, USDC.
Biology of Human Population at High Altitude.	HEW, NSF, NASA.
Chronobiology -----	HEW, NSF, DOD, NASA.

The internationality of the IBP may be illustrated in several ways.

Shown as an appendix to this statement are maps pertinent to 9 of our IBP-IRPs. The remaining 7, for various reasons, are not presented here. For example "Conservation of Genetic Material" involves a world-wide survey. A world map of all land areas would add little for our purposes. Our Phenology IRP concentrates on the U.S. and is coordinated world-wide—a map would serve little purpose.

Generally, among the 9 provided, we have shown the financial status of the IRP, the institutions both U.S. and foreign directly participating in these IRPs, and in various ways the principal thrusts or centers of gravity involved.

Report 3, Part 2, "Research Studies Constituting the U.S. Contribution to the International Biological Program", a report by the U.S. National Committee for the IBP released 25 April, lists all projects now included in the US/IBP. Projects being conducted jointly with scientists in 32 foreign nations are included and described. This report is being mailed to approximately 60,000 scientists. It is available for your examination.

The IBP Central Office in London periodically publishes "IBP News". Numbers 13 through 20 are Indexes of National Projects. Each issue is devoted to a major subjective area of the IBP, and national projects are listed under the various "themes" for each area. These issues of "IBP News" are likewise available for your examination.

The internationality of the IBP may be illustrated by another effort that we are attempting to support—"The need for a Global Network for Environmental Monitoring". The concept for such a network has been discussed among a considerable number of scientists and science administrators, nationally and internationally, government and non-government. It cannot be considered parochially as IBP. If feasible however, such a network would have world-wide benefits for many agencies—multi-national and of the United Nations,—and would greatly benefit US/IBP.

On 18 April we convened a working conference to address specific questions all concerned with feasibility. There were 51 participants from many Federal agencies and private institutions. The report of this conference (when written) will be integrated with similar reports of a three-man *ad hoc* Committee (U.S., USSR and Sweden) and the final report will be submitted to the ICSU Special Committee for the IBP.

And again international considerations seem apparent in a planned seminar with the World Bank. The Bank is interested in ecological considerations in-

volved in its projects. The seminar is planned for 23 May and I understand that 50 to 60 key people from the Bank will attend. Following (Appendix B) are some preliminary suggestions that we will make to the Bank.

Mr. Chairman, in summary I would like to say:

A significant number of US/IBP-IRPs have been submitted and the remainder will be submitted in accordance with the schedule contained in the body of this statement.

A budget program of \$15 million is needed for FY 70.

Multi-agency interests apparent to me are stated in the body of this statement. In addition to NSF they include HEW, Agriculture, AEC, Interior, NASA, the Smithsonian, Defense, State, Commerce, Housing and Urban Development and Transportation.

Enactment of this bill will require vigorous support and direction on the part of the Executive Branch if the interagency transfers envisioned are to be accomplished.

An alternative of increasing the NSF line item to \$15 million may be well worth considering.

The international cooperation involved provides a most economical basis for carrying out research in both human and environmental ecology necessary before we can adequately plan for maintaining and improving the quality of our environment.

Appendix A

U.S./IBP

INTEGRATED RESEARCH PROGRAM

ANALYSIS OF ECOSYSTEMS

The program on analysis of ecosystems is a broad program devoted to analysis of ecosystems with respect to short-term and long-term processes, complete inter-relationships between land and water systems, and production studies, in relation to human welfare. It proposes to establish a scientific basis for programs to improve environmental quality. It includes six biome studies: grasslands, desert lands, deciduous forests, coniferous forests, tropical forests, and arctic tundra and taiga regions.

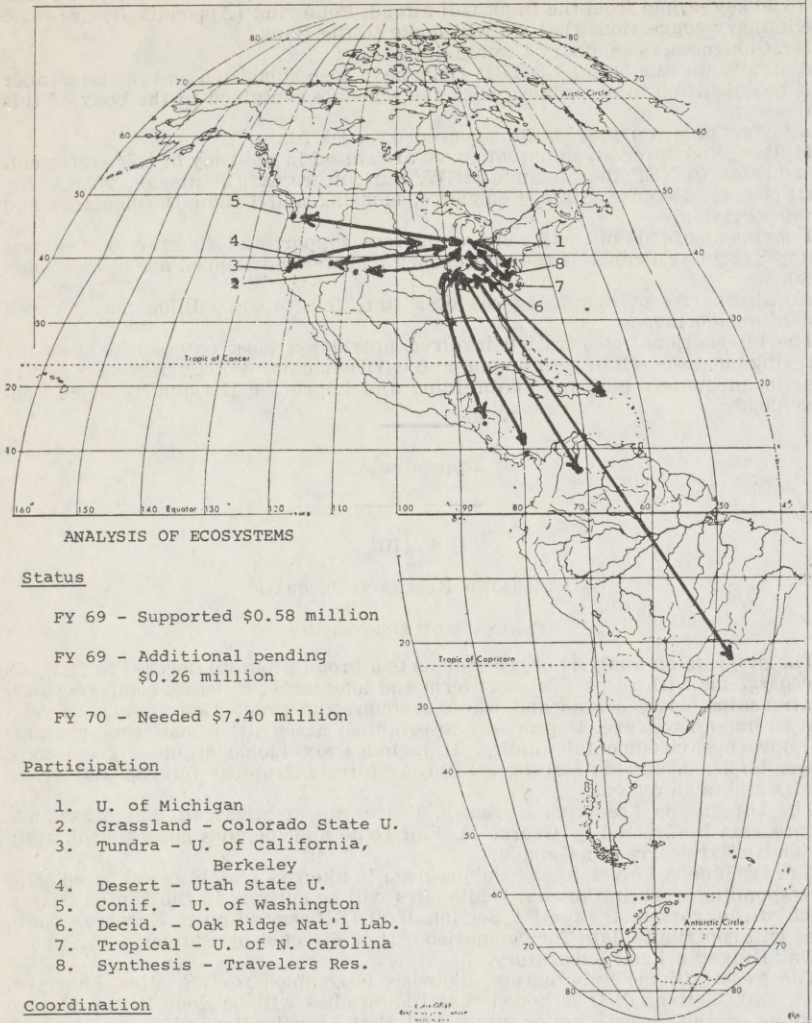
The Director is Frederick E. Smith, University of Michigan. The grasslands subprogram is directed by George M. Van Dyne and includes close coordination with a similar program in Canada.

The Deciduous Forest Biome Subprogram is likewise closely coordinated with corresponding work in Canada. While sites will be entirely in the United States, much of the work under the PT Section of SCIBP carried on in European countries will contribute data for comparison. It is directed by Stanley I. Auerbach of Oak Ridge National Laboratory.

The Desert Biome Subprogram, likewise, is confined to U.S. sites. However, when fully activated, it is hoped that like studies will be done in the Mexico portions of the deserts under study and that coordination with the Mexican work can be active. Related projects in other countries under the auspices of the IBP will be followed. It is directed by David W. Goodall of Utah State University.

The Coniferous Forest Biome Subprogram will be coordinated with related work in Canada. It is directed by Stanley P. Gessel, University of Washington.

The Tropical Forest Biome Subprogram is directed by Helmut Lieth of University of North Carolina. This subprogram, when fully developed, will involve several foreign countries to a greater extent than the other subprograms of the Analysis of Ecosystems. A number of Latin American countries, in particular, will hopefully coordinate in this work.

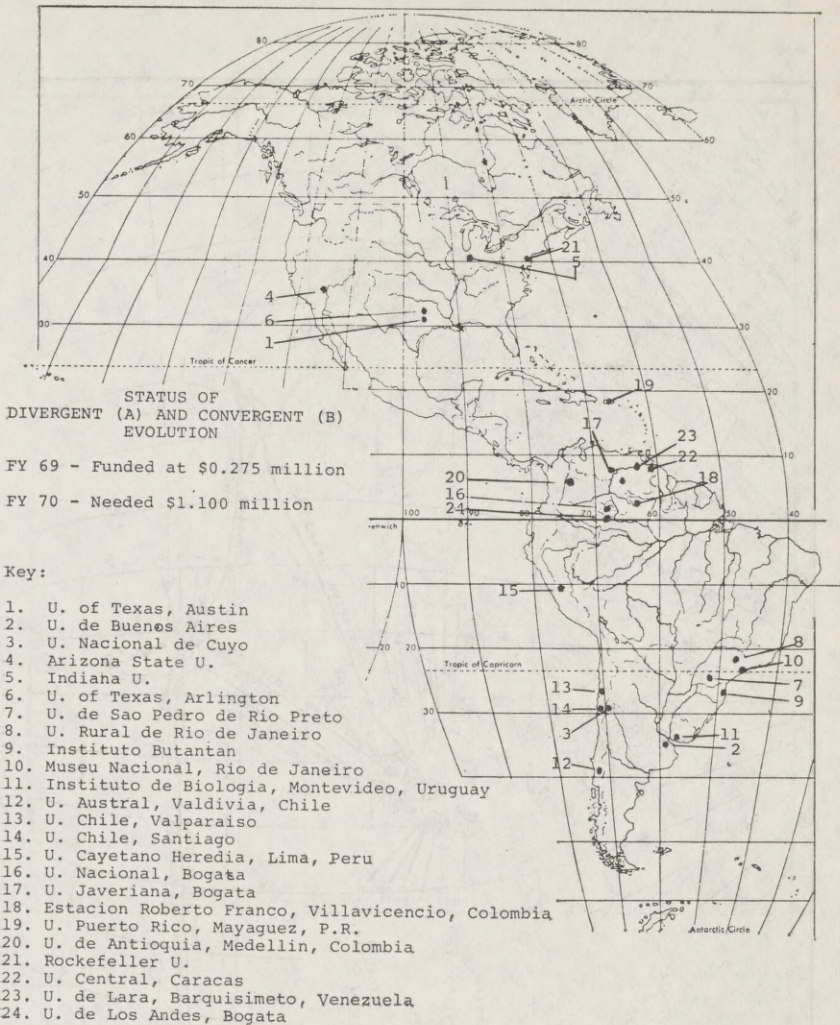


CONVERGENT AND DIVERGENT EVOLUTION

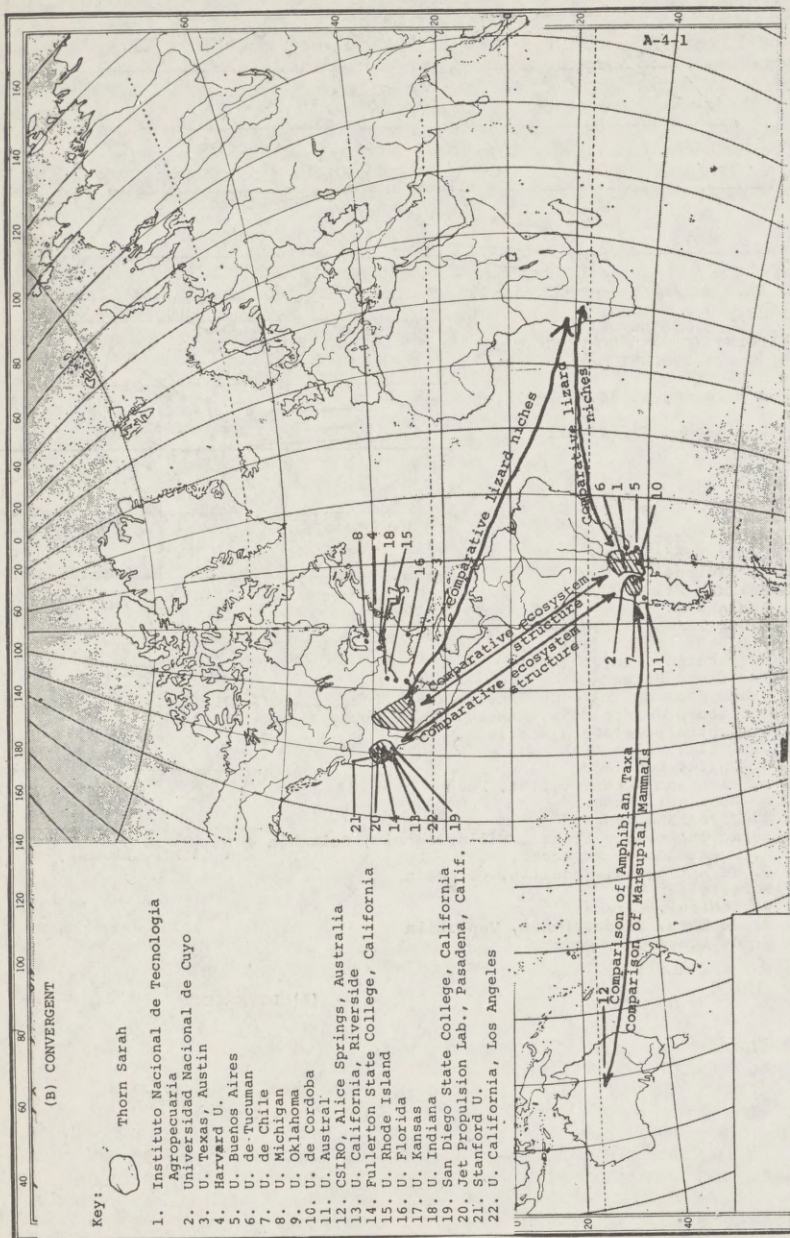
This Program is directed by W. Frank Blair, University of Texas. He is also Chairman of the U.S. Executive Committee for the IBP. His Co-Assistant Directors include, in addition to his U.S. colleagues, Fernando Dias de Avila-Pires, Brazil; Francesco di Castri, Argentina; Alvaro Fernandez-Perez, Colombia.

This Program was developed as a result of a series of working conferences that included representation from several countries of Central and South America and Australia. A major subprogram is the Hawaii Terrestrial Biology Subprogram in which scientists from Japan, Taiwan, Philippines, Malaysia, New Guinea, Australia, New Zealand, Canada, Netherlands, Hungary, in addition to U.S. scientists, participate.

Participants in coordinated work within this program, in addition to the above countries in the Hawaii Subprogram, include scientists from Argentina, Australia, Brazil, Chile, Colombia, Peru, Uruguay, Venezuela, and Mexico.



(A) DIVERGENT



AEROBIOLOGY

The Director of this program is William S. Benninghoff, University of Michigan. Participants in this program will coordinate their work with researchers internationally in many different countries. Collaboration has been established with the programs on Analysis of Ecosystems, Plant Gene Pools, and Phenology. Coordination with the international programs in Aerobiology was established at conferences in the United Kingdom. Dr. P. H. Gregory is the leader of aerobiology under the IBP in the United Kingdom. Similar research in India and Israel will be coordinated with the U.S. program. The international working group on Aerobiology will include scientists from Israel and the Netherlands in addition to those from the United States.

Active participation by scientists in Hawaii will involve coordination with scientists working in most of the Pacific Island groups, and with Japan.

PHYSIOLOGY OF COLONIZING SPECIES

The Director of this program is Calvin McMillan, University of Texas. It is in the proposal stage at the present time, and has not yet been funded. Plans include Jorge Morello, Argentina, and J. E. Rabinovich, Venezuela as Co-Assistant Program Directors, in addition to two U.S. scientists. The program consists of eight subprograms on plants, all of which involve foreign scientists, as follows:

1. Introduced grasses of temperate and tropical grasslands—Venezuela, Brazil, and Argentina.
2. Weedy herbaceous species—Mexico and Venezuela.
3. Woody species of semiarid subtropics—Argentina.
4. Eucalyptus—Australia, Colombia, with additional South American countries in the long-term plan. Records from Chile, Argentina, and Brazil will be used in the initial studies.
5. Colonizer with wide adaptation—Argentina. Material from New Zealand and European sources will be used in this study.
6. Marsh colonizers. A tropical locality in Venezuela will be used. Temperate localities will be in the U.S.
7. Colonizer trees in tropical montane forests—Costa Rica.
8. Cataloging the introduction, spread and current distribution of colonizing species—U.S. only at present. Specimens received from all parts of the world will be used.

Two subprograms on animals will include international scientists as follows:

- a. Invertebrates—Venezuela, and will be expanded.
- b. Vertebrates—Chile, with plans for expansion.

BIOLOGICAL PRODUCTION IN UPWELLING ECOSYSTEMS

The Director of this program is Richard C. Dugdale, University of Washington, Seattle. The major effort in 1969 will be devoted to the upwelling region of Peru, involving United States and Peruvian ships, and with scientists from Greece, Spain, Italy, and France participating, in addition to scientists from the United States and Peru.

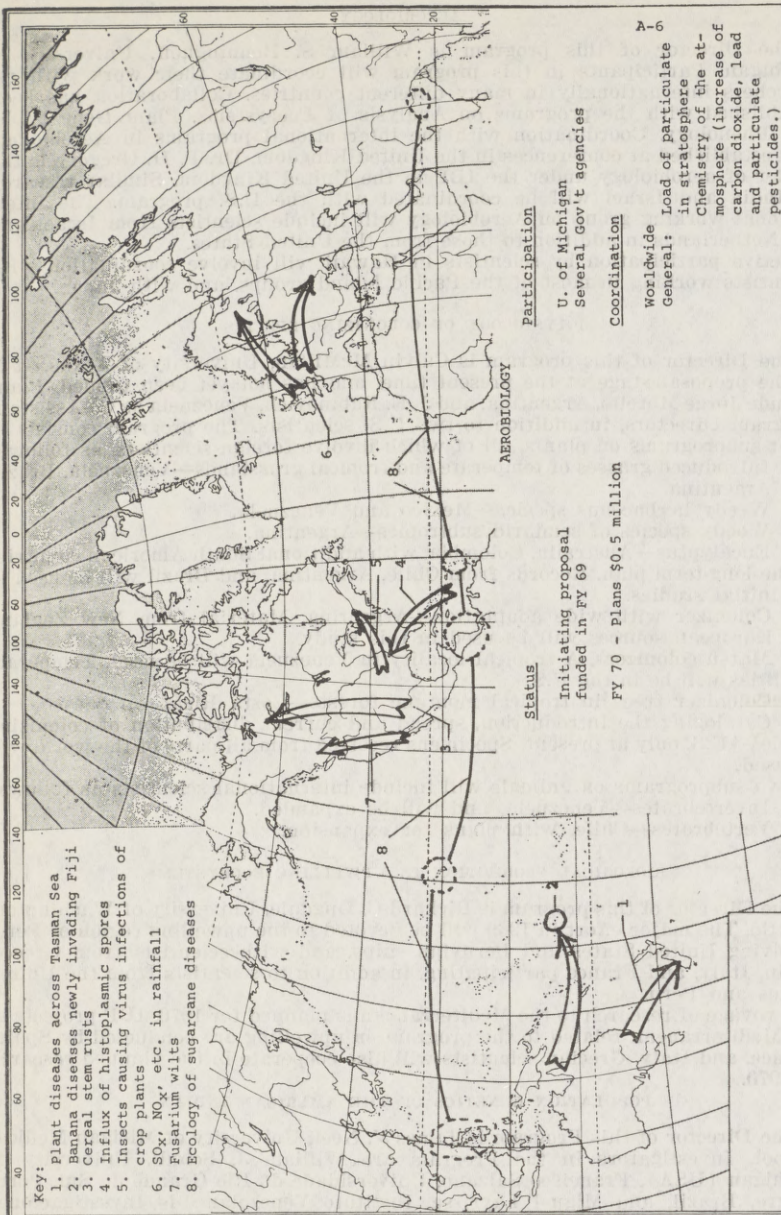
A voyage of research to the Mediterranean is planned for 1970. IBP projects in the Mediterranean related to the program on upwelling are conducted by Spain, France, and Italy. Grecian scientists will also cooperate in the planned research in 1970.

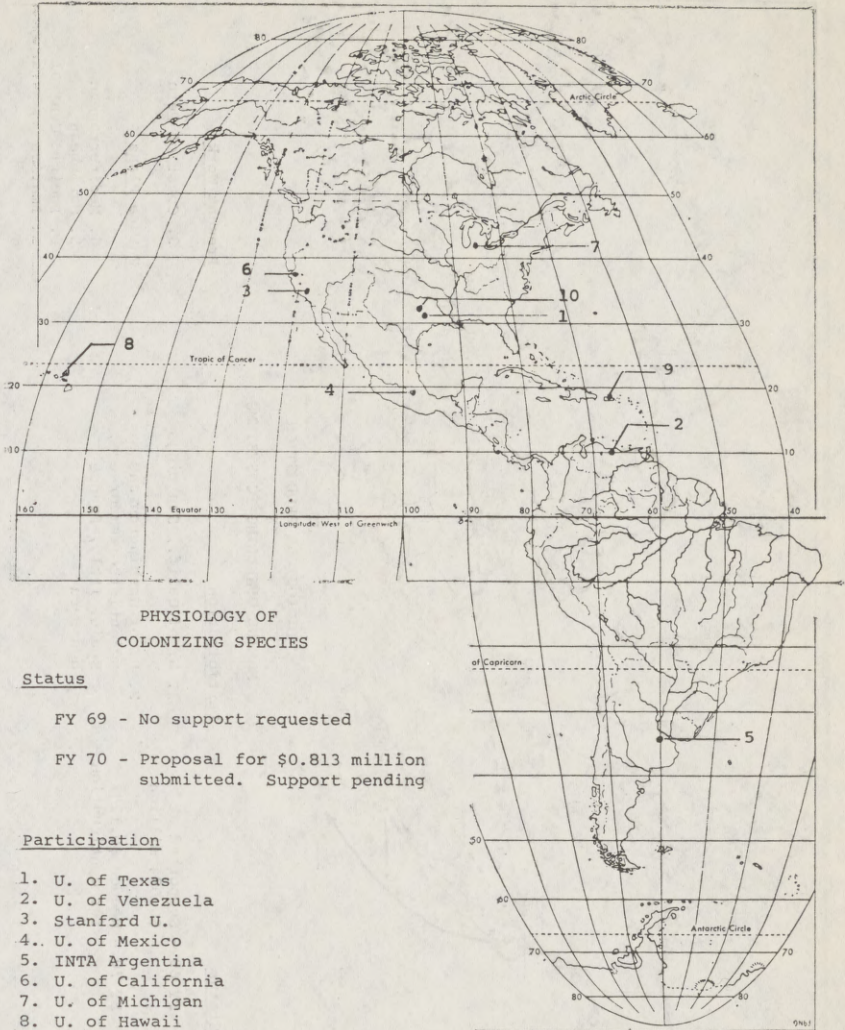
POPULATION GENETICS OF THE AMERICAN INDIAN

The Director of this Program is James V. Neel, University of Michigan Medical School. Investigators in the Program are William J. Schull, University of Michigan (USA), Francisco Salzano, Universidade do Rio Grande do Sul, Porto Alegre, Brazil, and Miguel Layrisse, Instituto Venezolano de Investigaciones Cientificas, Venezuela.

The present investigation centers on the Yanomama tribe of southern Venezuela and northern Brazil. It is planned to expand this work considerably and to include many other American aboriginal tribes. Data has been compared with that obtained in a United States community, and has been coordinated with data obtained on a population on the island of Hirado, Japan, obtained during 1964-65.

While current international interest in this program is confined to U.S., Brazilian, and Venezuelan participation, progress is closely followed by scientists in Japan, and others working with primitive tribes in New Guinea. It is anticipated that other countries will become more actively involved in this program.

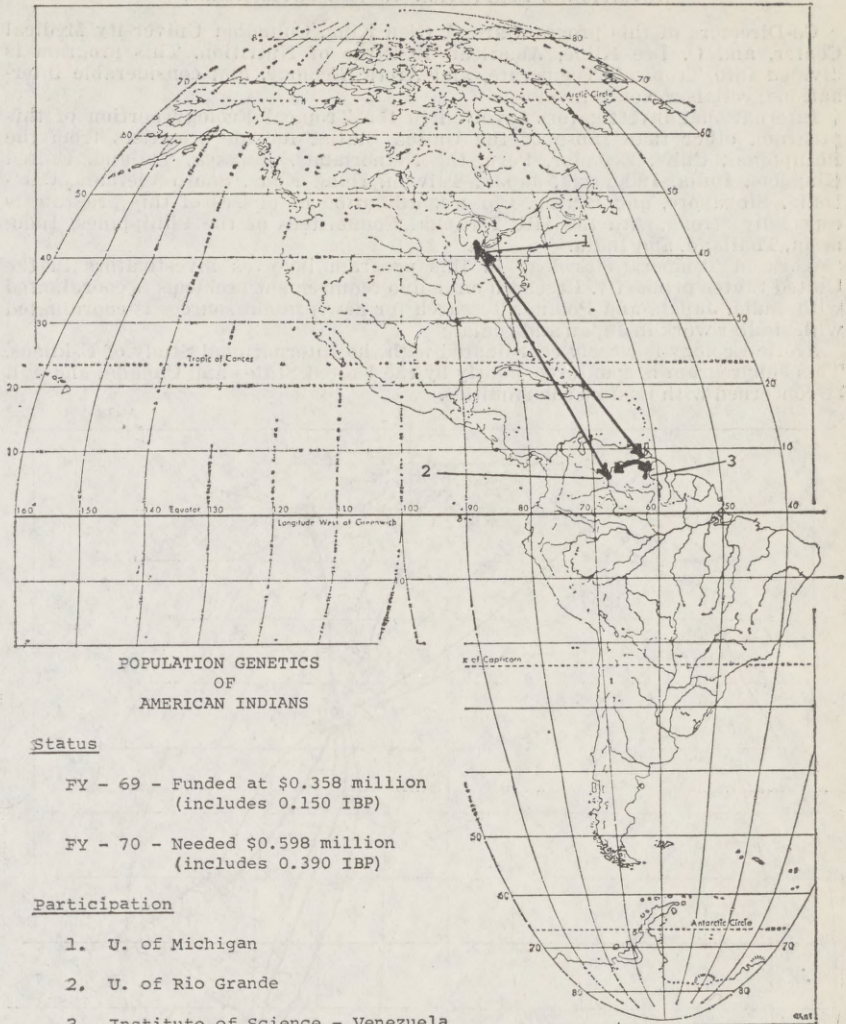






BIOLOGICAL PRODUCTION
IN
MARINE UPWELLING ECOSYSTEMS

<u>Status</u>	<u>Participation</u>	<u>Present Work</u>
FY 69 - Supported at \$0.094 million	1. U. of Calif., San Diego	3. Coast of Peru
FY 70 - Needed \$0.125 for continuation	2. U. of Washington and scientists from Greece, Spain, Italy, France and Peru	<u>Future Plans</u> 4. Mediterranean 5. Caribbean 6. Pacific Central America



NUTRITIONAL ADAPTATION TO THE ENVIRONMENT

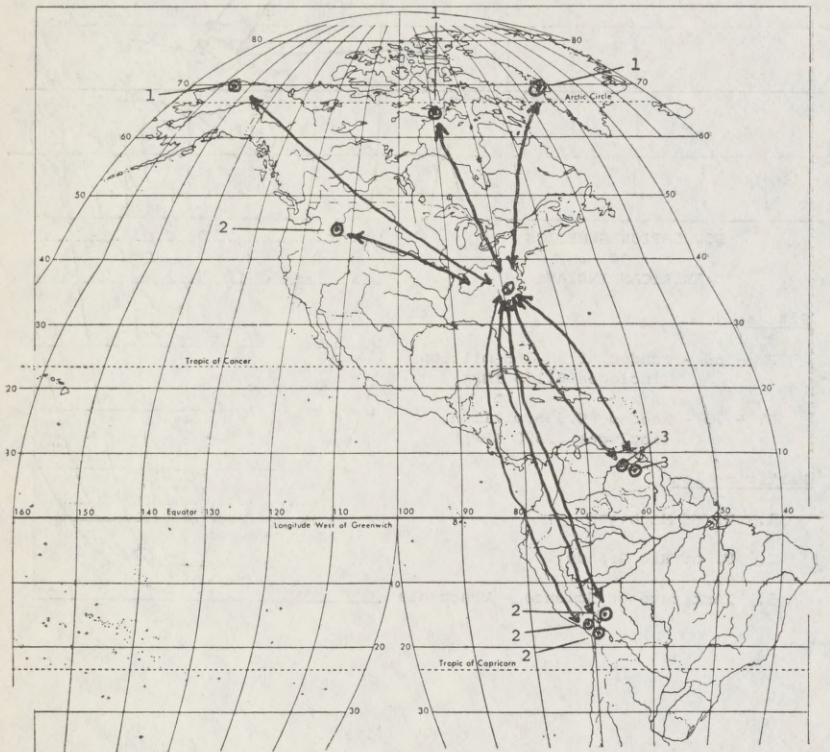
Co-Directors of this program are C. Glen King, Columbia University Medical Center, and O. Lee Kline, American Institute of Nutrition. This program is divided into Tropical, Temperate, and Arctic Ecology, and considerable international collaboration is involved.

International investigators involved in the Tropical Ecology portion of this program, other than those of the United States, include scientists from the Philippines, Chile, Ecuador, Peru, the Netherlands, Jamaica, Thailand, United Kingdom, India, Indonesia, Japan, Taiwan, Hong Kong, South Vietnam, Cambodia, Singapore, and Burma. Close coordination of phases of this program is especially strong with the IBP National Committees of the Philippines, Indonesia, Thailand, and India.

Work in Temperate Ecology in this program involves investigators in the United States primarily. Research on iodine requirement problems is coordinated with India, Japan, and Poland. Research for new protein sources is coordinated with similar work in Japan and India.

Arctic Ecology is closely coordinated with the International Study of Eskimos. This subprogram is sponsored jointly by the United States and Canada, and will be concerned with Eskimo communities.

A-14



NUTRITIONAL ADAPTATION TO THE ENVIRONMENT

Status

FY 69 - Coordinating Proposal for \$0.039 million submitted. Support pending

FY 70 - Needed \$0.290 million

Participation

1. Nutrition - Eskimos.
2. Nutrition - High Altitude
3. Nutrition - American Indian

INTERNATIONAL STUDY OF ESKIMOS

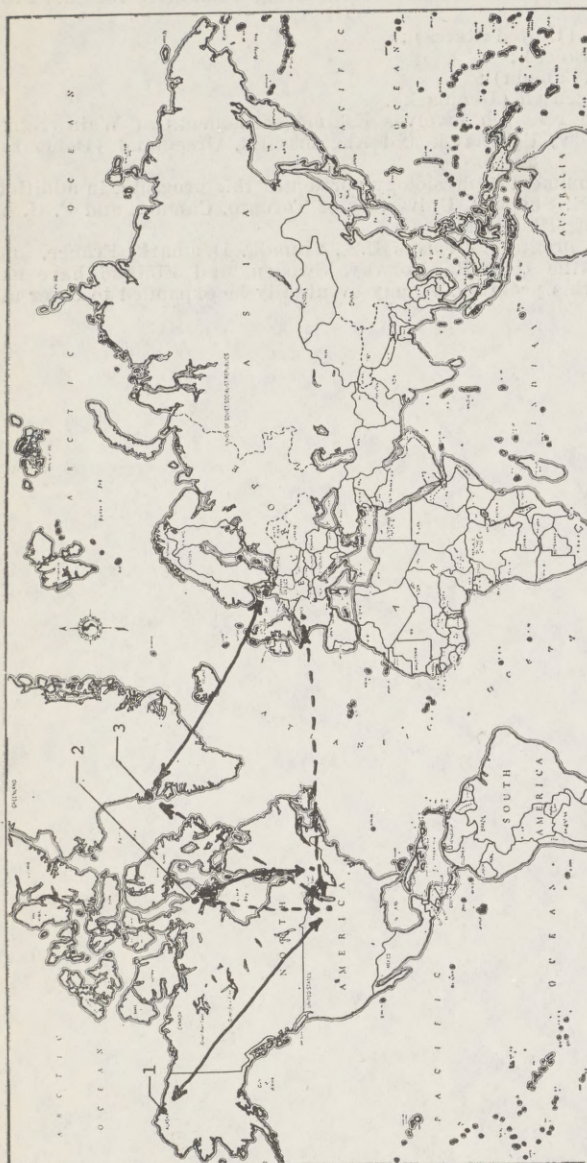
The title of this Integrated Research Program (IRP) was adopted especially to emphasize the international coordination within this IRP that has characterized it from its origin. The Director of the Program is Frederick A. Milan, University of Wisconsin. Members of the Coordinating Committee for this Program are:

Frederick A. Milan (United States);
Robert Gessain (France);
David R. Hughes, (Canada);
Jorgen Balslev Jorgensen (Denmark).

The initial coordinated research involves Eskimo settlements at Wainwright, Alaska; Igloolik, Canada; Upernavik and Angamssalik, Greenland (Denmark, France).

Involved in the environmental physiology portion of this program, in addition to U.S. scientists are: R. Shepard, University of Toronto, Canada, and P. G. di Prampero, University of Milan, Italy.

Participation in this program involves U.S., Canada, Denmark, France, and Italy. Scientists from the U.S.S.R., Norway, Sweden, and Finland have expressed an interest in this program. It may eventually be expanded to cover all circumpolar peoples.



INTERNATIONAL STUDY OF ESKIMOS

Status

FY 69 - U.S. portion
supported for
\$ 0.2 million

FY 70 - Continued support
needed

Participation

United States
Canada
Denmark
France

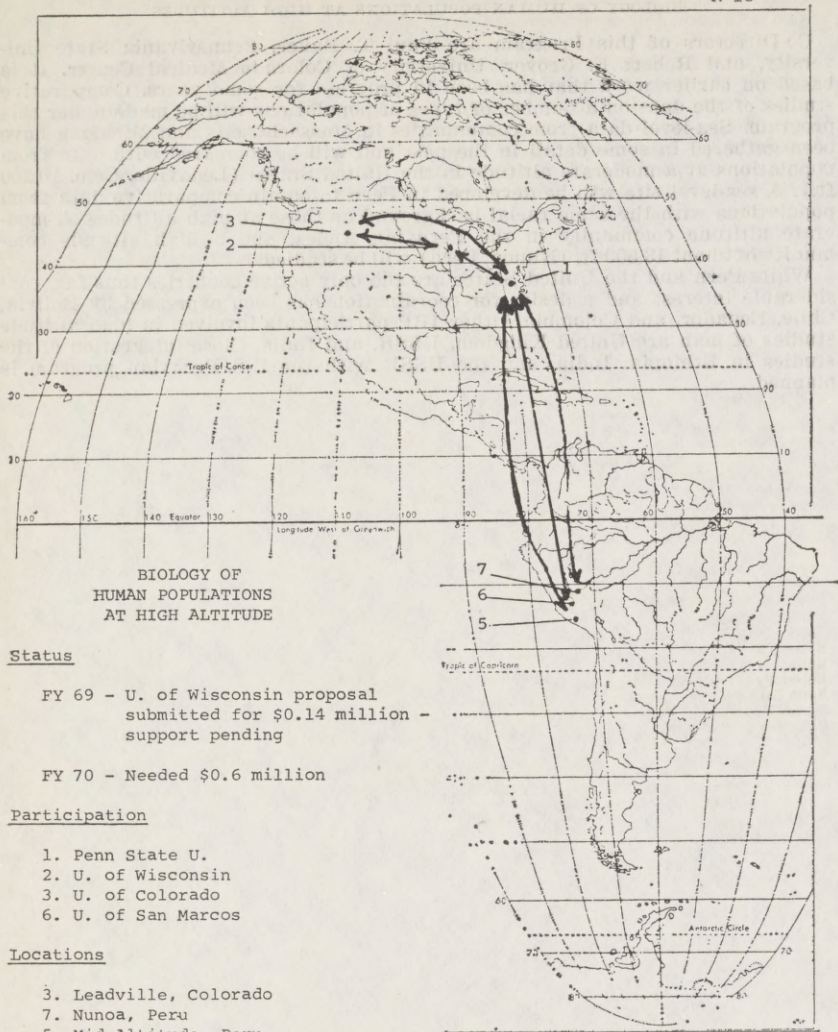
Locations

1. Wainwright, Alaska
2. Igloolik, Canada
3. Upernavik, Greenland

BIOLOGY OF HUMAN POPULATIONS AT HIGH ALTITUDES

Co-Directors of this Program are Paul T. Baker, Pennsylvania State University, and Robert F. Grover, University of Colorado Medical Center. It is based on earlier work that has been in progress for some years. Comparative studies of the data on a number of types of populations will be made under this program. Sea-level data from communities in Massachusetts and Michigan have been gathered in some detail in the past and will be compared with data from populations at a moderate altitude in the United States (Leadville, Colo. 10,200 ft.). A sea-level site will be developed in Peru to obtain comparative data from populations with the same racial background as those at high altitudes. A moderate altitude community in the Peruvian Andes, and a high altitude community of about 13,000 ft. (Nunoa, Peru) will be studied.

While Peru and the United States are the only active countries thus far, considerable interest and a desire for coordination has been expressed by Bolivia, Chile, Ecuador, and Colombia. Other IBP participants involved in high altitude studies of man are United Kingdom, USSR, and India. Close integration of the studies in Ethiopia, India, and the USSR with the U.S.-Peruvian program is planned.



Appendix B

GRADUATE TRAINING IN ECOLOGY

Two years ago I attempted to get an estimate of the annual production of Ph.D.'s in ecology in this country. The information, obtained by questionnaire, was supplied to the Chairman of the House Subcommittee on Science, Research, and Development.

This survey has just been repeated (see table) for the 2 years that have elapsed since the first survey. Although the 2 surveys are not exactly comparable, there seems to have been a significant increase in the output of ecologist Ph.D.'s of the order of magnitude of 50%.

The increased output of ecologists presumably reflects the growing concern about environment and the consequent interest in ecology as a profession. If this

trend continues, there should be an adequate supply of ecologists for IBP research and for subsequent programs of similar nature.

The growth in the past 2 years has been achieved without significant change in the level of Federal financial support for ecological training. One recent development, funding of several ecological centers by the Ford Foundation, should result in added production of ecologists in the next few years. However, increased Federal support will certainly be required if the number of professional ecologists is to meet anticipated demands of the coming years.

In analyzing the data presented here, it should be kept in mind that many specialties other than ecology contribute to the solution of environmental problems.

AVERAGE ANNUAL PRODUCTION OF PH.D.'S IN ECOLOGY BY THE LEADING UNIVERSITIES IN THIS FIELD

Institution	Mean number per year	
	5-year average, 1962-66	2-year average, 1967-68
University of California, Berkeley.....	2.0	(1)
University of Illinois.....	² 2.8	(1)
University of Minnesota.....	3.0	4.0
Rutgers University.....	4.0	7.0
University of California, Riverside.....	.4	1.5
Oklahoma State University.....	4.4	4.0
University of Oregon.....	1.2	1.5
Duke University.....	² 2.6	11.0
University of Michigan.....	7.8	12.5
Michigan State University.....	³ (8.0)	7.0
University of Texas.....	5.0	4.5
University of Wisconsin.....	.6	3.0
University of California, Davis.....	2.2	3.5
University of California, Los Angeles.....	1.4	4.0
Emory University.....	1.6	2.5
Yale University.....	³ (5.2)	2.5
Harvard University.....	³ (4.0)	6.0
University of Georgia.....	³ (2.0)	6.5
University of North Carolina.....	³ (3.4)	4.5
North Carolina State University.....	³ (2.4)	4.0
Cornell University.....	(1)	6.0
University of Washington.....	(1)	(1)
Total.....	62.0	95.5

— No report.

² Botany only.

³ Reported 1969.

APPENDIX C

NATIONAL REGISTER OF SCIENTIFIC AND TECHNICAL PERSONNEL, 1968—NUMBER OF SCIENTISTS, BY APPROACH TO BIOLOGY, PRIMARY WORK ACTIVITY, AND FEDERAL SUPPORT

Approach to biology and primary work activity	Total	Number receiving support	Agriculture	Atomic	Defense	Education	Health	Housing	International
Total.....	58,923	36,214	10,694	1,248	1,890	3,517	15,366	109	506
Environmental.....	12,215	(C)	2,798	339	542	847	2,123	23	161
Research and development (A).....	4,788	8,087	1,943	180	240	144	1,146	5	56
Basic research.....	2,665	3,808	932	139	127	113	844	4	35
Applied research.....	2,119	2,165	649	42	112	30	302	1	20
Management or administration (B).....	2,986	1,640	849	82	198	190	433	16	69
Management or administration of research and development.....	1,381	2,200	668	56	130	89	273	5	57
Teaching.....	3,136	1,047	200	56	37	453	372	2	22
Production and inspection.....	128	1,410	368	60	1	2	1	-----	-----
Consulting.....	173	56	8	-----	8	5	35	-----	-----
Exploration, forecasting, and reporting.....	313	90	24	3	14	5	14	-----	3
Other.....	368	246	89	2	26	22	38	-----	6
Not employed.....	288	-----	-----	-----	-----	-----	-----	-----	-----
No report of work activity.....	383	262	101	10	17	26	84	-----	5

NATIONAL REGISTER OF SCIENTIFIC AND TECHNICAL PERSONNEL, 1968—NUMBER OF SCIENTISTS, BY APPROACH TO BIOLOGY, PRIMARY WORK ACTIVITY, AND FEDERAL SUPPORT

Approach to biology and primary work activity	Natural resources	Public works	Rural development	Space	Transportation	Urban development	Other	No support	Support status unknown	No report
Environmental.....	2,632	127	206	249	52	83	758	3,287	286	555
Research and development (A).....	986	18	29	116	18	20	325	776	117	87
Basic research.....	542	6	10	71	3	8	214	362	71	67
Applied research.....	443	12	17	45	15	11	111	413	46	20
Management or administration (B).....	1,11	78	139	82	24	41	195	736	16	34
Management or administration of research and development.....	446	18	28	61	8	14	98	312	5	17
Teaching.....	308	5	14	32	3	11	165	1,510	125	91
Production and inspection.....	8	1	4	—	—	—	3	120	1	—
Consulting.....	10	—	1	1	—	1	2	99	6	2
Exploration, forecasting, and reporting.....	45	11	2	4	1	4	9	20	5	—
Other.....	91	6	14	3	2	6	28	104	9	9
Not employed.....	—	—	—	—	—	—	—	—	—	289
No report of work activity.....	74	8	3	11	4	—	31	7	7	49

Dr. BLAIR. I will address myself to three main points and then call on my colleagues from the U.S. IBP to round out the discussion by reference to particular components of the program. I will say a few words about the manpower situation as it relates to the development of the IBP in the United States.

I will speak to the funding problem, and finally I would like to give more emphasis to the international aspects of our efforts in the IBP than we have given in the previous hearings.

With respect to the manpower situation, appendix B of the prepared statement has a tabulation indicating the average annual rate of production of Ph. D. ecologists as identified by a canvas of key people who train ecologists.

Two years ago, for the chairman of this subcommittee, I made a survey the results of which are indicated in column 1 of this table. This has been added to a bit in the second survey. The estimate is that we were producing an average of about 62 Ph. D. ecologists per annum in this particular group of institutions.

The interesting thing is that the rate of increase has been rather remarkable.

In fact, there has been a 50-percent increase based upon these figures. These data should be cautiously interpreted, but I believe they are significant.

This apparently reflects numerous things. In part, I think it reflects the interest in the IBP. In part it reflects the general concern today about environmental quality, and increased interest of university students toward going into this field.

In addition, I have also added to the material some figures that I just got day before yesterday through the courtesy of Milton Levine of the National Science Foundation from the National Register of Scientific Personnel. This is a very interesting set of figures.

(The information referred to follows:)

National register of scientific and technical personnel, 1968

Distribution by level:

Number reporting level.....	35,615
Multilevel.....	9,501
Submolecular.....	884
Molecular.....	7,567
Cell Organelle.....	3,846
Cell.....	9,271
Tissue.....	7,066
Organ.....	6,328
Organism.....	12,339
Population.....	9,672
Community.....	5,702
Ecosystem.....	6,402
Not Applicable.....	2,676
No Report of Level.....	20,632

Distribution by approach:

Number reporting approach.....	33,339
Developmental.....	7,219
Environmental.....	12,215
Genetic.....	5,968
Behavioral.....	4,746
Morphological.....	6,989
Functional.....	14,100
Systematic.....	4,742
Pathological.....	6,893
Evolutionary.....	3,734
Historical.....	737
Philosophical.....	546
Not Applicable.....	3,133
No Report of Approach.....	22,451

NOTE.—These data are based on 58,923 scientists responding through AIBS or FASEB.

National register of scientific and technical personnel, 1968

Distribution of 12,215 environmental biologists by biological level:

Biological level:	<i>Environmental</i>
Multilevel.....	2,941
Submolecular.....	241
Molecular.....	1,150
Cell Organelle.....	688
Cell.....	1,855
Tissue.....	1,634
Organ.....	1,652
Organism.....	5,152
Population.....	5,945
Community.....	4,285
Ecosystem.....	4,855
Not Applicable.....	191

NOTE.—These data are based on 12,215 environmental biologists responding through AIBS or FASEB, who reported one or more biological levels.

For the first time, the national survey has asked questions that permit ecologists and others to be identified. The rather interesting thing to see is (on the first page of this short piece of paper) that when biologists were asked to identify themselves by level—level of organism from submolecular on through ecosystem—that about 40 percent fall in the group of population, community, and ecosystem.

Now, these, for the most part, are ecologists, and anybody who identifies himself as working at the ecosystem level is unquestionably an ecologist. This is the first time we have had any real measure of the representation of ecologists in the population of scientists.

Also, if we look at biologists by "approach" we see that among some 33,000 reporting, 12,215 have identified themselves as working at the environmental level, and again this is an identification of a very large group of ecologists.

The second page combines these and breaks down the environmentally identified biologists to the various levels of organization at which they work. I think there is a great deal of interest in the fact that 241 of those at the submolecular level indicate that they use the environmental approach.

I will merely call to your attention the legal-size sheet. This shows the disposition of the identified ecologists throughout the various agencies with which they are associated, particularly in terms of their research support.

One point we can make is that, while we do seem to have a lot of ecologists, they are widely scattered through many, many agencies.

Now, I would like to speak to the problems of funding and to what I believe to be the significance of the resolution which Chairman Miller and Chairman Daddario have introduced and which we are discussing today. On page 9 of the prepared statement we have presented an estimate, as accurately determined as possible, of the level of support of the U.S. IBP effort in fiscal 1969.

I would call your attention to the fact that there has been significant new money channeled into support of the IBP. This would be in the subtotal entitled "IBP originated." This identifies new money. The subtotal entitled "Pre-IBP" identifies old money that has been oriented to the objectives of the IBP.

I would also call your attention to the final column of \$3 million-plus of pending requests. I am very doubtful that very many of these will be funded in fiscal 1969, simply because of the stringencies of the budget.

Now, I would also call your attention to page 3. This is a very crucial part of this document. In this table our U.S. committee has prepared a breakdown of how we would utilize the \$15 million that was identified in the budget study made last year by the National Science Foundation at the request of the Bureau of the Budget. This table presents a very realistic approximation of where the money would go. There might be some changes of priorities, depending upon developments. Basically this level of funding would permit three of the ecosystem analysis studies to get really into research operations, a fourth to be phased in, and two to be simply a more or less holding operation—planning operations at some pilot level, and so on down the list.

I think this is a realistic breakout of what we could do if we had \$15 million in sight. Beginning at the bottom of page 10, we have made our own estimate of the agencies that we believe either are or should be interested in the various integrated programs that have been developed under the IBP. This does not coincide with the evidence of present interest as indicated by actual financial support of these various programs. Moreover, we feel that there are components of all of these IRP's that should be of interest to the various agencies identified with them.

Now, summing up the financial situation, it seems to me that the real one remaining problem is not the line item in the NSF budget,

but the \$10 million that hopefully will be found in the budgets of the various Federal agencies.

I am a realist, and I am not sure this \$10 million can be found. However, I am encouraged by the fact that this resolution may and hopefully will insure that some major fraction of this money will be put in support of IBP projects. There is one thing I would like to emphasize, and that is we are talking about \$15 million of new money. And, second, we are talking about new money for the support of the novel kind of imaginative research that is embodied in the integrated research programs. We are not talking about identifying individual ongoing research projects with the IBP.

We are talking about the newly originated, novel, and imaginative research that is directed to cooperative efforts to understand how our environment works. Consequently, we are really talking about the IRP's identified at the bottom of page 10.

Now, there are always problems, involved in an interchange of funds between governmental agencies, yet the budget study of last year seems to envision such interchange. An example of the kind of problem that may come up is illustrated by our very successful program of studying the population genetics of the American Indian.

This is really an expansion and some reorientation of ongoing research of Dr. Neal, and helped along by several North American and South American scientists. They have had support for this program from the AEC, and Dr. Neal has just given me an advance copy of a proposal for a considerable expansion of this program.

The anticipation is that this program is eligible for consideration for support under whatever new money comes along. Thus, the problem presented is of where does this money go? Is it money that can be transferred from agency to agency, or how does Dr. Neal's program get funded?

This example illustrates the kinds of problems we are up against of trying to fund the IBP with the mechanism at hand. There are various ways we could go. NSF might be willing to transfer money to AEC if they had enough money in the line item to do this.

Or maybe AEC would be willing to hand this project to NSF. We can't speak for the Federal agencies, but it is a question that clearly needs to be raised. Really, I think that the one big problem facing us is, where do we find money in addition to the \$5 million that presumably will remain in the NSF budget.

Finally, I would like to stress the international aspects of the integrated research programs before calling on my colleagues to speak to other aspects.

The document that we have prepared has a series of nine maps which identify the main centers of focus and identify the international connecting lines of nine of our IRP's.

Without going into details, I think it is quite apparent that we have developed a very definitely international effort, that we have—particularly with the Latin Americans—a great deal of cooperative research planned or ongoing. As I have said before to this committee, I cannot overemphasize the importance of working cooperatively with the Latin American scientists where we can.

We are working as scientific equals, not just bringing them up here to give them the training, so they can go back and be like us. Instead,

we go down and work with them, and this is what much of our work is directed to.

I think the payoff will be more than scientific, because as I said before, if we can upgrade basic science in Latin America, we can do a great deal toward political stability in Latin America. Scientific advancement should lead to a better climate for the political stability that is certainly lacking in some parts of Latin America today.

Without going into great detail, I think you can see that we do have a really international program. I would like to point out also that we have just published a description of the U.S. participation in the IBP. This is a document called Report No. 3, part 2. We can make copies available for the committee, but I won't introduce it into the record, because it is a lengthy document. This document identifies the integrated research programs of the United States, and identifies IBP related research projects. In addition, the International Secretariat for the IBP has just published an index of the international projects. This is contained in a series of eight numbers (13-20) of the so-called IBP News.

The latter set of documents includes an indexing of the entire world effort of the IBP which now includes 57 countries. Actually, some of the developing countries are still joining. The last two to join just in the last few weeks were Malawi and Panama, so even the very small developing countries are still joining the IBP effort.

Another thing that I should mention, is that as a part of the IBP effort, a committee has been formed to make a feasibility study for a global network for environmental monitoring.

There are many efforts more or less coordinated today to develop a world network for meteorological studies of one kind or another. This IBP committee is looking at the total picture, not only of the physical parameters, such as CO₂, temperature, and so forth, but it is also looking at the possibility of monitoring biological communities, genetic qualities physiological processes and so forth. This committee convened a meeting recently, where we had representation of the greater part of the U.S. expertise in this field. Similar studies are being done in Russia by a second member of our international committee, and in Sweden by the third member.

Eventually, there will be a report made to the International Council of Scientific Unions. So, this is one of the things relative to global environment that has developed from the IBP.

Lastly, the IBP is having an effect on what you might call technological development. Our group in the IBP in the United States has had three discussions with representatives of the World Bank concerning environmental problems that may result from major developmental projects. Now, at their request we have scheduled for May 23 a seminar with about 60 of the top people in the World Bank to talk about the environmental effects of developmental projects.

Where is the expertise? Where could they go to get the kind of advice on the environmental matters that they get on engineering matters whenever a major project is considered?

Chairman MILLER. Where will this be held?

Dr. BLAIR. Here in Washington.

Summarizing what I have said, it seems to me, we have a reasonable estimate of what we should spend and can profitably spend on the IBP

in this country in fiscal 1970. This is the sum of \$15 million, which received a great deal of consideration by our own committee, by people at the National Science Foundation, and by the Bureau of the Budget.

I would like to emphasize again that we are thinking in terms of support for the new kinds of integrated research projects. Now, the United States is going to get whatever program it can bring itself to pay for. I think this has to be said. We are going to have some kind of program in the United States, we already have one. However, I would hope that we can get the best that our scientists are capable of providing.

We have moved to a definite position of world leadership in this international effort, and I would hate to see us have anything but the best we can buy. One would like to cite one illustration of the effect our leadership has.

To the international committee that coordinates the worldwide studies of terrestrial production under the IBP, has reclassified its system of indexing projects to take into account the fact that there are the big kind of ecosystem studies that are being done in the United States. Several other countries have reoriented their programs to follow the pattern established by the U.S. studies. Chile is one. Some of the European countries have also moved in this direction. This is what our leadership means. We are in a position of world leadership, and I hope we can stay there.

Now, I would like to ask Dr. Fred Smith, who is the head of our ecosystem analysis program, to say a few words of where we stand with respect to that major program.

Mr. DADDARIO. Dr. Blair, before we do that, you mentioned as an aside the needs of the various agencies of Government to generate within themselves the enthusiasm necessary to participate in this program.

Why did you bring that up?

Dr. BLAIR. I brought it up because I really would like to see that \$10 million that was identified in the NSF-BOB document somewhere in sight or at least some part of it in sight. I feel that this is urgent. We have come up with what we think is a rather reasonable package of what we can do if we had the sum of \$15 million in new money in fiscal year 1970 for the integrated research programs.

Just identifying one of the projects in one of the agencies, and saying this is contributing to IBP, this is not going to do it. We are still talking about new money that contributes to the IRP's if we really want to put this program on the road.

Mr. DADDARIO. Some of that new money can generate itself. It doesn't take much of a turn in the direction for them to come up with new and imaginative programs or to go on to greater depth in the past.

Dr. BLAIR. That is right.

Chairman MILLER. Doctor, I was very much interested in what you had to say about South America. I was looking through these maps. I see there is a great deal of interest because you indicated you find a receptive atmosphere?

Dr. BLAIR. In most of the countries we find an enormous amount of enthusiasm. I can mention particularly three countries. In Colombia, as a result of our involvement with the Colombians, five of their universities are working together, and a sizable group of their scientists are working cooperatively with our own people who are working there.

There is no question at all in my mind that in Colombia we are going to see a major step forward in basic environmental science. The same is true in Argentina and Chile.

Chairman MILLER. How about Venezuela?

Dr. BLAIR. We are also cooperating with them, but perhaps to a lesser degree. There is no antagonism at all, and the emphasis on Colombia resulted in part from the fact that we found in Colombia a group of youngsters ready to go, and most of them are considerably younger than you and I—

Mr. CABELL. They were just babies; weren't they?

Chairman MILLER. The reason I asked, Doctor, last year, some of us went down for the dedication of a telescope in Chile. We were asked to come back through Venezuela. So we spent a night in Caracas.

We visited their Institute right outside of Caracas and found a great deal of enthusiasm and desire to cooperate at this particular place.

Dr. BLAIR. There is. I didn't mean to imply at all that there wasn't cooperation in Venezuela. We have had close coordination with the Venezuelan National Committee for the IBP and there has been parallel planning of projects.

Chairman MILLER. Of course, South America is a place where you need these studies.

Dr. BLAIR. We certainly have hopes of seeing this as a long-continuing program. We are developing a few centers down there so we can get North Americans, and anybody else who wants to go there working with the Latin scientists. As a result, the Latin American countries can expand the training of their graduate students in their own centers.

Don't bring them up here, but do it down there.

Chairman MILLER. Well, I hope that if Congress gets out in time I might induce my good friend on the left to take his committee down and visit some of these places.

Dr. BLAIR. I think it would be a very good trip.

Mr. DADDARIO. Dr. Smith.

Dr. SMITH. Thank you. I appreciate this opportunity to address the committee. First I would like to document the reality of our estimates for funding requests in fiscal 1970, since we are responsible for half of the IBP total, and I would like to introduce for the record our 26-page program report which condenses all of the information on the program since its inception in 1966, and carries through our funding plans into 1971.

On page 16 there are the budget estimates for 1970 and 1971. First of all, under the requested fiscal year 1969 column, the first two requests have been granted, but the others are pending and will come out of 1970 funds at this time, raising the total to nine different proposals that we expect to generate during fiscal 1970.

Now, of these, the grasslands proposal has already been submitted, and is being negotiated at \$1.8 million instead of 2.2, so that adding on the leftover funds of 1969 and deleting the cuts in the grasslands proposal, we are now expecting to ask for about \$7.5 million this year.

At the present moment three of these proposals are pending at NSF, and four more exists as proposals and are in the process of IBP review. This review is just completed for two of them while the other

two are just starting. This leaves only two that are not yet in draft form. These two are \$900,000 in coniferous and \$2.25 million in deciduous.

As example of where we stand, the coniferous forests have a small management proposal pending. They have an active group at the moment of 78 scientists from 19 agencies and institutions representing nine States.

They have identified the sites for intensive study, which is in a small region of Washington and Oregon, and the major source of personnel for these studies, which are primarily from the University of Washington and Oregon State University. Other studies are planned in California, Utah, Nevada, Colorado, Montana, Idaho and Alaska.

And so the actual plan for the coniferous study is well in hand, and we don't think it will take them too many months to come through with a proposal. As a demonstration that this can be done, the desert group received their management support in February of this year, and they already have in final draft the proposal for \$1.7 million.

The desert proposal emerged from the aggregate interests of 280 scientists that asked to participate in the desert study. A selection of 154 scientists from nine States, representing 32 institutions and agencies, have constructed a virtual federation of scientific talent from all of the desert States.

Their research design is adapted to the fragility of the desert in that they have broken the components of study among six different areas so that they will not be destroying the areas worked on. These sites are in Washington, Idaho, Utah, Arizona, New Mexico and Nevada.

In the tropical forest study we have a new director of the University of North Carolina, Dr. Lieth, who has a great deal of experience in South America and is multilingual so he can work very well there. In fact, he was in Columbia recently at a conference where they asked him to chair their sessions. The \$80,000 proposal indicated in the table has turned out to be \$95,000 as it goes into the second draft, and includes cooperation between North Carolina, Georgia, the Smithsonian, Battelle-Columbus, and Michigan in the planning of research programs. They will be working very closely with the IBP committees of Latin American countries.

Now, as a second point, I would like to discuss agency support for this program. Because in fact we enjoy very strong support from many areas including the Atomic Energy Commission, the Agricultural Research Service, the Forest Service, et cetera.

We are using their facilities. We are using their equipment and manpower. I think it would be excellent if these agencies documented this to show the level of their present support of the IBP.

It would run into several million dollars, but I want to stress as Dr. Blair did this does not constitute part of the money we are looking for. What we are looking for is new money in terms of logistic support.

I might add that the educational institutions also have an input into this program that has not been documented. We have made a study in our program and found that for every dollar we spend we can identify about \$2 of additional support. We have spent about \$50,000 of grant funds developing the program, and when we evalu-

ate the effort of over a thousand scientists that have participated it is well over \$300,000 worth of the time of university personnel.

With respect to funding, as I said, we are asking for half of the \$15 million for fiscal 1970, but in fiscal 1971 the analysis of ecosystems will be asking for \$14.3 million, and can't operate in all six biomes at less than that.

And a new issue confronts us. The IBP ends in 1972, and it will not be extended. If this schedule is pushed off 1 year, then the development of some biomes will be too late to be realistically a part of the IBP. Very shortly we are going to have to take another look at what we can call the IBP and what will have to be delayed until after the IBP is over with.

Mr. DADDARIO. Dr. Smith, how should we proceed taking into consideration your statement that the IBP will end in 1972 and will not be extended? How will the work that has been started go on?

Dr. SMITH. I don't think any of us expect these research developments to come to an end in 1972. The UN has scheduled a meeting in 1972—

Mr. DADDARIO. You stress the point that it will end in 1972 and not be extended.

Dr. SMITH. The thing that worries me is what we tell other countries what we are doing in the IBP, that we are working in these six biomes, and if we are not going to do this, I think we should tell them that pretty soon. Our approach of using systems techniques is being adopted across Europe, and they are looking to our people for leadership in this area. This has already happened in three of the biomes, although two of those are not yet funded in this country, and it seems to me we have a managerial problem. Can you call something a part of the IBP if it doesn't exist in the IBP?

Mr. DADDARIO. I think this is something you people who are managing the program have to decide. I get the feeling that as the need for doing this work is better and better understood; as you get more support for it in Government, as in fact you have, and as you develop the manpower and improve the planning which has been criticized in the past, that the opportunity to do more is quite apparent especially in the area that we talked about.

Dr. Blair gives me some reason to be enthusiastic by his saying that we have assumed a role in leadership, even in these circumstances of somewhat limited financing, and that other people are looking at us to see what we are doing and are supporting us.

Dr. Blair has said Chile is working in this biome area as a result of the work we have done. This would indicate to me some reason for optimism rather than pessimism.

I bring this up because I get the opposite feeling from you than what I get from Dr. Blair, and I would like to see how we can sort this out so that we know where we are headed.

Dr. SMITH. Well, I am very optimistic on the long-term development on this type of work. I am sure it has a future.

But the kinds of biome studies we are planning can't be half done. You cannot study half a system and come up with a study of the system. It is our responsibility to make the judgments as to which geographical region is turned off. Where one of these is involved in-

ternationally their role will have to become more advisory than participatory.

Mr. DADDARIO. Well, it appears to me from the testimony you have taken your experience with the desert biome which was building up the identification of studies in the coniferous forest area, and adopted this to your deciduous area. As you are able to bring in the manpower in the overall support covering many important institutions and geographical areas of the country, you will step by step develop a mechanism to put studies in shape so that they can get support in and out of Government.

This is work that needs to go on, and this would be a reason for us to be optimistic, and plan ahead. We shouldn't at this stage say it is not going to be supported. We haven't reached a point where we can come to that determination.

At least, that is how your testimony appears to me.

Dr. SMITH. Well, the grasslands biome is now able to go ahead with a program. But I should point out the deciduous forest group have had some programs ready for funding for nearly a year. What worries me is that we are going to ask for money faster than it is available under the present funding picture.

All six biomes are actively organizing, and it only takes about 6 months to go from early planning to a major proposal, once you have reached this critical mass of people. And I worry that we are going to have to tell two or three biomes, you can now just sit and wait another year or 2 years until funds are adequate.

Certainly the NSF at the present time does not have the capacity to support six biomes.

Mr. DADDARIO. Dr. Blair.

Dr. BLAIR. I would also like to introduce Dr. Milan, who is the program director of our Eskimo program under the human adaptability part of the IBP.

Mr. DADDARIO. Dr. Milan.

Dr. MILAN. I am from the University of Wisconsin. I would like to speak briefly about the international study of Eskimos, discuss the multiagency interest shown thus far in our program and state that each nation participating in this program is supporting its own research.

The aim of this 5-year program is to elucidate the biological and behavioral processes responsible for the successful adaptation and slow population growth of approximately 70,000 Eskimos in an arctic environment. Eskimos are resident in Siberia, Alaska, Canada, and Greenland; therefore international cooperation is needed to carry out a meaningful study.

In the planning phases of this program, which started in May 1966, we held a meeting in Ottawa; this was followed up by a meeting in Winnipeg in April of 1967, and finally a meeting at Point Barrow, in November of 1967. We invited to this meeting at the Naval Arctic Research Laboratory at Point Barrow delegates from six nations. The purpose of this meeting was to convene a working party to hammer out the actual methods of carrying out our study of Eskimos. What initially was to be a joint United States-Canadian effort became an international study of Eskimos at the Point Barrow Conference, and it was to consist of scientists of four nations: Denmark, Canada, United States, and France.

France was involved because French scientists from the Museum on Man in Paris have been studying the Eskimos on the east coast of Greenland at Angmagssalik since 1934.

This initial planning phase was supported by money for this purpose already made available to the International Biological Program. This amounted to perhaps \$10,000 for these three meetings. The ONR picked up the tab for our 6-day visit at Point Barrow. We became operational last summer according to schedule. The Air Force Office of Scientific Research (OAR) provided a \$25,000 grant. The National Institute of Dental Research (NIH) issued a \$6,000 contract to support dental research. The ecology branch of the Smithsonian Institution provided \$3,500 to pay for physiological studies. The Wenner Gren Foundation of Anthropological Research provided \$4,000. The arctic branch of the Office of Naval Research provided logistic support worth about \$5,000. The National Youth Council of OEO provided five Eskimo teenagers to work with us. The Bureau of Indian Affairs and the Alaska National Guard let us use buildings at Wainwright for establishing an examining clinic. With this approximately \$40,000 we were able to have a 19-man research team representing five universities, one State laboratory of health, and one foreign country (Italy) at our site for about 6 weeks.

In Canada, at the same time in the summer, they were being supported by the National Research Council, and they got their research team into the field at Igloolik. In Denmark they received money from their government through the Nordic Council, and they carried out comparable research at Upernavik in Greenland.

Then the initial field phase started last summer. We are now in the initial analysis phase. We had a meeting in Toronto in October to discuss the results of last summer, and my transportation and expenses were paid by the Canadians who also supported the participation of the Danish delegate. We are going into field operation again this coming summer, and our research is being supported by General Medical Sciences, one of the National Institutes of Health. This amounts to about \$115,000 which is about 60 percent of the money we feel we actually need to carry out a good study.

At our site, which is in northern Alaska, we will have a Canadian physician, a Soviet geneticist, and a Finnish scientist who is an ophthalmologist. We have planned a symposium at the annual meeting of the Association for the Advancement of Science in Boston in December of 1969, when we will have 1 day at the symposium devoted to presenting initial results of our respective studies.

Finally, in conclusion, as I see it, the practical result of this study is immediate health and dental benefits to Eskimos who are important minority citizens in Alaska, Canada, and Greenland.

These studies will also encourage international cooperation in scientific research. Further, we will actively train a number of future scientists, since graduate students will take an active part in these studies.

Thank you.

Mr. DADDARIO. Dr. Milan, the meeting at Point Barrow, you referred to as one where 10 nations participated.

Dr. MILAN. Six.

Mr. DADDARIO. You invited 10 and six came; is that how it worked out?

I understood you to say you called 10 nations and it worked out you developed a four-country cooperative program.

Dr. MILAN. Yes. We invited eight nations, because we invited the Soviet Union, but the Soviet Union said they couldn't send a delegate. Somebody told me afterward that they didn't actually have sufficient time to respond to our invitation. We invited Finnish participation, but none from Finland came. They are involved in studying the Lapps in Scandinavia. So, we had Danes, Norwegians, Americans, Canadians, Japanese, and a Swede.

Mr. DADDARIO. Well, my question is if you have eliminated other participants?

Dr. MILAN. That is right. We want to study circumpolar peoples on a cooperative basis. But since a lot of these circumpolar peoples are locked up in the Soviet Union, we have to get permission to get into the Soviet Union. In order to attempt this in the future, we have invited a Soviet scientist for this summer.

Mr. DADDARIO. Dr. Blair, this seems to fall more in the category of enthusiastic support from other agencies, is that correct?

Dr. BLAIR. Well, I would not like to give the impression that we have not had enthusiastic support for other programs. For example, our pilot studies in Latin America were initiated with support from the Air Force Office of Scientific Research, and various other agencies have been very enthusiastic. I would like to single out the Forest Service as one that has been very cooperative. But the point I would like to make is that there is an untapped source of support.

Mr. DADDARIO. Any questions on this matter, gentlemen?

Mr. BROWN. Could I inquire of Dr. Milan how broad this Eskimo study is? I gather you are investigating eyes, teeth, and other critical characteristics. Is it limited to aspects of physiological nature or does it extend to cultural and historical factors? Can you outline just how broad you are making this study?

Dr. MILAN. We are interested in studying human adaptability in the broadest meaning of the term; we know that these Eskimos have lived in the Arctic for about 10,000 years. We know they are living in an environment that is fairly rigorous as far as we are concerned and is characterized by limited environmental resources. We know this environment will only support a limited number of people. For example, in 1890, according to the census of that year, on the north coast of Alaska there were less than a thousand people. Well, we feel that we cannot study human adaptability in detail unless we utilized a multidisciplinary approach, so we have scientists trained in a number of different disciplines—such as anthropology, demography, genetics, cardiology, dentistry, epidemiology—and we focus their specialized talents on one community. This community numbers only 308. The ratio, then, is one scientist for each 15 Eskimos.

We study such things as family histories, genealogies and mating behavior. We are interested in the amount of inbreeding.

We are also interested in dental health. We did complete dental examinations, took chest X-rays for tuberculosis and evidence of cardiac disease, lower extremity X-rays for bone growth, and we brought back a lot of biological specimens with us: blood and urine, which is being analyzed in various laboratories for genetic markers, antigens, and the effect of 24-hour sunlight on the excretion of urinary electro-

lytes. After we finish our research in Alaska, we are going to compare the results here with results of studies in communities in the other parts of the Arctic region to see if we can sort out genetic effects from environmental effects.

Mr. BROWN. Is this untouched by technology factors?

Dr. MILAN. Not really. The Yankee whalers on the north coast of Alaska after 1850 hybridized some of the Eskimos, and by 1968 we found that there were about 56 of the 308 persons who were not 100 percent Eskimo. They were hybrids. And, of course, the Bureau of Indian Affairs has had an elementary school there since 1904.

In addition, there is a radar station 5 miles away across the tundra. It is one of the distant early warning stations that has been there since 1953. So there is a certain amount of contact with people such as ourselves.

Nevertheless, the people are Eskimo. They speak the language, maintain an Eskimo culture, and get 75 percent of their nutritional intake through hunting.

Mr. BROWN. I see. To really have comprehensive data it would seem you really have to have a study that includes a fairly long timespan here so that you can determine and get some indication of the changes that have taken place over time. I assume you have attempted to project backward as far as you can, and this would be a study that would continue sometime in the future.

Dr. MILAN. Yes. We figured our part will last 15 years. We know quite a bit about the prehistory of these people. We intend to carry out some more ecological investigations, and looking at the cultural remains and osteological remains we can tell a great deal about the people in the past, of the evolution of these people that occurred long before we got there.

Mr. BROWN. There is no written history, I presume.

Dr. MILAN. No, sir. There is no written language.

Mr. DADDARIO. Is that all you have at the moment, Dr. Blair?

Dr. BLAIR. I believe that presents our position fairly well, Mr. Chairman. I think it all comes back to money.

Mr. DADDARIO. We will toss it over to you, Dr. Carlson.

STATEMENT OF DR. HARVE J. CARLSON, CHAIRMAN, INTER-AGENCY COORDINATING COMMITTEE FOR THE INTERNATIONAL BIOLOGICAL PROGRAM, AND DIRECTOR, DIVISION OF BIOLOGICAL AND MEDICAL SCIENCES, NATIONAL SCIENCE FOUNDATION SUBCOMMITTEE ON SCIENCE RESEARCH AND DEVELOPMENT; ACCOMPANIED BY DR. BOSTWICK KETCHUM AND DR. PHILIP JOHNSON

Dr. CARLSON. Mr. Chairman, I would like to introduce Dr. Ketchum, and Dr. Johnson, from my staff, and I hope any questions that I can't answer that they will ably step into and answer the questions.

Mr. Chairman, members of the subcommittee, the Foundation appreciates this opportunity to appear again before this committee regarding House Joint Resolutions 589 and 625. I believe we are all part of a very encouraging dialog in this forum, by which the legislative and executive branches of the Federal Government are able

to interact with the scientific community. It is clear that many individuals have worked hard to develop the research programs of the International Biological Program. Science prides itself as prospering by self-criticism. It is that same spirit of constructive review that this committee has helped to foster in the public arena. In our judgment IBP has established a very commendable research program of great importance to the Nation and the world. We share the growing enthusiasm of the scientific community for the U.S. participation in IBP as well as the concern of the participants for funding delays.

Previous testimony before this committee during the IBP hearings of May 9, June 6, and July 12, 1967, and May 1 and 2, 1968, and during the authorization hearings on March 26, 1969, as well as such supporting testimony as the joint House-Senate colloquium on ecology, July 17, 1968 have quite adequately developed the purpose, the scope and initial developments of IBP. U.S. participation in the International Biological Program is conceived of in three phases:

Phase I is a 3-year development phase to stimulate ideas, approaches to manpower and initial funding;

Phase II is a 5-year operational phase, during which the research programs will be executed;

Phase III is a synthesis, evaluation and application period in which the results from different programs can be correlated and suitable applications implemented.

Inevitably these three stages overlap, however, phase I is now largely completed. It is likely that many portions of this kind of research should be continued after the official termination of IBP.

It is also evident that incorporation of fundamental knowledge generated by this international program is already influencing and stimulating thinking within the scientific and academic community. Application of the relevant data to major problems facing man will not await the termination of IBP and will certainly continue long afterward.

The Foundation's interest and enthusiasm for U.S. participation in IBP is based upon the fact that the knowledge sought is urgently needed and the research proposed is fundamental and innovative science to be undertaken through a challenging multidisciplinary approach.

The ecosystem analysis programs in particular are actively soliciting participation of Federal scientists and, through memorandums of agreements, are using Federal research facilities such as watershed installations, stream gages, controlled access experimental lands and certain research buildings. The Foundation finds this sharing of capital assets by university and Federal personnel to be in the spirit of a 1968 report by the committee entitled "Utilization of Federal Laboratories."

Responsibilities for U.S. participation in the IBP:

The IBP is not a program among nations and participation is not therefore a direct function of governments. Rather, it is a program of the international scientific community. Each country develops its own participation through appropriate scientific committees and seeks its own financing. Now that the U.S. IBP program is well developed, and, in fact, entering an operative phase with an optimistic outlook for increased funding, a number of management responsibilities need

further clarification. In refining and partitioning these responsibilities, the Foundation accepts the following premises:

One. U.S. participation in the IBP is desired by both the Federal Government and the scientific community;

Two. Development of scientific programs and their coordination with other international IBP activities is best achieved by a responsible set of scientists rather than by Government representatives;

Three. Responsibility for the proper use of congressionally appropriated funds necessarily rests with the Federal agencies;

Four. The Foundation is designated as the lead Federal agency for the IBP by the Office of Science and Technology;

Five. The success of IBP is a commitment of both the Foundation and the National Academy. It is now clear that successful achievement in IBP can be fostered only by cooperation of both NAS and NSF.

The U.S. Executive Committee for IBP was organized under the auspices of the National Academy of Sciences in 1965. This committee of six members holds primary responsibility for formulating, developing, and coordinating the scientific program. Its present revised and streamlined committee structure now seems to be working effectively.

National Academy of Sciences is the sponsor of the US/IBP committee and furnishes a Secretariat to support the Executive Committee, Program Coordinating Committee, International Coordinating Committee and Biometeorology Panel. This Secretariat (1) performs appropriate staff functions for the above coordinating committees including the screening of on-going research projects for appropriate inclusion in the US/IBP; (2) manages publicity and public information as directed by the Executive Committee, and (3) coordinates its activities with the Foundation and appropriate other agencies.

National Science Foundation is the lead Federal agency for the US/IBP. As lead agency it has organized an Interagency Coordinating Committee to affect liaison with the various Government agencies.

The Foundation or other cognizant agency evaluates and funds or declines those proposals for integrated IBP research recommended by the US/IBP Executive Committee. Those programs which are funded will be administered and monitored in accordance with the regular practices of the funding agency. Individual research proposals designated as IBP related are processed in the same manner as any other research proposal.

The responsibilities for various aspects of the IBP within the Foundation are assigned to the division director, biological and medical sciences. He also serves as chairman of the Interagency Coordinating Committee for the IBP. The Foundation has also created an additional program within the section of ecology and systematic biology and staffed it with appropriate professional scientists to carry out our response to IBP.

The Interagency Coordinating Committee, composed of 21 members representing six Federal departments and five independent agencies, will consider Federal policy issues regarding the IBP and reviews the annual contract to NAS/NRC for support of the IBP Secretariat. It is the purpose of ICC to advise and exchange information on IBP, particularly the ongoing related research which each agency supports and the developing integrated proposals appropriate to their

particular agency's mission. Table 3 lists the interests expressed by the member agencies in particular research programs, but without respect to their ability to fund such research.

EVALUATION PROCEDURES

In considering the status of IBP at this time, it is, I believe, useful to sketch the review procedures to which a major integrated research proposal is subjected. Since the organization of purposeful and meritorious programmatic research is sufficiently more complex than the individual research proposals commonly processed by the Foundation, several minor adjustments were necessary in the review procedure.

In the fall of 1968 the U.S. National Committee instituted a review system. Previously major program proposals were sent directly to funding agencies and concurrently to the IBP Secretariat. The Foundation now processes major program proposals after review and recommendation by the U.S. National Committee. We are confident that much better proposals are now presented for funding consideration.

The Foundation developed and the IBP Secretariat distributed a set of four criteria which are desirable for evaluating major program proposals. These criteria are:

Criteria for review of major IBP proposals

1. Each program proposal should demonstrate that it is necessary to group a set of research projects in space and time in order to achieve the scientific goals of the Program. That is, convincing arguments must be presented to show that support of individual, independent research projects would not achieve those goals. The whole, in this case, must be greater than the sum of its parts.

2. Substantive, operational questions of general scientific significance must be posed in order to give coherence and direction to the suite of research projects in the Program. Without such questions individual projects will tend to go their separate ways, thus placing the ultimate goal of the Program in jeopardy.

3. Each proposal must describe a system for coordination and rapid exchange of information and data among investigators so that each participant will profit from the efforts of others as the work proceeds.

4. Each proposal must provide a means of synthesizing the results of the several projects. Otherwise, the hoped for higher-order goals of the Program will be jeopardized.

We note that these criteria or very similar ones have also been adopted by the portion of the international IBP concerned with terrestrial productivity programs throughout the world in the various participating countries.

FUNDING CONSIDERATIONS

During this fiscal year and since the accounting furnished this committee in May 1968, the Foundation has awarded 13 grants in the amount of \$1,013,800 for IBP integrated research proposals—(table 1). Some of these funds were obtained by reprogramming scientific research project grant funds into the IBP.

IBP proposals for major programs now before the Foundation total over \$6.4 million.

Mr. DADDARIO. Do you mean by this, Dr. Carlson, that these proposals have gone through the process of having been examined, and are now the kind of programs which you believe deserve support?

Dr. CARLSON. Not all of them have received a complete review, Mr. Chairman.

In addition to funds provided by other agencies in support of the National Committee, three major programs, or parts of programs, on human adaptability are now funded annually as follows: adaptation of Eskimos populations—National Institute of General Medical Sciences, \$117,000; population genetics of the American Indian—Atomic Energy Commission, \$150,000; and ecology of urban and migrant peoples—National Environmental Health Institutes, \$188,000. The Grassland Biome received support from AEC, \$50,000. Other agencies have contributed very real support in the form of cooperating scientists, land or logistic support.

It is clear the \$5 million requested by the Foundation for the IBP will not support the whole program. Certain agencies have been able to support specific research programs closely related to their mission interest. The ICC has attempted to identify the interest of the agencies in particular IBP programs in two ways: Appropriate agencies have been asked by the IBP Secretariat to assist in listing ongoing research which should be designated as IBP related projects. This listing is maintained and published at intervals by the IBP Secretariat. Secondly, each agency was asked to identify those major IBP programs in which it was interested because of content, but not with respect to its funding ability. That listing is tabulated below (table 3).

There are mechanisms for transfer of funds between agencies. Most of the funds tabulated in table 2 for support of the U.S. National Committee were transferred to the Foundation and then placed in a contract to the National Academy of Sciences. The question of inter-agency support of the IBP seems to be not a question of new mechanisms, but rather of fiscal and program flexibility to employ such mechanisms.

In summary, Mr. Chairman, may I say that the Foundation, following a special study of the IBP completed last fall, is satisfied with the course and progress for the IBP. We have been most gratified by the cooperation of the Agencies which comprise the Interagency Coordinating Committee for IBP.

Further, the Foundation is confident that both substantive scientific programs and appropriate management are evolving. The Foundation envisions that the output of this innovative research will establish and stimulate team approaches to environmental and ecological sciences at fundamental as well as applied levels.

We are confident that the results of IBP research will help to provide the necessary platform of basic understandings on which society can base solutions or alternative activities to cope with ecological problems.

(The tables referred to follow:)

TABLE 1.—*Projected fiscal year 1969 funding by NSF for Integrated Research Programs*

Support of U.S. National Committee-----	\$125,000
Ecosystem Analysis:	
Grassland Biome -----	451,000
Desert Biome -----	20,200
Convergent and Divergent Evolution-----	100,100
Aerobiology -----	51,700
Upwelling -----	94,200
Biogeography of the Sea-----	171,500
 Total -----	 1,013,800

TABLE 2.—*Tabulation of support of the U.S. National Committee by member agencies of the Interagency Coordinating Committee for IBP, 1965-69*

Operation of ad hoc NAS-IBP Committee and SCIP contribution, fiscal year 1965:	
NSF -----	\$40,400
Operation of USNC and SCIBP contribution in fiscal year 1966:	
NSF -----	125,000
NIH -----	60,000
Total -----	185,000
Operation of USNC and SCIBP contribution in fiscal year 1967:	
NSF -----	113,800
AEC -----	50,000
HEW:	
NIH -----	35,300
PHS -----	30,000
USDA:	
ARS -----	20,000
CSRS -----	5,000
FS -----	13,000
DI -----	20,000
DOD:	
AFOSR -----	10,000
ARO -----	10,000
Smithsonian -----	5,000
Total -----	312,100
Operation of USNC and SCIBP contribution in fiscal year 1968:	
NSF -----	165,000
AEC -----	43,000
HEW: PHS-NIH-----	86,000
NASA -----	31,000
Commerce: ESSA-----	7,000
DI -----	7,300
USDA:	
ARS -----	20,000
CSRS -----	8,000
FS -----	13,000
Smithsonian -----	5,000
Total -----	385,300
Operation of USNC and SCIBP contribution in fiscal year 1969:	
NSF -----	125,000
AEC -----	43,000
USDA:	
FS -----	12,000
ARS -----	22,000
CSRS -----	6,500
Smithsonian -----	2,500
Total -----	211,000

TABLE 3.—*Expressions of interest in particular integrated research proposals by member agencies of the Interagency Coordinating Committee. The foundation has an interest in all of the programs.*

IRP	
A. Environment Component:	Interested agencies
1. Analysis of Ecosystems-----	NASA
Grasslands -----	AEC, ARS, USFS
Deciduous Forests-----	AEC, USFS
Desert -----	AEC, ARS, USFS
Coniferous Forest-----	USFS
Tropical -----	AEC, SI, USA, USFS
Tundra -----	AEC, AID, SI, USDI, USFS
2. Convergent/Divergent Evolution (including Hawaii)-----	AID, SI
3. Aerobiology -----	AEC, CPEHS, DOD, ESSA, HEW, NIH, ONR, USA
4. Upwelling -----	AEC, BCF, SI, NASA, ONR
5 Biogeography of the Sea-----	BCF, NASA, ONR, SI
6. Biological Control*-----	ARS, SI, USFS
7. Phenology -----	AEC, ARS, ESSA, NASA, USFS
8. Physiology of Colonizing Species -----	ARS
9. Marine Mammals*-----	NIH, ONR, SI, USDI
10. Conservation of Genetic Materials -----	ARS, NIH
B. Human Adaptability Component:	
1. American Indians-----	AEC, NIH, SI
2. Eskimos -----	AEC, NIH, PHS, USAF
3. High Altitude People-----	NIH, USA, USAF
4. Nutrition -----	ARS, FDA, NIH, OEO, USA
5. Urban and Migrant Peoples-----	CPEHS, NIH, NIMH, OEO
6. Chronobiology* -----	NASA, NIH

*Developing or potential programs

NOTE.—Key for symbols used in tables 2 and 3 :

AEC : Atomic Energy Commission.

AID : Agency for International Development.

AFOSR : Air Force Office of Scientific Research.

ARS : Agricultural Research Service.

ARO : Army Research Office.

BCF : Bureau of Commercial Fisheries.

CPEHS : Consumer Protection Environmental Health Sciences.

CSRS : Cooperative State Research Service.

DOD : Department of Defense.

ESSA : Environmental Science Services Administration.

FDA : Food and Drug Administration.

HEW : Department of Health, Education and Welfare.

NASA : National Aeronautics and Space Administration.

NIH : National Institutes of Health.

NIMH : National Institute of Mental Health.

NSF : National Science Foundation.

ONR : Office of Naval Research.

OEO : Office of Economic Opportunity.

PHS : Public Health Service.

SI : Smithsonian Institution.

USFS : United States Forest Service.

USDI : United States Department of Interior.

USAF : United States Air Force.

USA : United States Army.

Mr. DADDARIO. Dr. Carlson, when you asked appropriate agencies to assist ongoing research, which should be designated as IBP related projects, what do you get? Is it really asking for new innovative programs or is this just a regrouping of work already going on which would continue notwithstanding IBP support?

Dr. CARLSON. I believe that the latter is correct.

They have complied with the IBP National Committee in listing a group of ongoing research programs.

Now, in answer to your first question, Mr. Chairman, I believe that there really is a sincere interest on the part of the agencies. In

our recent ICC meeting last month, we examined each one of the Integrated Research Programs, and we asked if the agencies really had a sincere interest in each program, in the research proposed and in the supposed results that might become of interest to their agency. The interest volunteered by each agency is included in table 3.

As I stated, Mr. Chairman, to you in March, I am convinced that there will be participation by various agencies in the form of new money, but the one thing that we all have to understand is, that there are certain types of priorities within each agency and there are certain commitments that they have for their funds. After congressional action on the budget requests of the several Departments and agencies, then I look forward to some further participation in IBP with new funds. How much, I can't tell you.

Mr. DADDARIO. Dr. Smith has touched on the planning that has gone into various of these ecosystem programs. How do you see our support for these programs taking into consideration what he has said? Are those programs so advanced in their planning that they will run ahead? In fact, the money is available for them. Do they still need to go through a planning phase and a review to get them in the kind of shape, that means that we still have sometime to work on them?

Dr. CARLSON. Can I ask Dr. Johnson to respond and then I will add some comments?

Dr. JOHNSON. Mr. Chairman, our experience with the proposals for these biomes studies, the six to which Dr. Smith referred, is that they are progressing more rapidly than we anticipated a year ago, and I think, he is correct in stating that they are developing at a rate faster than we see funds developing.

Mr. DADDARIO. How does that leave us with moneys available toward the proposals being made? Can you give the committee some judgment about which of these have reached the point where you will give them support, which ones should be supported above the others?

Dr. JOHNSON. We have placed funds of major proportions in the Grasslands program as you are aware. We have placed money in the Desert biome. The judgment decision here is not which biome is of greater interest to the Foundation or to the Nation, but rather a question of the chronology in which these projects arrived at a state where they were ready for funding.

In response of the question you raised, stemming from Dr. Smith's comments, I think we face serious questions of judgment in trying to place priorities on which biomes should go forward at a given level within the limits of restraint caused by available dollars.

Mr. DADDARIO. Then you attribute merit to each of these proposals?

Dr. JOHNSON. Yes, sir.

Mr. DADDARIO. And overcome your problem of choice by taking them up chronologically?

Dr. JOHNSON. That is the way they have come to us. We have not been able to respond to the six in concert, and therefore we have not placed priorities on them.

Mr. DADDARIO. How does this affect the work going on in these areas in other countries? Do you attribute the same serious concern that Dr. Smith does, insofar as what it may or may not do in terms of the work other countries will do?

Dr. JOHNSON. I agree with Dr. Smith that the U.S. IBP program has had an impact on the international scene, and is in a sense being looked at very seriously for incorporation into the programs of other nations. The effect of a lower amount of funding than might be desirable to operate all six of these biomes, on programs of other countries is, I think, premature to pass judgment at this point.

Mr. DADDARIO. But as we go along, as you see these programs develop, as funds become available for their support, and if they do fall out of the time within which the International Biological Program is presently scheduled for, does this mean that these programs could not continue, or that they could not get international support within that period which would be meaningful?

Dr. JOHNSON. That is certainly a realistic appraisal. I think we must note that these six biomes are not in any sense individual programs. They are part of a plan which the IBP has been developing, that all six of these were intentionally programed to operate in different parts of the country and have feedback to our general understanding of principles of how ecosystems operate. We can best realize those goes by having efforts ongoing in the six biomes, so that concurrent data are compared rather than data taken in separate decade or 5-year periods.

Mr. DADDARIO. Can you see the funds available for this—there was some \$7½ million coming out of your present plans, including the moneys that you are requesting and those which could be applied to this work from other agencies as being put together in a meaningful way to come to this total to do all these things in this coming year?

Dr. JOHNSON. I think it is a responsible statement to say, that \$7 million cannot easily be envisioned in the present status of the budget of the Foundation. As to the amount that can be supplemented from other agencies, clearly until their budgets are further down the road in the budget processing, the agencies are not willing to commit themselves, and I am not sure that we can appropriately anticipate what funds they will be willing to employ in this program.

Dr. CARLSON. Mr. Chairman, may I comment on the International aspect. I think one of the real moves in the right direction, and I am sure you will hear this tomorrow, regarding the Canadian grassland program, is a good dialog between our grassland scientists in Colorado and those in the Canadian grassland program. Doctor Smith will have to say either "Yes" or "No," but the Mexican scientists are also involved. There is a good give-and-take in this international co-operation; although it is not large at the present time, I think it is expanding.

Mr. DADDARIO. Do you say "Yes," or "No," Dr. Smith?

Dr. SMITH. I say yes.

Mr. DADDARIO. Dr. Carlson, just one further question:

With the Foundation and the National Academy working closely together, the understanding I have from your statement, is that you put this all together and do all of the reviewing?

Dr. CARLSON. Yes, sir.

Mr. DADDARIO. Then pass it to this Secretariat who administers the programs?

Dr. CARLSON. No, sir. The Secretariat of the Academy is a working group of individuals that take care of all of the many administrative problems of the U.S. National Committee for the IBP and all of

their subcommittees. When a proposal is submitted to the Foundation, and the AEC, or the NIH, it is evaluated according to the procedures that we had already set up to take care of such proposals. If it passes merit, it is then funded, a grant is made to an institution, and in the case of the grasslands program, the institution is Colorado State University, and they administer the funds.

The Foundation and the AEC monitor this program very carefully and closely, but it is not the Secretariat that has anything to do with the funds once we award the grant to an institution. For instance, in Dr. Smith's program, the grant was awarded to the University of Michigan, and he has used these funds to operate his committee for development of the ecosystem analysis program. The Secretariat has no real function as far as the funds are concerned, and, if I implied this, I surely did mean to within my statement.

Dr. BLAIR. I might add something to what Dr. Carlson has said, and that is, each of the integrated research programs, even though one individual is the responsible individual for a grant from an agency, each program has developed management groups which are advisory in nature to the program manager. We have four Latins and four U.S. people on the advisory group for convergent and divergent evolution and these people do act in an advisory capacity to the program director.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. I am interested in the very strong expression of interest shown in your table 3 by the various agencies of the Department of Defense. In fact, the majority of the programs show some interest on the part of the DOD, and yet I notice that not since fiscal year 1967, has there been any financial support. And that was of a very modest nature.

Dr. CARLSON. That is right with respect to support of the U.S. National Committee for IBP.

Mr. BROWN. Now, do you have any anticipation that this interest could be translated into funding to any of the various agencies in the DOD in view of the fact that they have a rather substantial budget, although I understand there are pressures on them as well as other agencies?

Dr. CARLSON. This is very true. They have a large number of research programs to which they are more or less committed and again their priorities must be considered. They did indicate at the last meeting of the Interagency Coordinating Committee that there was definitely an interest in certain research programs, and it is a matter now of waiting and seeing whether they will come through with funds, and that is as far as I can say, Mr. Brown, at this time.

Mr. BROWN. I was struck that the great concern (of the scientific community) about the effects of Air Force operations in the forests of South Vietnam, in fact the total ecology of South Vietnam, through this use of sprays.

Dr. CARLSON. Yes.

Mr. BROWN. Obviously this is a situation which deserves some additional research. An understanding of the ecology of the types of regions in which they are using these kinds of agents would be very helpful to the Air Force, it seems.

Dr. CARLSON. Right.

The only way I can answer this, Mr. Brown, is that there are scientists that sit on the Interagency Coordinating Committee. They are interested in a number of these IBP programs, as well as the one that you bring up specifically, I am sure that they do have an interest, because many scientists throughout the United States and the world have become concerned with defoliation and the use of those types of substances in our environment.

Mr. BROWN. Well, I don't want to press that point.

I noticed that the AEC shows a consistent interest in a number of these programs and have provided some actual funding.

Dr. CARLSON. Yes, sir.

Mr. BROWN. Can you explain to me their greater financial interest in these things, than the DOD?

Dr. JOHNSON. I think, Mr. Brown, the AEC has been, very early in their charter, interested in the whole environment, because of the impact of the activities they were carrying out.

I speak of fallout activities, and, therefore, they have had scientists on their staff interested in the ecosystem approach, and one will find in laboratories operated by the AEC superb groups of ecologists working on the same kinds of things that we are trying to do in IBP.

Mr. BROWN. Thank you. That is a direct correlation of AEC activities, is that correct? Specifically, they are trying to correlate their interest in American Indians and Eskimos with the Atomic Energy Commission. Is that just because of interest on the part of the scientific community in the AEC, or is there a direct relationship of your studies of Eskimos and Indians and the AEC?

Dr. JOHNSON. I think both of these circumstances apply. As you are aware the Eskimos in Alaska have been concerned with the effect of fallout in Alaska, and the high body burden of radioactivity has caused the AEC to pay special attention to this group. They have been interested in Alaska because of activities in the Plowshare program that have been planned for Alaska, so I think both the interest of the AEC staff and their charter led to this interest in IBP.

Mr. BROWN. Following up on this, I think it is true that in every major installation of a nuclear type the question of environmental effects has always arisen. It has been the contention of many of the scientists associated with conservation groups and others that inadequate attention had been made to the total environmental effects of the heat pollution effects of nuclear discharge, if any, and things of that sort. It is understandable that the AEC, since it is directly involved with providing the fuel for these installations, would have the concern for these environmental effects.

I am wondering if their concern has been as broadly based on these ecological programs as it should be?

Dr. CARLSON. I really think it has, Mr. Brown, although I cannot provide the dollar basis for these ecological programs of the AEC. The laboratory at Oak Ridge, for instance, has a large group of ecologists that are concerned with large forest plots, and the director of this program is Dr. Stanley Auerbach, from Oak Ridge; and they have also encouraged this participation in the international biological program. Oak Ridge National Laboratory has been carrying on ecological research programs for a number of years.

Mr. BROWN. Well, I think this may be related in some fashion to the kind of issues raised by the Hughes organization in Nevada with regard to the deep testing going on there. There could be presumably some ecological effects as well as possible effects on earthquake faults. I think Hughes is raising these questions because of a feeling that there has not been adequate research. I would like to see what efforts AEC makes in order to answer these questions, because they are of rather fundamental importance.

Dr. CARLSON. Right.

Mr. BROWN. So far the budget proposals in this area have been reviewed by the incoming administration so that what we are receiving here in terms of indicated or expected support does have the approval of the new administration?

Dr. CARLSON. The \$5 million requested by NSF has been examined by the incoming administration, and the President did allow our budget without cuts.

Mr. BROWN. Without cuts?

Dr. CARLSON. Yes.

Mr. BROWN. You can't speak as authoritatively, I suppose, about the other agencies?

Dr. CARLSON. No, sir; unfortunately, I can't.

Mr. DADDARIO. You will be able to ask that question tomorrow.

Dr. KETCHUM. Mr. Chairman, may I answer one inquiry about the AEC's interest in this ecosystem type of approach.

If Dr. Blair will forgive me, I would like to add an addendum to one of the figures he presented. In the upwelling program, he has not indicated Woods Hole participation. I was there over Easter weekend and 10 Woods Hole scientists, who are supported by the AEC, were returning from Peru, and 10 were leaving to work in this program in Peru. The AEC has had a marine project at Woods Hole for about a quarter million dollars a year for many years. The objective is to study what happens to elements in the ocean, with the ultimate aim of finding out what would happen to radioisotopes if released. It could be as waste disposal, fallout, accidents, and ships have a way of running into each other, and so forth. There is always a potential of a release accidentally into the marine environment.

Mr. BROWN. Such was the release of the submarine that went down in the Atlantic.

Dr. KETCHUM. So far as I know, there has been no release of radioactivity to the ocean. Two large atomic power plants are sitting on the bottom of the Atlantic, southeast of the Azores and the other just south of the gulf of Maine.

I would also like to add that the participants indicated in Dr. Blair's map in the upwelling program from San Diego, are also mainly supported by the Atomic Energy Commission in a program that is quite similar to the one that they are supporting at Woods Hole. They are supporting ecosystem analysis-type investigations, both in the terrestrial and in the marine environment.

Mr. DADDARIO. Dr. Ketchum, that is as it ought to be, because obviously the ecologists working under the Atomic Energy Commission must have an overall involvement. They simply do not confine their activities to the byproducts with which the AEC is concerned. This calls attention to what Dr. Blair has said, that there is an opportunity

for involvement, and in fact, a broader opportunity to engage these people in other productive uses which at the same time can help provide data for their own mission objectives.

Dr. KETCHUM. I may say that I interpret your statement to mean that we must study the entire ecosystem before we can evaluate what effect a new activity may have on the ecosystem.

Mr. DADDARIO. Mr. Yeager.

Mr. YEAGER. Dr. Blair, on your chart there you show 10 or 11 agencies, and Dr. Carlson suggests 3 or 4 that contribute funding. Is it correct that these others are supporting in services, facilities, and scientists, rather than money?

Dr. BLAIR. Not entirely. There are some discrepancies between our two sets of figures. For example, under divergent evolution, which I know well, I know we have USAF listed, and not in Dr. Carlson's.

Mr. YEAGER. Could you provide us—

Dr. BLAIR. We could collate these and provide you a better answer. (Information for the record follows:)

NATIONAL RESEARCH COUNCIL,
NATIONAL ACADEMY OF SCIENCES NATIONAL ACADEMY OF ENGINEERING,
Washington, D.C., May 26, 1969.

DEAR MR. YEAGER: During the hearing on H.J. Res. 589 on 6 May, Dr. Blair, in response to a question by Congressman Daddario concerning agency participation in the IBP, stated that he would provide a collation explaining the apparent differences between his (Dr. Blair's) and Dr. Carlson's listing of agencies (page 5, line 8 of the transcript for 6 May).

The listings referred to were statements of opinion. Dr. Blair's listing (page 10 of his statement) was his own; Dr. Carlson's listing (table 3 of his statement) summarized individual opinions of members of the ICC/IBP. Neither listing was intended to reflect financial participation by the Federal agencies in the IBP-IRP's.

The most accurate summary of financial participation by the Federal agencies in FY/68 and FY/69 is shown in the table on page 9 of Dr. Blair's statement for this hearing. The agencies include NSF, AEC, Agriculture, the Smithsonian, DHEW, Department of Air Force, Interior, Department of Army, and AID. The Wenner-Gren Foundation and several universities and colleges also participated financially in FY/68 and FY/69 in the U.S./IBP-IRP's.

Sincerely,

RICHARD H. OLIVER, *Staff Officer.*

Mr. YEAGER. One other point, Dr. Carlson: Do you know or could you determine whether or not the NSF study on the IBP, which was submitted to the Bureau of the Budget, could be made available for the committee's record?

Dr. CARLSON. Yes, sir.

Mr. YEAGER. Could you find out?

Dr. CARLSON. I have inquired about that, and I do have permission to provide you with copies of the special study.

Mr. DADDARIO. Thank you, gentlemen.

This committee will adjourn until 10 o'clock tomorrow morning at the same place.

(Whereupon, at 12 o'clock noon, the committee was adjourned, to reconvene at 10 a.m., Wednesday, May 7, 1969.)

INTERNATIONAL BIOLOGICAL PROGRAM

WEDNESDAY, MAY 7, 1969

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:00 a.m., in room 2325, Rayburn House Office Building, Hon. Emilio Q. Daddario, (chairman of the subcommittee) presiding.

Mr. DADDARIO. This committee will come to order.

We are pleased today on the second day of our hearings on H.J. Res. 589, which is a joint resolution urging the support of Federal departments and agencies, as well as other persons for the International Biological Program, to have as our witness Dr. Lee DuBridge, Director, Office of Science and Technology, and Dr. N. E. Gibbons, vice chairman, Canadian national committee for the IBP, and to have this meeting coincide with a visit of the Special Committee on Science Policy of the Canadian Parliament with the chairman being the Honorable Maurice Lamontagne, and the vice chairman, Donald W. Cameron.

This is a Senate committee which will not only be with us today, but will sit with us tomorrow so we can exchange dialog about our methods of operating techniques and their's, and in this exchange I think we will find a great deal that will be beneficial to each of us in not only what we are presently doing in the area of science and technology from a parliamentary point of view, and what we might expect to do in the future. I would also expect that we might find some continuous activity which would allow us, as it would be proper for us to do, to keep in touch about these problems ahead, because most certainly in Canada and the United States, where technology is growing rapidly, it is having a tremendous effect on every phase of life that stems from both government and private activity. We must do much better than we have in the past in the management and administration of our resources, which is the whole objective.

The opportunity we have has been added to, as I have said, by the presence of Dr. DuBridge, who is now the science adviser to President Nixon, a person from whom we have had advice over the course of time which has been extremely helpful to the committee from the time of its formation to the present. We have been exceedingly grateful to him over these years, and have looked with great pleasure on his activities since he has been science adviser. We believe he has added great strength to the administration in this extremely vital area.

Mr. Chairman.

Mr. MILLER. Well, I would like to join in what you have just said, to welcome our guests here. I am very happy to see Dr. DuBridge here. I may say for their benefit Dr. DuBridge was head of the California Technological Institute, which operates the Jet Propulsion Laboratory. JPL has made part of our space program possible and jet planes in general.

I am very happy to see Dr. Gibbons here. He brings me a message from my brother-in-law, who happens to be engaged in the same field that he is in and I am very happy that you gentlemen, the Canadian Senate, can be here today. Now we will go on and give you just a little preview of how some of these things happen.

Mr. DADDARIO. Dr. DuBridge, if you would, please, come forward, and proceed with your testimony.

Dr. DuBRIDGE. May I ask Dr. King to join me?

Mr. DADDARIO. If you would. We also welcome Dr. Donald King, and are happy to have you with us.

STATEMENT OF DR. LEE A. DuBRIDGE, DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY

Dr. DuBRIDGE. Mr. Chairman, Congressman Miller, and gentlemen, it is an honor to be here this morning, especially in the presence of our distinguished Canadian colleagues, because as you will hear later the Canadians have been most effective in pursuing work in science related to the International Biological Program, and the relations on this between America and Canada have been very cooperative and will be very fruitful. The Joint Resolution 589, which is before your committee is, of course, an expression of interest and confidence in the work of the International Biological Program. It goes further than that in providing legislative authority to the various agencies to cooperate with each other in the United States to forward the goals of this program, to provide exchanges of people or funding where this is appropriate, and I hope because of the international nature of this program to assist in encouraging the various agencies of Government to allow and encourage the travel of U.S. scientists to other nations as we seek collaborative effort in this area of biology, particularly in those areas of biology that are of global impact and interest.

I was not involved in the development of the International Biological Program originally. I have seen the effort and enthusiasm for this effort that was shown by others, and particularly the enthusiasm shown by this committee, all of whom are interested in improving the basic sciences as the first elements of the programs are becoming operational as they are today, it is clear that careful planning has been necessary for a program of this type.

Mr. DADDARIO. Dr. DuBridge, I do think it is worthy, of comment that last year, when your predecessor, Dr. Hornig, appeared before this committee we were advised of their feeling about the necessity of additional planning, and of their recommendation that we not support it on a line-item basis in any considerable amount at that particular time, but to give it the opportunity to fill in its planning. They expected from what they had seen at that time, that the next year would be the time in which that could be done. I believe that their observations in that regard have been correct.

The information we have had through staff activity and other kinds of testimony prior to yours also shows a tremendous amount of activity and progress. We are convinced at this stage of their activities that the planning manpower needs have been adequately filled in to the projects which have been proposed to us.

Dr. DuBRIDGE. Yes, I think you are correct that a year ago the planning was still in its elementary stages. It is a big and complex program. Biology is a complex subject, and the world is a large place, and to find out those things in biology, which are appropriate and feasible to do has not been an easy task.

There are many things going on in biology in this country that have important international interest. To consolidate any group of programs into the IBP has taken a good deal of thought and a good deal of planning, but now the work is underway. With the help of the National Academy of National Sciences and of the National Science Foundation, the focusing of the planning has been complete.

Now, planning has to be continued for a long time. This is not the kind of program that is going to be done in a year or 2 or 5 or 10, and planning for the future is underway, and must remain underway.

After reviewing the records of previous IBP hearings before this subcommittee, I am convinced that you deserve a very considerable share of the credit for the successful launching of the U.S. program. You have already developed a thorough record of the IBP's formulation and progress. At the risk of redundancy I would like to review the current situation regarding the IBP as I see it.

First, the international response to the Program has been varied. The U.S. effort compares favorably with those of others. In contrast to most other countries, the United States has developed a structured effort with a central core of projects specifically designed to meet the objectives of the International Biological Program. I should say that the Canadian programs have been excellent and fine programs have been carried on by our neighbors across the border.

The integrated research programs that make up the core of the U.S. IBP efforts crystallized from a large number of proposed research efforts. They were painstakingly developed by committees of competent scientists under the aegis of the National Academy of Sciences.

The IBP is unique in several respects. It represents a major new kind of undertaking for the biological community in that it requires the coordinated efforts of scientists from diverse disciplines who are accustomed to highly individual research projects.

This is not like the International Geophysical Year, requiring one type of collaboration. This requires more diverse types of activity.

Further, the Program is addressed to improving, on an unprecedented scale, our understanding of human adaptability to the environment and our knowledge of natural systems. In view of the multiplicity of programs that are directed toward improving man's welfare, it is difficult to estimate the contribution the IBP will make, particularly in those areas concerned with the environment. We should not, of course, except that a scientific program such as IBP will provide the solutions to environmental management problems. Nevertheless, I believe that the IBP is the type of scientific endeavor that will con-

tribute basic information that can be used to develop methodology for effective management of the environment.

I feel that activities within the U.S. IBP effort are properly the interest of several Federal agencies. The scientific talent and support of agencies should be utilized when IBP objectives coincide with agency missions. Some minor adjustments may be necessary in relevant agency programs to make them more compatible with IBP objectives.

Multiagency interest and responsibility has made necessary special organizational and management arrangements to provide funding and Federal oversight for the IBP. As you know, an Interagency Coordinating Committee, chaired by NSF has been established to coordinate Federal participation in and support of IBP.

Mr. DADDARIO. Dr. DuBridge, I have been concerned, and I wonder what your feeling is about how other agencies will participate in the future. We are fearful in the judgment of the listing of programs in other agencies as IBP, that they are just a continuation of what has already been done, and that the need to redirect or to develop innovative programs for accomplishing IBP objectives is not.

Dr. DuBRIDGE. Well, I recognize both of these problems. I know there are biological programs underway both nationally and internationally, and I think that these worthwhile programs should be continued, but that they are related to the general purposes as well as to the new programs. A major IBP policy is to get new programs underway, or programs altered as to their style so they fit into the IBP. One can say that all biology is international biology. It relates to every human being all over the world, but that isn't the purpose of designating this particular program. It is an opportunity to select programs which are feasible and important, and the impact on the environment is clear, and hopefully, direct.

I don't think I can answer your question more fully than that, unless Dr. King might give some specific answers to some of the specific programs in other agencies.

Dr. KING. I think it is a program that is related to many other ongoing programs, and what the agencies can allocate specifically to the IBP depends on priorities and other agency missions.

Mr. DADDARIO. Well, the idea in these agencies, is that there will be more significant involvement with IBP in the hope that if this might be one of the objectives of the office of the Science Advisors.

Mr. MOSHER. Mr. Chairman, I am not sure this is the place for this question, but Dr. DuBridge, I would like to know what your view is on the wisdom of eventually establishing a Center for Ecological Research? I think what we are talking about here today goes beyond biology in any limited sense, and we are talking in the broader sense about ecology. And certainly your statement indicates a strong belief in the importance of the ecological approach.

Do you foresee the time when we should concentrate our national efforts structurally in a new agency of that type?

Dr. DuBRIDGE. A new Government agency you are suggesting?

Mr. MOSHER. Yes.

Dr. DuBRIDGE. I think this is one of the problems that faces any new scientific enterprise, whether it is better and more productive to have many institutions and organizations involved or to have a central one. I am not against dispersal of programs in universities—

Mr. MOSHER. Can you have the ecological emphasis and have dispersal?

Dr. DuBRIDGE. Yes. I think that is possible.

Of course, when you do not have dispersion you have the danger of putting all the Federal funding into a center and not supporting the other activities going on around the country. And this is one of the fears that some people have, that by the existence of a central agency you channel too much of the larger funding into it rather than into the supporting activities in the country.

Nevertheless, a focus is often necessary. I don't think I can answer yes or no, whether the time has arrived for an Ecological Institute.

Mr. MOSHER. I think we are going to have to think about this.

Dr. DuBRIDGE. You are right. I think it is something that should be looked at.

Chairman MILLER. Doctor, I would like to draw a parallel between this and oceanography. I had the pleasure to be the first chairman of the Subcommittee on Oceanography. A very fine study, that the Academy of Science made was referred to us Mr. Mosher in another committee is now carrying out a lot of this work.

We found that oceanography was spread throughout the Government, there was no thread, no connection, and no common meeting place. One of the first things we had to do was set up a data center where we could keep tab on what seven different agencies of government were doing, and correlate this information. Again, it wasn't an attempt to center it all in one place. It was necessary to know what was being done.

Isn't this true in the field of ecology? This concerns me a great deal. We are seeing a lot of our natural resources destroyed. There are many acres of rich land in San Joaquin Valley, in California. They are out of production because they are saturated with fertilizer and detergents. We go out and spray DDT over everything to get rid of certain insects and kill the robins. We kill more than the robins.

Dr. DuBRIDGE. We do kill the bugs, too.

Chairman MILLER. Well, it is important to kill the bugs, but it may be more important to let nature take its own course. I remember an experiment that was made when I was with California Fish and Game. We were going to take out all of the snakes. We cut out a piece of property that was isolated where we could do this. Then, the rodents immediately multiplied on the spot to where it was quite dangerous.

Don't you feel this particular field is the most important we have to deal with? Can we take our time and say, "Well, we will take this in our stride and let some private investigators do it."

I agree with you, we have got to get it into the universities. We want more cooperation with them. But how are we going to bring this about in this field of biology which generally was my experience where you find people in different phases that won't talk to each other. Isn't that true, Dr. Blair? [Laughter.]

Dr. DuBRIDGE. That is correct. The coordination of disparate activities is very difficult. It depends on whether you are thinking more of the basic science investigations that are back of the ecology or whether you are thinking of trying to focus on what you already know.

We often do not understand the total cost one agent produces on the environment. I feel that DDT was a great invention which saved crops

and prevented hunger, but we weren't aware of the way that it would disperse so widely. We don't know how to take full advantage of it and other insecticides. We would have greater crop destruction, and spread of diseases by insects, if we didn't have some sort of pesticides.

Chairman MILLER. You talk about these pesticide controls. The one that kills the boll weevil has a great affinity for shrimp.

Dr. DuBRIDGE. That is why we need these ecological studies.

Dr. KING. May I add something here? I think an Institute of Ecology is a difficult kind of thing to consider, and one of the difficulties is arriving at what an institute is going to do. We have to decide whether ecology is a concept that embraces a group of sciences and within it we do little things, keeping in mind this ecological overview, or whether we attempt to tackle everything at once.

Mr. BROWN. May I offer a comment at this point?

I gather we are discussing the problem of organizing efforts in this field of ecology. From your statement, Dr. DuBridge, we are talking about the broad problem of human adaptability of environment and ways of developing a methodology for the environment. We have already, within the structure of the Federal bureaucracy, the Environmental Sciences and Services Administration. Also we have within the National Science Foundation two divisions: One of which is serving to manage the IBP, and the other is designated as the Environmental Sciences Division.

It seems to me that the question is how do we best bring order and focus to the many activities already aimed at this broad program and define their relative spheres so they operate efficiently and effectively together.

I don't know if we are at the point, as you, yourself, have indicated, where we can make this decision. But it seems obvious if we are to avoid a proliferation of different and possibly competing operations some thought should be given to this. You are in a position where you need and can give this kind of thought. I trust at the proper time some appropriate recommendations would be forthcoming from you.

Dr. DuBRIDGE. Exactly. As Dr. King said, environment is practically everything. It includes everything from automobile exhaust to DDT, to health problems, to effects upon our physical environment, of strip mining, for example, and of building highways that are inadequately conceived from the standpoint of preserving the beauty of the environment.

These are problems in chemistry, physics, mathematics, systems analysis, and all the rest.

Mr. MOSHER. And politics? [Laughter.]

Dr. DuBRIDGE. This is what brings it all together or tears it all apart, I suppose, and therefore, when people are interested in using the word "environment," they may attach these things which have little relation to each other. Even if you confine yourself to these problems as the IBP tries to do.

In the field of basic research on these problems, there is always, I think, undue fear of lack of coordination. Basically research people in universities have a way of coordinating their work by publishing their work, and no scientists are going to do the same work that has been done. When it comes to applied efforts one must look at duplication of efforts. It is important to find out what is happening in other organizations.

Mr. DADDARIO. Dr. DuBridge, I would like to add one further thought: The questions that have been raised here all point not just to how we manage our environmental and biological problems, but to all our programs. I would expect from what you have already said, the work of the IBP, if it continues developing and if properly supported, can go a long way.

You have already said that this is a program that will not be done in 1 or 2 years but will go on for 5 or 10. It represents a new undertaking that requires coordinated efforts from those of different disciplines. We see multidisciplinary activity growing in a multitude of places where people unaccustomed to working in this way are beginning to. We expect great progress will be made. As we go along, this will fit into the pattern of what we need to do. As this is done, you will be in a better position to make the recommendations and determinations to the administration and the Congress as to what needs to be done.

My question would then boil down to: Aren't we putting together the necessary elements through which we can come to better determination as to how to better manage our resources in this area than we have in the past?

Dr. DuBRIDGE. Yes. I think that is the whole purpose, first to lay a foundation of knowledge, second, to apply it by scientists in this country, and finally, to collaborate with scientists in other countries. This is the kind of a program that I must confess I do not have much experience in the operation of, and we have to feel our way in bringing people together and focusing their ideas on the specific problems.

So it is a beginning of what we hope will be a long continuing effort to really study the problems of the human being living on this particular earth, with many human beings being added every year, with each human being changing our living conditions and filling up the environment with more and more things.

Mr. DADDARIO. Thank you.

Dr. DuBRIDGE. The problem of support for IBP efforts as they become operational was a major point of a study performed by the National Science Foundation last fall. In substance, the conclusions pertinent to funding were that the Federal agencies should support those parts of the Program that are closely related to their missions, and that NSF should have funds available (1) to directly support IBP activities; and (2) to transfer to other agencies, where appropriate, to supplement their support for IBP projects.

In the latter case, the lead responsibility for a particular integrated research program or other IBP related project would rest with one of the mission agencies.

I agree that this is a desirable approach. It will permit multiagency involvement and still leave with NSF the overall responsibility for coordinating Federal support for IBP. The alternative is to provide completely centralized IBP funding. This solution would be more tidy and perhaps easier to coordinate but an important dimension of the program would be lost—that is, the involvement of mission agencies.

As you know, there has been criticism of the planning, organization and management arrangements made for the U.S. IBP effort. The questions that existed undoubtedly contributed to funding problems

in prior years. I believe that these earlier deficiencies have been overcome, but that continued efforts are necessary.

As additional program elements are developed, one cannot help but be impressed with the overwhelming amount of diverse information that will be collected and must be digested if useful conclusions are to be reached. Great care will continue to be needed in designing experiments and arranging for storage, manipulation, and most importantly, utilization of research data.

The resolution with which we are concerned today is designed to facilitate IBP support by Federal agencies other than NSF.

As you stated when you introduced the resolution, Mr. Chairman, it provides no new authorization or specific appropriation. You further commented that: "This provision appears to be necessary in view of the uncertainty of some of the departments and agencies concerning their present authority to aid the IBP through the Interagency Coordinating Committee for the IBP even though the amounts involved are relatively nominal."

To the extent that the agencies involved may feel they do not have congressional approval for supporting IBP activities—even though properly related to their missions and funding authority—the resolution should help. In this sense, passage of the resolution could remove a stumbling block to the development of the program. It clearly places IBP in a position to compete on an equal footing with other programs which the agencies consider worthy of support.

I am certain that no one envisions that the passage of this resolution will guarantee substantially increased funding for the IBP program. However, I feel that, as the details of additional worthwhile project elements are worked out, the chances are good that IBP will be able to compete successfully for Federal funds.

The administration is requesting \$5 million in the NSF budget for the IBP. I share this committee's hope that mission agencies will be able to participate in supporting the program. If the administration's fiscal year 1970 budget is adopted, I believe the Federal support for the IBP will be able to keep pace with the development of the technical and managerial aspects of the program.

Perhaps I can anticipate a question here to the effect that although the system appears satisfactory, many IBP supporters would like to know where and when additional funds will be provided for the program. They could well point to the difference between amounts currently committed and those considered desirable for maximum progress.

I did mention earlier that as specific program elements have been developed, IBP has held its own in competition for research funds. I am certain that scientists interested in other programs, could make convincing arguments for support of their concerns. So long as resources are limited, responsible individuals in both the executive and legislative branches must weigh allocations for competing programs. The modest level of IBP funding does not stem from lack of interest on anyone's part. On the contrary, I believe that endorsement is widespread. Sincere efforts are being made in both the executive and legislative branches to advance the program, and these efforts will continue. The Office of Science and Technology will continue to sup-

port the International Biological Program and maintain its interest in the program's sound development.

Thank you, very much.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. I don't think I have any questions, Mr. Chairman. I want to commend Dr. DuBridge for this positive statement of support for the program.

I think the question, as he puts it, revolves around some recent judgments as to priorities and allocation of very scarce resources at this point, and I think that he is well aware that in this committee, we feel that this is a program of very great promise in terms of organizing a field of knowledge that is obviously becoming of major importance to successfully continue human adaptation to a wide range of problems.

Mr. DADDARIO. Mr. Mosher.

Mr. MOSHER. I don't think I have any further questions. I certainly welcome Dr. DuBridge's positive support. Very helpful.

Mr. DADDARIO. Mr. Chairman?

Chairman MILLER. I would like to say that I appreciate Dr. DuBridge's interest. As you know, gentlemen, Dr. DuBridge is an alumnus of this committee. He has served well for many years, and we will never let him get away.

So thank you, Doctor.

Dr. DUBRIDGE. It has been a pleasure for me to meet with this committee among old friends.

Mr. DADDARIO. Dr. DuBridge, I have one question that pertains to the way in which you see the IBP developing.

You indicate, that the modest levels of support that presently exist are in keeping with both the planning levels and the manpower capabilities presently in existence; and that there is a competition for funds which come about because of restricted financing capabilities at this time. How do you see its international effect, in not only the scientific impact in other countries, but also in economic development. There creeps into testimony, from time to time, the need that organizations such as the World Bank have, for example, to go to these people, so they can get information on which to base their planning. They do not depend just on the economic situation, but on what the capabilities might be for the development of certain types of activity within developing countries, and where they could put their funds for better use.

How does that appear to you from an international point of view?

Dr. DUBRIDGE. Well, you are asking a physicist in a field of biology.

As I indicated, I think this is an experimental program. To explore what we know, to explore what we can find out, and to explore ways to improve the human condition. This, as I say, is an example of a new kind of venture in the scientific world in which problems of national and even global importance are emerging as problems that are now possible to attack.

A number of years ago, we were not in a position to say we would be able to attack these problems, we just didn't know enough. Now, knowledge has advanced to the point where attacks can be made, but knowledge is still inadequate to do everything that one would like to do. Incentive to attack this on a global basis has enormously increased

over the years, as we have become aware of the enormous environmental problems that face us because of our increased population, and the environmental problems around the world. We have come to the point where we can put together the basic knowledge and the objectives for applied science in a general attack. But we are just at the beginning of this, and it seems to me, we will require a number of years of experience as we try to bring in various international groups, private and public, and work together. They will find the ways to attack new problems. They will discover the things that are possible now to do, and other things that take further research.

I think it might be a mistake to too rigidly lay out things for the future, because, I think, it should develop as ideas accumulate and as we become more aware of which are the most urgent of problems to undertake.

We have to try to solve those problems where the knowledge and ability are there to enable us to make progress. Therefore, I see this as a developing program that will present to the Congress next year new programs and international relationships which we can't see very clearly now.

Mr. DADDARIO. Dr. DuBridge, I have been interested in a statement Dr. Blair has made, not only in his testimony yesterday, but in the past. He sees—in Latin America—people going there to work rather than bringing their scientists here. Therefore IBP has the opportunity of being very helpful in raising the scientific basis and the possibility of developing greater political stability in those countries as a result of this activity.

This appears to me to be an extremely important premise and one, which has great validity.

Dr. DuBRIDGE. Well, I certainly endorse that statement, and your statement on it. I think international scientific collaboration is a worldwide stabilizing influence of great potentiality. President Nixon has said this on a number of occasions, that our worldwide collaboration on scientific and engineering problems is something that the United States ought to be keenly interested in, because of its value to us, its value to improving our relationships with other nations, and its value of solving problems of international scope and concern. Therefore we should contact other nations and work together. It is a matter of trying to examine the problem that others face, and adapting the technology to fit.

I think a good many people thought that if other countries used only our kind of corn and our kind of wheat that they could improve their agriculture, and this turned out to be false. Our strains of various crops simply do not grow well in other countries, do not have the pest resisters, and do not adapt to the climate, and often agricultural techniques had to be adapted to other countries.

The United States was very helpful in Mexico and the Philippines in developing agriculture appropriate to the climates and habits of those other countries.

This kind of mutual understanding of problems is very essential and also very productive, but it requires an incentive on our part to go and apply what we know in these other countries and we will learn a great deal in return.

Mr. DADDARIO. Mr. Yeager.

Mr. YEAGER. Yesterday, I believe, Dr. Blair stated that there was no plan to extend the IBP beyond its expiration date in 1972, after that what happens internationally may depend upon, in part, on a United Nations program scheduled for about that time. Are you cognizant about what is going on in the executive branch about participating in that U.N. Conference when it comes, or can we be apprised of planning as it develops?

Dr. DuBRIDGE. Yes; there has been talk about this Conference, but what the planning has been—Dr. King can add to that.

Dr. KING. The Federal Council for Science and Technology's Committee on Environmental Quality has a subcommittee, chaired by a representative from the State Department, involved in preparations for the U.N. Conference on Problems of the Human Environment. The same subcommittee is also involved with the followup on the Biosphere Conference of UNESCO, which also provides for continuation of IBP-like activities.

Mr. DADDARIO. The chairman calls my attention, Dr. DuBridge, about some recognition that you got from Wesleyan University, which is my school, back in 1946. This is the third of the whole series of degrees which you have on an honorary basis. I am happy that Wesleyan saw talent. We certainly appreciate your testimony, and as we always have, we have learned a great deal from you, Dr. DuBridge. We appreciate your being here.

Dr. DuBRIDGE. Thank you very much.

Mr. DADDARIO. Our next witness, as I have previously said, is Dr. N. E. Gibbons, vice chairman of the Canadian IBP.

We are pleased, Dr. Gibbons, that you are here. We have this distinguished group of Senators here today who are certainly as anxious to hear about your program as we. If in the course of this they care to ask a question they may do that.

Chairman MILLER. I might extend that same privilege to the distinguished Senator sitting in the second row.

Senator, I think you should know, under our rules the chairman of the committee and the ranking minority member of the committee are ex officio members of all other subcommittees. So when I am here he wears the big hat and I wear the little hat.

Mr. DADDARIO. That is what he says.

STATEMENT OF DR. N. E. GIBBONS, VICE CHAIRMAN, CANADIAN COMMITTEE, INTERNATIONAL BIOLOGICAL PROGRAMME

Dr. GIBBONS. Thank you, Mr. Chairman. Honorable Senators:

We are very pleased to be here to tell you something about the Canadian program. I think you will find it somewhat different, or our approach as being different in the United States. As far as the centers are concerned, I think the IBP was mentioned in a very small part in the national research report to that committee, and I do not think they have heard it yet in detail.

As I am employed by a government agency I must say that I am appearing here only as a member of the Canadian Committee for the International Biological Programme—CCIBP—and not as a representative of the Government of Canada.

I shall present a brief summary of IBP activities in Canada and will be glad to enlarge on any items of interest should you wish.

The early indications were that IBP would be mainly concerned with human welfare and a committee set up by the National Research Council—NRC—in 1963 was weighted toward human physiology. When the broader-based program for the IBP was outlined at the first general assembly in 1964, the original committee was disbanded and a new one constituted. The CCIBP consists of senior officials from the Federal Government Departments concerned, NRC councilors and representatives of a number of universities. This committee is the policymaking committee and subcommittees on the working level were set up for each of the seven sections proposed by IBP. Our program is along official IBP lines and we have adhered to the sections suggested.

The decision was made very early that we would support a limited number of projects in depth rather than dissipate funds and manpower in a number of small, unrelated projects. In this way, one or two new projects in each section would be possible.

A program along these lines was outlined by the subcommittees, approved by the CCIBP, a 5-year projection of costs provided and discussed with Treasury Board officials. It was decided each Federal Department concerned would finance its own contribution to IBP. NRC would provide the national office, assume the responsibility for planning and coordination through its CCIBP and for the financing of university participation.

NRC has for many years been supporting research in universities and last year, 1968–69, grants were made totaling \$36 million in science and engineering; of this \$8.5 million was for biology in general.

These grants are made to individuals for projects of their choice. For IBP grants, however, the subcommittees recommend the projects and CCIBP approves them. Many of them are large, multidisciplinary undertakings so a memorandum of agreement is signed with each project director which indicates that the funds are to be used for the approved IBP study, how the funds are to be allocated between capital and operating expenditures, that the work is to provide data for IBP and that regular reports are required. On this basis, the CCIBP made grants to projects totaling about \$300,000 in 1967–68 and \$880,000, in 1968–69. Our budget for projects this year is \$1,030,000 and we hope it will continue at about this level for the next 2 years, tapering off thereafter as IBP officially ends and projects are phased out. Discussions are now underway about the continuation of some projects and the conservation aspects. The figures given are the NRC input by university programs only. There is also a substantial input by participating universities, Government laboratories, and other agencies of about double these annual amounts, making a total of approximately \$2 million, in 1968–69.

Mr. DADDARIO. Dr. Gibbons, these funds that go into the IBP, are they separate and apart; if we take the 1968–69 figures you give us, are they separate and apart from the 8½ million from biology, or will they be included in that figure?

Dr. GIBBONS. They will be included in that figure. It comes from the National Research Council. It is a separate vote for university support.

Mr. DADDARIO. The only difference, then, is the way that these programs are handled. You develop different guidelines so far as the program director is concerned so that this work can be channeled to the work laid out by the IBP program.

Dr. GIBBONS. That is true. In the usual grant the money is given to a professor for a program of his own making; he conducts it as he sees fit. We require the program to be carried out along IBP lines and we demand reports so we know what is going on and can direct it along these lines.

Mr. DADDARIO. But it follows along the same program so you can get money into research.

Dr. GIBBONS. Yes; but ours is through the IBP committee of grants on research.

Mr. DADDARIO. The leveling off over the years, how do you see that at this stage of the game? Do you think it is proper that we would reach the time when these programs would phase out, or do you see the work that is being done given enough impetus, so it would develop working arrangements between the United States and Canada, or interhemisphere work which would provide funds for added work in this area?

Dr. GIBBONS. Some of them will undoubtedly phase out with the end of IBP. Some will carry on. Our Matador project, I am certain, will carry through as there was considerable enthusiasm about the Grasslands project. We have a midpoint review which will decide just what will happen to the project, whether it will carry on, or be phased out. If it is going to be carried on, funding would have to be considered.

Mr. MOSHER. I notice in Dr. Gibbons' statement, that each department would finance its own contribution to IBP. How has that worked out in actual practice? Have the departments gone ahead and financed their own participation?

Frankly, the testimony we've heard indicates that in our own case, although the National Science Foundation has gone ahead, we have been a little bit concerned about some of the other departments, whether they would really take up the ball and run with it. What are your departments doing?

Dr. GIBBONS. Well, they are not taking up the ball and running with it, Mr. Mosher. Some of them have. This comes out in the next part of the prepared draft—

Mr. MOSHER. I realize I may be anticipating some of your comments.

Dr. GIBBONS. Yes. There has been excellent cooperation with some departments, not as much with others.

Mr. MOSHER. It is spotty.

Dr. GIBBONS. Yes, it is spotty.

Mr. MOSHER. Now, one other question: You are about to tell us about some of these specific projects, I judge.

Dr. GIBBONS. If you wish.

Mr. MOSHER. Is there a mechanism for coordinating those Canadian projects with the work that is done in our country, and in other participating countries, so you aren't duplicating? It is an effective mechanism, is it?

Dr. GIBBONS. In the cases where there is effective cooperation, yes. In some, of course, these are quite specific studies. A fresh water lake, for example, is studied as a unit, but can be compared with other lakes, if the methodology is comparable. This is another thing that I should mention, that we insist that at least minimal IBP standards of methodology be followed in these programs.

Mr. MOSHER. And you check to see that some person in the United States is not doing something unnecessarily in duplication?

Dr. GIBBONS. I think duplication will be hard to find, because environment changes so much. The idea was that it would be on a parallel basis, that we are doing polar studies, you are doing temperate studies, others tropical studies, and so on.

Mr. DADDARIO. Proceed, Dr. Gibbons.

Dr. GIBBONS. Now, a brief summary of our projects by sections:

In PT we have one major project which is a combined PT/PP undertaking. The Grasslands Ecosystem at Matador, Saskatchewan under Professor R. T. Coupland's direction has become one of the most comprehensive terrestrial ecosystem studies in the world and has attracted a great deal of interest. Matador has recently been designed as an International Centre for IBP Grasslands studies for information and data storage by the IBP/PT Section. Close working relations are maintained between the U.S. Pawnee grassland project and Matador.

This project has taken about one-third of CCIBP's funds as a large capital expenditure for the field station was necessary. At present some 25 scientists and 50 others are involved in studies on energy flow in primary producers, consumers and decomposers involving soil microbiology, soil fauna, plant production above and below the surface, insect, bird and small mammal populations, soil physics, water cycling, photosynthesis, nitrogen fixation, and meteorology.

There are three fresh water projects—PF: Productivity and energy flow in Marion Lake, Char Lake, and Eutrophication of Lakes. Canada had been asked to include an Arctic lake but at the beginning there seemed little interest and Marion Lake was started, under Prof. Ian Efford's direction, as a training programme. However, it is now a full-fledged study on productivity. Soon after it was established Prof. F. H. Rigler of the University of Toronto indicated an interest in Arctic studies and, after a survey during the summer of 1967. Char Lake, near Resolute, was chosen. Preliminary studies got underway last year and year-around studies will start this year. The third project is being undertaken by the Fisheries Research Board (FRB) at its Winnipeg Laboratory. It is under the direction of Dr. J. R. Vallentyne.

Mr. MOSHER. Could I interrupt at that point? I happen to live on the shores of Lake Erie, in Ohio. I notice your project having to do with the eutrophication of lakes.

Is there potential findings there that will be helpful to Lake Erie?

Dr. GIBBONS. I don't know if this is being done on Lake Erie at this time. The effects of adding pollutants to small lakes and then studying their recovery is being undertaken. There are also studies at the Great Lakes Institute.

On the marine side, there are four projects, three of which are manned and financed by FRB. One of these on the Strait of Georgia

was started well before IBP began. It was accepted as it was definitely along IBP lines. Other studies include a study of productivity in St. Margaret's Bay, Nova Scotia, and one dealing mainly with secondary production in Frobisher Bay, Baffin Island.

A CCIBP-funded study on the Gulf of St. Lawrence starts this summer. This was given serious thought for some time as it is such a large body of water that a study in the depth we would like for IBP projects is not possible with the men and money available. However, some studies on seasonal cycling will get underway with the cooperation of three universities, the Government of Quebec Department of Industry and Commerce and FRB. An Oceanographic Identification Centre has been established by the National Museum of Natural Sciences at Ottawa to handle the samples.

In addition to the PP studies at Matador, there are several supporting programs: One, dealing with photosynthesis-productivity measurements in young trees in a controlled environment was started to provide background for a forest project. The main project has fallen by the wayside but the tree photosynthesis project has provided useful data, as have studies on nitrogen-fixing and other soil micro-organisms in the proposed forest site.

This is an example where one department started off with some enthusiasm, but the enthusiasm faded away.

Early in the program, also, the shortage of agrometeorologists was apparent, and a training program was started at the University of Guelph. A research program on photosynthesis, transpiration and respiration of corn and other field crops, using both ecophysiological and meteorological approaches complements this training program.

HA: The CCIBP supports one HA project—the study of Eskimos at Igloolik, which is the Canadian contribution to the international study in cooperation with the United States, Denmark and France. Dr. D. R. Hughes of the University of Toronto directs the Igloolik project and Dr. Milan of the University of Wisconsin is the International Coordinator. Considerable progress was made last summer and winter, and the scope will be expanded this year. There has been close cooperation on the methods used at the three sites as well as an exchange of workers and more is expected. Dr. Mayhall has made dental examinations at Wainwright and will now examine the Igloolik Eskimos. Dr. Hughes will be making anthropometric and anthroposcopic measurements, and Dr. MacArthur, psychological studies at both Igloolik and Upernavik.

Two other projects have been completed: one on methodology standardization and one on fitness of athletes. Three others are underway: Comparative studies in small isolated French communities in Canada, the Antilles and Cambodia; dental, caranio and maxillo-development of French-Canadian children; and fitness and growth of Saskatchewan children. All of these were underway when IBP started and are independently financed.

Our UM program has been slow getting underway. Two projects are now being considered—some aspects of biological control of pests and a study of plant gene resources and their conservation.

Our conservation program—CT—is very active. Ten regional panels are concerned with the check listing of presently conserved areas and the preservation of typical and unique ecological areas. Ex-

cellent cooperation is being given by Federal and Provincial authorities and already several new areas have been designated as ecological reserves.

In summarizing, there are now 19 projects in operation plus the conservation program coordinated by CCIBP. These involve about 150 participants and an expenditure of about \$2 million per year. Of this, about \$1 million a year is for new projects by universities, carried out at the request of CCIBP upon the advice and under the supervision of its seven scientific subcommittees, and funded by the Canadian committee.

To date, some 20 papers have been listed as Canadian IBP contributions, mostly from projects that were already underway when they received IBP recognition.

I will be glad to answer any questions.

Mr. DADDARIO. Dr. Gibbons, do you see, as this work progresses, that this undertaking has put a requirement on scientists to coordinate their efforts as Dr. DuBridge has said from different disciplines where they have been accustomed to individual research activity? Have you seen the same kind of progress in these areas?

Dr. GIBBONS. This has been very noticeable at Matador where people were used to working on their own in their own particular field. But under the leadership of Dr. Coupland they have certainly gotten together, and are working together. This did take some doing, and I think it took a dedicated and a good director. It can be done.

The same thing is shaping up at the Marion Lake project, and most of the studies of fresh water are coordinated. And I think the polar project is another good example where you have a great many types of people and disciplines all working together very closely and well.

Mr. DADDARIO. Do you see this as positive? By supporting projects which forces the disciplines to work together, we can see a better way to handle some of the environmental problems.

Dr. GIBBONS. I think so. Because this is what ecology is all about. I am not an ecologist, but I am learning a lot since I became involved in IBP, and I think this has been the problem in the past, that too many people had been working alone, and not thinking about the environment as a whole—even a small ecosystem, as a whole—and this is what they are doing now. This may not be the best way of working now, but it certainly is a start. We are getting people trained to look at this, and using not only a concerted effort on a small system, but also applying systems analysis to this sort of thing to help solve these problems.

Mr. DADDARIO. Whether these are the best systems to work in is not necessarily as important to the idea that through development of these programs we will learn the techniques and methodologies that will direct us to the use of many disciplines toward the problems which deserve this attention. We could not properly get a grip on these unless we had done this work.

Dr. GIBBONS. As far as we are concerned, I think this is very much the case. We would like to get a team up on the tundra, and we feel that the training given on the grasslands project will be most valuable for a total ecosystem approach.

Mr. DADDARIO. Mr. Chairman.

Chairman MILLER. I want to thank Dr. Gibbons for a very fine statement. I think he has given us a lot to think about in this field under which we are all doing a little pioneering.

Thank you very much.

Dr. GIBBONS. Thank you.

Mr. DADDARIO. Mr. Mosher?

Mr. MOSHER. I don't have any further questions, Mr. Chairman, but I would like to express my personal delight about this whole situation. I think this a breakthrough that ought to be repeated. We have a lot to learn from each other across this mutual border of ours, and particularly in the scientific area. I think we should continue what has been started here, to continue this relationship, this exchange.

Mr. DADDARIO. Mr. Brown?

Mr. BROWN. Dr. Gibbons, I think it is very difficult to compare levels of effort between our two countries in this program. But it seems to me you are indicating, or you have indicated about a \$2 million level of effort of this IBP. I wonder if it would be fair to say that that represents at least the same level of effort as our program in this country, which is a little difficult to attach a dollar volume to, but which seems to be adding all the different components at a \$10 to \$15 million level. Considering the size of your budget, it seems to come out favorably for Canada. Would that be your reaction to it?

Dr. GIBBONS. I don't think I should say. I don't do very much with GNP's and so on, but I think from what I have heard, that ours will be a little less than your effort.

Mr. BROWN. Well, as I said, it is a little difficult to draw a direct comparison, but it certainly seems to me that it is not drastically out of line with the effort in this country.

Mr. MOSHER. Will the gentleman yield?

Mr. BROWN. Certainly.

Mr. MOSHER. I notice that the chairman of the Canadian committee is shaking his head. He is a distinguished economist and I suggest he may want to say something on that question.

Senator LAMONTAGNE. If we compare this program with our total scientific effort, I think we do more proportionately in Canada on the basis of these figures. I understand your budget for research and development in the United States is about \$25 billion for all the United States, including the private sector. Our figure is about \$800 million now, so if you compare the two I think that we proportionately devote more money within our own science and research effort than you do.

Mr. BROWN. I think this is probably true, but I doubt if that considers the very heavy component of military-funded research, which is the major element in our program here.

I had another question about human adaptability. I was interested in your study of small isolated communities in Canada. This has nothing to do with French Canada's separatist movement in any way?

Dr. GIBBONS. I don't think so, seeing that it goes on to the Antilles and Cambodia as well. The interest is in small isolated groups that have grown up, such as on the small islands in the Caribbean, and which have been isolated for many years.

Mr. BROWN. Well, I was being facetious. Actually, I am very interested in this type of study for a number of reasons. I am wondering how broad your studies are.

For example, do they involve any analysis of the sociology and the other problems of these communities, and the prevalence of such social phenomenon, as crime, and war, in less isolated or more developed economic community?

Dr. GIBBONS. I am not sure of this one. We have had it studied by our subcommittee, but I have not seen it discussed at our (CCIBP) level. The dental program in Montreal certainly takes in the various economic sections and does a study of this as well as their dental and developmental studies. I think they have carried this side quite far.

Mr. BROWN. I had seen a study at Harvard Medical School on the factors in small isolated communities. I recognize that these are not completed as yet. You state that they are underway, but I would be rather interested in the opportunity to review the kinds of results that develop from these sometime in the future.

Dr. GIBBONS. I am sure we will be glad to pass them along.

Mr. BROWN. Thank you.

Mr. DADDARIO. The committee is happy to have here this morning the senior member on the Republican side, Mr. Fulton. Happy to have you back, and do you have any comment here?

Mr. FULTON. I have just gotten in from a rather isolated grouping from Tel Aviv, Israel, last night.

My comment is that you have the same disease that your American counterparts in government have. That disease is use of the alphabet system in designating governmental agencies and committees so you get all sorts of things like CCIBP, which sounds like indigestion. [Laughter.]

Dr. GIBBONS. This is an international disease.

Mr. FULTON. I hope you didn't catch it from us.

I am pleased that two committees have now made contact, and we will know of the work of each in the scientific field, both in Canada and the United States. I compliment the chairman and the subcommittee in its work in this regard. I believe the projects of the Gulf of St. Lawrence and Lake Erie, as I come from Pennsylvania, are very worthwhile, and the learning of methodology of how we control man's invasion of these areas is a very important point that we should emphasize.

I am sorry that you are going to be reducing Project Matador in favor of some other things that I might not put as first priority.

Dr. GIBBONS. I think you have misunderstood. We may not. We will be studying this very shortly to see if it will carry on at a certain level. The area will certainly be conserved as a virgin area, and we definitely want to preserve it as an ecosystem.

Mr. FULTON. I wonder about the practical use of a project such as the fitness of athletes. Why would that be performed as a biological program? I would imagine that athletes are generally fit, and there might be some difference in some slight degree as between the best and the better, but I don't see what that approach is.

Dr. GIBBONS. This was done at the Pan American games which were held in Winnipeg a couple of years ago, and the opportunity was taken to study these athletes to see if they were better than the general population. I think more will be coming out of the study of the Saskatchewan children where their abilities—

Mr. FULTON. What is the practical use of that?

Dr. GIBBONS. This is a practical use that many of these youngsters are put in a hockey game for 8-year-olds where they should be in a sixth-year hockey game, and this may be damaging.

Mr. DADDARIO. Considering your winning the Stanley Cup, it may have.

Mr. FULTON. I do feel that these programs must be made in concert, and likewise to complement and supplement each other so that we don't have an overlapping. But I likewise feel that we should look at our research as we are doing on this subcommittee in the United States, that it is amounting to something so we are not just laying up a set of figures which future historians might find interesting but of no real value.

Dr. GIBBONS. Well, I suggest that you should maybe talk to our National Health and Welfare Department.

Senator CAMERON. Mr. Chairman, it may be part of our chagrin of our hockey teams against the Russians.

Mr. DADDARIO. You have only sent your amateur teams to Russia.

Mr. FULTON. Maybe the Russians have gotten along without a survey.

Mr. DADDARIO. Well, I imagine you could make a very good case for studying any group susceptible to disease. I am sure Mr. Fulton is raising no objection.

Mr. FULTON. If I could make a serious point, it is that there should be a practical use, and if one is simply laying up statistics, perhaps it should be resurveyed on a priority basis.

Mr. MOSHER. Jim, you certainly recognize the axiomatic truth, that information that is discovered in basic science which may not seem to have any practical use now can well have tremendous practical use 10 years, 20 years, 30 years from now.

Mr. FULTON. Yes. But I want to stick with my point. We should look at all programs. I would want them to serve a generic and practical purpose.

Chairman MILLER. Jim, since research gives us facts, and we put them in the bank of knowledge, can you always tell that when these studies are made when they are going to be valuable or when you are going to call on them. You know the old story I tell about the elimination of the screw-worm in this country. I am certain that if anyone were to tell people 30 years ago that a couple of idiotic biologists isolated the scent by which the female screw-worm attracted the male, somebody would say that is not generic and we don't need it.

Mr. FULTON. I am for these biological programs—

Chairman MILLER. Well, the people who did this didn't know whether the data they were accumulating were going to be used.

Mr. FULTON. Of course. We might have you Canadians do a study on the chairman, because he always has an inner motor still going when the rest of us fall by the wayside.

That is all, Mr. Chairman.

Mr. DADDARIO. I can recall, over the course of the years, several studies which some friends of mine have done as they have worked for their doctorates—isolated groups of people—making evaluations about stresses and strains that have led to some very strong careers in medicine and in other fields. I wouldn't offhand subgrade this particular project. But at any rate, we are not here to discuss each project by

itself but, rather, to take an overall look at what has been done. Before closing, I wonder if anyone of the committee from Canada has something to say?

Senator LAMOMTAGNE. I have a question.

Senator PHILLIPS. Mr. Chairman, I was particularly interested in the reference to the study on the dental, cranio, and maxillo development of French-Canadian children.

I think probably the longest and most comprehensive study is being carried on by the University of Toronto, in one of the suburbs. They have followed the children from about 3 until the oldest child would be about 20. In September this program was removed from the list of those receiving assistance from the Department of National Health and Welfare and they came to the United States and received financial assistance to continue it.

I think it was from the Kellogg foundation that supports dental research.

I was wondering why this project was removed.

Then you refer to and emphasize a much shorter and incomplete study on the development of French-Canadian children.

Dr. GIBBONS. This is also independently financed—I believe the Rockefeller Foundation has financed it for a number of years. It has been added to the IBP Program because it is in line with the human adaptation and the experimenter wanted to be able to make international comparisons.

Senator LAMOMTAGNE. Is the cost of this study included in your total amount?

Dr. GIBBONS. Yes. In the total amount of \$2 million.

Senator LAMOMTAGNE. We should add this to the American contribution, then.

Mr. DADDARIO. Any further observations?

Senator GROSART?

Senator GROSART. One observation, if I may, arising out of the statement Dr. Gibbons has made about this physical fitness study, one thing that occurs to me is that physical fitness is one of the most important things in the field of ecology, but the question is whether this arises out of the guidelines in the seven sectors that has been set down by the organizations, because we have a statement here that the Canadian programs are along the IBP lines, and we have adhered to the sections projected.

Does this come under the broad heading—

Dr. GIBBONS. I believe this comes under the heading of ecology. As you know, we have been criticized as being very unfit as a whole Nation. I can't say if this applies south of the border, but yes, I think this is part of the—

Senator GROSART. In other words—

Dr. GIBBONS (continuing). It is somewhat similar to what is being done in South America on adaptation to the stress of high altitudes.

Senator GROSART. In other words, it makes sense to study human beings as well as their environment.

Dr. GIBBONS. This is always part of a study of human environment—

Senator GROSART. So if you studied Chairman Miller you would find out why all the rest of us in Canada are unfit, as you say.

Mr. FULTON. Mr. Chairman, why don't you mention Lake Erie in your statement and what we should do about that large body of water.

Mr. MOSHER. I raised the question as to whether their proposed study on eutrophication in fresh water lakes applies, would have some value to Lake Erie. The answer was "Yes."

Mr. FULTON. That shows the importance of Lake Erie in their biological study.

Mr. MOSHER. The gentleman referred earlier to two or three other activities they have, concerned with Lake Erie, but not with this IBP program. Is that right?

Dr. GIBBONS. We are studying ecosystems as close to the baseline as you can get, and Lake Erie is far from that.

Mr. FULTON. Why wasn't Lake Erie mentioned in your statement?

Dr. GIBBONS. We are doing work with other lakes; Lake Erie isn't one of them.

Chairman MILLER. Well, why don't we start attacking the root of the trouble rather than talk about the things that have taken place? If we had proper sewage that emptied into Lake Erie, you wouldn't have the problems right now. Is that right?

Mr. DADDARIO. Dr. Gibbons is making a study as to how we got where we are. These studies can help us in managing the problems that do come about in Lake Erie and many other lakes. At least, that is the way I understand the program.

Dr. Gibbons, we appreciate your testimony, your contribution, and I would just like to, before closing, address to that statement my good friend, Mr. Mosher, has made about how satisfied he is about this meeting and the idea that it does give him hope that it will lead to other activity in the future through which we can, on a more solid basis, develop more parliamentary activity. And I would certainly add my hope that that might be done.

This has been an extremely interesting morning from our point of view because there has been added this flavor of international cooperation. It is added to by the fact that our countries, with a contiguous necessity of working together in many problems affecting us in the same way. It is certainly a very helpful sign that you, Mr. Chairman, and the members of your committee, have come here, and we are looking forward to the opportunity tomorrow when we will be sitting down together, at which time I would hope that Mr. Fulton will be present, as he has been invited to be, and we will all have a chance to ask each other all kinds of questions at that time. I am looking forward to that particular session because I think it will be extremely helpful to us all.

If there are no further comments, this committee will adjourn to the call of the Chair.

(Whereupon, at 11:45 a.m., the committee adjourned, to reconvene at the call of the Chair.)

APPENDIX A

BIOGRAPHIES OF WITNESSES

DR. WILLIAM FRANKLIN BLAIR

Chairman, U.S. National Committee for the IBP; Professor, Dept. of Zoology, University of Texas, Austin 12, Tex. Zoology, Ecology. Dayton, Tex., June 25, 12; m. 33. B.S. Tulsa, 34; M.S., Florida, 35; Ph.D. (zool.), Michigan, 38. Asst., mammal div, mus. zool, Michigan, 35-37, res. assoc, lab. vert. biol, 37-46; assist. prof. zool Texas, 46-47, assoc. prof, 47-54, prof, 55-, res. scientist genetics found, 51-54, dir. res. vert. speciation, 53- U.S.A.A.F, 43-46. AAAS; Soc. Nat; Soc. Mammal; Soc. Ichthyol. & Herpet. (v.pres, 56); Genetics Soc; Ecol. Soc. (v.pres, 56, pres, 63); Soc. Study Evolution (treas, 55-57, v.pres, 58, 62); Soc. Syst. Zool. Population genetics; ecology and speciation of mammals, reptiles and amphibians; mating call as an isolation mechanism in anurans; population dynamics of terrestrial vertebrates; biogeography of North America.

DR. HARVE J. CARLSON

Specialty: Bacteriology, Virology.

Field of Specialty: ultraviolet irradiation; airborne organisms; oligodynamics of metals; effects on bacteria and viruses; effect of chemical agents of poliomyelitis virus; research administration.

Born: June 10, 1911—Jerome, Idaho.

Married: 1937.

Children: 3.

B.S., University of Washington, Seattle, Washington—1934, Fellow 1934-36; California, 1937; M.S.P.H., Michigan, 1940, D.P.H., 1943. Laboratory technician Idaho, State Department of Health, 1936-39; assistant bacteriologist, 1939-40; University of Michigan, 1940-41, research associate, 1941-42, instructor bacteriologist, 1942-43, assistant professor pediatric research, Western Reserve, 1946-51; biologist, Office of Naval Research, California, 1951-56, science liaison officer, England, 1956-58, Head Microbiologist, Branch 1958-59, U.S.N. 1944-46; Program Director, Facilities and Special Programs, National Science Foundation, 1959-60; Deputy Assistant Director for Biological and Medical Sciences, National Science Foundation, 1960-61; Division Director of Biological and Medical Sciences, National Science Foundation, 1961-present.

Societies: Society of Bacteriology; Science of Experimental Biology and Medicine; American Society of Microbiology; Academy of Microbiology.

DR. LEE A. DUBRIDGE

Born in Terre Haute, Indiana.

Married Doris May Koht, September 1, 1925. Children: Barbara Lee (Mrs. David MacLeod), born in 1931, living in Canoga Park, California; Richard Alvin, born in 1933, living in San Jose, California; three grandsons; one granddaughter.

Education: Cornell College, Mount Vernon, Iowa, A.B., 1922; University of Wisconsin, Madison, (major field: physics) A.M., 1924; Ph.D., 1926; *Honorary Degrees*: Cornell College, Mount Vernon, Iowa Sc.D., 1940; Polytechnic Institute of Brooklyn, New York Sc.D., 1946; Wesleyan University, Middletown, Connecticut Sc.D., 1946; University of British Columbia, Vancouver, B.C. Sc.D., 1947; Washington University, St. Louis, Missouri Sc.D., 1948; University of California, Los Angeles LL.D., 1948; Occidental College, Los Angeles, California Sc.D., 1952; University of Rochester, New York LL.D., 1953; University of Maryland, College

Park Sc.D., 1955; Columbia University, New York City Sc.D., 1957; Indiana University, Bloomington Sc.D., 1957; University of Southern California, Los Angeles LL.D., 1957; University of Wisconsin, Madison Sc.D., 1957; University of Redlands, Redlands, California L.H.D., 1958; Northwestern University, Evanston, Illinois LL.D., 1958; University of Judaism, Los Angeles, California L.H.D., 1958; Union College, Schenectady, New York D.C.L., 1961; Pennsylvania Military College, Chester Sc.D., 1962; DePaul University, Greencastle, Indiana Sc.D., 1962; Loyola University of Los Angeles, California LL.D., 1963; Pomona College, Claremont, California Sc.D., 1965; The Rockefeller University, New York City D.Sc., 1965; Carnegie Institute of Technology, Pittsburgh, Pa. Sc.D., 1965; University of Notre Dame, Indiana LL.D., 1967; Illinois Institute of Technology, Chicago LL.D., 1968.

Career Summary: 1925-26—Instructor of Physics, University of Wisconsin, Madison; 1926-28—Fellow of the National Research Council at the California Institute of Technology, Pasadena; 1928-33—Assistant Professor of Physics; 1933-34—Associate Professor of Physics, Washington University, St. Louis, Missouri; 1934-46—Professor of Physics and Chairman of the Department; 1938-42—Dean of the Faculty of Arts and Science, University of Rochester, New York; 1940-45—On leave of absence from the University of Rochester for war service as Director of the Radiation Laboratory (radar research) at Massachusetts Institute of Technology, under the U.S. Office of Scientific Research and Development; 1946-1968—President, California Institute of Technology, Pasadena; 1969—Director, Office of Science and Technology, Scientific Advisor to President.

Professional Societies: American Physical Society (Vice President, 1946; President, 1947); American Philosophical Society; National Academy of Sciences; and Royal Society of Arts, London, England.

Honor Societies: Phi Beta Kappa, Sigma Xi, Eta Kappa Nu.

Awards: King's Medal for Service in the Cause of Freedom, (British) 1946; United States Medal for Merit, 1948; Arthur Noble Award (City of Pasadena), 1961; Honorary Fellowship and Gold Medal, American College of Cardiology, 1966.

Publications. (Books): *Photoelectric Phenomena* (with A. L. Hughes). New York: McGraw-Hill Book Company, 1932; *New Theories of the Photoelectric Effect*. Paris: Hermann and Company, 1935; *Introduction to Space*. New York: Columbia University Press, 1960.

Numerous articles in various scientific and other journals.

Additional Professional and Civic Activities: Scientific Advisory Board, United States Air Force 1945-49; Naval Research Advisory Committee, United States Navy, 1945-51; Science Advisory Panel, United States Army, 1946-48; General Advisory Committee, Atomic Energy Commission, 1946-52; Board of Trustees, Rand Corporation, Santa Monica, California, 1948-61; National Science Board, 1950-54; 1958-64 (Vice-Chairman, 1962-64); President's Science Advisory Committee, 1951-56 (Chairman, 1952-56; Consultant, 1956-62); Board of Trustees, Carnegie Endowment for International Peace, 1951-57; Board of Directors, Los Angeles World Affairs Council, 1955-; Board of Trustees, Mellon Institute, Pittsburgh, Pennsylvania, 1958-67; Board of Trustees, Rockefeller Foundation, New York, 1956-67; Board of Directors, Los Angeles Chamber of Commerce, 1959-61; Board of Governors, Los Angeles Town Hall, 1959-63; Honorary Board, 1965; Panel on Science and Technology of the Committee on Science and Astronautics, United States House of Representatives, 1960-68; Board of Trustees, Thomas Alva Edison Foundation, Inc., 1960-68; Board of Directors, Community Television of Southern California, Los Angeles, 1962-68, (Chairman, 1962-68); Board of Trustees, Henry E. Huntington Library and Art Gallery, San Marino, California, 1962-68; Board of Directors, National Merit Scholarship Corporation, 1963-68; Science and Technology Advisory Committee for Manned Space Flight, National Aeronautics and Space Administration, 1964-68; Board of Directors, National Education Television, New York, 1964-68; Carnegie Commission on Education Television, 1965-67; *Greater Los Angeles Urban Coalition*, 1968- (Chairman, 1968-); *Club Memberships:* Bohemian, San Francisco; California. Los Angeles; University, New York.

DR. NORMAN EDWIN GIBBONS

Head of the microbiology section and assistant director of the division of biosciences of the National Research Council of Canada was born April 8, 1906 at Niagara Falls, Ontario.

Dr. Gibbons received his BA (Hon) from Queen's University in 1927 his MA from Queen's in 1928 and his PhD from Yale University in 1932.

Career History: 1927-28 demonstrator bacteriology Queen's University; 1927-31 (summer) biological board of Canada; 1931-36 Scientific asst fisheries experimental station Halifax; 1936-37 asst bacteriologist fisheries experimental station; 1937-41 assistant research biologist NRC; 1941-45 assoc res biologist NRC; 1946- assoc res biologist II NRC; 1946-49 research biologist NRC; 1949-57 senior res officer NRC; 1957- principal research officer; 1959- assistant director biosciences; 1968-assistant director div of biology.

Honours: NRC Bursary under Dr. G. B. Reed 1928-29; Arts Travelling Fellowship from Queen's University 1929-30; University scholarship Yale 1929-30, 30-31, 31-32; Elected to Sigma XI 1932; Member Order of the British Empire Civil July 1946; Centennial Medal on recommendation of the Canadian Society of Microbiologists; Honorary Member Can Soc Microbiology June 1968.

Societies: Canadian Society of Microbiologists; Secretary-treasurer 1951-55; Vice-president 1958-59; President 1959-60. Royal Society of Canada Fellow 1955; Honorary treasurer 1956-59. American Society of Microbiology; Society of Applied Bacteriology; Society for General Microbiology; Canadian Institute of Food Technology; 1962-66 Secretary-General International Association of Microbiological Societies 1966; Secretary-General and Treasurer International Association of Microbiological Societies; presently chairman Canadian National Committee for the International Union of Biological Sciences; Vice-chairman Canadian Committee on the International Biological Programme; Board of Trustees Biological Abstracts 1964; chairman 1969 board of trustees Bergey's Manual Trust 1965; member of the executive committee of the International Union of Biological Sciences representing division of microbiology (1967-).

Other items of interest: Edited "Recent Progress in Microbiology VIII" the symposia and proceedings of the VII International Congress for Microbiology. Dr. Gibbons has made extensive contributions to the microbiology of stored eggs and stored meat. For some years he has been interested in halophilic bacteria and the reason they require salt for growth. More recently he has become interested in organisms growing at low temperature.

APPENDIX B

COMMUNICATIONS

IDAHO STATE UNIVERSITY,
OFFICE OF THE DIRECTOR,
DEVELOPMENT AND INSTITUTIONAL RESEARCH,
Pocatello, Idaho, April 3, 1969.

HON EMILIO Q. DADDARIO,
House of Representatives,
Washington, D.C.

DEAR MR. DADDARIO: It is our understanding that your committee is currently hearing testimony on a resolution to fund the International Biological Program. We would like to express our support of the Resolution, and if you deem it appropriate we would urge you to bring our support to the attention of your committee.

As you may know, Idaho State University has been designated by our State Board of Education as a center for development of the Life Sciences, and through the years we have built a capability in the basic sciences and especially in the areas of biology and microbiology.

In the opinion of our science faculty in the above referenced departments, the *Analysis of Ecosystems* portion of the IBP program represents a significant contribution to the understanding of man's environment. Such an understanding seems to be imperative for man's ultimate survival on the face of the earth.

Man with his technology and know-how and his continuing increase in numbers is rapidly changing the environment in which he lives. And yet we are dependent upon that environment for our survival. Our planet is a fragile life-support system; disruption of the so-called balance of nature could have an impact on our lives as profound as the dropping of a hydrogen bomb. There can be little doubt that we must gain an understanding of our environment on a world-wide basis; that we must be able to predict what the influences of various man-generated disturbances will be, or that we must learn to repair damage to the environment that may have already taken place. In our opinion, the International Biological Program is a major step in this direction.

As you are well aware, there is currently a tremendous interest in the space program and, to a lesser degree, in oceanography. Enormous sums of money have been spent and will be spent on these programs. While outer space and the oceans admittedly represent great frontiers for exploration and research, the comparative glamour of these programs often obscures the fact that there are still huge gaps in our knowledge of the terrestrial and fresh-water ecosystems upon which we are directly dependent. Favorable action by your committee and subsequent favorable action by the Senate proposes to close many of these gaps, and we cannot urge you too strongly to move toward such a goal.

As you undoubtedly know, the IBP *Analysis of Ecosystems* will focus on systems relatively untouched by man, as well as those which have been affected to various extents by the pressures of civilization. In this way we can learn how man has altered his environment from the "natural" state, and we can thus have a better idea of how to cope with these changes. The International Biological Program is of vital importance to the future of mankind on this planet. We strongly urge your support and the support of your committee for this program both in principle and in funds.

Sincerely yours,

DONALD F. KLINE,
Director.

DEPARTMENT OF STATE,
Washington, D.C., May 6, 1969.

HON. GEORGE P. MILLER,
Chairman, Committee on Science and Astronautics,
Washington, D.C.

DEAR MR. CHAIRMAN: In answer to Mr. Ducander's request of April 13 there is transmitted herewith a report on H.J. Res. 625 concerning the International Biological Program. H.J. Res. 625 is identical with S.J. Res. 89. The Department of State now as in the past gives its support to the International Biological Program. We endorse the Joint Resolutions as an aid to that end. It appears especially important that Federal departments and agencies concerned with the objectives of the Program should support and cooperate fully to assist the activities of the U.S. National Committee for the IBP and the Interagency Coordinating Committee.

The Bureau of the Budget advises that from the standpoint of the Administration's program there is no objection to the submission of this report.

Yours sincerely,

WILLIAM B. MACOMBER, Jr.,
Assistant Secretary for Congressional Relations.

INTERNATIONAL BIOLOGICAL PROGRAM AND ITS RELATION TO H.J. RES. 625

The International Biological Program (IBP) is a broad effort established on a world-wide basis. It is being conducted by more than fifty nations in order to establish an ecological base for managing the environment and for preventing its deterioration. Within the United States it is being coordinated by the National Academy of Sciences and the National Academy of Engineering, to which is attached the U.S. National Committee for the IBP, and, for the Federal Government in particular, by a special interagency coordinating committee. The National Science Foundation serves as the U.S. Government's lead agency.

In the United States the National Committee has formed a series of subcommittees which are responsible for the planning of substantive research in various fields; such research necessarily concerns a number of Federal agencies.

The Department of State welcomes the support which the joint resolution gives to U.S. efforts in behalf of IBP action. The encouragement to Federal agencies to give their support to the program should help to guarantee an important role for the United States in the IBP. Such cooperation is altogether appropriate in our continuing efforts to seek productive and peaceful ties with other countries. A strong IBP will stimulate productive exchange among world scientists and it will prepare the way for further joint efforts planned for the 70s.

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D.C., May 9, 1969.

HON. GEORGE P. MILLER,
Chairman, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: This is our report on H.J. Res. 625 "Expressing the support of the Congress, and urging the support of Federal departments and agencies as well as other persons and organizations, both public and private, for the International Biological Program."

This joint resolution would declare that the International Biological Program (IBP), established under the auspices of the International Council of Scientific Unions and the International Union of Biological Sciences and sponsored in the United States by the National Academy of Sciences and the National Academy of Engineering, deals with one of the most crucial situations to face this or any civilization. That situation is the immediate or near potential of mankind to damage, possibly beyond repair, the earth's ecological system on which all life depends. The joint resolution would also declare that the IBP provides a means of meeting this situation. The Program's stated objective is increased study and research related to biological productivity and human welfare in a changing world environment.

The joint resolution commends and endorses the IBP and expresses support of the Committees having responsibility for the Program in the United States.

The Federal departments and agencies, other persons and organizations, private and public, would be called upon to support and cooperate fully with the Program. The joint resolution authorizes and requests all Federal departments and agencies having functions or objectives coinciding or related to those of the IBP to obligate or make appropriate transfer of funds to the Program from moneys available for such functions or objectives and provide such other support as may be appropriate.

The Department of Agriculture endorses the general objectives of H.J. Res. 625.

We strongly support the objectives of the IBP. A large proportion of the agricultural and forestry research of the USDA is concerned with environmental management and the interaction of man with his environment. The objectives of the IBP are relevant to all the commodity production, resource conservation, rural development, and human welfare responsibilities of this Department.

The USDA feels that the IBP has a unique and important role in bringing a broad interdisciplinary and international approach to the solution of environmental problems. This approach complements the Department's mission-oriented domestic effort. It also holds promise for solution of certain environmental problems that are international in character.

USDA scientists are participating in planning and coordinating the Program through memberships in the Executive Committee, the Federal Interagency Coordinating Committee, and committees of the individual programs. This Department also contributes part of the financial support for the operation of the U.S. National Committee.

The USDA is collaborating actively in the ecosystem studies of IBP. For example, Department scientists are or will be conducting studies as an inherent part of integrated research programs such as the Grassland, Forest, and Desert Ecosystem Studies. Also, USDA is providing research resources such as experimental forest and range areas and research natural areas.

Further, many of the Department's research projects are IBP-related. More than 60 of the 266 IBP-related projects listed in IBP Report No. 3 are USDA projects. This Department also provides partial support for participation of State agricultural experiment station and forestry school scientists in several IBP-related projects.

The Department of Agriculture intends to continue its support of IBP. The USDA is mainly an in-house research organization and does not have large blocks of grant funds. However, the Department will continue to work through its research planning and budgeting procedures to support appropriate parts of IBP. USDA will likewise work with developing IBP programs that are related to its missions.

The Bureau of the Budget advises that there is no objection to the presentation of this report from the standpoint of the Administration's program.

Sincerely,

J. PHIL CAMPBELL,
Under Secretary.

APPENDIX C

QUESTIONS AND ANSWERS FOR A SPECIAL STUDY ON THE INTERNATIONAL BIOLOGICAL PROGRAM

The U.S. National Committee for the International Biological Program was asked to respond to the following questions and requests for information. Attention is drawn to the fact that in some instances specific facts were sought, in other instances opinions only were expected. Throughout its responses the Committee was urged to distinguish between, and comment on, what the facts were or seemed to be, in contrast to what the Committee thinks the situation should be.

This material was provided by the Committee, together with that from other sources, will constitute some of the ingredients from which the National Science Foundation will prepare its reaction to the Bureau of the Budget's Prospectus on International Biological Program.

Question 1. a.: The term "objectives," as used here, implies broad, general statements of direction or policy in contrast to specific, limited goals or targets. Concisely stated, what are the basic objectives of the International Biological Program?

Answer: The ICSU Special Committee on the International Biological Program established the objectives for this program in the following statement:

"The rapid rate of increase in the numbers and needs of the human populations of the world and their demands on the natural environment has greatly increased the need for biological research. The International Council of Scientific Unions (ICSU) has therefore initiated an International Biological Programme (IBP) entitled 'The Biological Basis of Productivity and Human Welfare,' with the objectives of ensuring the worldwide study of:

- (1) Organic production on the land, in fresh waters, and in the seas, and the potentialities and uses of new as well as of existing natural resources. and
- (2) Human adaptability to changing conditions."

Question 1. b.: What are the objectives of the U.S. efforts?

Answer: Objectives of the International Biological Program are to provide basic insight and foresight about changing environmental relations of man, in order to cope with increases in the numbers and needs of human populations; also with the impact of these increases upon the interconnected ecological systems of the Earth (see Daddario Report on IBP).

The size and complexity of this task demands prompt, internationally coordinated research on lands and waters: both on near natural and modified ecological systems; on their changes, processes of maintenance, and biological productivity. Related studies focus on selected biological problems of man's adaptations as a part of diverse ecosystems and his roles as an agent acting on them. Wise resource use and management, and preservation of a special systems and species, all call for improved exchange of information and joint research, plus action.

The United States shares all of the worldwide objectives. But we further see the processes which normally control much of life (dispersal and selection of organisms, biological conversions of solar energy, circulation of nutrients) also threatening to spread pollution; to deflect balances of plant and animal populations and of their productivity; and to degrade "Environmental Quality" (see Daddario Report on this subject). Americans, most particularly, seek ways of understanding such *by-products of technological developments* avoiding their disadvantages and using their advantages. Resulting changes, either way, can be rapid in industrial societies, and in neighboring and remote countries affected by them (see Daddario Report on "Managing the Environment").

The objectives were further defined by the U.S. Executive Committee in a meeting of 30 April-May 1, 1968, as follows:

"Our objectives are to participate in a worldwide study of organic production in all environments, and of human adaptability to changing conditions. In the United States, the maintenance of environmental quality is critical for both human welfare and long-term productivity. Thus, the U.S. program focuses on two major components: (1) problems of human adaptability, and (2) problems of environmental management."

Question 1.c: To what degree are the U.S. objectives, as established, widely publicized?

Answer: The U.S. objectives have been publicized in three reports by the U.S. National Committee with distribution of each report to over 60,000 scientists. These have also been distributed to scientific and lay press through the IBP Press Relations Officer who is housed in the Office of Information at the National Academy of Sciences. Numerous press releases and magazine articles have been prepared by this office and by IBP scientists for both scientific and lay audiences.

From January through April of 1968 alone, 86 different publications carried stories on some aspect of the IBP; newspapers in 40 states have had stories on the program. A number of editorials have also been written supporting the IBP including those recently in the *Washington Post* and the *New York Times*. Press releases are also being issued by the universities and government agencies involved in IBP research, while a new quarterly publication of the U.S. Committee, *IBP Inter-American News*, has been widely distributed in both North and South America to scientists and press alike. International coverage of U.S. objectives and plans has been good, especially in English publications such as *Nature*.

Numerous symposia have been held in conjunction with meetings of scientific societies. The latest of these is cosponsored by the American Institute of Biological Sciences, and will take place at the Columbus, Ohio convention in September, 1968. A scientific exhibit illustrating the aims and objectives of the U.S. effort will be set up at the Columbus convention.

A report by the House Subcommittee on Science, Research, and Development entitled, "The IBP, Its Meaning and Needs" has also been widely circulated and has contributed greatly in communication with a large body of scientists and interested lay men.

Plans are now underway for the organization of an ad hoc IBP Committee on Public Education which will deal with the possibilities of films, speaking tours, books and other publications on the U.S. IBP.

Question 1.d.: Can it be assumed that these objectives are fully understood in appropriate segments of the scientific community?

Answer: An increasing understanding among appropriate segments of the scientific community is apparent. However, it cannot be said that IBP "objectives are fully understood" by all individuals, institutions, and agencies that make up these segments. Among some individual scientists there is the feeling that the programmatic concepts of IBP are fiscally competitive with other programs with which they are associated. When these individuals see opportunities in IBP and new funds become available to support their work, their indifference to IBP will disappear. Among institutions and agencies, there has been misunderstanding because these organizations are categorically oriented and their panels and study sections have specialized and specific mission objectives. These organizations do not seem prepared to evaluate programmatic multidisciplinary longitudinal research. Continuous efforts by US/IBP Committee have begun to clarify these problems and to capture mutual interests from among programs of institutions and agencies. Future plans, when carried out, should result in further progress. These plans include scheduled interchanges between USEC/IBP and each interested agency on a program-by-program basis.

Question 1.e.: Can it be assumed that they are interpreted in uniform fashion by those public and private organizations that are involved in support of the IBP effort?

Answer: Public and private organizations involved in support of the IBP do now, and will continue to interpret IBP objectives in relation to their own mission. Increasingly, all supporting organizations will recognize continuity of interest in IBP objectives as well as interests peculiar to their own missions.

Question 1.f.: By what means and by whom were the U.S. objectives established?

Answer: The U.S. objectives were identified by the U.S. National Committee during a 4-day working conference with its subcommittee members and other invited scientists (86 individuals) in October 1966. Objectives were further developed in a series of meetings culminating in a 2-day session of the USEC/IBP, 30 April-1 May 1968. The primary product of this meeting was the attached draft, "Man's Survival in a Changing World."

Question 1.g.: What authority and procedures exist to allow for changes in these objectives?

Answer: The Executive Committee is authorized to make changes within the general objectives of the IBP. Proposed changes would be reviewed by the Executive Committee and if approved, would be published in an appropriate report. To date, the objectives have been elaborated but not changed.

Question 1.h.: To what degree are the U.S. objectives as currently stated in need of alteration?

Answer: There is, in our opinion, no known need for alterations to the U.S. objectives.

Question 1.i.: What do we know about the stated IBP objectives of other nations, and in what way do they relate to our own?

Answer: Based on a general review of available program objectives of other participating nations, all appear to be derived from the stated SCIBP objectives; and therefore all are interrelated. A central focus on ecosystems operations seems apparent in most national programs. Programs differ in goals, content, depth and dimensions. These differences seem attributable to (1) national economic interests, (2) national resources, and (3) resident scientific interests and capabilities. With an apparent adherence to the SCIBP objectives and a general acceptance of the ecosystem central focus, differences in national programs seem to be complementary and mutually reinforcing.

Question 2. The term "goals," as used here, implies major accomplishments contributing toward realization of general objectives. In most instances these goals and their associated target dates will be consonant with the completion of particular studies, programs, or projects. "Subgoals" are dates for completion of specific sequential steps leading toward goals. They may be considered as reference points or mileposts against which to measure progress.

Comment: Among the accomplishments of the organizational phase of IBP have been the publication of handbooks and reports on methods to be used in IBP investigations, the identification of various animals and plants, and glossaries to systemize data collection, storage and retrieval. In these various activities U.S. scientists have played an active role. These publications include:

1. *Assessment of Heat Tolerance*. Occupational Health Research and Training Facility, U.S. Public Health Service, Cincinnati, Ohio. 1967.

2. *Glossary of Thermal Physiology*. Draft to be discussed at Satellite Conference on Thermal Physiology, International Congress of Physiological Sciences, August 23, 1968, and then referred to IUPS Committee on Terminology and Nomenclature for final approval.

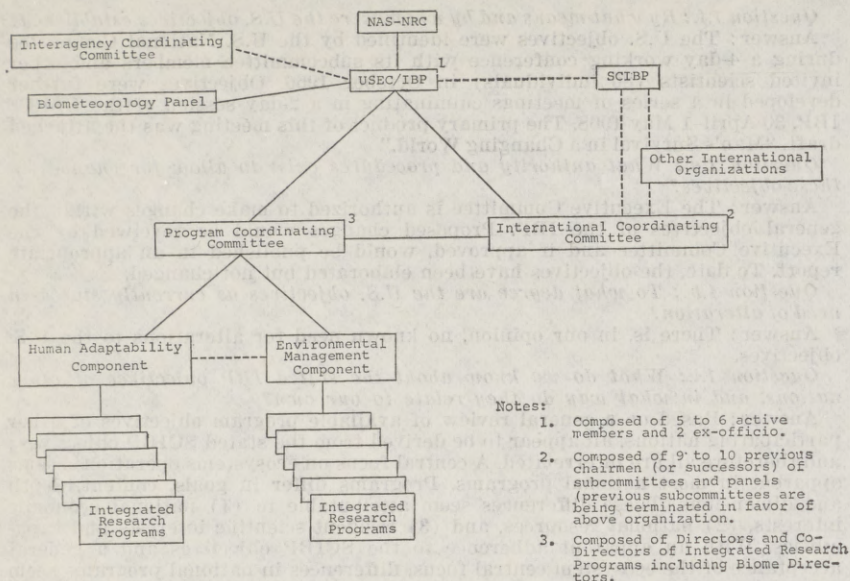
3. *North American Systematists Interested in the IBP*. Division of Biology and Agriculture, NAS/NRC, 2101 Constitution Avenue, N.W., Washington, D. C. 20418.

4. *Research Natural Areas on Federal Lands*. A detailed listing of all such areas, U.S. Government Printing Office, Washington, D. C. 20402.

The above are examples. A total listing may be supplied if desired.

Goals, subgoals, accomplishments and target dates as defined above are inseparable from the organization established for the achievement of these goals. The organization for carrying out the U.S. effort is implicit in a draft paper entitled "Man's Survival in a Changing World". This paper was the primary product of a 2-day session of the USEC/IBP with directors of integrated research programs, 30 April-1 May. The draft, attached hereto, was distributed to all members of the ICC on 20 May.

A schematic of the organization of the U.S. effort is:



Examination of the above structure will show that goals, subgoals, target dates, etc. are the direct functional responsibilities of directors of integrated research programs (IRP); and that the diagrammatic supra committees have interests and responsibilities toward assuring development of the IRP's.

The following answers are in consonance with the above comment.

Question 2. a.: Precisely stated, what are the specific goals to be achieved in the U.S.-IBP effort, and what are the dates for attaining these goals?

Answer:

(1) HUMAN ADAPTABILITY COMPONENT

a) General—The broad goal of this component of the US/IBP is to advance knowledge of (a) the genetic, and (b) the physiological and behavioral adaptations of man. It now includes five integrated research programs—others may develop. They supplement those on-going researches that already provide a wide array of information. Each IRP will attempt to exploit certain unusual opportunities to understand critical aspects of the adaptive process. These programs, their goals and target dates are:

i. International Study of Eskimos

(a) Goals—To elucidate biological and behavioral processes responsible for the successful adaptation and the continuous but slow population growth of 70,000 Eskimos in an arctic environment.

(b) Target dates—

July–September 1968—Establish nucleus of U.S. research teams based on Wainwright, Alaska. Establish direct coordination with parallel research teams (1) from Canada based on Igloodik, and (2) from Denmark and France based on Upernavik and Angmagssalik.

September 1968–July 1972—Carry out research according to the following schedule:

	Fiscal year				
	1969	1970	1971	1972	1973
Health and performance:					
General health.....	X	X	X	X	X
Cardiology.....	X				X
Radiology.....	X	X	X	X	X
Serum epidemiology.....	X				
Physiology:					
Work capacity.....	X	X			
Activity patterns.....		X	X		
Heat/cold adaptation.....		X	X		
Endocrine function.....		X	X		
Chronobiology.....	X	X	X	X	X
Nutrition.....		X		X	
Growth:					
Anthropometry.....	X	X	X	X	X
Bone mineral content.....	X	X	X	X	X
Dentition.....	X	X	X	X	X
Genetics:					
Demography.....	X	X	X	X	X
Gene markers:					
Blood.....	X	X	X	X	X
Dermataglyphs.....		X			
Behavior:					
Psychology.....		X	X		
Behavioral genetics.....		X	X		
Ecology:					
Ecosystem.....	X	X	X		
Prehistory.....		X	X	X	

ii. Population Genetics of American Indians

(a) Goals—To acquire from primitive tribes of South American Indians baseline information on mating patterns, control of fertility, birth and death rates, genetic characteristics, food utilization and disease pressures, and to link these studies in time with studies on the much more changed Indians of the United States. From these quantitative studies of primitive and transitional groups can issue an understanding of the changing stresses of modern man and possibly some insight into their consequences. U.S. Venezuelan and Brazilian participation is involved.

(b) Target dates—These studies are under way. Completion by July 1972 is planned.

iii. The Biology of Human Populations at High Altitudes

(a) Goals—To study selected populations living at altitudes above 3,000 meters for (1) physiological adaptations to chronic hypoxia from before birth to old age, (2) medical and obstetrical problems which are direct consequences of maladaptation, and (3) modifications of diseases. (Some recent observations indicate that high altitude may protect against degenerative cardiovascular disease.)

It is planned to study (1) a North American population at 3,100 meters, (2) a South American population at 3,100–3,500 meters, and (3) an Andean population at 4,000 meters.

(b) Target dates—

July 1968—Apply for planning funds (submitted).

December 1968—Begin demographic study of Leadville, Colorado, at 3,100 meters altitude.

March 1969—Submit detailed program proposal to USNC/IBP, and to Federal Agency for funding.

December 1969—Undertake definitive epidemiologic and related physiologic studies, and training, in Leadville, Colorado.

December 1970—Undertake parallel studies in South America.

December 1974—Complete 5 years of field work.

iv. Nutritional Adaptation to Environment

(a) Goals—To coordinate studies of the effects of nutritional stresses on selected population groups in the Arctic, Subarctic, Temperate and Tropical areas, and to assess the development and performance of these groups within the ecological systems in which they are components. The diets of polar populations approach the limit of physiological tolerance to protein and fat. Tropical diets appear very deficient in protein and high in starch and sugar. Temperate

diets appear more balanced and yet frequent deficiencies in vitamins and essential trace elements, and excessive caloric intakes are observed.

(b) Target dates—

September 1968—Submit proposal for program coordination to ICC.

September 1968–July 1972—Carry out coordination required.

v. *Ecology of Migrant Peoples*

"The typical Chicago rioter—1968 version—was a 23-year-old Negro migrant from the South."—*Chicago Daily News*, April 27, 1968.

In discussions and reports on the recent outbreaks of violence in America's cities, not much attention has been paid to one of the very basic, underlying causes of the problem—non-adjustment of ghetto residents, both physically and socio-culturally, to a highly stressful urban environment.

Many Negroes now living in northern cities have migrated from rural areas in the South. They experience many environmental changes which have great bearing on their behavior in the northern ghettos—decreased physical activity; increased living-space, congestion and noise stresses; confrontation with impersonal routines and authority; exposure to deviant behavior; changes in mate choice and fertility.

(a) Goals—To measure adaptability responses to migration and urbanization, the program in Ecology of Migrant Peoples will concentrate on populations living under highly stressful conditions. Certainly one of the most significant populations under stress in the United States today is that of the Negro. Therefore, as the major focus of the program, Negro populations in both rural and urban areas will be measured for adaptation trends. The rural population study will be in Holmes County, Mississippi, the poorest county in the United States with a mean annual income for Negro families of \$900 per year. Chicago will be the site of the urban studies since the majority of Holmes County migrants live in the Maywood and West End sections of the city—centers of violent unrest during 1968.

In the Mississippi portion of the study, a thorough biomedical and demographic assessment of the population will be made by specially trained residents of Holmes County under scientific supervision. It is hoped that this survey will identify needed medical treatments and will also serve as a means of training residents for future jobs. Experimental questions will also be considered—how much more developed are children who are enrolled in a Head Start program; how much of an effect will more adequate education and prenatal care have on reducing the very high fetal and neonatal death rates in the county?

The studies in Chicago will be used to determine what attributes predict successful adaptation among young adults ages 15 through 35. The degree of education, acquisition of employment, maintenance of family relations, development of new relationships and social behavior will all be evaluated for their effect on successful or non-successful adaptation. Studies will be made of street gangs and of the incidences of narcotic addiction, prostitution, chronic alcoholism and criminal convictions among the migrants, and how these rates compare to the native city dwellers in the same area. Efforts will be made to illuminate the part non-adjustment to an urban environment plays in Negro discontent.

In later stages of this program, adaptation of Negro populations migrating from Evans County, Georgia, to New Rochelle, New York, and residents of four races in the subarctic city of Fairbanks, Alaska will be investigated. Work is also planned on Spanish-American and Indian populations. Coordination will be maintained with similar programs under the IBP in Israel, Yugoslavia, Australia and Canada.

This work will yield basic data on the phenomenon of migration. It will also help develop an adequate biosocial characterization of the nation by providing intensive research on "nonwhite", "poor" and "rural" populations. It will help develop assessments of interactions of genetic and environmental components in human adaptation and provide a better understanding of adaptation to an urban and industrialized habitat. But most important of all, it will contribute directly to the urgent search for social justice and tranquility called for by the President's Commissions on Rural Poverty and Civil Disorders.

(b) Target dates—

December 1968—Submit proposal for Central Coordination to ICC.

July 1968–December 1968—Obtain financial support for 2 research proposals now submitted.

July 1969—Submit 2 research proposals to appropriate granting agencies (N.B.—University of Illinois now supporting initial organizational work with direct allocation of \$20,000. This support will terminate before December 1968).

(2) ENVIRONMENTAL COMPONENT

a) General—The broad goals of this second component of the US/IBP are (1) to formulate a basis for better understanding of the interactions of all components of selected and representative biological systems, (2) to extend this understanding toward an increased biological productivity, (3) to provide bases for accurately predicting the consequences of environmental stresses, both man-originated and natural, on the performance of biological systems, and (4) to enhance our ability for better management of our natural resources. Within this component are 6 integrated research programs (IRP) and additional IRP's may develop. All are supplemented by researches that provide a wide array of information. These integrated programs, their goals and target dates are:

i. *Ecosystems Analysis*

(a) Goals—(1) to understand how ecological systems operate with respect to both short-term and long-term processes, systems disturbed to varying degrees by man are included; (2) to analyze interrelationships between land and water systems, so that broad regions may be considered as wholes; (3) to estimate existing and potential plant and animal production in the major climatic regions of this country, particularly in relation to human welfare, as our contribution to the world-wide goals of the IBP; (4) to add to the scientific basis of resource management, so that optimization for multiple use and for long-term use can be improved; and (5) to establish a scientific base for programs to maintain or improve environmental quality.

In this program an intensive team effort will be made to study six kinds of ecosystems—grasslands, tundra, desert, coniferous forest, deciduous forest, and tropical forest. Each of these six intensive studies will involve many scientists of varying disciplines and each study has its own management structure. In turn, efforts in the six studies are coordinated through a program director and staff. Also, there are some research projects and services at the ecosystem program level. Strong modeling and synthesis projects are characteristic of this program.

In effect, the program on intensive analyses of ecosystems provides a structure or framework which references and utilizes information from all the integrated programs on plants and animals as described in subsequent paragraphs.

(b) Target dates—

January 1968—Submit proposal to ICC for central operations and coordination (submitted and funded).

January 1968—Submit proposal for analysis of Grasslands Biome (submitted and partially funded).

January 1968—Submit proposal for remote sensing applications within the program (submitted).

June 1968–December 1968—Submit remaining 5 biome research designs and associated proposals.

January 1968–January 1973—Accomplish proposed research.

ii. *Convergent and Divergent Evolution*

(a) Goals—(1) understanding of the processes and results of both convergent and divergent evolution in structure, behavior, and physiological adaptation of various kinds of organisms of the New World and understanding of the puzzling relationships between various South American and Australian groups, (2) understanding of the composition, ecological niches, and functioning of ecosystems that have evolved in similar environments of the Southern and Northern Hemispheres, and (3) understanding the native and invading biotas of the land areas of the Hawaiian Islands.

Selected biologists from several American countries and Australia have planned a cooperative research program with six subprograms on specific groups; (1) Amphibia, (2) Fish, (3) Mammals, (4) Reptiles, (5) Insects, and (6) Plants. Each has investigators and institutions named to a limited extent that will expand as the program proceeds. Two subprograms are directed to the question of convergence in ecosystem structure or to convergence in physiological adaptation; (1) Ecosystems, involving investigators representing UCLA and Stanford in the U.S., University of Chile, Central University Venezuela, and INTA (Argentina); (2) Physiological Adaptation, involving investigators of Cornell University, University of California at Riverside, University of Rhode Island, Fullerton State (California), and Universidad Nacional de Cuyo (Mendoza, Argentina).

A third subprogram is directed toward an understanding of the evolutionary and ecological phenomena of the Hawaiian Islands.

(b) Target dates—

May 1968—Submit proposal for both central coordination and research on the South American subprograms to ICC (submitted).

September 1968—Modest expansion of presently existing research to extent permitted by level of funding.

December 1968—Submit proposal on the Hawaii subprogram to ICC.

September 1969–September 1972—Continuation of research at a sharply increased level of funding.

1972–1973—Coordinated reports on the results and probable continuation under some other auspices.

iii. *Biogeography of the Sea*

(a) Goals—to develop the ecological and physiological knowledge required to predict how environmental factors limit or enhance the abundance and productivity of selected marine organisms of interest to man. Studies will be in the U.S. and other IBP countries.

Knowledge gained on the mechanisms of marine productivity is basic to: (1) an identification of the environmental factors and stresses which limit the distribution of organisms and help explain evolutionary diversity; (2) a definition of optimal environmental and functional conditions useful for assessing aquacultural potentialities for selected species; (3) an understanding of the significance of selected marine organisms in trophic chains important to man's welfare; and (4) a definition of the adaptive capacity of organisms for life in modified or disturbed environments.

Program coordination will be accomplished by the co-directors and a full-time research coordinator. An advisory committee of senior scientists will provide scientific guidance and evaluation. The research will be conducted in terms of "packages" of separate projects, all dealing with a particular organism or group of closely related organisms. Investigators representing different disciplines will study various physiological parameters on a coordinated cooperative basis. Training will be accomplished within individual *projects* by investigators engaged in direct research participation.

(b) Target dates—

May 1968—Submit proposal for over-all coordination to ICC (submitted).

June 1968—Submit first packet of research proposals (submitted).

December 1968—Submit remaining packets of research proposals.

iv. *Phenology*

(a) Goals—(1) To conduct detailed studies on plant and animal species, both aquatic and terrestrial at a number of sites within the United States in order to prepare phenological maps; (2) to obtain clues to the physiologic limitations that determine climatic limits of species, explain the biological basis for phenological timing; (3) test the hypothesis that such studies will aid in understanding evolutionary mechanisms, and (4) to contribute to understanding the role of phenologic phenomena in the structure and productivity of ecosystems.

The program provides for overall coordination, and three sub-programs on mechanisms, phenology within communities, and phenologic maps. Broad studies will be conducted with the aid of a large network of stations and observers. They can be done at several levels of sophistication, providing participation by all people with all levels of scientific training. Special sites will be selected and intensive multidisciplinary studies made of measurements of environmental parameters and population structure, breeding behavior, and physiology of organisms. A chief aim will be development of phenologic maps that would predict planting and harvesting dates for crops and outbreaks of plant and animal borne diseases as well as other biological events.

(b) Target dates—

September 1968—Submit proposal for central coordination and mapping to ICC.

December 1968—Submit proposal for subprogram on mechanisms to ICC.

June 1968–December 1968—Integrate subprograms on phenology within communities with ecosystems analysis programs.

January 1968–January 1973—Accomplish research described.

v. Aerobiology

(a) Goals—(1) To organize, integrate, and extend present investigations of airborne spores, pollen, microbes, insects and other small organisms, and biologically significant non-living materials such as toxic gases, (2) to identify critical problems not yet under investigation and initiate new projects to meet those needs, (3) to cooperate with other nations in aerobiological studies and relate those studies to global monitoring of environmental conditions, such as the monitoring by WMO under the United Nations.

The program will comprise segments for research technology, phytopathology, allergenic particles, transport of genetic material, human and animal disease microbes, wind-carried insects and other small animals, and gases toxic to organisms. Much of the needed research is already underway, especially by Federal and State laboratories, and the Aerobiology Program will provide the leadership and communications to build the projects into an integrated program. The American Phytopathological Society, which has for many years fostered international cooperation for study of plant diseases and amelioration of resulting losses, has placed its IBP steering committee within the framework of this Program to assist in the prosecution of three related areas within phytopathology: (1) Mode and places of origin of organisms causing plant diseases in major crops, (2) processes by which plant disease organisms are dispersed, (3) assessment of world-wide plant disease losses.

The atmospheric dispersal program will share efforts with several other IBP programs, primarily Ecosystems Analysis and Phenology. Various Federal agencies, three scientific societies, and numerous private and university laboratories have requested opportunity to participate in and assist this program.

The Program will increase the quantity and improve the quality of research on atmospheric dispersal of biologically significant materials, while taking full advantage of the new opportunities for working in the full context of world-wide investigations.

(b) Target dates—

August 1968—Submit proposal for central coordination to ICC.

August 1968—Endorse first 3 proposals for research on sources and origins of plant pathogens. Conduct reviews of proposals to select "Associated Projects."

December 1968—Complete links with international coordinating networks.

December 1968-January 1973—Accomplish research and coordination proposed.

February 1969—Conduct first in series of symposia on current problems in aerobiology.

September 1969—Begin training program.

vi. Physiology of Colonizing Species

(a) Goals—(1) To understand the characteristics of species that are able to expand their distribution, (2) to determine the role of habitat alteration in promoting these species invasions, and (3) to determine the degree to which invading species have diverged physiologically and biochemically under the pressure of new selective forces in a variety of habitats. Comparative studies will yield insight into the factors of population adaptation.

A range of species will be studied, varying from those possibly representing local expansion of a specially adapted type to broad expansion of a type with generalized adaptation. The habitats that will be evaluated include those from a broad latitudinal and altitudinal diversity in the western hemisphere. From these studies should come a fuller understanding of the interplay of the disturbance of habitats and the physiological adaptation of invading species.

The basic characteristics of invading plant species may include the following: opportunistic ability to expand or contract a life cycle to fit growing seasons of varying length; the production of chemical inhibitors; the ability to survive in relatively pure stands; broad tolerance of temperature, light intensities, photoperiods, etc.; less palatability; less dependence on a particular insect for pollination; regulative propagation and/or other asexual reproduction; self-fertility. The studies will determine if certain characteristics promote invasion of a given habitat and/or at a given latitude.

(b) Target dates—

September 1968—Submit proposal both for central coordination and for planned research to ICC.

September 1968-January 1973—Accomplish research and coordination.

vii. Conservation of Ecosystems for Scientific Purposes

(a) Goals—(1) To provide registries of protected natural areas and areas requiring protection on:

- (a) Federal lands
- (b) Nonfederal public lands
- (c) Private lands

(2) to provide for descriptions of these areas, (3) to provide guidelines useful in managing and protecting the areas, (4) to provide registries of experimental areas necessary and used for scientific purposes such as experimental forests, watersheds, ranges, etc.

- (a) On Federal lands
- (b) On State lands
- (c) On privately owned lands, e.g., university areas

(5) to cooperate with other countries of this hemisphere in providing for scientific reserves; specifically, to prepare a list of needed reserves and to stimulate establishment of these, (6) to catalog freshwater areas valuable for scientific purposes, and (7) to catalog existing reserved marine areas and to contribute to devising a suitable mechanism for selecting and protecting marine areas.

(b) Target dates—

Goal No.	Item	Method or source
1-A.....	March 1968.....	Directory published.....
		Federal Committee on Research Natural Areas.
1-B,C.....	September 1968.....	Plan for proposal.....
		Conservation Foundation.
2.....	December 1968.....	Complete arrangement for financial support.....
		Conservation Foundation.
3.....	June 1969.....	Complete checksheets on Federal areas.....
		By responsible agency.
4.....	December 1968.....	Formulation of plan for compiling.....
		USDA compiler.
4-A.....	December 1969.....	Complete first draft.....
		Conservation Foundation.
4-B,C.....	do.....	Complete plan for accomplishment.....
		Conservation Foundation plus IBP planning.
5.....	do.....	Complete arrangements for Hemispheric Conference.....
		IBP planning.
6.....	do.....	Complete first draft.....
		Conservation Foundation.
7.....	September 1968.....	Complete list draft of existing areas.....
		Dr. Randall, at no cost to IBP.
	Continuing.....	Devise program.....

Question 2.b.: By what means and by whom were these goals established?

Answer: The goals stated above were generally defined in the program statements of subcommittees of the USNC/IBP and were agreed at the Williamstown Conference in October 1966 but there has been a considerable amount of evolution, refinement and redefinition of these goals as a result of work conferences and of communication within the IBP organization.

The specific goals are distillations from more than 40 successive working conferences that have radiated into an increasing number of concerned scientists (estimated now at over 2,000). Generally the working conferences have been held under the sponsorship of the concerned subcommittees of the USNC/IBP. Plans and goals for the IRP's have been reviewed by the USNC at successive stages of program development.

Question 2.c.: What mechanisms should be employed to ensure continued focus on these goals and dates?

Answer: In paragraph 2.a. above the current USEC/IBP organization is described. Support of this organization, and of the Integrated Research Programs included, will insure continued focus on these goals and dates. The organization for U.S. participation in the IBP is structured at levels of responsibilities from project director to program coordinator to program director to coordination committee to U.S. Executive Committee to NAS-NRC.

Question 2.d.: A variety of events could alter progress toward the goals and subgoals set—technical difficulties might arise in the research programs, unexpected cost increases might occur, funds might become available in significantly greater or lesser amounts than planned, etc. Such events may necessitate employment of alternative means for achieving the goals, or adjustment of existing subgoals to make them more realistic. The following questions relate to the strategy contemplated for coping with such problems.

What group using what procedures should be responsible for assessing the progress of the IBP and, if it seems necessary, making the decision to retain or adjust the subgoals or implement alternative operating plans?

Answer: Decisions on subgoals and alternative plans will be made within the framework of the USEC/IBP and its subordinate committees. Interactions with the ICC should be involved in these decisions, but responsibility for the U.S. participation in the IBP rests in the Executive Committee as a committee of the NAS-NRC.

Question 2.e.: What authority exists to allow this group to alter the subgoals, goals, or plans?

Answer: The USEC/IBP derives its authority from the National Academy of Sciences—which in turn operates as an adhering member of the International Council of Scientific Unions.

The USEC/IBP, in consultation with IRP directors, coordinators and investigators, may modify subgoals, goals or plans as funding or other exigencies may require. The USEC/IBP will assure continuing communication with ICC and its members through staff and principal investigators, IRP directors and coordinators as appropriate.

Question 2.f.: Describe any alternative means, procedures, or activities that might be employed to keep the Program on course and on schedule if present plans prove inadequate. What are the merits and deficiencies of each?

Answer: It is the opinion of the USEC that the IBP program in the U.S. is rapidly proceeding on course as the IRP's are planned and implemented. Each IRP has an organizational structure, and the central organization for the US/IBP has a smoothly functioning structure that has evolved in response to need. With these organizations, we can see no serious problem of keeping the U.S. effort on course with respect to the basic goals and objectives. On the other hand, we would reject as unworkable and undesirable, any course that was so rigid as to prevent evolution of details of the objectives as the work progresses.

With respect to keeping the program on schedule, then the program has slipped a full year, and further slippage seems certain as a result of inadequate financial provision for the program in the Federal budget and of the failure generally of private foundations to see the significance of the program as it relates to their own interests. If the IBP is as important to our national and international interests as the USEC believes it to be, and as at least a strong segment of the Congress believes it to be (see Daddario Subcommittee Reports), then the slippage can be countered by an extension of the period of the U.S. effort.

Question 2.g: How will established goals be modified if there are significant increases or decreases in sums available, or if the availability of funds is delayed? For this purpose estimate a baseline figure that might permit the IBP effort to proceed at a reasonable but less than optimum rate, and then consider budget levels 20, 40, and 80 percent lower and higher.

Answer: In general, decreases in funds will result in stretch out of funded programs and projects; increases will be applied to expansion of programs and projects on which plans are fully developed (proposals submitted or ready for submission to granting agencies.) The establishment of a "baseline figure" for the Integrated Research Programs was a major point of consideration during the meeting of 30 April—1 May. Each director and convenor for a major subjective area (potential IRP), as an agenda item, was asked in advance to estimate funding needs for his program or potential program. (Descriptions of these programs are contained in the answers to questions 2a and 9b.) The total of these estimates for FY 70 was \$30.9 million. This is considered as optimal funding. It is the opinion of the Executive Committee that one-half that amount represents "a baseline figure that might permit the IBP effort to proceed at a reasonable but less than optimum rate." Thus the range of figures as defined in the question is:

	Fiscal year 1970 (million)
Base minus 80 percent.....	\$3.1
Base minus 40 percent.....	9.3
Base minus 20 percent.....	12.2
Base	15.5
Base plus 20 percent.....	18.2
Base plus 40 percent.....	21.7
Base plus 80 percent.....	27.9

The USEC/IBP believes it is very unrealistic to consider a one year budget for a program such as the IBP and desires to reaffirm that in its opinion the appropriate budget for a 5-year program is $\$150 \times 10^6$.

Note that base plus 80% is less than the optimal amount, so that priorities of allocation are required at all levels defined in the question. The basis of allocation is described in the answer to Question 10, and includes the present level of funding for each major study. On the following table, a modest level of present funding is indicated by one plus, while two pluses indicates that more than half of the included research is presently funded.

Allocations are detailed on the following table. Three columns are of particular interest: base minus 80%, base, and base plus 80%.

At base minus 80%, or \$3.1 million of additional funds, three fourths of the major studies will be placed on a holding basis, with the minimal support needed to maintain communication and organization.

	Re- quested addi- tional funding, fiscal year 1970	Present suppor	Allocation of various levels of additional funding, fiscal year 1970						
			-80 percent 3, 100	-40 percent 9, 300	-20 percent 12, 200	Base, 15, 500	+20 percent, 18, 200	+40 percent, 21, 700	+80 percent, 27, 900
Eskimos.....	160	+	100	145	145	145	160	160	160
American Indians.....	150	++	0	50	100	150	150	150	150
High altitudes.....	400	+	15	400	400	400	400	400	400
Nutrition.....	5, 193	++	15	500	750	1, 000	1, 100	1, 500	2, 225
Migrant populations.....	5, 000	+	1, 000	2, 000	2, 800	3, 500	4, 000	4, 500	5, 000
Convergent/divergent evolution.....	1, 000	+	250	500	600	700	800	900	1, 000
Biogeography of the sea.....	1, 734	0	100	200	300	400	500	600	1, 000
Aerobiology.....	1, 030	0	50	250	350	480	595	700	1, 000
Phenology.....	280	0	25	100	150	180	200	235	280
Conservation of ecosystems.....	560	+	15	30	30	30	30	30	50
Colonizing species.....	560	0	200	260	260	260	310	360	560
Ecosystems analysis.....	50	++	10	50	50	50	50	50	50
Grasslands.....	1, 300	+	1, 200	1, 300	1, 300	1, 300	1, 300	1, 300	1, 300
Deciduous forest.....	2, 000	0	15	1, 000	1, 500	2, 000	2, 000	2, 000	2, 000
Coniferous forest.....	2, 000	0	15	500	700	1, 000	1, 200	1, 600	2, 000
Desert.....	2, 000	0	15	500	700	1, 000	1, 200	1, 600	2, 000
Tundra.....	2, 800	0	15	400	450	500	800	1, 000	2, 000
Tropical.....	1, 800	0	15	400	500	600	900	1, 200	2, 000
Biological control.....	2, 929	++	0	300	500	1, 000	1, 400	2, 000	2, 900
Nitrogen.....	561	0	15	200	250	280	350	450	560
Marine mammals.....	668	++	0	100	150	200	200	450	650
Crop stress.....	600	0	15	100	200	300	400	500	600
Gene pools.....	15	+	15	15	15	15	15	15	15
Total.....	31, 245								

These small allocations are made in the expectation that later years will produce more funds, and that we should attempt to preserve the progress that has been made.

This column also indicates studies of highest priority, with major support going to the Grasslands Study and the program on Migrant Peoples. Smaller levels of support are provided for the studies of Eskimos, Convergent and Divergent Evolution, and Colonizing Species.

At base, or \$15.5 millions of additional funds, all studies can receive significant support. Here also, however, some will be funded at levels well above one half of the amount requested, others at levels well below one half the amount requested.

At base plus 80%, or 27.9 millions, most of the studies can be funded at the levels requested. Among them, the programs on Nutrition and on Biogeography of the Sea are, in our opinion, least likely to be ready to use their estimated requests.

These allocations represent our current view. Since the readiness of investigators may change, these allocations may be changed. It is expected, for example, that allotments among the biome studies (except Grassland) may change as research designs are developed.

Question 2.h.: How can modified goals be introduced and made acceptable to the public and private organizations involved?

Answer: The mechanism for introduction and modification of goals is generally described in the answers to Questions 1.c. and 2.b. Adhering to the organizational structure described and with full interaction with the ICC changes would be considered and courses of action decided. All means of communication available would be pursued.

Question 3. The name "International Biological Program" is not accurate as a descriptor of the U.S. effort. Why is it not changed, at least in the U.S., to one of those suggested forms that is more descriptive?

Answer: The name "International Biological Program" was arrived at internationally and cannot be changed unilaterally.

Question 4. Briefly, what scientific, economic, or social benefits or advantages relevant to national problems might accrue from a greater understanding of natural or man-induced changes in the environment?

Answer: Benefits from the IBP, in contrast with those of many projects that would be accomplished without the program, derive from the scope and degree of integration that characterize the major studies. Synthesis of information will produce a level of understanding in complex systems that is not otherwise possible.

In this way, the scientific and management resources of the nation can be utilized to a level commensurate with the problems of our time. As Dr. Ivan Bennett testified recently in Congress:

"While environmental change is not qualitatively new, today's problems and our concern are new because of the new quantitative aspect of the change—the scale, variety, and speed of the changes in man's physical and social environment."

The Integrated Research Programs of the US/IBP provide a scale of synthesis adequate to solve these problems. Our ability to predict the consequences of new developments will be vastly improved. In similar fashion, we will be much more able to locate the source of problems in the performance of complex systems, so that we may correct the source rather than alleviating the problem with symptomatic treatment.

Direct benefits will accrue to a wide array of major problems ranging from urban violence to the preservation of natural areas, from the genetic and physiologic potential of man to the productive potential of the biosphere, and from the acculturation of primitive people to the restoration of environmental quality. In all of these, the scientific, economic, and social gains are inseparable.

Seemingly the President of the United States recognized the world-wide need for this program and the scientific, economic and social benefits that it would produce when he commented at Glassboro State College on 4 June 1968:

"Scientists from this country and the Soviet Union—and from 50 other countries—have already begun an international biological program to enrich our understanding of man and his environment.

"I propose that we make this effort a permanent concern of our nations. I propose that the United States scientists join with the scientists of the Soviet Union and other nations to form an international council on the human environment."

Comment: The four parts of this question all are concerned with national/international participation in IBP research. The entire idea of a successful IBP rests on the need for *coordinated, cooperative* efforts by scientists of all participating nations; and with the interlacing of these efforts at all levels. This concept embraces team efforts, preagreed individual efforts which when added to all others presents a cohesive whole, agreed methods, and collection, storage, retrieval and sharing of data.

Under the above concept it seems somewhat inappropriate to so partition the U.S. national program from the programs of other nations that the purpose of the *international* program is obscured.

Within the following answers an endeavor is made to retain as fully as possible the concept of this comment.

Question 5. a.: What benefits to the international effort might result from U.S. participation in the IBP?

Answer: The first benefit of the IBP from U.S. participation is wider access of the biologists of the world to the capabilities of U.S. biologists and their research information. This is accomplished by joint participation in work sessions and research projects, and by communication and by exchange of published information.

The unique technical capacity of this country in systems design and analysis; and acquisition, storage, manipulation retrieval and availability of data will be a large part of the above.

Question 5. b.: Identify any instances in which programs of other nations are dependent on findings from U.S. studies. Include here, for example, any known cases in which basic knowledge resulting from U.S. studies is essential before a

planned study can be successfully undertaken or completed by another nation.

Answer: The U.S. will be able to aid the scientific and technological advance of developing countries (e.g., those in Latin America) through its participation in cooperative international programs. Interactions between US-IRP's and similar programs among participating nations will result in mutual overall benefit. The apparent ones on which agreed interactions have been established are:

Human Adaptability Component

International Study of Eskimos—U.S., Canada, France, Scandinavia, and probable participation of Russia.

Genetic Studies of American Indians—U.S., Venezuela, and Brazil.

Ecology of Migrant Peoples—U.S., Israel, Japan, Canada, and other possible participation.

Biology of Human Populations at High Altitudes—U.S. and Peru, and developing participation of other nations,

Nutrition—worldwide coordination is involved and in the formative stage.

Environmental Component

Ecosystems Analysis—U.S., Canada, Mexico, and Latin America with worldwide coordination established through SCIBP and being refined through UNESCO conference on "The Rational Use of the Biosphere." Worldwide coordination on Grasslands established through SCIBP.

Aerobiology—U.S., U.K., and Australia with worldwide coordination being established through (1) First International Congress on Phytopathology and (2) a SCIBP committee for establishing a worldwide network of monitoring stations.

Phenology—International coordination in formative stages.

Biogeography of the Sea—U.S., U.K., Canada, Brazil, and other Latin American countries, Germany (FRG), Austria—SCIBP is fostering participation from among nations that have special economic interests in marine species and genera.

Convergent and Divergent Evolution—U.S., Venezuela, Brazil, Argentina, Chile, Colombia, Peru, Puerto Rico, Uruguay, and Australia, and under the Hawaii Terrestrial Biology Subprogram—Pacific nations and territories: Samoa, Fiji, French Polynesia, New Zealand, Australia, New Guinea, Indonesia, Philippines, Southeast Asia, Taiwan, and Japan.

Physiology of Colonizing Species—U.S., Venezuela, Brazil, Argentina, Mexico, Colombia, Costa Rica, Chile, and Australia.

Other major studies that might be undertaken (potential IRP's) are discussed under Questions 8a and 9b. International coordination and participation of foreign scientists in comprehensive workshops (program planning) in each of these potential major studies have been accomplished.

Question 5.c.: Separately identify those studies in which the U.S. ought to be an active collaborator with another nation in a jointly sponsored project and explain why.

Answer: The U.S. not only ought to be, but actually is, a collaborator with other countries in several integrated IBP programs. The study of Eskimo peoples logically involves nations with interests in the Arctic, hence the collaboration of the U.S. with interested countries in studies of *Eskimo populations* is natural. Studies of man's adaptation to high altitudes are of similar international interest, and so are the studies of the genetics of American Indians.

The U.S. IBP is working in close collaboration with pertinent biologists of 8 South American countries in an assessment of the diversity and evolutionary history of the biota of the Western Hemisphere. Specific programs include: (1) Convergent and Divergent Evolution, (2) Physiology of Colonizing Species, (3) Biogeography of the Sea.

Question 5.d.: By what means and to what degree should the U.S. (in the form of the U.S. National Committee, the Federal agencies, or the participating universities) foster development of research studies involving close collaboration with other nations?

Answer: The U.S. organization for IBP should take, and already has taken, a strong role in fostering the development of research studies that involve close collaboration with other nations. This has been particularly true of Latin America, where large numbers of Latin biologists have become involved in cooperative U.S.-Latin American efforts through the intervention of U.S. scientists. The holding of three U.S.-sponsored IBP conferences in Latin America (Convergent and Divergent Evolution and Physiology of Colonizing Species in Venezuela, and Plants Under Stress in Costa Rica) has greatly stimulated Latin

American participation in the IBP and coordination of their research programs with those of the U.S. Two conferences (Biology of Human Populations at High Altitudes and another dealing with Population Genetics of American Indians) held in Washington have had strong participation by Latin American biologists.

Question 6: In what way will the over-all international program, or the programs of other specific countries, benefit the U.S.?

Answer: The over-all international IBP will benefit the U.S. in various ways:

(1) it will provide the best assessment presently available of the state of preservation or deterioration of the biosphere.

(2) It will provide the bases for predicting future changes in the biosphere as a result of man's activities.

(3) It will permit comparison of similar ecosystems of the world under relatively different levels of human exploitation.

(4) International coordination and cooperation under the IBP should accelerate the development of basic scientific knowledge and technological "know-how" of developing countries and hence reduce the financial burden which the U.S. has borne for development of such countries.

(5) It will increase basic knowledge of the biological diversity of the world in which we live.

Question 7: The terms problem, project, program, study, integrated study, and others have been used in various ways in referring to IBP undertakings. To minimize confusion in interpreting responses to the questions below, we ask that the Committee explain the terminology that should be employed, and is employed by the Committee, in referring to IBP undertakings of various sizes, scopes, complexities, and interrelationships. Our term "major study" is intended to refer to something roughly equivalent in scope to the "grassland project", but it is intentionally left vague so the Committee can interpret "major study" in terms appropriate to its answers.

Answer: It is important that the answer to this question be clearly understood among all Federal agencies and among all scientists participating in the US/IBP. The U.S. effort has produced two general types of proposals; (1) proposals for central coordination and operation of integrated research programs and subprograms and (2) project proposals. The latter may be submitted in either of two ways. First, separate project proposals representing essential components of IRP's may be submitted to different granting agencies. Second, project proposals generated independently by investigators responding to the nation-wide invitation of USNC/IBP may be submitted to one or more granting agencies.

It is the strong opinion of the USEC/IBP that IRP proposals and related essential components can be evaluated for support *only by the ICC*. Evaluation of such proposals by scientific review panels and study sections of granting agencies usually results in extensive misunderstanding, prolonged explanations, frequent observations by the panel involved that the IRP proposal does not fall within the panel's established field of review.

With the above background the following definitions are offered:

1. *Man's Survival in a Changing World*: the theme of the U.S. effort.

2. *Components*: the primary elements of the theme; they are:

(a) *The Human Adaptability Component* and

(b) *The Environmental Component*

3. *Integrated Research Program (IRP)*: within one of the defined components, a program to provide central services, coordination and synthesis of scientific results of a group of subprograms and projects. Established IRP's are listed in the answer to Question 2a. Examples are "International Study of Eskimos," "Genetic Studies of South American Indians," "Ecosystems Analysis," "Convergent and Divergent Evolution," "Biogeography of the Sea" etc.

4. *Potential IRP*: a specific subjective area in which one or more working conferences have been conducted for the purpose of promoting program planning for an IRP; but in which agreed relationships have not been established and program development has not yet been proposed to and approved by the USEC/IBP. Examples are "Ecology of Nitrogen," "Plant-Insect Chemical Interactions," etc. A complete listing will be shown under Question 9b.

5. *IRP Subprogram*: a major subdivision of an IRP. Examples are the six biomes of "Ecosystems Analysis" ("Grasslands," "Deciduous Forests," "Coniferous Forests," "Tropical Rain Forests," "Tundra," and "Desert"), the several subprograms of "Convergent and Divergent Evolution" etc. All include a significant number of projects, coordination of which is sufficiently complex as to require this intermediate level.

6. *IRP Project*: a basic element of an IRP. The project proposal may be (1) self-contained within an IRP or an IRP Subprogram or (2) submitted subsequent to submitting an IRP proposal.

7. *IRP Proposal*: a proposal to the ICC for support of an IRP as defined above. An IRP proposal requires approval of the USEC/IBP prior to submission to the ICC.

8. *IRP Project Proposal*: a proposal to a granting agency or agencies for support of an IRP project.

9. *IBP Related Project*: a proposal independently developed and submitted to a granting agency; and as a related matter submitted to the IBP Staff for identity with the "U.S. Research Studies for the IBP" as defined above. When funded, such projects are *not* included within an IRP until coordination between principal investigators results in mutual acceptance of the principles and details of program coordination.

Question 8. a.: What are the presently identified major studies?

Answer: Twelve major studies of the US/IBP are specifically identified as IRP's. These are described in some detail in the answer to Question 2a. In addition, the following are in various stages of development:

1. Ecology of Nitrogen
2. Biological Control (three parts)
3. Crop Production under Stress
4. Productivity and Conservation of Marine Mammals
5. Conservation of Genetic Materials

Question 8. b.: For each major study describe the scientific purpose, its expected contribution toward IBP objectives, and the presumed benefits in approximate order of importance that can be anticipated.

Answer: For the 12 major IRP's the descriptions are to be found in the answer to 2a. Descriptions of the 5 additional major studies named above are as follows:

1. *Ecology of Nitrogen*—Considering the over-all need for a program to provide nitrogen in a fixed form to meet the needs for an adequate world food supply, it is necessary to obtain information on the following general subjects:

a. The evaluation of the nitrogen status of the world both in isolated native ecosystems and in broader socio-economic structures with particular emphasis on man.

i. The determination of the significance of symbiotic nitrogen fixation, both by legumes and by nonleguminous plants—microbial associations in native ecosystems.

ii. The determination of the extent of nonsymbiotic nitrogen fixation in tropical, temperate and arctic climates.

b. A comparative study of the protein and caloric yield of leguminous plants utilizing atmospheric N_2 as a nitrogen source as contrasted with (a) leguminous plants grown on exogenously supplied nitrogen, and (b) other plants, particularly cereals, utilizing exogenously supplied nitrogen at optimal levels.

c. A combined economic and sociological study to determine the optimum comparative balance between the dependence upon biological systems for nitrogen fixation and the use of industrially fixed nitrogen fertilizers, taking into consideration the potential for a given area to produce biologically fixed nitrogen in terms of its food needs as contrasted with the economics and logistics of providing industrially fixed nitrogen.

d. A study of the effect which the use of nitrogen fertilizers may have on the quality of the environment with special reference to:

i. The contribution of nitrogenous fertilizers to nitrate in ground water, levels of nitrate in ground waters which can be tolerated over a long-term basis, and means for minimizing this contamination.

ii. The effects of high levels of nitrogen fertilization upon the quality of food products.

iii. The potential effect of nitrification inhibitors on the quality of food products.

e. A critical evaluation of the extent to which an energy input for the industrial fixation of nitrogen in a given social unit can, by the increased production of food in that unit, result in an increased total efficiency and a higher living standard.

f. The expansion on all parts of investigations concerning the processes of nitrogen transformation with special emphasis on the processes of nitrogen fixation, nitrification, denitrification and the movement of nitrogen in soils and ground waters. *Although information is necessary in all of these areas, some of*

them are more critical than others and some of them are more amenable to immediate solution under a biological program. The present proposal concerns itself only with the following specific items.

- i. An evaluation of nonsymbiotic nitrogen fixation in tropical, temperate, and arctic climates both in native systems and in agricultural environments.
- ii. A comparative study of nonsymbiotic nitrogen fixation and the use of industrially supplied nitrogen fertilizers in meeting the nitrogen needs for efficient food production.
- iii. The nitrification reaction as carried on by autotrophic organisms and hetetrops in relationship to agricultural practices.
- iv. The significance of nitrates in ground waters, streams and lakes and mechanisms for maintaining the qualities of these waters.
- v. Systems of nitrogen loss including leaching and denitrification reactions.

Coordination and Administration

The coordination of such a program of study should yield results beyond those which could be expected from a number of independent workers communicating only through the journals or occasional scientific meetings. It would be desirable to offer coherence, coordination and direction by the provision of some administrative structure for the activity. A possible mechanism would be to have a program coordinator who would have over-all responsibility and would perform these duties in addition to his ordinary research activities. He could have an advisory committee consisting of either the Production Processes Subcommittee of the IBP National Committee or another group of individuals selected by the Production Processes Subcommittee to guide him in the selection and coordination of programs and other policy matters. He would profit by having a program administrator who would handle matters of communication, budgeting, publication and other details.

2. *Biological Control*—This subject has developed along three lines. They are:

a. *Plant/Insect Chemical Interactions*—It has been shown that plants contain highly active substances that may attract insects for feeding, for mating, or for oviposition. Such substances may be highly selective in their biological activity. Intensification of research in this area could contribute to the ultimate goal of achieving effective, safe, and more specific insect control methods. Highlights of research developments are reviewed in this report.

Although full knowledge of the toxicology of these new types of chemicals derived from plants and animals is lacking, there is every indication as developed during the conference that they are highly selective in action on insects, often on a narrow range of closely related insects. Thus, the hormonal and other new types of growth- and behavior-regulating chemicals offer opportunities for developing new classes of biologically active agents that are selective in action of destructive insects, without hazard to man and his environment. Moreover, unique biological properties of these agents, such as delayed disruption of insect development, interference with reproductive processes or changes in the behavior of insects could lead to highly effective, safe, and novel approaches to insect control.

Efforts need to be maintained on such alternate methods in order to develop the most effective and acceptable approaches to insect control. However, other new approaches may materialize as the result of basic research on fundamental life processes in insects. As revealed in the work conference, rapid progress has been made in establishing the presence of, and in, the isolation and characterization of natural agents in insects that regulate insect development and behavior. Moreover, it has been shown that some of the natural growth regulating chemicals that occur in insects may also occur in plants and in animals other than insects. Chemists have succeeded in synthesizing several of these natural agents, including the juvenile hormones and ecdysones. New chemicals, structurally related to naturally occurring chemicals, are being synthesized which may possess biological activity greater than the naturally occurring parent compounds.

The goals in insect/plant interactions would be to gain information on, and eventually develop for practical use, naturally occurring hormones in insects and/or plants for the selective control of destructive insects, without creating adverse effects on nontarget organisms in the environment. Practical achievements, based on current rate of progress in this field, could be realized in two years, but a period of five years would be needed to fully explore the potential for this approach to insect pest control.

b. *Plant/Plant Chemical Interactions*—A great variety of substances produced by plants or animals stimulates or depresses the development and growth of neighboring organisms. Local concentrations of wastes or other animal excretions may be sufficient to exert measurable influences, but chemicals of plant origin are more abundant and generally are more complex so that they are of more widespread consequence in the natural environment.

Inhibiting or stimulating effects may be produced by substances released from one plant when they contact another plant of the same or a different kind. The active substances may be synthesized in any part of the donor plant and may be released by volatilization, excretion, leaching, leakage, or during decay of dead matter. These phenomena appear to be universal in occurrence and of great importance in natural and managed vegetation. They affect productivity (including crop yields), nutritive value, susceptibility to disease, nutrient cycling (for example, by inhibiting nitrifying organisms), and they are of primary importance in population density control and in the development and maintenance of pattern in vegetation.

The immediate objectives of this program are: (1) to discover plant species that release, from living or dead tissues, chemical substances which stimulate or inhibit the germination, growth, or reproduction of other plants or micro-organisms and to determine the effects of such substances on the structure and function of natural and managed ecosystems; (2) to determine the identity of the chemical substances involved, to discover their pathways of synthesis, movement, and accumulation within the donor plant and how these processes are affected by genetic, physiological, and environmental conditions, and to determine the mechanisms by which the chemicals escape; (3) to determine the fate of such chemicals in the environment, including sites of accumulation in soil, structural alterations by micro-organisms or soil chemicals, secondary compounds formed by breakdown, and duration under various conditions and in different habitats; and (4) to determine the mechanisms of entry into receptor plants and the mode of action that stimulates or depresses vital processes of the receptor.

The ultimate goal of the program is to relate the knowledge produced by its basic research to more effective management of the earth's landscape, especially to the production of agricultural crops and other usable plant products. Stimulatory substances appear to have a potential to increase crop production beyond levels obtainable with fertilizers and other amendments in current use. Depressants, or inhibitors, probably will be discovered which will allow highly selective elimination of undesirable plants from croplands, rangelands, forests, and other managed areas. Synthesized biochemicals may be used to effect rapid reforestation of cutover, cleared, or burned sites or they may be used to prevent the growth of all or selected species of trees and shrubs. Management of the last type could be used immediately for low-cost maintenance of highway and utility rights-of-way and to create and maintain open fields for aesthetic or utilitarian purposes. It also could be employed to maintain fallow cropland in an easily reclaimable condition. Research Proposal Received (9 July 1968): Subprogram A. Biochemical interactions in natural and semi-natural ecosystems (including forestry, range management, landscape management, and related less intensive management).

Terpene release and its effects on neighboring vegetation in pine stands in Southeastern United States (H. Lieth, University of North Carolina).

Chemical interactions as driving and retarding mechanisms in vegetation development on disturbed soils (J. McCormick, Academy of Natural Sciences of Philadelphia).

Inhibitory effects of sunflower on associated species in fallow cropland (R. Wilson and J. McClure, Miami University, Ohio).

Production by seed plants of chemicals inhibitory to microorganisms and higher plants and the roles of such substances in old-field succession (E. L. Rice, University of Oklahoma).

Role of biochemical interactions in the vegetation of the later stages of old-field succession (R. B. Hanawalt, University of Pennsylvania).

Biochemical interactions among some woody plants of central New York (K. L. Greene, State University of New York, Morrisville).

Role of biochemical interactions in the establishment of alien plants in mature forests (M. F. Buell, Rutgers, The State University of New Jersey).

Inhibition of nitrification in climax vegetation (E. L. Rice, University of Oklahoma).

Subprogram B. Biochemical interactions in intensively managed ecosystems (agricultural, horticultural, and related).

Study of phytotoxic substances in crop residues and microorganisms and their effect on subsequent crop growth (T. M. McCalla, Nebraska Agricultural Experiment Station).

Role of ethylene in competitive relationships between crop plants and weedy witch grass (*Agropyron repens*) (K. P. Buchholtz, University of Wisconsin).

Subprogram C. Genetics, physiology, and structure of stimulatory and inhibitory plant substances (studies not related to direct vegetation effects).

Composition of terpenoids in conifers (E. Zavarin, University of California, Berkeley).

Physiology and genetics of terpenoid production in conifers (E. Zavarin, University of California).

c. *Biological Control of Pest Insects and Mites*—A great many of our arthropod pests are aliens from foreign lands that have arrived here without the natural enemies that hold them in check in their home environments. Chemicals used against such pests of our crops often entail the destruction of the endemic enemies of formerly innocuous alien or endemic species, occasioning the appearance of such species as "new" pests. Moreover, use of such chemicals often results in development of resistance to the chemicals used against them and further aggravation of the problems. Importation of the enemies of the alien pests and conservation and encouragement of endemic enemies of both the alien and resident pests often serves to alleviate such problems in ways that do not add to the ever-increasing load of environmental pollution by use of pesticides.

A program of biological control of pest species bears directly on the main theme of IBP, that is, productivity and human welfare. It is a means of managing our agricultural environment with proper concern for long-term human needs. It is directly related to productivity in that pest species can so greatly reduce productivity, particularly the yield to man, if they are not controlled, and it is directly related to human welfare in that control by their enemies is not attendant with the environmental pollution and direct hazards to humans and to wildlife that is occasioned by use of toxic chemicals.

The above three elements of Biological Control have been grouped and have been included at the 6th step in the funding estimates at Question 2g.

3. *Crop Production Under Stress*—The clear necessity of matching food production to the needs of the world's population requires an accurate knowledge of the factors limiting primary production in the various regions and environments of the globe. The objectives of this program are: (1) to identify the environmental factors that limit production of plant materials, particularly foodstuffs; and (2) to encourage and coordinate research on the nature of the physiological responses of plants to environmental stresses.

Recognizing the limitations of time, funds and personnel, this program focuses on certain immediate problems of a specific nature in the Western Hemisphere. These are: (1) increasing plant tolerance to drought, (2) increasing plant tolerance to temperature extremes, and (3) increasing rooting zone volume particularly in tropical soils. The program encourages investigations of environmental factors using an international team approach with local and visiting scientists working together. Concomitantly with field studies, laboratory and model studies are encouraged. The end results of this program will provide a logical basis for manipulation of the environment and biological factors involved in plant production.

This Potential IRP is included at Step 7 in the funding estimates in answer to Question 2g.

4. *Productivity and Conservation of Marine Mammals*—Marine mammals are largely pelagic, truly international, and represent a large source of protein and fats. Their exploitation has largely been heedless of biological realities so that population after population has been drastically depleted. It is striking that the adaptation, systematics, distribution and abundance of most species remain uncertain or unknown.

Current research on marine mammals in the fields of systematics, behavior, physiology, acoustics and anatomy is urgently in need of expansion and integration so that an intelligent approach to this major resource will evolve on a national and international level. The IBP offers the best opportunity to gather together research-oriented marine mammalogists into a comprehensive, international, non-political program. The U.S. program will initially establish a Marine Mammal Coordinating Council to integrate existing programs, will aid

to develop a Central Museum Repository for specimens, and a liaison with the National Oceanographic Sorting Center will investigate a training program for students, will sponsor international marine mammal symposium, and will cooperate closely with several other phases of the US/IBP (phenology, human adaptability, biogeography of the sea, etc.). Broader research programs will develop with sea-going logistics, paramount among which is a ship or ships especially committed to the program (oceanographic and/or commercial vessels) and capable of capture and observation of specimens.

The U.S. program is in close liaison with the international program through the PM Section of the U.K. Already, viable programs, especially in population dynamics and behavior, are emerging in the U.K., U.S.S.R., and Japan, among others.

Only by developing a strong U.S. program with international ties will we collectively develop effective research leading to a full understanding of even a portion of the aquatic adaptation of marine mammals. Only by understanding those adaptations will use and management be approached intelligently on a world basis and the full potential of marine mammals be realized. The IBP represents perhaps the last great opportunity fully to understand these unique and historically important animals for their own sake and for the benefit of man.

This Potential IRP has been included at step 7 in the funding estimates in answer to Question 2g.

5. *Conservation of Genetic Materials*—The genetic resources of plants by which we live are dwindling rapidly and disastrously. Yet these are the very raw materials on which plant breeding and related agricultural research depend for increasing production efficiency.

The United States, with no native resources of major crop plants, has Agency programs (USDA) on the introduction, evaluation, and conservation of genetic materials from abroad. There is a national need to assure the protection of these invaluable resources on a world-scale through fundamental research. These efforts will provide future generations with one of the most powerful, single weapons for agricultural improvement.

In the international field, IBP is a source of scientific expertise in problems of exploration, utilization, and conservation of plant gene resource; since these are essential to developing and developed countries alike. On the national scene, IBP is a vehicle for relating research in the academic area to the needs of Agency programs of plant introduction, utilization and conservation.

These programs will benefit from new inputs in crop evolution, systematics, and plant geography as they relate to world centers of diversity. The remarkable changes undergone by cultivated plants in a very short period of time and the projected changes in the future offer remarkable opportunities to study primitive crop ancestors and their weedy relatives as a basis for more effective programs of plant exploration, use, and conservation of this essential base of crop variability.

Outputs of the IBP efforts in conservation of genetic materials are (1) effecting support in FAO for a program officer on plant introduction and (2) the development in 1968, of a text on plant introduction methods for college use and as a guide for developing countries. A US/IBP input of national interest is a symposium on Centers of Plant Diversity and Conservation of Germ Plasm at the forthcoming AIBS meeting, Columbus, Ohio.

The Presumed Benefits of the Major Studies follow:

I. HUMAN ADAPTABILITY COMPONENT

A. INTERNATIONAL STUDY OF ESKIMOS

1. Definition of environmental limits of adaptive process.
2. Biological and behavioral mechanisms of population regulation among peoples living in a harsh environment.
3. Growth norms for Eskimos.
4. Dental and medical health of Eskimos.

B. POPULATION GENETICS OF AMERICAN INDIANS

1. Baseline studies of primitive peoples providing insights into biological and behavioral adaptive capabilities of modern man who lives under rapidly changing stresses
2. Dental and medical health of American Indians

C. BIOLOGY OF HUMAN POPULATIONS AT HIGH ALTITUDES

1. Definition of environmental limits of adaptive process.
2. Biological and behavioral mechanisms of population regulation among peoples living in harsh environment.
3. Insights into mechanisms of cardiovascular diseases (Incidence of these diseases low among people living above 10,000 feet).

D. NUTRITIONAL ADAPTATION TO ENVIRONMENT

1. Definition of requirements for nutrients among peoples living under environmental extremes.
2. Insight into cultural differences in food habits and their nutritional consequences.
3. Definition of minimal requirements for nutrients.

E. ECOLOGY OF MIGRANT PEOPLES

1. Insight into biological and behavioral adaptations made by migrant groups.
2. Insight into processes of unrest during social change.
3. Insight into adaptive capacity for stresses of urbanization and industrialization.

II. ENVIRONMENTAL COMPONENT

A. ANALYSIS OF ECOSYSTEMS

The six biome studies are further integrated through a central program, which could be considered a major study in itself. The benefits of this central program, which apply also to the biome studies, are:

1. Understanding of ecosystem principles.
2. Landscape management for the maintenance of environmental quality.
3. Resource management for optimal land use.
4. Resource management for multiple use.
5. Potential for the production of biological products useful to man.
6. Conservation of water supplies.
7. Baseline studies for programs of weather modification, pollution abatement, etc.

B. AEROBIOLOGY

1. Document the pathways and mechanisms of atmospheric dispersal in the biosphere.
2. Clarify routes of transmission of airborne diseases.
3. Document the dispersal of allergenic substances.
4. Produce information on the dispersal of harmful airborne pollutants.

C. PHENOLOGY

1. Produce climatic maps that integrate many weather variables in ways most meaningful to plants and animals.
2. Produce seasonal schedules of natural events that are most useful in many problems associated with agriculture, forestry, pest control, and conservation.
3. Through a better understanding of mechanisms, a better ability to predict the viability of an organism in a new environment, and of traits to be selected in breeding.

D. CONVERGENT AND DIVERGENT EVOLUTION

1. Provide an up-to-date and scientifically accurate assessment of the diversity that exists in tropical ecosystems and a scientifically definable theory as to how that diversity has come about.
2. Lay groundwork for increased knowledge of tropical ecology. Acquisition of such knowledge has priority if the present trend toward reckless and scientifically unbased exploitation of tropical systems is to be reversed.
3. Boost the quality of basic biology in the Latin American countries, and the conferences and intercommunication under this program have already demonstrated that it is quite possible to break down the traditional national barriers to scientific cooperation that have plagued Latin American science.

E. CONSERVATION OF ECOSYSTEMS

1. Provide an inventory of those natural areas which this country has already set aside for conservation and for research. This is being done at the levels of the Federal structure, state governments, and the private sector. Such an inventory is essential to an assessment of our needs for additional areas.
2. Provide an inventory of high priority areas for preservation in all of the New World, through collaboration with counterpart scientists of this hemisphere.
3. Stimulate conservation efforts by groups other than the IBP task force, and these activities should foster an increased awareness by the general public of the need for conservation or representative samples of ecosystems.

F. BIOGEOGRAPHY OF THE SEA

1. Increase knowledge of how economically important estuarine animals respond genetically and physiologically to latitudinal gradients.
2. Increased cooperation and joint training among North and South American scientists. Among other things this will enhance basic skills and knowledge of an important food resource (i.e., estuarine organisms).

G. PHYSIOLOGY OF COLONIZING SPECIES

1. A much better understanding of why some species are capable of becoming "weeds," while most lack such capability. Applications are obvious for present and future management of the earth ecosystems.
2. Promote competence in basic biology in the collaborating Latin American countries.

H. CROP PRODUCTION UNDER STRESS

1. Heat, cold, moisture and root volume are major parameters determining crop yields. In many environments, yields might be doubled by use of better adapted plants and the manipulation of plants and these environmental variables.
2. Crop stress problems are of critical importance in developing countries where, for example, drought often means starvation for many people.

I. ECOLOGY OF NITROGEN

Efficient use of nitrogen could save billions of dollars in cost, enhance the world's food supply and contribute substantially to the quality of our environment.

1. In the U.S., we add 6 million tons of nitrogen fertilizer annually. Current dollar return shows a 3:1 advantage and use is increasing rapidly here and in all the world. Use must increase to feed the world.
2. Biological fixation of nitrogen by legume-bacterial symbionts, free living bacteria, and blue green algae, together with nitrogen compounds entering the biosphere dissolved in rain, are the replenishing nitrogen sources which, together with decomposition of crops and other residues contribute most of the nitrogen in harvested crops of the world at present levels of fertilizer usage.
3. As nitrogen availability increases, efficiency of use by plants diminishes. As we double current applications, no more than half the additional amount will be harvested. The remainder will enter the environment, chiefly through the atmosphere.
4. Some will enter the runoff water and contribute to eutrophication, some may enter ground water.

J. BIOLOGICAL CONTROL

1. When feasible, plant diseases, insects, and weeds can assure food production without the cost and hazards of chemical control and save many billions of pounds of food. With respect to plant diseases, genetic resistance is a major tool in current use in all developed countries. Biological control of insects and weeds has been substantially replaced by chemical control, resulting in persistent residues of chlorinated hydrocarbons, and sometimes of mercury or arsenic in the biosphere.
2. Feasibility of biological control of scale insects, for example, is established. Viral and bacterial insect pathogens are potentially safe and useful. Parasites and predators offer further possibilities as does the sterile male technique. The U.S. can gain immensely through biological materials obtained in areas of origin of our crop plants—where the parasites and predators of their insect pests may be found. Developing countries have most to gain.

K. CONSERVATION OF GENETIC MATERIALS

1. The spectacular success of IR-8 rice and Mexipak wheat illustrate the benefits to be derived from fortunate combinations of genetic materials. IR-8 was derived from the eighth cross of rice made at IRI. Mexican wheat incorporated the dwarf gene, originally found in Japan, and used earlier in producing Gaines wheat in Washington State. The current incorporation of genes for high lysine and high protein found in Indiana into the maize of many countries using this crop as a food grain is further evidence of potential.

2. Sorghum and cassava present other opportunities, indeed every plant does. But since half the world's food is cereal, and source yield, composition of product and disease resistance are all subject to biological manipulation, cereals are of first concern.

L. PRODUCTIVITY AND CONSERVATION OF MARINE MAMMALS

1. Complete knowledge of the distribution and abundance of mammals such as the Antarctic phocids, the smaller cetaceans, and the northern mammals associated with pack ice.

2. The conservation of species currently comparatively unexploited but which could and probably will be increasingly used as a source of food.

3. Studies must be international, and such a broad program can only be effectively pursued under a program such as the IBP.

4. This research will require significant advances in underwater telemetry and observation techniques, development with considerable application to many other oceanographic fields.

Question 8.c.: Describe the ways in which these benefits are relevant to solution of current national problems and expected future problems.

Answer: This question has been previously answered, in a general way in the answer to Question 4 and in detail in answer to Question 8b.

Question 8.d.: Which of the benefits described might be quantifiable?

Answer: From the observations and data accruing in these IRP's, the several benefits should be quantifiable, and be directly applicable to the solution of national problems.

Question 9.a: For each develop displays (suggested formats are attached) showing significant dates for the study, funds required for each stage of development, and kinds of activities included.

Answer: The requested tables are shown at end of appendix C.

Question 9.b.: What other major studies might be undertaken?

Answer: The following major study might also be undertaken: Chronobiology—the study of the temporal characteristics of biologic phenomena including as subspecialties: a) Chronophysiology—study of physiologic factors underlying biologic temporal characteristics, e.g., adrenal, renal and metabolic factors underlying the phase-shifting of rhythms following intercontinental flights (see below); b) Chronopathology—study of alterations in biologic temporal characteristics as 1) functions of disease, and, what seems more important, as 2) determinants of disease; c) Chronopharmacology—study of drug effects 1) upon biologic temporal characteristics and 2) as a function of biologic timing. Thus, by improving the toxic-therapeutic ratio of a drug, added benefit may be derived from now conventional therapy, e.g., a reduction of side effects. More important, to the extent that rhythm alteration, e.g., circadian desynchronization, contributes as a determinant of disease, new therapeutic applications may be found for now conventional drugs (e.g., ACTH for resynchronization) or new drugs may be developed; d) Chronotoxicology—study of undesired or harmful effects from chemical, physical or other agents, including poisons, pollutants and overdoses of drugs 1) upon biologic temporal characteristics and 2) as a function of biologic timing. Work in any one of these subspecialties is within the scope of the program since such work depends heavily upon the quantification of biorhythms and the phase shifting for the study of interactions among rhythms.

The international program on chronobiology includes among its aims:

1) Rhythms as Chronobiologic Reference Standards for Biomedical Applications:

From rhythmometry, endpoints will be sought to complement various ranges, zones or percentiles of most frequently encountered "Normal values" in a given variable and population. Thus, reference standards will become available from different geographic settings for rhythms in body core temperature, 17-hydroxycorticosteroids in plasma and/or urine and other physiologic variables. Among

others, circadian, circaseptan, circavigintan and menstrual, as well as circannual spectral components are to be mapped. Under several specified conditions to be standardized, the overall level of each variable, C_0 ; the extent of any predictable rhythm, i.e., the amplitude, C ; and an estimate of the rhythm's timing, the acrophase, ϕ , are to be determined—to assess the degree of generality, the reliability and potential applications for chronobiologic information in several population groups.

2) Facilitation of Rhythm Shifts Required to Odd Work Routines or Intercontinental Flights:

To study the effect of rapid shifts in work-rest routines upon circadian and other rhythms—in the absence and presence of geographic displacement. The corresponding phase shift of rhythms will be evaluated primarily on healthy volunteers, first without displacement across time zones into a new societal as well as geographic setting such as that encountered after intercontinental flights, and thereafter with the addition of such flights, involving rapid crossings of time zones. In this stage of study, flights in an East $\longleftrightarrow$ West direction will be controlled by “up-down” flights involving circling above the point of departure and results will be compared also with effects of North $\longleftrightarrow$ South flights. Several large-scale studies on “passenger” and “crew” type subjects will be aimed at checking on earlier findings suggesting that delays of rhythms are physiologically more favorable than advances thereof, in that the number of transient cycles required for adaptation to a new time routine thus is reduced. Further work will be done to determine the potential deficit in terms of mental, circulatory and other performance immediately following a shift in routine or an intercontinental flight.

Question 10.a.: What are the priorities assigned to the major studies?

Answer: These priorities are described in detail under Question 2.g.

Question 10.b.: On what basis are they assigned?

Answer: Basis of Assignment of Priority:

- (1) Relevance to IBP.
- (2) Relevance to fundamental understanding of urgent national problems.
- (3) Funding status, e.g., now funded or new proposal.
- (4) Conceptual clarity of program proposal.
- (5) Competence of responsible investigators in research administration.
- (6) Potential for successfully becoming a major interdisciplinary investigation.
- (7) Potential for relating to on-going or planned federal departmental research.

Question 10.c.: What group is or should be responsible for making and changing the assignments?

Answer: The U.S. Executive Committee for the IBP is responsible for making and changing priority assignments.

Question 10.d.: In what fashion should the priorities be readjusted, assuming the same changes in IBP funding used in responding to Question 2.g.

Answer: Most of the major programs proposed for the U.S. are best funded at least 50% of requested budget. These programs have been conceived as innovative multidisciplinary approaches to fundamental questions. When funds are less than optimal high priority IRP's should be funded to at least 50% and remaining funds should be distributed to other IRP's so that planning of research design, development of innovative methodology, and pilot studies can proceed. As more funds become available, the active research phases of these IRP's can be initiated.

Question 11.a.: What should be the duration of the U.S.-IBP effort, and what are the factors that should influence the choice of any particular time frame?

Answer: The ICSU proposal for an IBP defined a 2 year planning phase terminating in July 1967 and a 5 year research phase terminating in 1972. In describing these limits ICSU has carefully pointed out that:

- The dates assigned are primarily for administrative program definition.
- The planning activity is a continuum extending from several years prior to 1965 through the entire administrative life of the program on into efforts that will follow the administrative end of the IBP.
- The research and coordination initiated within the IBP will certainly continue after the terminating date of the program.

The factors that influence the choice of the time frame are:

International agreement among ICSU members on the dates selected. The U.S. National Academy of Sciences is an ICSU member. The agreements involve representative scientific bodies of 54 nations (the U.S. National Academy of

Sciences, the National Academy of Sciences of the U.S.S.R., the British Royal Society, the French National Academy—etc.).

The recognized urgency for establishing the coordination and accomplishing the research described.

The success achieved to date in obtaining the agreed participation of a great number of scientists.

Question 11.b.: What type of further activity might the Government be called upon to support after formal termination of IBP?

Answer: In general the Government might be called on to support any significant efforts associated with the IBP. These efforts might be identified (1) during the IBP, or (2) at the termination of IBP, or (3) prior to the IBP.

The President of the United States identified one such effort when he stated: "I propose that this effort (IBP) be a permanent concern of our nations. I propose that the United States scientists join with the scientists of the Soviet Union and other nations to form an international council on the human environment."

Another is the recommendation for the establishment of a "National Center for Ecology."

There seems to be a high probability that the SCIBP recommendations for the "establishment of a world network of monitoring stations" will lead to a long term effort requiring U.S. Government support. The associations of the U.S.-IRP's, "Aerobiology" and others with the SCIBP recommendation will require intensive coordination. There seems to be no doubt that this coordination will be achieved.

It is certain that the IRP's now being developed and the coordination now being accomplished will lead to long term programs requiring Government support.

Question 11.c.: If follow-on programs are advisable, what group should be responsible for initiating action?

Answer: Initiating action for follow-on programs might come from a variety of sources. The President of the United States has already taken one initiating action by recommending a world council on human environment. Other initiating actions should originate from recommendations of the USEC/IBP, recommendations of the President's Science Advisory Committee, legislation introduced in the Congress, recommendations of ICSU, the UN and its agencies.

Question 12.a.: From what non-Federal sources, and if possible, in what amounts, might funds be provided to augment IBP support, e.g. states, local governments, universities, industry, private foundations?

Answer: It is hoped that support from private sources to IRP's and projects included within the IBP will increase as programs are further refined. Currently the foundations appear to consider individual proposals on their specific merit and pertinence to the objectives of the foundation with little regard as to their application to goals of the IBP. Only two projects supported by private foundations are currently within the program. Attempts to have the private foundations propose on-going work for the IBP have not been successful. Two of the States are supporting work directly applicable to the Nutrition IRP. Efforts to arouse the interest of the Agricultural Experiment Stations have produced little results. Sufficient staff and funds for more direct personal contacts with industry and with state and other non-Federal agencies have not been available. Practically all universities receiving grants from the Federal agencies contribute a considerable share of the total expenses of the research approved from their own resources. This support is detailed in the applications for Federal support. There seems little probability of substantial support from any sources other than Federal.

Question 12. b.: If significant sums can be procured from non-Federal sources, what implications might this have on the Committee's over-all supervision, coordination, and guidance of the IBP effort?

Answer: Non-Federal sources provide funds for research that they have approved in detail. Such work may have already been within a planned IRP, or directly related to IBP goals. It is coordinated between individual scientists. Support from non-Federal sources would be welcome to the Committee and would give no particular coordination problem. However, as indicated in 12a, efforts to obtain support for the U.S. participation in IBP have proved nearly fruitless.

Question 13: What advantages (or disadvantages) might result from handling IBP as a national program with a special budget rather than as a series of related projects relying on existing budget items.

Answer: It is the considered opinion of all members of the USEC/IBP that the U.S. effort requires a national budget program with a special budget. A less comprehensive approach will result in destructive competition for money among principal investigators; and the goal of sophisticated coordination among scientists; nationally and internationally, will be destroyed. Likewise the planning efforts, carried out with past years' fiscal support, will be largely negated.

Experience to date confirms the great difficulty in maintaining a programmatic approach on the IBP. The interests of the Federal agencies in any one IRP are not sufficient to preserve program integrity; and time-phased plans exhaustively developed among many scientists seemingly do not influence the agency review panels.

It has been suggested that we should not "put all our eggs in one basket" in this manner; and that the diffuse support from multi-agency interests is better than no support at all. The USEC/IBP is convinced that the U.S. Program for the IBP can compete with other budget programs, and that this competition process should be carried out. The position taken by OST during the recent hearings on H.J. Res. 1240 unfortunately, but understandably, has been interpreted worldwide as a lack of interest by the U.S. in the IBP. Strong efforts are required if this impression is to be overcome.

Question 14: In reasonable detail, what management-administrative devices do you think should be, or could be employed between and within university-level groups that would promote the:

- a. Orderly planning and execution of studies?*
- b. Coordination of researchers and their staffs?*
- c. Appropriate sharing of facilities and resources?*

Answer: (14 a., b., c.) The planning process largely precedes the identification and recognition of each IRP. Leadership in the planning lies with the scientific director who must satisfy both the USEC/IBP and the funding agency that he can mobilize the capability to perform the projected studies. In the execution of the studies the scientific director must depend upon and exploit effectively the professional community of interest that is centered upon the project goals.

Coordination of the scientific efforts of peers, either within a university or in separate institutions, can best be accomplished if there is mutual respect, and understanding of the contribution which each must make to the common goal. Under such circumstances the sharing of facilities and resources need present no problems. Successful scientific direction is an adroit performance in personal interrelationships, rather than the imposition of defined administrative techniques.

Question 14, d.: Exchange of accumulated data?

e.: Integration and analysis of results?

Answer: The opportunity of ready access to related or comparable data obtained elsewhere is of itself a device that will foster coherence within and between research groups and may be expected to yield dividends in the recognition of interactions and in the development of more broadly-based conclusions; than would otherwise be possible.

Question 15. a.: By what mechanisms do you think researchers working on essentially similar problems should be, or can be, encouraged to cooperate in directing their efforts toward any predetermined common end?

b.: By what mechanism should, or can their simultaneous efforts be coordinated and integrated into a coherent interdisciplinary end product?

Answer: Researchers are attracted to the program through their interest in helping to solve large-scale problems while at the same time pursuing their own objectives. Where plans overlap, the efficiency of each is improved through a division of labor together with a sharing of results. By subdivision of the problem the analysis achieves greater depth, while the sharing of results produces an overall economy. So far, these benefits have been so self-evident that no problems have arisen.

Question 16. a.: What procedure should be used to ensure that in gathering numerical or quantifiable data the most appropriate scale and level of measurement is employed?

Answer: There are levels of answers to this question that extend from the SCIBP planning for IBP Handbooks, to the U.S. Subcommittees that have pro-

moted development of U.S. Integrated Research Programs, to the program planning involved in the IRP's, to the individual projects and project proposals that make up the total U.S. effort.

SCIBP has published 4 IBP Handbooks and 7 are in preparation. Extensive international collaboration has been accomplished on all, and "the most appropriate scales and levels of measurements to be employed" are understood. The needs for these types of definition and agreement have been among the primary goals of the "International Convenors" of SCIBP. Progress at this level is published regularly by SCIBP in a series entitled "IBP News." This series has had 10 issues to date, and agreement on common units and methods are described in good detail.

Publication of program goals in the Program Statements of the USNC/IBP subcommittees has led to workshops from which Integrated Research Programs have developed. Program planning within each IRP has included definitions of common units and agreed methodologies as essentials for the IRP. Agreements among investigators are accomplished during successive IRP workshops and emanating reports define those agreements. The Biometeorology Panel, an advisory panel for the total U.S. effort and having collateral responsibilities to the NAS Committee on Atmospheric Sciences, is a primary source for agreed common units and methods within that area. This panel coordinates directly with its international counterparts and with other national groups in its area.

The principal investigators on IBP projects and proposals accept the above when they agree to participate in the IBP.

Question 16.b.: What group should be responsible for determining what the appropriate scales and levels of measurement are?

c.: How can that group promote or ensure compliance with their established standards such that independent investigators contributing to IBP efforts will record data that is mutually comparable and useful?

Answer: Answered in 16a above.

Question 17.a.: What plans should be laid and what steps should be taken to provide for application of findings to national problems?

Answer: The data accumulating in the IBP will provide useful baselines for the solution of national problems. The application of these and other data to the national problems should be planning functions of the proposed Ecology Panel of PSAC, the proposed National Center for Ecology, local, state and federal agencies, industry, university, and citizens groups.

Question 17.b.: What plans should be laid and what steps should be taken to foster and promote follow-on research efforts.

Answer: Answered in 11b and c and in 17a above.

Question 17.c.: What group or groups should be responsible for developing and implementing these plans?

Answer: All groups interested in the national welfare—public and private sectors.

Question 18.a.: What steps should be taken to ensure that the large amounts of data that will be collected (statistical, quantifiable, and other types) will be put to maximum use?

Answer: An outstanding characteristic of the U.S. IBP is storage and availability of the data. Several of the programs include specific research on mechanisms for maximizing the ease of access to the data by all scientists.

It is explicit in many cases that the same data will be used many times over in the program.

The maximum utilization of the large amounts of data that will be collected is, or will be, explicitly described in each Integrated Research Program. IRB proposals, submitted to ICC or on which ICC is informed, in which these details are now shown are:

Aerobiology

Analysis of Ecosystems

Grasslands—Subprogram

International Study of Eskimos

Biogeography of the Sea

Convergent and Divergent Evolution

Ecology of Migrant People

Question 18.b.: What group should be responsible for this effort?

Answer: Answered in 18a above.

PLANNED TIMING FOR MAJOR IBP STUDIES

Key: a—proposal preparation begins; b—proposal preparation completed; c—submission to national commission; d—submission to Federal agency; e—work on study begins; f—work complete

Major study	Fiscal years											
	1968				1969				1970			
	1	2	3	4	1	2	3	4	1	2	3	4
Human adaptability component:												
International study of Eskimos.....	a	b	c	d	e							
Population genetics of American Indians.....	d	e										
Biology of human populations at high altitude—Central.....												
(1) Leadville.....		a	b	c	d	e						
(2) Andes—Huanacayo.....		a	b	c	d							
(3) Andes—Nunao.....		a	b	c	d							
Nutrition adaptation to environment.....					a	b	c	d	e			
Ecology of migrant peoples—Central.....					a	b	c	d	e			
(1) Mississippi—Illinois.....		a	b	c	d	e						
(2) Georgia—New York.....		a	b	c	d	e						
(3) United States—Fairbanks.....		a	b	c	d	e						
(4) California.....		a	b	c	d	e						
(5) Chicago.....		a	b	c	d	e						
(6) New York City—New Jersey.....		a	b	c	d	e						
Environmental component:												
Ecosystem analysis—Central.....		a	b	c	d	e						
(1) Grasslands.....		a	b	c	d	e						
(2) Deciduous forest.....		a	b	c	d	e						
(3) Desert.....		a	b	c	d	e						
(4) Coniferous forest.....		a	b	c	d	e						
(5) Tundra.....		a	b	c	d	e						
(6) Tropical forests.....		a	b	c	d	e						
Conservation of ecosystems ¹ for scientific purposes:												
(1) Registries of protected natural areas and proposed natural areas.....		a	b	c	d	e						
(2) Description of natural areas (check sheets).....		a	b	c	d	e						
(3) Guidelines for management.....		a	b	c	d	e						
(4) Registries of experimental areas.....		a	b	c	d	e						
(5) International coordination on reserves.....		a	b	c	d	e						
(6) Catalog fresh-water areas.....		a	b	c	d	e						
(7) Catalog marine areas.....		a	b	c	d	e						
Biological control:												
(1) Plant/insect.....		a	b	c	d	e						
(2) Plant/plant.....		a	b	c	d	e						
(3) Pests, insects and mites.....		a	b	c	d	e						
Ecology of nitrogen.....		a	b	c	d	e						
Marine mammals.....		a	b	c	d	e						
Crop production under stress.....		a	b	c	d	e						
Plant gene pools.....		a	b	c	d	e						

¹ Plan only.

The objective is to compile complete registries of natural reserve areas that can be used for scientific purposes, including fresh-water and marine areas. The "q" refers to completed drafts of sections of the report, and not to final international compilations, the completions of which cannot be estimated.

Note: The finishing dates shown in 1st quarter fiscal year 1973 are administrative only. It is anticipated that all essential work would continue.

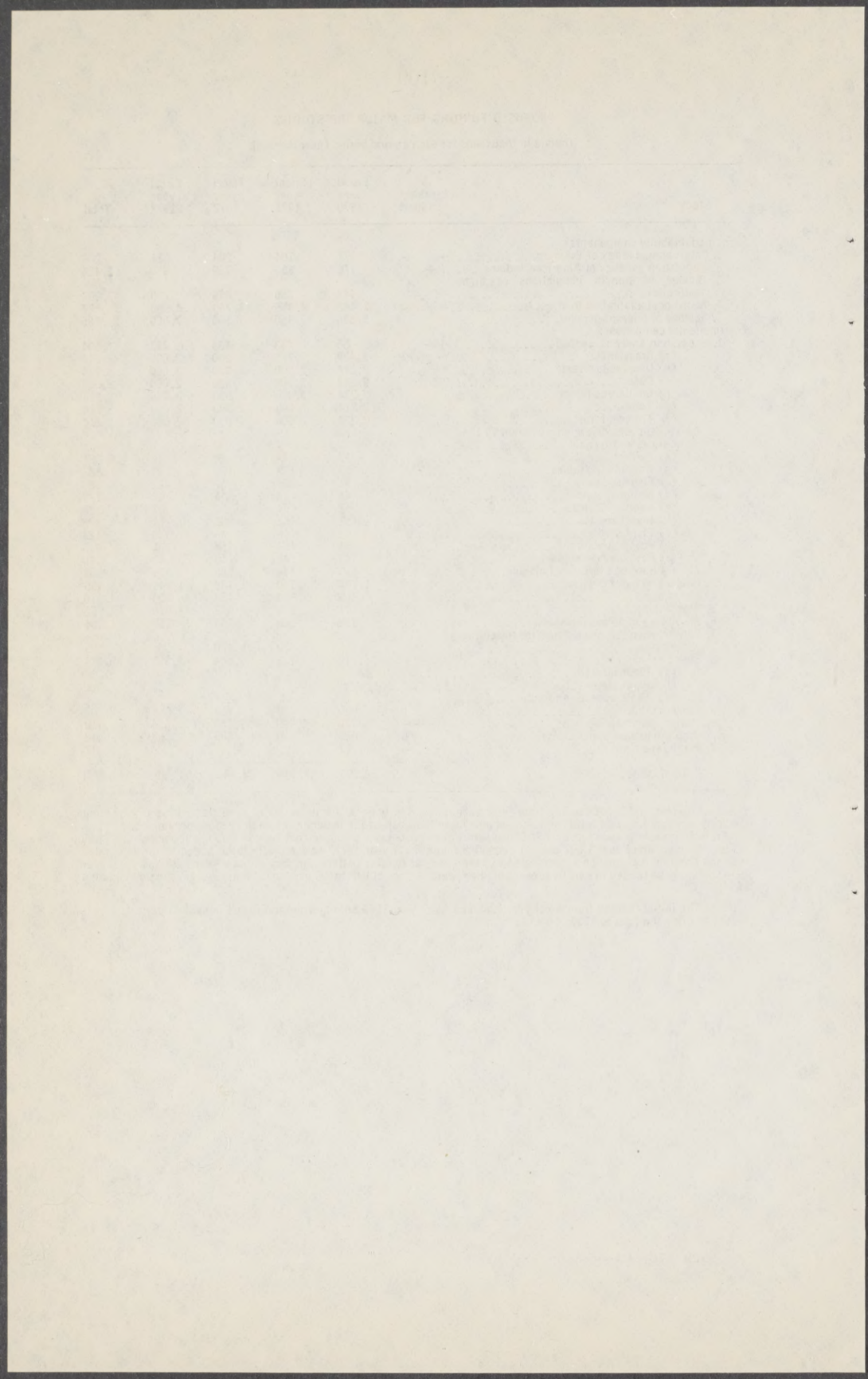
PROPOSED FUNDING FOR MAJOR IBP STUDIES
[Dollars in thousands for each annual period (new money)]

Study	Present ¹ support	Fiscal year 1970	Fiscal year 1971	Fiscal year 1972	Fiscal year 1973	Total
Human adaptability component:						
1. International study of Eskimos.....	+	177	194	204	211	286
2. Population genetics of American Indians.....	++	176	650	750	850	2,426
3. Biology of human populations at high altitudes.....	+	443	850	850	850	2,993
4. Nutritional adaptation to stress ²	++	2,462	4,375	4,150	4,500	15,487
5. Ecology of migrant peoples.....	+	5,535	7,150	7,500	7,500	27,685
Environmental component:						
1. Ecosystem analysis, central.....	++	55	483	483	483	1,504
(a) Grasslands.....	+	1,439	2,775	2,000	2,000	8,214
(b) Deciduous forest.....	0	2,214	2,000	2,000	2,000	8,214
(c) Desert.....	0	2,214	2,000	2,000	2,000	8,214
(d) Coniferous forest.....	0	2,214	2,000	2,000	2,000	8,214
(e) Tundra.....	0	2,214	2,000	2,000	2,000	8,214
(f) Tropical forest.....	0	2,214	2,000	2,000	2,000	8,214
2. Convergent and divergent evolution in the Americas and Hawaii.....	+					
(a) Central.....		32	44	84	44	204
(b) Amphibian studies.....		88	198	198	198	682
(c) Fish studies.....		32	32	32	32	128
(d) Mammal studies.....		44	44	44	44	176
(e) Reptile studies.....		57	57	57	57	228
(f) Insect studies.....		152	152	152	152	608
(g) Plant studies.....		46	46	46	46	184
(h) Ecosystem studies.....		154	154	154	154	616
(i) Physiological studies.....		40	40	40	40	160
(j) Hawaiian terrestrial biology.....		410	394	398	406	1,608
3. Biogeography of the sea.....	0	1,107	1,750	1,789	1,840	6,486
4. Phenology.....	0	310	350	450	500	1,610
5. Aerobiology.....	0	1,107	1,675	2,010	2,070	6,862
6. Physiology of colonizing species.....	0	399	285	285	285	1,254
7. Conservation of ecosystems for scientific purposes.....	+	55	20	20		95
8. Biological control.....	++	3,210	3,222	3,544	3,898	13,874
(a) Plant/insect.....						
(b) Plant/plant.....						
(c) Pests, insects, and mites.....						
9. Ecology of nitrogen.....	0	620	734	752	659	2,765
10. Marine mammals.....	++	720	1,190	1,250	1,550	4,710
11. Crop production under stress.....	0	642	600	600	600	2,442
12. Plant gene pools.....	+	17				17
Total.....		30,599	37,464	37,842	38,969	144,8741

¹ Contemplates additional funding from prior year funds. See page 92 for definition of symbols: 0 equals no present support; + equals modest level; and ++ equals more than half of the included research is presently funded.

² Projects presently accepted by USNC included in the proposal are 100 percent funded through fiscal year 1970, 80 percent through fiscal year 1971, and 30 percent through fiscal year 1972. New projects to be added to the integrated research program on nutrition are expected to have a similar funding pattern. Funding in fiscal year 1973 and fiscal year 1974 will likely be funded in part by present funding sources. Special IBP funds needed for these 2 years can be estimated at \$4,500,000.

Note: The initial funding from fiscal year 1968 and fiscal year 1969 on major programs and individual projects is expected to bring the total to \$150 × 10⁶.



APPENDIX D

ANALYSIS OF NEEDS AND OBJECTIVES OF THE U.S. INTERNATIONAL BIOLOGICAL PROGRAM

Prepared by the Staff of
National Science Foundation

Date: 20 September 1968

Released 8 November 1968

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I. SYNOPSIS

The National Science Foundation has analyzed the needs and objectives of the United States portion of the International Biological Program (IBP). This analysis was made solely to determine the requirements of a sound IBP program without regards to questions related to the budget process; i.e. no analyses were made of the relative needs of the IBP as compared to those of other scientific programs. It is the conclusion of the National Science Foundation that the U.S. portion of the IBP program will have potential research results of great importance to our national interest.

The broad objective of the IBP is to provide insight and foresight about the changing relations between man and his environment. The U.S. effort, as an integral part of an international program, is concerned with achieving a better understanding of the impact of (1) the increasing size and needs of human populations, (2) the impact of these increases upon the interconnected ecological systems of the Earth, and (3) the impact of the resulting effects on man. The U.S. effort is organized into major studies called Integrated Research Programs: 12 have been endorsed by the U.S. National Committee for IBP, and 5 are under consideration. Each major study represents a coordinated research effort involving numerous U.S. scientists and often is closely related to IBP efforts in other countries. The scope of most projects is much greater than has been customary in the past, thus making possible a more complete understanding of man and his environment.

The document describes each of the 17 major studies including relevant details of anticipated benefits, schedules of progress, cost estimates, and priorities. These schedules, priorities, and levels of activity have been determined by examining the scientific promise, feasibility, and status of preparation of each major study. Some of the studies are underway and should be expanded. Others are certain to be ready for significant funding in FY 1970. A few, in the opinion of NSF, need to be modified to increase the participation of social scientists. Efforts will be made to achieve this during the next year.

Parts of the ongoing activities of various Federal agencies can, with adequate coordinating efforts, be made parts of the Integrated Research Programs. The effect of this varies from agency to agency and from Program to Program. However, many important parts of these Programs cannot be undertaken on an adequate scale, or in some cases cannot be undertaken at all, without additional funds.

NSF believes that a reasonably comprehensive program will require \$8 million of special funds in FY 1970 and a total of \$43 million during the period FY 1970 through FY 1973. It is recognized that budgetary pressures may necessitate a reduced program, especially in FY 1970. Only small amounts of non-Federal funds are available. As an aid in the understanding of the effects of different budget levels, higher and lower budget projections are given. With a high level of funding the scope of the studies could be broadened and the intensiveness of research increased. At a low level of funding a programmatic stretch-out will be necessary; benefits will be correspondingly reduced, and some studies may not be started at all.

The Interagency Coordinating Committee for IBP (ICC) will continue to oversee Federal participation. The management of the several projects which are parts of the Integrated Research Programs will often be facilitated by subcommittees within the ICC. Transfers of funds between agencies will be necessary in order to centralize the management and administration of some projects.

The U.S. National Committee for the IBP has the primary responsibility for formulating the scientific policies and guiding the development of detailed plans for each Program. The NSF-IBP staff will work with the National Committee to enhance the probability that when submitted for Federal consideration IBP proposals will be as nearly acceptable as possible.

Adequate scientific manpower is available and interested in carrying out an IBP effort at the level recommended. Because of the better logistics and technical support needed for large-scale, coordinated efforts, the cost per senior scientist per year will be about double that previously normal in environment biology. Therefore, to maintain the momentum that has been generated, special funding at a reasonable level is essential in FY 1970.

II. CONCLUSIONS AND RECOMMENDATIONS

On the basis of extensive study and consultations with other Federal agencies, the scientific community, and other groups concerned with IBP, NSF has reached the conclusions and makes the recommendations below for future management of the US-IBP.

(A) CONCLUSIONS

1) The US-IBP is a conceptually sound program. Virtually all of the component IRPs should be ready for funding at a substantial level early in FY 1970.

2) Federal agencies, other than NSF, should support those parts of the IRPs that are closely related to projects regularly supported under each agency's mission. The total of such support probably will be small except in the case of two IRPs: Biological Control and Nutrition.

3) Other Federal agencies will accept responsibility for IBP research, either in-house or extramural, if special funds are provided for that purpose by transfer from NSF.

4) No agency except NSF has a mission broad enough to justify requesting a budget item for funding all the diverse activities encompassed by IBP.

(B) RECOMMENDATIONS

1) NSF should assume primary responsibility for overall management of IBP at the Federal level.

2) The U.S. National Committee and the Interagency Coordinating Committee should continue to serve the Foundation in an advisory capacity on IBP matters.

3) For FY 1970, NSF should be assigned special funds for support of the Integrated Research Projects. A reasonably comprehensive effort will require about \$8.0 million of such funds, but budget stringencies may necessitate a lower level of support and hence a reduced program.

4) To facilitate long-range management of IBP, a guideline of \$43 million should be recognized as the minimum funding level required to maintain the IBP during the period FY 1970-FY 1973.

5) Authority should be provided to NSF to transfer and to receive from other agencies funds in amounts necessary to carry out specific IBP projects.

III. INTRODUCTION

This analysis provides information about the United States' participation in the International Biological Program (US-IBP). This information mainly concerns priorities, funding levels, and management plans. Issues raised and questions asked are quoted in this document at the beginning of each appropriate section.

This document serves two purposes. It considers the problems and issues that the Government, especially NSF, is likely to encounter in managing a large national experiment in research program management involving a scientific community unaccustomed to such practices. The document also represents a report on the current status of the IBP. It demonstrates the validity of maintaining and funding IBP as a National Program; it delineates the major studies for which planning has been completed and for which funding is appropriate for FY 1970; and it indicates the scale of future support necessary to develop the US-IBP. It does not attempt to cover completely the historical origins of IBP or its past problems. These matters are covered in more detail by the extensive Congressional hearings held on the IBP.¹

For this Special Study paper NSF received information and assistance from the U.S. National Committee for IBP (USNC) including its views of the current status and future requirements of the IBP effort. NSF also sought information from each of the agencies represented on the Interagency Coordinating Committee for IBP (ICC) concerning their interest in specific IBP projects, funding plans, suggestions on management, and other matters that would assist NSF in developing a financial-administrative arrangement compatible with agency practices and management requirements. Responses were received from most agencies; some were extensive, some brief.

NSF was designated to coordinate Federal support of the US-IBP in November 1965. An Interagency Coordinating Committee was established that currently includes 12 major Executive organizations (see Table 3). It serves as a forum for discussion of problems related to development and support of the US-IBP and as a mechanism for liaison among agencies.

U.S. participation in IBP is coordinated through the USNC (sponsored by the National Academy of Sciences), which group provides advice and assistance to the agencies involved in operational management of the US-IBP.

In July 1967 the US-IBP consisted of two groups of research programs, one group specifically generated by and designed for the IBP, the other of projects related in various ways to the aims and goals of the Program.

An effort to interrelate these diverse ideas and programs for a better focus of the research effort resulted in the restructuring of the USNC in the spring of 1968, the chairmanship passing to W. Frank Blair of the University of Texas. The earlier, large, and loosely organized group was dissolved; the USNC now consists of about two dozen scientists. Three staff members, supported by NSF and ICC funds, aid with administrative matters. It was actually the Executive Committee of the U.S. National Committee that provided information for this paper; for convenience we refer to the Executive Committee in this document as the USNC.

The US-IBP is a new and different kind of research effort in the field of biology. The characteristics that make it unique are:

- 1) A conceptual approach that concentrates on intensive study of a few carefully selected large-scale systems, systems far larger than any studied comprehensively before.

- 2) The use of coordinated, interdisciplinary research teams to focus integrated attacks on carefully defined problems.

¹Hearings on H. Con. Res. 273 before the Subcommittee on Science, Research and Development of the House Committee on Science and Astronautics, May 9, June 6, July 12, and August 3 and 9, 1967; and hearings on H.J. Res. 1240 before the Subcommittee on Science, Research and Development of the House Committee on Science and Astronautics, May 1 and 2, 1968.

3) A massive emphasis on the changing interrelationships of organisms with man and his environment.

4) The coordination of activities as part of a multinational research effort.

Large-scale *Integrated Research Programs (IRPs)* represent the core of the U.S. program. Other individual research projects may support the goals and objectives of IBP (i.e., IBP-related projects), but because they are not integrated as part of the large-scale projects, they are not recognized as part of the U.S. national program. This difference is important because it is proposed to support IBP-IRPs through special funding arrangements, whereas IBP-related projects will compete within regular Federal support programs.

Presently 12 major studies are identified as IRPs. (For convenience "Conservation of Ecosystems" is included though it is not a research study in the usual sense.) These are classified under two *Components*—Human Adaptability and Environmental Management. In addition, five more major studies are being considered as potential IRPs. These 17 major studies and the numerous projects that comprise them vary considerably in size and scope, in organizational and funding complexity, and in focus. Some of the IRPs are divided into discrete *Subprograms*. Each IRP or its Subprograms will consist of a series of *Projects*; these are the basic units of organization and of actual research operations. Table 1 shows the Components, IRPs, and some Subprograms. Each of the IRPs is described in Appendix B. All IRPs are subject to continuing review by the USNC, the ICC, and NSF as detailed plans are developed and put into operation.

The International Council of Scientific Unions (ICSU) proposed a five-year research phase for IBP beginning in July 1967 and terminating in July 1972. The first IRP to be supported from funds allocated specifically for IBP (Ecosystems Analysis: the Grasslands Biome Subprogram) began field operations in July 1968. NSF considers initiation of work on that project as the starting date for a five-year US-IBP effort.

The five-year time frame for the US-IBP effort is based on the following considerations:

- 1) This period was established by agreement between 54 nations.
- 2) The urgency for accomplishing the research described.
- 3) Success in gaining commitments to participate from a large number of scientists.
- 4) The period necessary to conclude at least the first phase of research on most IRPs.

Although the IBP is a five-year program, it is expected that IBP-type activities will continue for a decade or more and continue to influence future Federal support of environmental studies. President Johnson recognized this possibility when he stated:

"I propose that this effort (IBP) be a permanent concern of our nations. I propose that the United States scientists join with the scientists of the Soviet Union and other nations to form an international council on the human environment."

IV. OBJECTIVES AND SCIENTIFIC IMPORTANCE

"U.S. National Committee views . . . for each major area of study:

- 1) Identify the scientific objectives and goals.
- 2) Describe the relative importance of these objectives and goals:
 - in terms of their scientific impact
 - in terms of the relevance to the solution of 'national problems' (e.g. what is the relationship to current problems of environmental changes?)."

"Federal agency evaluation and plans for support . . . for each major area of study:

- 1) NSF views on the objectives and importance of the proposed research . . . identifying differing views from those of the U.S. National Committee.
- 2) Views of other agencies when different from those of NSF."

The objectives of the US-IBP grew out of an international activity established by the International Council of Scientific Unions (ICSU) based on the theme, "The Biological Basis of Productivity and Human Welfare." In July 1964, ICSU established a Special Committee for the IBP which adopted the following statement of broad objectives for IBP:

"The rapid rate of increase in the numbers and needs of the human populations of the world and their demands on the natural environment has greatly increased the need for biological research. The International Council of Scientific Unions (ICSU) has therefore initiated an International Biological Programme (IBP) entitled 'The Biological Basis of Productivity and Human Welfare,' with the objectives of ensuring the worldwide study of:

- (1) Organic production on the land, in fresh waters, and in the seas, and the potentialities and uses of new as well as of existing natural resources, and
- (2) Human adaptability to changing conditions."

The goals and objectives of the US-IBP have been under continuous development since 1965 when the USNC was organized. The most recent development occurred during a two-day conference of the USNC, April 30 to May 1, 1968, at which the theme, "Man's Survival in a Changing World," was adopted for the U.S. effort. Also a statement of philosophy and rationale for the US-IBP effort was drafted as an introduction to the description of the IRP. This is included as part of Appendix B.

There appears to be no early general statement of the separate goals and objectives of the US-IBP to define areas of emphasis. In Report No. 2 of the National Committee in October 1966, the Committee, after explaining the rationale of the US-IBP, states:*

"Greater understanding will make it possible for man to respond to opportunity as well as to react to need. To gain such understanding is the underlying purpose of the International Biological Program.

"This program has three related objectives: Human welfare, scientific advance, and international scientific cooperation. These three objectives cannot be separated."

"Our scientific objectives are also limited. Our basic interest is the development of scientific ecology in its broadest sense. We believe we should give special emphasis to the genetics and dynamics of populations, to the factors that control biological productivity, to the ways in which plants, animals, and especially men, adapt to their environment, to the changing distribution of living things in the sea and in the air and on the land."

*"U.S. Participation in the International Biological Programs," Report No. 2 of the U.S. National Committee for the International Biological Program. See also "The International Biological Program, Its Meaning and Needs," Report of the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, 90th Congress, Second Session.

In preparing for the Special Study, NSF asked the USNC: What are the objectives of the U.S. effort? The Committee responded:

"Objectives of the International Biological Program are to provide basic insight and foresight about changing environmental relations of man, in order to cope with increases in the numbers and needs of human populations; also with the impact of these increases upon the interconnected ecological systems of the Earth (see Daddario Report on IBP).

"The United States shares all of the worldwide objectives. But we further see the processes which normally control much of life (dispersal and selection of organisms, biological conversions of solar energy, circulation of nutrients) also threatening to spread pollution; to deflect balances of plant and animal populations and of their productivity; and to degrade 'Environmental Quality' (see Daddario Report on this subject). Americans, most particularly, seek ways of understanding such *by-products of technological developments* avoiding their disadvantages and using their advantages. Resulting changes, either way, can be rapid in industrial societies, and in neighboring and remote countries affected by them (see Daddario Report on "Managing the Environment").

"The objectives were further defined by the U.S. Executive Committee in a meeting of 30 April-1 May 1968, as follows:

"Our objectives are to participate in a worldwide study of organic production in all environments, and of human adaptability to changing conditions. In the United States, the maintenance of environmental quality is critical for both human welfare and long-term productivity. Thus, the U.S. program focuses on two major components: (1) problems of human adaptability, and (2) problems of environmental management."

As presently conceived, IBP goals and objectives have two levels of generality—the higher level of generality divides the US-IBP effort into two component parts dealing with studies of environmental relationships and human adaptability. The broad goals of the human adaptability and environmental components of the US-IBP have been defined as follows by the National Committee (in answer to an NSF request, July 1968):

Human Adaptability Component

"The broad goal of this component of the US-IBP is to advance knowledge of (a) the genetic, and (b) the physiological and behavioral adaptations of man."

Environmental Component

"The broad goals of this second component of the US-IBP are (1) to formulate a basis for better understanding of the interactions of all components of selected and representative biological systems, (2) to extend this understanding toward an increased biological productivity, (3) to provide bases for accurately predicting the consequences of environmental stresses, both man-originated and natural, on the performance of biological systems, and (4) to enhance our ability for better management of our natural resources."

From these component parts, specific statements of goals and objectives have been formulated to guide the development of the Integrated Research Programs, which form the heart of the US-IBP research effort. The National Committee has informed NSF that "the specific goals are distillations from more than 40 successive working conferences that have radiated into an increasing number of concerned scientists (estimated now at over 2,000)."

The goals and objectives of the IRPs that fall under the two component parts are excellent statements that have been carefully worked out in detail (see Appendix C). The USNC's view about the relative importance of IRP goals and objectives in terms of scientific impact and solution of "national problems" are also included.

NSF believes that the objectives of the IRPs, for the most part, are soundly conceived and the proposed research activities are important to promote in the public interest. Some IRPs may require modification to broaden or contract their scientific scope after detailed plans are developed. The information derived from the IRPs should be important to all government agencies in placing problems in a new and larger perspective of human welfare.

NSF views and those of other Federal agencies responding to NSF's inquiries are in substantial accord with the National Committee's statement of objectives and importance of the proposed research.

The issue of the relative importance of the objectives and proposed research activities presents a more difficult problem for which NSF has no immediate answer. It is difficult to compare in a meaningful way, for example, the importance of a study on the adaptations of Eskimos to severe climatic conditions, with a study on the natural phenomena that regulate population levels of insects, with a study of the social effects of mass migrations from Mississippi to Chicago.

Similarly, each IRP will have an impact on the development of scientific knowledge in its own particular field, but comparison of impacts between fields is difficult. The same problem is encountered in respect to assessing relative importance to the solution of national problems. NSF-IBP staff, however, intend to develop, in cooperation with National Committee staff, ways of providing a better basis for assessing the relative importance of the IBP-IRPs.

Despite the difficulty of assessing relative scientific importance, funding priorities among the several IRPs have been set by the USNC and NSF as described in Section V. These priorities, however, are based largely on readiness for funding and the dependence of other projects on techniques or knowledge developed.

V. ALTERNATIVES, PRIORITIES, AND BENEFITS

"Identify the priorities for the various parts of the research effort by describing both alternative program content and timing within and among major areas of study for various alternative levels of total funding through fiscal year 1972 for IBP such as \$10, \$20, \$40, and \$60 million."

"For each alternative level of funding, develop displays . . . covering the major IBP studies that are proposed for Federal support showing:

- significant dates
- levels of funding required during the various periods
- kinds of activity during the periods included."

"Identify differences in benefits for alternative funding levels."

"[Give] NSF's assessment of alternatives, priorities and management—as outlined. . . ."

"[Give] views of other agencies when different from those of NSF."

(A) PRIORITIES

In order to assess the USNC's opinion on what is needed to support the US-IBP effort and the priorities of programs at various budgetary levels, NSF asked that group to estimate a baseline figure for fiscal year 1970 that might permit the IBP effort to proceed at an acceptable but less than desirable rate, and then consider budget levels 20, 40, and 80 percent lower and higher.

The USNC developed in response a table (adapted here with the addition of corresponding NSF estimates) that shows relative priorities, and therefore alternative program content and timing, for each of the IRPs. Table 1 (Appendix E) shows the situation as envisioned for fiscal year 1970 for various levels of funding. Table 2 (Appendix E) shows funding for the period fiscal year 1970 through fiscal year 1973.

All USNC estimates are total cost requirements, including costs for programs that are normal activity of an agency and new programs that might be supported from regularly available funds. The USNC could not provide a breakdown of these two categories because data were not available from ICC agencies. NSF has estimated other-agency support, but there is a high degree of uncertainty in such estimates. The uncertainty derives primarily from the existing tight Federal budget situation. NSF support shown in Tables 1 and 2 assumes a gap-filling role and the core support required to maintain the integrity of the US-IBP effort.

The USNC estimated that (1) \$28.7 million would represent desirable funding for fiscal year 1970, and (2) approximately one-half this amount would represent a USNC baseline figure that would permit progress at an acceptable rate. The acceptable rate would permit support of all IRPs. At 20 percent of baseline (about \$3.1 million) major support should go, according to the USNC, to the Grasslands Biome Subprogram and the IRP on Migrant Peoples. Smaller amounts would be provided for IRPs on Eskimos, Convergent/Divergent Evolution, Biogeography of the Sea, and Colonizing Species. The remaining IRPs would receive the minimum support needed to maintain them in condition to mount a significant effort a year later.

NSF estimates that \$8.0 million would be required to make most effective use of the plans and teams of scientists that will be ready to start during fiscal year 1970. Estimates shown for individual IRPs are based on staff knowledge of program development, actual needs, and program relevance to present agency activities. The alternative funding levels in Table 1 for totals larger than the \$8.0 million baseline are not recommended at this time, but show only relative funding priorities. At 20 percent of the NSF baseline, (\$1.6 million), NSF thinks that only the Grasslands and Deciduous Forest Biome Subprograms can be supported. Other IRPs necessarily would have to be deferred.

NSF disagrees with the USNC in the priorities assigned to several IRPs (see Table 1). NSF thinks that the Deciduous Forest Biome should have a higher priority at the minimum funding level in fiscal year 1970 than indicated by the USNC because this Subprogram is too well developed to put aside and thereby jeopardize its momentum. Conversely, NSF thinks the Migrant Peoples IRP should have a lower priority because the Program is still too poorly developed.

In Table 1 (Appendix E) the principal differences between the USNC baseline figure and the estimated Federal total occur for the Migrant Peoples, Nutrition, and Biological Control IRPs. NSF thinks that applicable existing activities by ICC agencies are far larger for the last two IRPs than the USNC estimates suggest, and it is this that causes the NSF estimate for total costs to exceed that of the USNC.

(B) BENEFITS

With funding at the \$8.0 million baseline level, all or most of the major studies could proceed at an acceptable pace, and benefits appropriate to the input could be realized. For most IRPs, support during FY 1970 below the \$100,000 level would mean that further planning and some preliminary studies could be undertaken, but no substantial scientific progress could be expected and few concrete benefits would materialize. With such limited funds the start-up would be slow, but at least the projects would remain viable. It is evident from Table 1 that the studies supported and the benefits to be derived at a 20 percent level of funding would be extremely limited. At this level of funding the US-IBP remains a noncritical endeavor in the sense that a limited study of parts of two biomes (Grasslands and Deciduous Forests) will not contribute much toward a comparative analysis of ecosystems. The product will remain much as it is now, piecemeal facts from piecemeal research. With such an inadequate level of funding in FY 1970, the US-IBP would probably become nonviable as well; enthusiasm would diminish, scientists would become involved in other projects, and few of the hoped-for benefits would materialize.

Anticipated benefits are not limited to acquisition of scientific knowledge for its own sake. Indeed, other purposes are at the heart of the planning. The data developed will be useful for solution of rapidly growing national problems, e.g., urban unrest, pollution, increasing world populations, the training of needed manpower in the fields of ecology and environmental science, development of a methodology for handling the study of large and complex environmental systems, and aiding, through cooperation and coordination, the IBP efforts of other nations. These benefits largely will fail to be realized if funding for the IBP effort is inadequate.

It is not possible at the beginning of a long-term program involving hundreds, or perhaps thousands, of scientists to predict detailed benefits with confidence. Earlier and similar long-term programs paid off, usually with some unexpected results. The International Geophysical Year, it is agreed by most scientists and administrators, had a profound effect on many aspects of geophysics; atmospheric science and aeronomy came of age during that effort, and practical benefits, real and potential, can be traced from seismology, submarine technology, and the U.S. Antarctic and space programs. It is the belief of NSF that IBP will do for ecology, including human ecology, what IGY did for the earth sciences, and in the process it will upgrade much basic biology.

(C) RESEARCH SCHEDULE

Table 4 (Appendix E) is a calendar of events as they have occurred or as they are planned for each IRP and its subprograms. This is taken with few changes from data provided by the National Committee. At best this schedule can be used as a rough guide only, for the scheduling of future events is largely dependent on the availability of funds.

In the opinion of NSF the schedule fails to recognize the lack of funds for the research starts listed for FY 1969, and it underestimates the time necessary between submission of a proposal to the USNC for initial endorsement and provision of appropriate Federal support.

Completion dates in FY 1973 should not be construed as the time at which work would be finished. The significance of that date varies widely in the different IRPs. For example, the Ecosystems Analysis Program is highly structured and, with a prompt start and no stretch-outs resulting from low funding, is expected to actually terminate by the date shown. Follow-up studies should be expected however. The Nutrition Program and Biological Control Programs, by contrast, are relatively loosely structured and termination in FY 1973 will represent little more than an administrative formality; work will continue under some other arrangement or rubric for additional years.

Although other Federal agencies have not expressed opinions about IBP alternatives, priorities, or management of program design, we know of no disagreement with NSF views.

VI. FUNDING REQUIREMENTS AND POSSIBILITIES

"Identify the level of each agency's funding for IBP and directly related research during FY 1968 (actual) and FY 1969 (estimated)."

"[Does the US-IBP] have potential results of sufficient importance to our national interest to warrant special funding beginning in Fiscal Year 1970 . . . ?"

"Identify amount of funds needed for each major area of study that would not be provided by mission agencies. Describe the proposed funding method."

"When the objectives of the area of study are related to mission requirements of one or more agencies, identify the agencies and describe the relationship."

"Identify parts of the proposed major area of study that can be supported during FY 1970 and future years by each agency (assuming no significant change in overall funding levels) with mission interest through the normal funding for research (extramural or in-house) through:

—on-going programs

—new commitment of funds."

"[Indicate] how agencies can be encouraged to support as much of the IBP effort as possible through normally available funds rather than relying primarily on special funds."

"Identify instances where the major area of study is of interest to an agency but the agency is unable to provide support through one or more of the above means."

"Identify IBP work, if any, that could be financed through the use of excess foreign currency."

"Identify amount and source of funds requested or available from sources other than the Federal Government (e.g. state funds)."

(A) JUSTIFICATION FOR A FISCAL YEAR 1970 START

In a time of budgetary stringency, strong justification is necessary to launch a new national scientific program. Such justification is abundantly evident for the IBP. This Program will serve to advance significantly our fund of scientific knowledge, but more importantly it will provide information bearing on some of the crucial social and environmental problems that the Nation faces today. From one viewpoint it may be fortunate that a budgetary pause is available during which scientific information can be collected to guide future social decisions that will require expenditures of many billions of dollars. IBP-derived information can provide a better perspective for predicting the consequences of future spending decisions so that massive expenditures do not turn out to be only massive mistakes. A second reason for an FY 1970 start is that the US-IBP, as conceived, probably will not survive much further delay.

1) Our Nation now faces immediate national problems rapidly approaching crisis levels—excessive migration to the cities, urban unrest, pollution, population pressures, limited food production, environmental degradation, etc. The basic information necessary even to think clearly about these problems is so meager that selecting paths toward solutions proceeds more by guess than by reason. IBP will help develop the knowledge on which critical and sound decisions for operational programs can be based. For example, in the near future extensive programs to rebuild our cities will be undertaken; some entirely new cities are even being planned. These efforts are likely to involve the expenditure of hundreds of billions, yet the information base on which the decisions will be made can only be characterized as puny. Where should cities not be located environmentally? What changes will a new city impose on the environment? How can design help minimize the environmental and social stresses on the inhabitants? The information that will be developed through the IBP on human populations and man's interaction with his environment will help provide the basic knowledge on which better applied research programs can be mounted.

2) The U.S. has agreed to participate in an interrelated, multinational IBP effort. If U.S. scientists are unable to launch their part of a program that was cooperatively planned and coordinated with groups in other nations, it will in-

hibit, or perhaps jeopardize, the international effort and cause the U.S. a loss of prestige.

3) Planning for several US-IBP studies is already well developed. By FY 1970 most of the major programs will have been planned and much of the professional personnel will be ready to begin. Many of the scientists who now plan to start work in FY 1970 understandably will move to other tasks and commitments if IBP programs cannot be undertaken at that time. This would represent a serious and crippling blow for the future of IBP because participation of the scientific community could not be assured at some indefinite future starting date.

(B) SUPPORT IN FISCAL YEAR 1968 AND FISCAL YEAR 1969

NSF asked each ICC agency to identify sums obligated for: (1) IRP projects in FY 1968, (2) IBP-related projects in FY 1968 (i.e., projects directed toward IBP goals but not part of the IRPs), and (3) estimated obligations in FY 1969. Only a few agencies were able to identify separate funding of IBP activities as requested.

(C) FUNDING FOR FISCAL YEAR 1970

Only four agencies can identify specific support for IRPs during FY 1968 and 1969. These same agencies indicate probable support for IBP projects during FY 1970 and later years. None except NSF seeks new funds. No agency except NSF is prepared to definitely commit future funds for IBP purposes.

DOD (Air Force), the only DOD agency providing figures, estimates that \$25,000-\$40,000 per year might be redefined to serve IRP purposes. No specific projects can be named. All support will be extramural.

Smithsonian estimates expenditures of about \$600,000 per year for IBP-related projects. No projects are identified. All research is in-house.

USDA (Forest Service) estimates that about \$2.0 million worth of research per year will be redefined to serve IBP purposes, but no funds can be reassigned. All is in-house activity. USDA (Agricultural Research Service) states that it hopes to reassign \$3.5 million per year for increased activity on crop stress. Most of this is in-house research, and a review of the Agricultural Research Service programs indicates that only about \$550,000 per year can be considered part of the Crop Stress IRP.

Information from ICC agencies clearly indicates that many IRPs will receive support in FY 1970 only to the extent that funds are made available especially for that purpose through NSF. A few IRPs can expect limited support from mission agencies using reassigned funds, but the agencies are unprepared to state how much.

To make the IBP a worthwhile national endeavor will require substantial funds beyond those normally available, and NSF estimates the requirement as \$8,000,000 specifically for IBP in FY 1970 (Table 2, Appendix E).

(D) AGENCY RELATIONSHIPS AND COMMITMENTS TO IRP'S

ICC agencies tend to express interest only in programs for which they are providing or plan to provide support. In some instances no interest is evident despite relevance to the agency's mission. Table 3 (Appendix E) shows the relationships between IRPs and the agencies. It is constructed from ICC responses to an NSF inquiry and from information provided by the USNC. Interests are shown at four levels according to NSF's assessment of the situation: (1) strong interest and planned commitment of \$500,000 or more per year; (2) moderate interest with commitment of \$100,000 to \$500,000 per year; (3) minor interest with commitment of less than \$100,000 per year; and (4) moral support, but no funding planned. Most agencies clearly state that so long as funds remain in too short supply to accommodate existing responsibilities and programs, they can display neither ability nor willingness to support IBP and will make no commitment for future support.

NSF has an interest in and intends to provide some support for all but two IRPs—Conservation of Ecosystems and Gene Pools. Justification for support of the former is lacking yet, and all support needed for the latter is apparently being provided by the USDA.

(E) OTHER PROBLEMS RELATED TO SUPPORT

Mission agencies supporting biological research are geared mostly to deal with small projects and modest programs, not large-scale integrated studies of the

IBP type. Agency interest in an IRP is usually restricted to a rather limited part; rarely does it include the whole research project. Furthermore, the staffs and advisory groups of most Federal agencies are accustomed to think and react in accord with specific mission objectives. These groups seem unprepared to evaluate programmatic, multi-disciplinary, longitudinal research. Efforts by the USNC and ICC hopefully can reduce this problem, but little success can be reported to date.

NSF knows of no means by which agencies can be encouraged further to use normally available funds for IBP, although it may be that once IBP has demonstrated its success as a program other agencies will become more actively involved.

Lack of funds for extramural support inhibits participation of some agencies. The Forest Service states that under existing budget levels practically no funds are available for extramural studies. The Agricultural Research Service estimates that only about 3 percent of its funds can support domestic extramural work. The Cooperative State Research Service reports that although 100 percent of its funds are for extramural use, decisions on the projects supported are entirely the prerogative of the local agricultural station director. The Smithsonian Institution has no funds for domestic extramural support. Only about 25 percent of Interior's research funds are available for extramural use.

(F) USE OF FOREIGN CURRENCY

Three ICC agencies indicate that they might be able to use excess foreign currency (PL 480 funds) to support IBP projects. Others indicate that PL 480 funds are not available to them.

Commerce (ESSA) claims an interest in cooperating with Indian scientists. The Smithsonian has offered use of minor amounts for support of IBP administrative costs. USDA (ARS) claims that about \$1.2 million per year of its PL 480 funds support projects pertinent to IBP; the validity of that pertinence to IBP is uncertain. NSF presently has no access to PL 480 funds except in exchange for dollar credits.

If excess foreign currencies were more readily available, international aspects of IBP might be enhanced, but no direct and specific benefit to the U.S. is identifiable yet (see International Relationships, Section VIII).

(G) NON-FEDERAL FUNDS

Support augmenting that from Federal sources should come from the states, local governments, universities, industry, and private foundations.

Occasionally private foundations have the opportunity to review IBP proposals, but they do so on the basis of the pertinence of the proposal to the objectives of the reviewing organization and without regard for its relationship to other IBP activities. Parts of only two major studies are supported by private foundations currently (Wenner-Gren—Eskimos; American Institute for Medical Science, Mental Retardation Foundation, and Nutrition Foundation—Nutrition). Attempts to have the private foundations submit ongoing work or proposals under review for coordination with IBP have been unsuccessful. Funds awarded so far amount to \$200,000.

The University of Wisconsin and Louisiana State University, using state funds, are supporting work directly applicable to the Nutrition Program. The Migrant Peoples Program is partially supported by the University of Illinois. Colorado State University is providing a large new building specifically for the Grasslands Biome study. The University of Michigan is contributing in several ways to the Ecosystems Analysis Program. Practically all universities receiving grants from Federal agencies contribute a reasonable share of support from their own resources (in part through cost-sharing requirements).

Nevertheless, the amount provided from non-Federal sources is minor, and probably amounts to less than \$200,000 per year. Consequently there seems little probability of support of a substantial nature from sources other than the Federal Government in the foreseeable future.

VII. MANAGEMENT

"Describe the management arrangements for each large scale integrated study; e.g., planning, analysis, integration of data; coordination of work or researchers and of supporting staff."

"For each major area of study, particularly the large scale integrated studies, identify the locus of responsibility in the Federal Government and the arrangements for:

- securing and integrating supporting work financed under separate grants and contracts
- handling necessary coordination with other Federal agencies participating in or supporting the study monitoring the research progress and management."

"Identify steps needed—beginning in the planning process—to assure the effective application of findings in the solution of national problems or in furthering follow-on research. (For example, what steps can be taken to assure that the large amounts of data that will be collected will be put to good use?)"

"Some of the studies (e.g., those of ecosystems) require special attention to management arrangements at all levels of involvement to assure orderly execution of studies and utilization of findings; e.g.,

- on logistics at the research site
- in integration of research and support, including systems analysis, computer services, and data exchange
- in the National Committee, its subcommittees and study planning groups
- in the development of studies which will involve many researchers from various disciplines and institutions
- on the part of Federal agencies in carrying out program management responsibilities."

The Bureau has correctly recognized that management of the IBP presents many special problems; they have to do with administering a large national and international program having a quasi-governmental status, and with fashioning a management program for a situation in which the Federal Government is the principal source of financial support, yet the main site of performance resides in the private sector. The problems and issues posed by this sort of arrangement have never been resolved completely in the past, and clearly each situation must be examined on an *ad hoc* basis. NSF is confronted with a particularly difficult problem, for the resolution of this arrangement may require a sharp demarcation from the Foundation's past management role in the biological sciences.

Effective management of the IBP will require coordinating a great many diverse research activities involving many public and private performer organizations and individuals. Mechanisms and procedures must be adapted or devised to deal with planning, evaluation, funding, and monitoring research activities that are not required in dealing with conventional NSF research grants. IBP projects involve broad-scope, integrated, complex proposals, and each IBP appears to have its own special problems. The management necessarily will be similar to that of the International Quiet Sun Year and the International Indian Ocean Expedition, but not as detailed as that of the U.S. Antarctic Program.

The overall management organization for the US-IBP has been an evolving proposition that has been considered in some detail in previous Congressional hearings.* Briefly, the current management structure places responsibility on NSF

*Hearings on H.J. Res. 1240 before Subcommittee on Science, Research and Development of the House Committee on Science and Astronautics, May 1 and 2, 1968; "The International Biological Program—Its Meaning and Needs," Report of the Subcommittee on Science, Research and Development of the House Committee on Science and Astronautics, 90th Congress, 2nd Session; and hearings on H. Con. Res. 273 before Subcommittee on Science, Research and Development of the House Committee on Science and Astronautics, May 2, June 6, July 12, and August 3 and 9, 1967.

for determining Federal policy positions for IBP and for overall coordination of Federal management, including Federal funding. The U.S. National Committee has primary responsibility for formulating scientific policies and strategies to ensure that proposed research activities are consistent with IBP goals and objectives and are integrated into both the overall U.S. effort and the international effort. The ICC assist NSF in formulating Federal policies, coordinating funding, integrating specific IBP and related research activities, and generally overseeing the participation of the Federal Government in the US-IBP. Within this general framework there is extensive interaction between NSF, ICC agencies, the National Committee, and national and international policy and performer organizations (public and private) that help determine proposed US-IBP policies, research activities, priorities, and management procedures.

Management of the US-IBP effort has encountered past difficulties and no doubt will encounter difficulties in the future, although to a lesser degree, that can be traced (1) to the aversion of academic scientists to having their research studies planned, or programmed, and (2) to participating in large-scale projects that require integrating newly discovered knowledge on a constant basis. The importance of the attitudes of academic scientists to the ultimate success of the IBP should not be minimized, but neither should particular episodes be taken to reflect a general situation.

Similarly, Federal program managers find it difficult to reorient their research programs to meet IBP objectives or to mesh with IRP-sponsored projects. The successful integration of Federal and IBP programs will depend on: (1) defining the goals and objectives of the US-IBP effort more concisely so as to emphasize relevance to Federal missions; (2) the availability of Federal personnel in other agencies specifically assigned, and with adequate time, to arrange for desired coordination; (3) the time and financial pressures on other agencies to accomplish mission-related tasks unconnected with the IBP; and (4) the availability of strong NSF and National Committee staff resources to whom other Federal agencies might look for guidance.

We have previously discussed the all-encompassing nature of the IBP goals and objectives and believe it would be wasteful to undertake a classification of all Federal research activities as falling within or outside these goals and objectives. However, careful consideration must be given to activities already underway that bear on the design and management of the IRPs which are adopted as the US-IBP effort.

The Foundation believes that successful Federal management of the IBP depends on establishing a strong staff complement with management expertise within the agency having central responsibility—that is, NSF. Only in this way will effective interagency coordination, and coordination among performer organizations, come about. Only in this way will opportunities be maximized for applying IBP findings to the solution of national problems or for encouraging follow-up research. As the NSF staff develops experience, and the IBP effort becomes crystallized, NSF will be in a position to develop detailed procedures for ensuring optimal utilization of IBP information.

The various IRPs are different in origin, structure, content, and objectives, but share common aspects having to do with substance and research methodology. All IRPs have been designed to gain a broader understanding of an inadequately studied area of biology by employing an integrated and coordinated research methodology. Because the IRP studies concern widely different subject matter, it is obvious that management problems will differ in details also. Until NSF builds a special staff with experience in operating IBP programs, a flexible management policy will be maintained to permit rapid response to the different situations that are likely to arise.

Three examples will serve to illustrate the different management situations that might arise. The Ecosystems Analysis Program is easily the most ambitious and complex of the IRPs. It consists of highly integrated, multidisciplinary, team studies of six biomes involving field operations ranging widely over geographic areas from the arctic to tropical regions. NSF will be required to provide substantial staff time to arrange for logistical problems that may be expected to arise in connection with the hundreds of scientists and dozens of performing organizations that will be involved in this IRP. The Nutrition Program, by contrast, is a rather loosely knit series of projects. Though many researchers and organizations will be involved in data gathering, the level of integration will be much less and will be concentrated in the data analysis phases. The Gene Pools Program will be conducted almost entirely by the in-house scientific staff of the USDA.

In the discussion below, consideration is given to management arrangements at different levels of involvement and to the locus of responsibility within the Federal Government for managing particular aspects of the different IRPs. Further attention is given to management arrangements in Appendix B, where the IRPs are described in detail.

(A) FEDERAL MANAGEMENT

Each ICC member agency was asked by NSF to suggest mechanisms for the evaluation, funding, administration, and monitoring of the IBP projects that would recognize the interests of their agency. The responses are described in Appendix D. Most of the agencies that responded agreed in general with NSF views given below.

It would belabor the obvious to explain why the US-IBP cannot achieve its ambitious goals if management at the Federal level is fragmented, dispersed, and dependent on voluntary contributions or the achievement of consensus of inter-agency subcommittees. There must be a central focal point for formulation and coordination of US-IBP programs and arrangements for subsequent integration of the research activities. Without this the IBP would be little more than an array of separate projects not much different from those supported under disciplinary programs.

The US-IBP effort is characterized by its broad environmental scope. By contrast, Federal agencies usually have statutory objectives defined long ago that do not recognize recent advances made in understanding ecological applied research in all areas of science encompasses the full scope of the IBP objectives. This is why NSF was designated by the Director, Office of Science and Technology to coordinate Federal support of U.S. participation in the IBP.

The Director of the NSF Division of Biological and Medical Sciences is Chairman of the ICC. A description of NSF's internal organization for IBP is given in Section IX.

The Foundation in exercising its responsibility as lead agency believes that the most effective Federal management system would incorporate the following procedures:

- 1) ICC members would serve as an advisory group to NSF and as liaison links with the various groups within their agency.
- 2) All IRP proposals would be submitted to NSF either before or concurrently with submission to the USNC or any other Federal agency.
- 3) NSF in consultation with ICC members would determine Federal responsibility for evaluation, support, monitoring, and coordinating any research activities that are subsequently supported.
- 4) Each designated agency contact point would be responsible for overseeing the development of assigned projects and for maintaining their proper relationship to other parts of the IRP and IBP.
- 5) Interagency monitoring and coordinating groups would be established under the ICC to monitor IRPs that are funded by two or more agencies, not including NSF. This arrangement would permit, but would not require, NSF or any other single agency to manage an entire IRP.

NSF management might therefore embrace any one of several management arrangements. At one extreme NSF might refer a proposal to another agency for funding and monitoring. Proposals concerned with the Gane Pools Program might be handled in this way. USDA is apparently prepared to fund this IRP fully. NSF involvement consequently might be limited to an oversight role, that is, keeping abreast of developments and ensuring that the Program does not falter. At the opposite extreme, NSF might be the only appropriate agency to support a given IRP. The Colonizing Species Program might fall into this category, and responsibility for administration, supervision, and monitoring of this IRP would be the responsibility of the Foundation's IBP staff.

The majority of the IRPs probably will fall into an intermediate category in which two or more agencies will support mission-related components of an IRP. In such cases coordinating responsibility would be assigned to one agency on the basis of predominant interest or special competence, and interagency liaison would be arranged through an appropriate subgroup of the ICC. The details of such arrangements would necessarily depend on the specific nature of each IRP. When two or more agencies contribute to the support of a project under an IRP, consideration will be given to arranging for single-source funding by the agency managing the project. Special attention will have to be given

to situations in which an in-house project of one agency must be closely coordinated with a project managed by another agency.

Regardless of which Federal agency is finally assigned responsibility for funding and managing a particular segment of IBP research, NSF, as the lead agency, will maintain oversight through agency contacts, particularly those contacts assigned through the ICC.

(B) ROLE OF THE NATIONAL COMMITTEE

Although the Foundation does not think it is appropriate, generally, to assist prospective grantees in proposal design, a mechanism must exist through which concerned scientists can collaborate to develop sound IBP proposals with some central source of guidance. To provide such guidance the Foundation makes funds available to the USNC through the National Academy of Sciences/National Research Council for the purpose of planning, coordinating, and designing IRP proposals.

This is consistent with the role of the USNC in (1) coordinating US-IBP activities with the international office (SCIBP) and (2) providing publicity and liaison for IBP within the scientific community.

When planning and proposal preparation is completed, the USNC has the responsibility for reviewing and, when appropriate, endorsing the document. The purpose of this endorsement is to advise the Government that the subject matter is pertinent to and properly a part of the IBP effort. This endorsement attests not only to the appropriateness of the proposal for Federal consideration, but also that all data gathered will be in approved form that can be analyzed and distributed to other IBP groups as warranted. NSF staff will work with the proposal designers and the USNC, both before and after USNC endorsement, to enhance the likelihood that when formally submitted for Federal consideration IBP proposals will be as nearly acceptable for Federal support as possible. As appropriate, internal and external evaluation reviews will be employed by NSF and other ICC agencies.

(C) MANAGEMENT AT THE PERFORMER LEVEL

Special attention will have to be given to the management practices of grantee institutions, particularly to administrative policies and practices that may work to frustrate large-scale, multiuniversity projects. Problems may arise in connection with sharing or transferring funds, sharing facilities and equipment, and transferring personnel between institutions. NSF staff will develop guidelines on these and other matters and, to the degree possible, resolve potential problems at the proposal review stage.

Leadership in executing IBP studies will reside with scientific directors who will be responsible for each IRP. These leaders will be eminent scientists with managerial capability. They will be responsible for: (1) communication with the relevant scientific communities; and (2) working with NSF and USNC to see that all research activities are consistent with IRP goals. Normally the scientific director will be chosen by the USNC with the advice and consent of NSF.

(D) APPLICATION OF FINDINGS TO NATIONAL PROBLEMS

Plans for maximum utilization of the large amounts of data that will be collected are expected to be included in each IRP proposal. Without such plans support funds will not be provided. The question of ensuring efficient information transfer of IBP findings to national problems has been given considerable attention. Consequently, NSF intends to encourage plans for conferences, special meetings, and publications to distribute IBP data, and for establishment of special data centers. Beyond this, NSF staff will be responsible for developing appropriate mechanisms for information transfer with other governmental agencies (Federal, state, or local) that have relevant program responsibilities in different problem areas.

VIII. INTERNATIONAL RELATIONSHIPS

"Describe the relationship of U.S. IBP efforts to the goals and objectives of the international effort.

—Identify the benefits to the U.S. from participation in the international program.

—Identify any cases where programs of other nations are dependent upon finding in U.S. studies."

"Identify IBP work, if any, that could be financed through the use of excess foreign currency."

Review of the available program objectives of other participating nations reveals that all are derived from objectives established by SCIBP. Concern with the operation of ecosystems is apparent in most national programs; however, the programs differ in their content, depth, and goals. These differences are attributable to national economic interests, resources, and scientific capabilities. Consequently, because of adherence to SCIBP objectives and general acceptance of the ecosystem as a central focus, national programs are complementary and mutually reinforcing.

There can be no doubt but that the U.S. will benefit from participating in this worldwide endeavor. The overall IBP effort will benefit the U.S. by providing comparative information without which our own studies will be incomplete. Information from other nations will allow an assessment of the state of deterioration of the biosphere and provide the basis for predicting changes in the biosphere as the result of different levels of exploitation by humans. In most instances the benefits can be described only in qualitative terms. For example, the U.S. can anticipate enhanced international understanding and goodwill resulting from cooperating in team efforts involving scientists of several nations. In other instances the benefits may be describable in economic terms, e.g., information on the abundance and distribution of remaining stocks of marine mammals, or increases in crop productivity yields resulting from nitrogen supplementation of wet and dry tropical soils.

The success of IBP is predicated on obtaining coordinated and cooperative efforts by scientists of all participating nations. This will require uniform scientific methodologies, and the collection, storage, retrieval, and sharing of standardized data. The US-IBP is designed so it is not dependent on the cooperation of other nations; however, without their participation the potential of many IRPs will not be fully realized.

The IBP is not alone in attempting to advance man's ability to cope with major environmental problems through multinational research programs. UNESCO is organizing Biosphere Conferences that might lead to an international program serving as a follow-up to the IBP.

U.S. participation is essential to maintaining the worldwide IBP effort, and U.S. scientific data will contribute greatly toward realization of objectives by other nations. The unique technical capability of the U.S. in systems design and analysis, and in acquisition, storage, manipulation, and retrieval of data, constitutes a large and vital part of our contribution to the world program.

In several instances findings from U.S. studies are desirable or essential before a planned study can be successfully completed by another nation. Often the foreign and U.S. teams will work together on the same project. IRPs on which agreed interactions have been established are:

Eskimos—U.S., Canada, France, Scandinavian countries and probably the U.S.S.R.

American Indians—U.S., Venezuela, and Brazil.

Migrant Peoples—U.S., Israel, Japan, Canada, and possibly others.

High Altitudes—U.S. and Peru, and developing participation of other nations.

Nutrition—Worldwide coordination is involved but is still in the formative stage.

Ecosystems Analysis—U.S., Canada, Mexico, and other Latin American countries, with worldwide coordination through SCIBP and aid from UNESCO.

Aerobiology—U.S., U.K., and Australia, with worldwide coordination through the International Congress on Phytopathology and a SCIBP committee establishing a worldwide network of monitoring stations.

Phenology—International coordination is under development.

Biogeography of the Sea—U.S., U.K., Canada, Brazil and other Latin American countries, Germany and Austria. SCIBP is fostering participation of nations that have special economic marine interests.

Convergent/Divergent Evolution—U.S., Venezuela, Brazil, Argentina, Chile, Colombia, Peru, Uruguay, Puerto Rico, and Australia, and additionally through the Hawaii Terrestrial Subprogram, Samoa, Fiji, French Polynesia, New Zealand, New Guinea, Indonesia, Philippines, Taiwan, Japan, and other south-east Asian countries.

Colonizing Species—U.S., Venezuela, Brazil, Argentina, Mexico, Colombia, Costa Rica, Chile, and Australia.

The U.S. has taken a leadership role in developing research studies that involve close collaboration with other nations particularly those in Latin America. Holding three U.S.-sponsored IBP conferences in Latin America (two in Venezuela, and one in Costa Rica) has greatly stimulated Latin American participation.

Excess foreign currencies are available for the following countries participating in IBP: India, Israel, Poland, Yugoslavia, Ghana, and Indonesia. If excess currencies were more readily available, some international cooperative aspects of IBP might be enhanced. However, because specific IBP plans are not available from these countries at this time, NSF makes no recommendation. The matter will be studied further.

IX. SPECIAL PROBLEMS

(1) "The U.S. National Committee was flooded with project and program ideas with the result that it has been difficult in the time available to delineate and define the elements of the program that would be proposed for Federal support."

Ideas and suggestions were solicited from the scientific community during early planning of the US-IBP. They came in abundance. Some see the early, frequent, and rather profound changes as poor planning and instability; others think the screening of many ideas and adoption of only the best has permitted development of an especially sound Program. With the recent reorganization of the USNC, the appointment of a new chairman, and the definition and description of the IRPs, the U.S. effort can claim to be stable, soundly organized scientifically, and ready to proceed as soon as funds become available. Unsettledness in program definition is no longer an important issue.

(2) "Some major studies proposed involve scientists and disciplines that are not accustomed to the development and management of large-scale integrated field studies requiring coordinated effort of researchers from several disciplines."

"Biologists have typically dealt with one another and with Federal agencies mostly on an individual basis. Relationships have been primarily direct and personal. With the formulation of the IBP-Integrated Research Program concept, former simple relationships between agency and investigator, and amongst investigators, cannot persist.

Recently the designers of the Grasslands Biome Subprogram and their university administrators displayed a gratifying ability to deal with special and complex problems they saw arising. As an example, those five universities employing different indirect cost rates now have an agreement that satisfactorily resolves this matter among themselves and between them and NSF.

This willingness and ability to formulate new procedures and assume new responsibilities for the benefit of IBP operations, we see a hopeful sign of progress in management at the local level.

NSF sees as one of the major indirect benefits of the IBP the generation, at both the Federal and local levels, of a workable management procedure for large but dispersed scientific undertakings.

(3) Some studies require special attention to management arrangements at all levels of involvement.

For the statement in its complete form and NSF's comments refer to Section VII, Management.

(4) "Those in the scientific community who are primarily interested in the more conventional forms of biological research are not convinced as to the special merits of the IBP and may look at IBP programs as undesirable competition, especially in a time of limited Federal research support money."

Some scientists fear that Federal support for IBP will reduce support for programs with which they are associated. Though this may occur in some instances, increasing numbers of scientists are recognizing the scientific opportunities in IBP and the practical importance of the Program. After IBP has functioned for awhile and has demonstrated the potential of integrated studies, sceptical scientists will recognize the special merits of IBP. The importance of the IBP makes support necessary even at the cost of lesser progress in other areas of biology.

(5) "Some of the major studies proposed for IBP are directly related to the missions and objectives of several agencies (including HEW, Interior, Agriculture, Defense, AEC, NASA, Smithsonian, Commerce, HUD, and NSF). However, there is not yet any clear indication on the part of some agencies of ability and willingness to support IBP programs. With some exceptions, the ICC has had difficulty in getting agency commitments."

Refer to Section VI, Funding Requirements and Possibilities.

(6) "In the area of biology research, the mission agencies involved are primarily geared to financial support of projects and modest programs rather than to larger-scale integrated studies of the type represented by some proposed for IBP."

Refer to Section VI, Funding Requirements and Possibilities, part E.

(7) "Some mission agencies (e.g., Agriculture, Interior) that could be expected to have an interest in studies proposed for IBP have a limited fund for support of extramural studies and competition for those funds is already high."

Refer to Section VI, Funding Requirements and Possibilities, part E.

(A) NSF ORGANIZATION FOR IBP

NSF experience in managing large programs indicates the desirability of creating a special organizational unit for administering the IBP. This unit will be part of the Environmental and Systematic Biology Section of the Biological and Medical Sciences Division, but distinct from its existing research programs. It will be staffed by experienced professionals selected in part for their ability to handle the special managerial problems of IBP. Overall agency personnel ceilings may, however, preclude the rapid buildup of an adequate staff. The responsibilities of this new unit will include, in addition to administering NSF-IBP matters:

- (1) Liaison with the USNC and ICC;
- (2) Reviewing all IBP proposals;
- (3) Maintaining awareness of the status of all IBP activities regardless of whether the activity is one financed by NSF or by some other Federal agency;
- (4) Maintaining awareness of the status of IBP activities and developments at the performer level;
- (5) Interagency coordination, including negotiating with other agencies with respect to management responsibilities and transfers of funds.

This unit will call upon other NSF Divisions to provide expert advice on matters that go beyond the competence of the staff of the Biological and Medical Sciences Division.

(B) MANPOWER REQUIREMENTS

The requirement for additional scientific talent is not as large as it might appear at first glance. In the past the average NSF support level in Environmental Biology has been about \$23,000 per Ph. D. per year. This rate of expenditure is expected to double for IBP projects because of the costs of the better logistics and technical support needed for the large-scale coherent IRPs, especially the Analysis of Ecosystems Program. The \$8.0 million baseline program would thus require between 150 and 200 scientific leaders in addition to junior scientists and supporting staffs. The community of scientists from which this manpower is to be drawn is adequate. It includes, in addition to trained ecologists, biologists with a full spectrum of interests including agriculture, and many physical and social scientists as well. Part of the manpower needs will be met by scientists now employed in other work and part from recently-trained Ph. D.'s. We believe, therefore, that sufficient scientific talent will be available to conduct the US-IBP at the level of activity recommended in this document.

(C) PARTICIPATION OF SOCIAL SCIENTISTS

Current plans for some of the Human Adaptability IRPs do not provide for sufficient participation by social scientists. The Foundation intends to call upon the staff of its Division of Social Sciences to assist in rectifying this situation.

APPENDIX A—OUTLINE FOR NSF STUDY

THE PROBLEM

Emerging from the planning and development of U.S. participation in the IBP is the question of whether elements of the U.S. portion of that program have potential research results of sufficient importance to our national interest to warrant special funding, beginning in FY 1970, i.e. beyond that provided through directing existing programs to IBP objectives or through the normal, competitive support of project proposals. If special funding is proposed, attention must also be given to the question of how agencies can be encouraged to support as much of the IBP effort as possible through normally available funds rather than relying primarily on special funds. In addition, management of some IBP studies presents potential problems requiring special consideration and planning.

BACKGROUND

IBP is a multi-nation program, organized under the ICSU, directed toward advancing our understanding of the relationships among living organisms, and their interaction with the environment, with attention concentrated on better understanding of a limited number of large scale systems (i.e., larger systems than have been studied in the past). A principal benefit of the proposed programs would be the scientific understanding of the impact of environmental changes—understanding which may contribute to the effectiveness of such current efforts as control and abatement of environmental pollution.

On November 30, 1965, the President's Science Advisor designated NSF as the agency to coordinate Federal support of U.S. participation in the program. NSF then established the Interagency Coordinating Committee (ICC) for IBP.

Scientific planning for U.S. participation in the IBP has been underway for four years under the direction of a U.S. National Committee for IBP, established by the National Academy of Sciences. Theoretically, IBP began in July 1967 and will continue for five years, though work begun during the five year period probably will continue thereafter.

IBP activities outlined thus far by the U.S. National Committee include several (six to twelve) major program areas, some of which—such as Analysis of Ecosystems—consists of several major studies.

In the early stages of planning, NSF (with support from the ICC) proposed (a) separate identification of funds for IBP in agency budgets, and (b) funds for IBP as an increment over funds for ongoing biological research support. However, the Bureau of the Budget did not agree to any large scale separate or incremental funding because it felt that (a) the program was not yet sufficiently developed to warrant special funding consideration and protection, (b) proposals directed toward IBP objectives should compete with other research proposals for support and (c) support obtained as a result of proposals submitted and evaluated through the normal project support route would be sufficient.

In addition to extramural project support, an ICC survey of Federal agencies indicated that some in-house research efforts had relevance to IBP aims and it was assumed that agencies would be able to focus some additional in-house research toward IBP objectives.

As planning for the program has progressed, large-scale interdisciplinary studies—rather than collections of projects—have emerged as a central focus of the U.S. effort. The nature and scope of programs now planned for U.S. participation in IBP are different from past Federally-supported biological research in that several of the major studies would involve the integrated and simultaneous interdisciplinary efforts of researchers on a single program.

The six to twelve major study proposals that are under development or completed are of varying size, organizational and funding complexity, and focus. Some are related to the missions of several agencies. Others appear to be primarily within the area of interest and funding authority of a single agency—so that one agency would quite clearly have lead responsibility for support and program management.

PROBLEM AREAS

Apart from the normal problems faced in the competition with other activities for Federal financial support, U.S. IBP studies appear to have encountered the following difficulties:

- The U.S. National Committee was flooded with project and program ideas with the result that it has been difficult in the time available to delineate and define the elements of the program that would be proposed for Federal support.
- Some major studies proposed involve scientists and disciplines that are not accustomed to the development and management of large-scale integrated field studies requiring coordinated effort of researchers from several disciplines.
- Some of the studies (e.g., those of ecosystems) require special attention to management arrangements at all levels of involvement to assure orderly execution of studies and utilization of findings; e.g.,
 - on logistics at the research site;
 - in integration of research and support, including systems analysis, computer services and data exchange;

in the National Committee, its subcommittees and study planning groups in the development of studies which will involve many researchers from various disciplines and institutions;

on the part of Federal agencies in carrying out program management responsibilities.

- Those in the scientific community who are primarily interested in the more conventional forms of biological research are not convinced as to the special merits of the IBP and may look at IBP programs as undesirable competition, especially in a time of limited Federal research support money.
- Some of the major studies proposed for IBP are directly related to the missions and objectives of several agencies (including HEW, Interior, Agriculture, Defense, AEC, NASA, Smithsonian, Commerce, HUD, and NSF). However, there is not yet any clear indication on the part of some agencies of ability and willingness to support IBP programs. With some exceptions, the ICC has had difficulty in getting agency commitments.
- In the area of biology research, the mission agencies involved are primarily geared to financial support of projects and modest programs rather than to larger-scale integrated studies of the type represented by some proposed for IBP.
- Some mission agencies (e.g., Agriculture, Interior) that could be expected to have an interest in studies proposed for IBP have a limited fund for support of extramural studies and competition for those funds is already high.

SPECIAL STUDY

A special study is needed to identify the issues and alternatives and to identify benefits likely to result from alternative IBP program content, timing, and levels of funding. The memorandum should also deal with actions needed to solve the practical funding and management problems resulting from multi-agency involvement in IBP support. Such a program memorandum should be available in draft by August and in final form by September 1968 for decisions on the FY 1970 budget.

A special study should be undertaken to develop information outlined below. Participation of other agencies, perhaps through the ICC, will be necessary in carrying out the study and developing the PM.

A. Program Description

Briefly describe the U.S. IBP effort.

Identify the major areas of study for which Federal support is desired.

B. U.S. National Committee Views

1. Scientific Merit and National Interest

For each major area of study:

- a. Identify the scientific objectives and goals
- b. Describe the relative importance of these objectives and goals:
 - in terms of their scientific impact,
 - in terms of the relevance to the solution of "national problems" (e.g. what is the relationship to current problems of environmental change?)

2. Overall Program Development: Alternatives, Priorities, Management

a. Identify the priorities for the various parts of the research effort by describing both alternative *program content* and *timing* within and among major areas of study for various alternative levels of total funding through FY 1972 for IBP such as \$10, \$20, \$40, and \$60 million.

b. Identify differences in benefits for alternative funding levels.

c. For each alternative level of funding, develop displays (along the lines of Attachments 1 and 2) covering the major IBP studies that are proposed for Federal support showing:

- significant dates,
- levels of funding required during the various periods,
- kinds of activity during the periods included.

d. Identify amount and source of funds requested or available from sources other than the Federal Government (e.g. state funds).

e. Describe the management arrangements for each large-scale integrated study; e.g., planning, analysis, integration of data; coordination of work of researchers and of supporting staff.

f. Identify steps needed—beginning in the planning process—to assure the effective application of findings in the solution of national problems or in furthering follow-on research. (For example, what steps can be taken to assure that the large amounts of data that will be collected will be put to good use?)

g. Describe the relationship of U.S. IBP efforts to the goals and objectives of the international effort.

- Identify the benefits to the U.S. from participation in the international program.

- Identify any cases where programs of other nations are dependent upon findings in U.S. studies.

C. Federal Agency Evaluation and Plans for Support

1. Scientific merit and national interest

For each major area of study:

a. NSF views on the objectives and importance of the proposed research—as outlined in B.1, above—identifying differing views from those of the U.S. National Committee.

b. Views of other agencies when different from those of NSF.

2. Overall Program Development: Alternatives, Priorities, Management

a. NSF's assessment of alternatives, priorities and management—as outlined in B.2, above.

b. Views of other agencies when different from those of NSF.

3. Federal agency Participation, Funding and Program Management

For each major area of study:

a. When the objectives of the area of study are related to mission requirements of one or more agencies, identify the agencies and describe the relationship.

b. Identify the level of each agency's funding for IBP and directly related research during FY 1968 (actual) and FY 1969 (estimated).

c. Identify parts of the proposed major area of study that can be supported during FY 1970 and future years by each agency (assuming no significant change in overall funding levels) with mission interest through the normal funding for research (extramural or in-house) through:

- on-going programs;
- new commitment of funds.

d. Identify IBP work, if any, that could be financed through the use of excess foreign currency.

e. Identify instances where the major area of study is of interest to an agency but the agency is unable to provide support through one or more of above means.

f. Identify amount of funds needed for the major area of study that would not be provided by mission agencies. Describe the proposed funding method.

g. For each major area of study, particularly the large scale integrated studies, identify the locus of responsibility in the Federal Government and the arrangements for:

- securing and integrating supporting work financed under separate grants and contracts;
- handling necessary coordination with other Federal agencies participating in or supporting the study;
- monitoring the research progress and management.

APPENDIX B—DESCRIPTIONS OF INTEGRATED RESEARCH PROGRAMS

"In our times of unprecedented change, biologists are well aware of the rapidly growing ability of their fellow human beings to alter the face of the earth through technology. But they are equally aware that these alterations can bring about far-spreading and often destructive changes in the web of life that is stretched so thinly over the surface of our planet. Our technology has out-paced our understanding, our cleverness has grown faster than our wisdom.

"Because of our limited understanding of the relationships among living things, we are limited in our ability to predict the effects of technical change or to help the technologists conserve the values and utilize the abundance of the world of life. Our goal should be not to conquer the natural world but to live in harmony with it. To attain this goal we must learn how to control both the external environment and ourselves. Especially we need to learn how to avoid irreversible change. If we do not we shall deny to future generations the opportunity to choose the kind of world in which they want to live.

"Greater understanding will make it possible for man to respond to opportunity as well as to react to need. To gain such understanding is the underlying purpose of the International Biological Program."—Roger Revelle, Past Chairman, U.S. National Committee for the International Biological Program.

INTRODUCTION

The International Biological Program (IBP) grew out of mounting scientific concern throughout the world for the major problems confronting mankind today—the rapidly increasing population, food shortages and environmental destruction. As early as 1959, scientists began discussing the possibilities of organizing an international program which would deal with increasing food supplies and keeping the earth a fit place in which to live.

In July of 1964, the IBP was voted into reality by the International Council of Scientific Unions (ICSU) which set up a Special Committee for the IBP (SCIBP). Based on the theme of "The Biological Basis of Productivity and Human Welfare," the program was divided into two main phases: the planning stage from 1964 through June of 1967, and the five-year operational phase from July of 1967 through June of 1972.

Possibilities for United States participation in the IBP were explored by an ad hoc committee of the National Academy of Sciences which, upon the recommendations of this group, organized the U.S. National Committee for the IBP in 1965 with Roger Revelle of Harvard University as chairman.

Fifty-three other nations also agreed to participate in the IBP and formed national committees. Each country has developed or is in the process of developing a national program which fits into the broad international aims set up by ICSU, but which also concentrates on special problems within their own nation. Many of the developing nations in the IBP have directed their efforts toward methods for increasing food production and for better population control, while the more industrial nations have concentrated on investigating the problems of urbanization and environmental pollution.

Because of the degree of advanced technology in the United States—which can be harmful as well as beneficial—the U.S. scientists departed from the scheme of trying to reorganize on-going research as many of the other countries had done. They decided instead to develop entirely new methods for handling the very complicated ecological problems found within the country. This new type of approach—which has been called the beginnings of "big biology"—involves the use of multidisciplinary teams of researchers working on all components of a specific environment and the interactions that occur between them.

Special concern was also given to man himself and how he fits into and affects his environment—and how it affects him. Man's adaptation to environmental stresses such as cold, high altitude and urbanization was of particular interest to the IBP scientists.

With the advent of the operational phase in July of 1967, the U.S. National Committee found itself with a group of integrated research programs specifically generated by and designed for the IBP. Also a part of the U.S. effort were smaller, individual research projects that were not IBP-originated, but closely related to the aims and goals of the program.

The major effort of the U.S. Committee for the next few months was to interrelate these programs for a better concentration and management of research effort. Along with these actions, the structure of the Committee itself was altered with the chairmanship passing to W. Frank Blair of the University of Texas, and the formulation of plans to streamline the group to meet the needs of the operational phase of the program.

Through these efforts, the large-scale integrated research programs which formed the major core of the U.S. contribution, focused more sharply on the two main centers of international interest—problems of human adaptability and those of environmental management. Although the number of integrated programs in these two areas has been and is still subject to change through the addition of new studies or the merger of others, the contributions to be made over the next few years should be of significant value in helping to "not conquer the natural world, but to live in harmony with it."

PROBLEMS OF HUMAN ADAPTABILITY

As a result of rapid technological advances and increasing population pressures, man is so seriously disturbing his environment that he is subjecting him-

self to a wide variety of new stresses and strains. Man is an enormously adaptable animal, but it is clear that his adaptability has limits, and that attempts to exceed them produce a toll in disease and death. Clearly, we must greatly improve our understanding of the processes of human adaptability if we are to cope with the emerging crises of human survival.

The scientific basis of human adaptability has two major components—the genetic, which sets the limit of the organism's capacity to respond, and the physiological and behavioral, which determines the range of responses available to the organism given its genetic set. At one extreme of the spectrum of inquiry that can be brought to bear on human adaptability is population genetics, and at the other extreme, environmental physiology. In between, many aspects of modern medicine and anthropology come into play.

Human behavior, in contrast to the behavior of other organisms, includes a large set of cultural activities, the domain of the arts and social sciences. These establish a context, a pattern of civilization, within which the more biological attributes of human adaptability must operate. It is the limited adaptability of the latter, expressed in genetics, physiology and behavior, that are the central theme of this program.

Each U.S. IBP integrated research program in human adaptability attempts to exploit certain unusual opportunities to understand critical aspects of human adaptability. Some of these opportunities are associated with vanishing cultures and will soon disappear. It can be truly said that this is the last generation of scientists to have the opportunity to study primitive cultures, and the first generation to have adequate tools in genetics, molecular biology and physiology to do it. As an aggregate, these programs will clarify many mechanisms of human adaptation to environmental extremes and to urbanization. They are articulated by a number of common subjects, especially nutrition and population genetics, and by research on the same populations under varying conditions, such as Eskimos in the Arctic hunting and in urban settings. They are also coordinated with the environmental programs through commonalities of place, time and personnel.

INTEGRATED RESEARCH PROGRAMS IN HUMAN ADAPTABILITY

International Study of Eskimos

Eskimos, similar in race, language and culture across a distance of 3,000 miles at the top of the world, represent the greatest linear dispersion of one group of people in human history. Their habitat, snow-covered two-thirds of the year, is marked by low temperatures, seasonal extremes in light and darkness and relatively meager resources. The aim of this five-year program is to elucidate biological and behavioral processes responsible for the successful adaptation and slow population growth of 70,000 Eskimos in an arctic environment.

The integrated program involves multidisciplinary scientific teams from the United States, Canada, Denmark and France who are cooperatively and simultaneously studying their own Eskimo citizens (excepting France) in Alaska, Canada and Greenland. Methods to be used, previously approved by IBP working groups following World Health Organization recommendations, will be comparable to simplify synthesis of results.

The research categories are: (1) general health and performance, with special attention to the cardiovascular system, work capacity and the antibodies present in the blood and serum; (2) child growth, including long-term studies of the size, form and composition of the body at different ages, the definition and bone mineral content *in vivo*; (3) genetics, including genetic markers, the population structure and demography; (4) behavior, including cognition, psychomotor and expressive behavior and behavioral genetics; and (5) ecology, including quantification of nutritional energy flow through the ecosystem of which the human population is a part.

The studies will provide immediate dental and health benefits and growth norms for Eskimos, who are increasing population numbers at about three and one-half percent per year, as well as contribute to basic knowledge of small group population genetics, of human survival in a harsh environment, and of relations within a small isolated population between genetics, stress, environment and disease.

Population Genetics of the American Indian

Scattered throughout South America are still to be found tribes of Indians living by hunting, gathering and simple agriculture, much like the ancestors of

most civilized populations a few thousand years ago. These tribes provide a rapidly disappearing opportunity to obtain a baseline on the vital statistics and health patterns of primitive man. At the same time, dispersed throughout the United States, but especially in the Southwest, are groups of relatively pure Indians who are in the mid stream of transition from the primitive state to the Atomic Age. In their lifetime, these Indians are subject to biological adjustments which in the Old World were spread over several thousands of years. Thus, the study of these transitional Indian population in conjunction with the study of primitive groups should provide important insights into the kind of biological adjustments modern man is being called upon to make and some of the consequences of these adjustments.

This specific investigation at present entails the collaboration of U.S. investigators with those in Venezuela and Brazil. Several very primitive tribes living on tributaries of the Amazon and Orinoco Rivers have been selected for studies of their mating patterns, methods of fertility control, birth and death rates, genetic characteristics, food utilization characteristics and disease pressures. The early effects of acculturation are being explored in the expectation of linking these studies in time with studies on the much more changed Indian of the United States. From the careful, quantitative study of groups such as these, an understanding of the changing stresses of modern man and, possibly, some insight into their consequences can be found. All over the world the remaining primitive societies are being rapidly disrupted; this is probably the last generation of scientists to be able to study them.

Biology of Human Populations at High Altitudes

A significant portion of the world's population, more than 25 million people, live at altitudes above 10,000 feet. This number can be expected to expand as world-wide pressure for living space increases. The former stability of ancient high altitude populations is rapidly disappearing as transportation facilities improve. In some communities, there is a constant influx and efflux, yet the population dynamics of such communities are poorly understood. In particular, the reasons why people leave high altitude have never been examined systematically. The role of biological inability to adapt to chronic hypoxia in comparison with other environmental stresses such as cold and dryness has not been thoroughly investigated as well as the economic, social, political or cultural factors that affect these populations.

United States participation in the study of man living at high altitudes will be concentrated in the Western Hemisphere, with emphasis on collaboration between scientists in both North and South America. At the same time, the program will integrate with investigations in such countries as Ethiopia, India and the Soviet Union. Three human population groups will be examined in the U.S. program: a North American population at 10,175 feet in the Rocky Mountains; a South American population also living at 10,175-11,500 feet; and a predominantly native Andean population living at the more extreme altitude of about 13,000 feet.

In each of these populations, the human biological investigations will have three main foci—physiological adaptations to the chronic hypoxia of high altitude from before birth to old age; medical and obstetrical problems which are a direct consequence of maladaptation to high altitude such as incidence of fetal wastage and malformations; and modification of disease by high altitude. In this last category, one provocative hypothesis is that residence at high altitude may protect against degenerative cardiovascular disease.

The study of these three populations will allow judgments to be made concerning the relative significance of genetic and physiological processes in human adaptability. The peoples to be studied in the Rocky Mountain communities enjoy such conveniences as central heating, adequate clothing, sanitation, refrigeration, adequate nutrition, good medical care and private transportation. Hence, the primary uncontrollable environmental factor is the reduced atmospheric pressure and the resulting hypoxia. For the Andean populations who have lived at high altitudes for many generations, these amenities are not readily available. A hypothesis that can be examined in these studies is that their adaptation has been primarily genetic whereas the North American peoples have made their adjustments physiologically.

Nutritional Adaptation to Environment

The nutritional studies in the IBP are based on research that is integrated on a national and international basis with other programs of human adaptation.

The results will hopefully assist mankind in making adjustments to present and future circumstances in relation to food.

Experience in typical arctic, tropical and temperate zones has resulted in three extreme ranges of food practices that are in sharp contrast as related to critical margins of success or failure in human adaptability. Limitation to animal sources of food in polar areas of Alaska, Canada and Greenland has resulted in diets that are close to the limit of physiological tolerance in their high content of protein and fat and their low content of carbohydrates and vitamin C. In tropical areas of Latin America, Africa and Asia the reverse is true: diets there tend to be critically low in good quality protein, high in starch or sugar and seriously low in total energy content. Temperate zones as in the United States and Western Europe permit varied and more adequate food production and generally a more favorable economic environment. Nutritional adaptation research in this area is needed to identify requirements for all essential nutrients including vitamins and trace elements such as zinc and chromium, and to investigate the tragic hazards of excess caloric intake.

Within the integrated programs, the Eskimo study includes a nutritional examination of food consumption by different age groups and metabolic measurements to identify the degree of functional adaptation to the restricted and extreme types of diets.

Among the tropical and subtropical populations, protein deficiency is a major hazard to health and human development. There is an urgent need for U.S. cooperation in identifying the degree of protein deficiency and its differentiation from caloric and other dietary deficiencies that may exist concurrently.

In the temperate zone, good quality protein foods are available. Nevertheless, many problems require intensive research on quality, safety and nutritive value of foods in their production and use for domestic and export purposes. Studies will be directed also to impoverished urban and rural areas, to migrant populations and other groups living in stress environments.

The Ecology of Migrant Peoples

The planned research on the ecology of migrant peoples will improve understanding of how people who migrate from a rural to a highly urbanized environment adapt to change. Involved in migration are various factors including the physical environmental (increased congestion, noise, traffic, and climatic differences), the institutional environment (impersonal routines and authority, and conformity to rigid time schedules), and the social environment (changing family patterns, exposure to gangs and to deviant behavior such as narcotics addiction). These factors constitute critical changes in the ecology of migrants.

Work on the ecology of migrants of varied racial and ethnic origins can clarify the broadest common denominator of human response to industrialization. Worldwide, at least a billion people have migrated since World War II, yet rigorous bio-social studies of migrants are almost totally lacking.

In this program, priority has been given to source populations under high physical and socio-psychological stress in Mississippi and Georgia and in receiving areas like the inner city of Chicago and Fairbanks, Alaska. Specifically, Holmes County, Mississippi, appears to be the most economically deprived area in the United States, and the areas to which Holmes County people migrate in Chicago—Maywood and the West End—have been foci of violent unrest. Consequently, the work proposed would yield basic data on the phenomenon of migration and also contribute directly to the urgent search for social justice and tranquillity called for by the President's Commissions on Rural Poverty and on Civil Disorders. Furthermore, the program's methodology would have world-wide relevance and its field operations would provide a basis for associated programs to alleviate chronic poverty and deprivation.

PROBLEMS OF ENVIRONMENTAL MANAGEMENT

An increasing human population coupled with an expanding technology has placed unprecedented stress upon the biosphere, the world environment in which man lives. More of the productive capacity of the earth must be harnessed for the benefit of man, while at the same time more space is used for other activities and more waste and contamination are released. Improperly managed, these activities become incompatible, reducing both the quality and the productive capacity of the environment. Each local problem can often be allayed with a "quick technological fix," but such a piece-meal approach usually shifts the place or time of the

problem rather than eliminating it. Mankind is running out of both places and time.

The scale of these problems is larger than the scale of conventional research. Their solution requires the skills and knowledge of many disciplines, the coordinated efforts of many scientists, the experimental manipulation of large environmental-biological systems, the study of interactions in such systems and the synthesis of large amounts of information into working models. Only by such an approach can the predictive powers of the separate sciences be integrated to reach the needed level of reliability.

Figure 1

Scientific Basis for Environmental Management

- A. Changes in Plants and Animals
 - 1. Evolutionary Adaptations
 - 2. Physiological and Behavioral Adaptations
- B. Changes in Relationships of Plants and Animals
 - 1. Interactions with the non-living environment
 - 2. Interactions with other organisms
- C. Structure and Function of Ecosystems

The scientific basis of environmental management combines a variety of basic and applied problems in several major components (figure 1). A major biological aspect of the environment concerns the changes that occur in plants and animals in response to variations in their surroundings. These areas parallel those in human adaptability. Evolution has produced, for each species, a genetic composition that sets limits to its environmental responses. Within these constraints, physiological and behavioral mechanisms define an array of responses that can be used to cope with environmental change. Both areas, applied to the several thousand species in an ecosystem or the several million in the biosphere, will make use of enormous amounts of information already on file, as well as requiring much more research as this information is integrated and the underlying processes become better understood.

A second major biological aspect of the environment concerns changes that occur in relationships between organisms or between organisms and the non-living environment in response to environmental change. The presence or absence of species in a region is largely determined by such relationships, and for each species present its many relationships are continually shifting as the composition of the environment changes. The effects of changes imposed by man could be predictable if we knew much more about the mechanisms influencing such relationships. Better control of particular species is certain to result. Here the role of the meteorologist, soil scientist and chemist are as significant as those of the ecologist, behaviorist and molecular geneticist.

The environment as a whole includes both biological and physical-chemical processes. Their interactions in given regions produce complex ecological systems. These ecosystems in turn interact in larger regions producing on the largest scale the earth's biosphere, the total system in which organisms participate. The ecosystem is the smallest unit in which environmental management can be applied if problems are to be solved rather than moved. One goal of this program is to learn much more about the structure and function of such systems.

Most of the IBP integrated research programs in environmental management are concerned with the processes discussed above. In addition, urgent problems in conservation face mankind. The U.S. IBP includes the search for and preservation of representative ecosystems. Areas preserved for long-term scientific use provide natural laboratories for the study of ecosystems in all their variety and complexity including their inherent biological productivity. They can serve as check areas against which the effects of use, protection and management of comparable areas of land and water can be measured. They provide for the continued existence of large numbers of species whose potential use by man is yet unknown, as well as the preservation of many genetic stocks, wild precursors of domesticated organisms, from which breeding of more useful strains may be continued.

INTEGRATED RESEARCH PROGRAMS IN ENVIRONMENTAL MANAGEMENT

Convergent and Divergent Evolution in the Americas

This cooperative research program has three main purposes: the understanding of the processes and results of both convergent and divergent evolution in

structure, behavior, and physiological adaptation of various kinds of organisms of the New World as well as the puzzling relationships between various South American and Australian groups; understanding of the composition, ecological niches and functioning of ecosystems that have evolved in similar environments of the Southern and Northern Hemispheres; and the understanding of native and invading biotas of the land areas of the Hawaiian Islands.

Selected biologists from several American countries and Australia have planned a cooperative research program with subprograms on six groups—amphibia, fish, mammals, reptiles, insects and plants. Each has investigators and institutions named to a limited extent that will expand as the program proceeds. In addition, there are two subprograms concerning the questions of convergence in ecosystem structure and convergence in physiological adaptation.

In the Hawaiian Islands, the native terrestrial biotas are most seriously threatened. Many island species have become extinct; but most of the remaining species can be saved with better understanding of the interactions between the plants and animals and their changing environments, especially where man is having a serious influence. The rich Hawaiian flora and fauna evolved from about 700 immigrant species, under conditions of extreme isolation in the course of a few million years. This provides an unsurpassed natural laboratory for the study of evolutionary and ecological phenomena.

Experimental Biogeography of the Sea

This program seeks to develop the ecological and physiological knowledge required to predict how environmental factors limit or enhance the abundance and productivity of selected marine organisms of interest to man. Studies will be in the United States and other IBP countries in the Americas.

Knowledge gained on the mechanisms of marine productivity is basic to an identification of the environmental factors and stresses which limit the distribution of organisms and help explain evolutionary diversity. It would also aid in identifying optimal environmental and functional conditions useful for assessing aquacultural potentialities for selected species and provide an understanding of the significance of selected marine organisms in food chains important to man's welfare. In addition, information would become available on the adaptive capacity of organisms for life in modified or disturbed environments such as polluted waters.

The IBP research will be conducted in terms of "packages" of separate projects, all dealing with a particular organism or group of closely related organisms. Investigators representing different disciplines will study various physiological parameters on a coordinated cooperative basis.

Physiology of Colonizing Species

Species of plants and animals which invade disturbed habitats will be investigated in this program to first, obtain a better understanding of the characteristics of these species that allow distribution expansion and second, to determine the role of habitat alteration in promoting these invasions. A range of species will be studied varying from those possibly representing local expansion of a specially adapted type to broad expansion of a type with generalized adaptation. The habitats to be evaluated will encompass a broad latitudinal and altitudinal diversity in the Western Hemisphere. From these studies should come a fuller understanding of the interplay of the disturbance of habitats and the physiological adaptation of invading species.

Basic characteristics of invading plant species that will be investigated include: (1) opportunistic ability to expand or contract a life cycle to fit growing seasons of varying length; (2) the production of chemical inhibitors; (3) the ability to survive in relatively pure stands; (4) broad tolerance of temperature, light intensities, and photoperiods; (5) less palatability; (6) less dependence on a particular insect for pollination; (7) regulative propagation or other asexual reproduction; and (8) self-fertility. These studies will try to determine if certain characteristics promote invasion of a given habitat at a given latitude.

The program also seeks to measure the degree to which invading species have diverged physiologically and biochemically under the pressure of new selective forces in a variety of habitats. These comparative studies will yield insight into the factors of population adaptation. Attention will be given to habitat influences since man's disturbance of habitats plays a major role in species invasion.

*Atmospheric Dispersal **

This program is designed to meet urgent problems of airborne diseases, allergenic substances, and biologically harmful pollutants in the air around man. It will organize, integrate, and extend present investigations of airborne spores, pollen, microbes, insects and other small organisms and biologically significant non-living materials such as toxic gases. It will also identify critical problems not yet under investigation and will initiate new projects to meet those needs. The IBP provides unprecedented opportunities for attacking these problems because of the free cooperation between nations and because of concurrent development of schemes for global monitoring of environmental conditions.

The program will include segments for research technology, phytopathology, allergenic particles, transport of genetic material, human and animal disease microbes, wind-carried insects and other small animals and gases toxic to organisms. The American Phytopathological Society, which has for many years fostered international cooperation for study of plant diseases and amelioration of resulting losses, has placed its IBP steering committee within the framework of this program to assist in the prosecution of three related areas within phytopathology: mode and places of origin of organisms causing plant diseases in major crops; processes by which plant disease organisms are dispersed; and assessment of world-wide plant disease losses.

The atmospheric dispersal program will share efforts with several other IBP programs as well as various Federal agencies, scientific societies and numerous private and university laboratories. It will increase the quantity and improve the quality of research on atmospheric dispersal of biologically significant materials, while taking full advantage of the new opportunities for working in the full context of world-wide investigations.

Phenology

Plants and animals undergo rhythmic changes from season to season. These biological rhythms collectively are termed the phenology of the organism. These phenological changes are the response of the organism to regular, seasonally varying meteorological inputs such as light, heat and moisture. Because man has many uses of phenological information about plants and animals, it is important to obtain a broader and more predictive knowledge of these phenomena.

The objectives of the phenology program include detailed studies on plant and animal species, both aquatic and terrestrial at a number of sites within the United States in order to prepare phenological maps; to obtain clues to the physiologic limitations that determine climatic limits of species and explain the biological basis for phenological timing; to test the hypothesis that such studies will aid in understanding evolutionary mechanisms; and to contribute to understanding the role of phenologic phenomena in the structure and productivity of ecosystems.

The program provides for overall coordination and three sub-programs on mechanisms, phenology within communities, and phenologic maps. Broad studies will be conducted with the aid of a large network of stations and observers. They can be done at several levels of sophistication, providing participation by people with all levels of scientific training. Special sites will be selected and intensive multidisciplinary studies made of measurements of environmental parameters and population structure, breeding behavior and physiology of organisms. A chief aim will be the development of phenologic maps that will predict planting and harvesting dates for crops and outbreaks of plant and animal borne diseases as well as other biological events.

Analysis of Ecosystems

Plants and animals live together and interact continually with the non-living parts of their environment. These ecological systems or ecosystems are the units of landscape or seascape of immediate importance to man. Understanding or predicting the responses of ecosystems to man's activities requires knowledge of the whole integrated system as well as of living and non-living components.

The purposes of the Analysis of Ecosystems program are: (1) to understand how ecological systems operate with respect to both short-term and long-term processes, including those disturbed to varying degrees by man; (2) to analyze interrelationships between land and water systems so that broad regions may

*Also referred to as the Aerobiology Program.

be considered as entities; (3) to estimate existing and potential plant and animal production in the major climatic regions of this country, particularly in relation to human welfare; (4) to add to the scientific basis of resource management, so that optimization for multiple use and for long-term use can be improved; and (5) to establish a scientific base for programs to maintain or improve environmental quality.

In this program an intensive team effort will be made to study six kinds of ecosystems called biomes—grasslands, tundra, desert, coniferous forest, deciduous forest and tropical forest. Each of these six intensive studies will involve many scientists of varying disciplines and each study has its own management structure. In turn, efforts in the six studies will be coordinated by the overall program director and his staff. Strong modelling and synthesis projects are characteristic of this whole program.

Within each of the six biomes, a comprehensive study involving natural gradients or contrasts of climate or sites is planned. These will sample the range of conditions that exist in the biome. For example, the deciduous forest biome includes contrasting forest types (oak-hickory, beech-maple), a variety of geological conditions (granite, limestone, gravel, clay), variations in the steepness of topography and variations in the degree of alteration by man. Many of these will be utilized to improve the power of analysis concerning ecosystem function.

At least one site in each biome will be the location of an intensive study—as complete a study as modern technology permits. All of the components of the system will be studied, and all processes will be evaluated in relation to other variables. On different subareas within the study unit, different treatments will be imposed to stress the system or to shift its configuration into a different state. This general plan will be modified to fit specific situations within each biome.

The synthesis of results toward an understanding of ecosystems will be a major research activity. It will be supported by a staff of planning and analysis experts in each biome who will develop models of ecosystems that incorporate all of the data, attempting to view the system as a whole. This information synthesis will begin with data from the several states of one system in the intensive study, continue with data from system variants in the comprehensive study, and finally include data from markedly different systems in different biomes.

The many benefits that will be derived from this large-scale attempt to understand ecosystems can be divided into three main areas—biological productivity, resource management and environmental quality.

Biological Productivity.—Productivity is one measure or capability by which systems as different as the grasslands, forests and lakes will be compared. It is a measure of their biological conversion of solar energy—their ecological efficiency. With information from the six biomes, extensive knowledge on total natural plant and animal production as well as economic products in the United States should become available. In collaboration with other IBP countries, actual and unrealized potential production can be assessed also on a world-wide basis, in circumpolar, temperate and tropical zones.

By gaining knowledge of the interactions that occur between green plants, herbivores (animals that eat plants), predators (animals that eat other animals) and decomposers (the microorganisms in organic matter), levels or allocations of production can become understood. This information is vitally important for agricultural systems and in the field of biological control of pests.

Resource Management.—Multiple use of natural resources is increasing steadily: for example, combining timber production, hunting, fishing and recreation. Management programs for this multiple use are already developing but are very complex and cumbersome because of lack of knowledge. The principles and facts about ecosystems that will be produced by this program will establish a theoretical base on which to design the complex management systems needed. Once the principles governing whole ecosystems become familiar, management should become both simpler and less expensive than it is at present. Mistakes should be foreseen and avoided where possible.

Quality of the Environment.—A rapid deterioration of the environment is often due to obvious causes that can be corrected if enough people decide to do so. The solution of these problems seldom requires more than the most elementary level of ecology.

But, of growing concern are the less visible, more chronic, insidious changes that take place over decades. Many phenomena of varying importance to man can be listed: the thinning of the soil, the increasing need to spray crops, the increasing abundance of weeds, the dense algal blooms in lakes, the decreasing

abundance of sport fish and changes in species of birds in towns. These and many others combine to produce profound changes over long periods of time.

Many of these problems are deeply rooted in ecological systems. They are system responses in which the visible effect appears in one part of the system while the cause lies in another. The relation between cause and effect, and recommendations for improvement would be much easier to determine if the operations of ecological systems were better understood.

In effect, the program on intensive analyses of ecosystems provides a structure or framework which references and utilizes information from all the integrated programs on plants and animals in the U.S. IBP.

Conservation of Ecosystems for Scientific Purposes

Increasing human populations, with their attendant demands upon their surroundings, make increasingly urgent the selection and preservation of representative samples of environments. Already, some of these environments are disappearing while changes in use are affecting many others. Some experimental areas with records of study extending back several decades are threatened by encroachment of buildings or highways. Future generations will find even more urgent the need for natural or near natural areas for comparative study and areas with long histories of study.

The overall purpose of this program is to assure to protection and preservation of a full range of environments—both those relatively little disturbed by man and those that have been appreciably modified by his activities; of those rare or endangered species not subject to protection by reservation of areas; and of those areas, aquatic and terrestrial, with long histories of scientific records.

Specific goals include the provision of registries and descriptions of protected areas and areas requiring protection as well as guidelines useful in managing and protecting them. Assistance will be given to other nations also interested in accomplishing these same purposes.

The program will be accomplished by stimulating and providing a focal point for those activities already underway by governmental or private units. Thus, the Directory of Research Natural Areas on Federal Lands published in 1968, will be updated and additional natural areas added. An assessment and plan of action for publishing similar information on non-federal lands will be carried out by a foundation under the program's direction. An inventory of freshwater and estuarine areas has begun as has a study of mechanisms for assuring protection in marine areas.

PROPOSED RESEARCH FOR THE U.S. IBP

The programs classified as proposed research have also been generated specifically for the IBP but have not yet reached the stage of development necessary for final approval of the U.S. National Committee as an integrated research program. There are several alternatives for each of these programs—they may be considered adequately housed in existing IBP related research, or they may be incorporated into an existing integrated program, or indeed be established as an additional integrated program. As the U.S. Committee continues to examine the spectrum of past, present and planned research in relation to its objectives in human adaptability and environmental management, additional research needs may also be found.

Conservation of Genetic Materials.

The genetic resources of plants by which we live are dwindling rapidly and disastrously. Yet these are the very raw materials on which plant breeding and related agricultural research depend for increasing production efficiency.

The United States, with no native resources of major crop plants, has programs within government agencies on the introduction, evaluation, and conservation of genetic materials from abroad. There is a national need to assure the protection of these invaluable resources on a world-wide scale through fundamental research. These efforts will provide future generations with one of the most powerful, single weapons for agricultural improvement.

In the international field, IBP is a source of scientific expertise in problems of exploration, utilization and conservation of plant gene resources since these are essential to developing and developed countries alike. On the national scene, IBP is a vehicle for relating research in the academic area to the needs of the governmental programs of plant introduction, utilization and conservation.

These programs will benefit from new inputs in crop evolution, systematics and plant geography as they relate to world centers of diversity. The remarkable changes undergone by cultivated plants in a very short period of time and the projected changes in the future offer remarkable opportunities to study primitive crop ancestors and their weedy relatives as a basis for more effective programs of plant exploration, use and conservation of this essential base of crop variability.

An information center recording the unusually high production levels of selected crops under favorable conditions of environment and cultivation would help summarize the maximum levels of energetic efficiency or protein quality that are possible under conditions of intensive management. These data would be correlated with the results from the Analysis of Ecosystems Program, and studies of natural and managed ecosystems of other countries.

Crop Production Under Stress

The clear necessity of matching food production to the needs of the world's population requires an accurate knowledge of the factors limiting primary production in the various regions and environments of the globe. The objectives of this program are: to identify the environmental factors that limit production of plant materials, particularly foodstuffs, and to encourage and coordinate research on the nature of the physiological responses of plants to environmental stresses.

Recognizing the limitations of time, funds and personnel, this program focuses on certain immediate problems of a specific nature in the Western Hemisphere—increasing plant tolerance to drought and to temperature extremes and increasing rooting zone volume particularly in tropical soils. The program encourages investigations of environmental factors using an international team approach with local and visiting scientists working together. Concomitantly with field studies, laboratory and model studies are encouraged. The end results of this program will provide a logical basis for manipulation of the environment and biological factors involved in plant production.

Productivity and Conservation of Marine Mammals

Marine mammals are largely oceanic, truly international, and represent a large source of protein and fats. Their exploitation has largely been heedless of biological realities so that population after population has been drastically depleted. It is striking that the adaptation, systematics, distribution and abundance of most species remain uncertain or unknown.

Current research on marine mammals in the fields of systematics, behavior, physiology, acoustics and anatomy is urgently in need of expansion and integration so that an intelligent approach to this major resource will evolve on a national and international level. The IBP offers the best opportunity to gather together research-oriented marine mammalogists into a comprehensive, international, non-political program. The U.S. program aims initially at the establishment of a Marine Mammal Coordinating Council to integrate existing programs and at the development of a Central Repository for specimens.

Only by developing a strong U.S. program with international ties, will effective research be developed leading to a full understanding of even a portion of the aquatic adaptation of marine mammals. Only by understanding those adaptations will use and management be approached intelligently on a world-wide basis and the full potential of marine mammals be realized. The IBP represents perhaps the last great opportunity fully to understand these unique and historically important animals for their own sake and for the benefit of man.

Nitrogen Management—Evaluation of Inputs and Outflow

Major factors limiting production in tropical, temperate, and arctic climates are the fixation and changes of nitrogen. Familiar schematic pictures of the nitrogen cycle need to be measured as quantitative budgets to understand these rates. Nitrogen budgets will be studied both in native environments and under agricultural conditions to determine the extent to which this process contributes to the total nitrogen and monetary economy in food production. Research on factors affecting fixation of gaseous nitrogen, from the atmosphere by microorganisms of roots and leaves, is being coordinated in a world study on symbiotic fixation. The U.S. program will further evaluate nonsymbiotic nitrogen fixation and the extent to which this process can be exploited in the production of food will be estimated. Sources of fixed nitrogen will be compared with industrial nitrogen sources as potential contributors to food production in order to pinpoint rations

that will have to rely—for social, economic or logistic reasons—on biologically fixed nitrogen instead of industrially prepared nitrogenous fertilizers. The potential effect of large-scale use of nitrogen fertilizers on the quality of the environment and on food quality will also be explored. Mechanisms for avoiding contamination of the environment with excessive quantities of nitrogen and for dealing with inordinately high levels of nitrate in ground waters, lakes and streams will also be considered.

Chemical and Biological Controls of Organisms

A great variety of substances produced by plants or animals stimulate or depress the development and growth of neighboring organisms. Although local concentrations of solid and liquid wastes or other animal excretions may be sufficient to exert measurable influences, chemicals of plant origin are more abundant and generally are more complex so that they are of farther reaching consequence in the natural environment. The same general groups of chemicals are involved in interrelations between plants and animals.

Inhibiting or stimulating effects may be produced by substances released from one plant when they contact another plant of the same or a different type. The active substances may be synthesized in any part of the donor plant and may be released by volatilization, excretion, leaching, leakage or during decay of dead matter. These phenomena appear to be universal in occurrence and of great importance in natural vegetation and in crop growth. They affect productivity including crops yields, nutrient cycling and population density control.

As a part of the U.S. IBP, this program will seek to identify plants which produce such chemicals in natural and managed ecosystems and develop methods to utilize such active species or the substances they produce to obtain greater and more natural control over vegetation and increase the yield of usable plant materials. The pathways of synthesis and movement and sites of accumulation of these chemicals within the donor plant, the manner in which they enter the environment, and the pathways of entry and mechanisms of their action in the receptor plant will all be investigated. Research will also be considered to determine the fate of these substances in the environment when affected by microorganisms, soil conditions, fire, and climatic agents and to discover the influences of these and other environmental, genetic, and physiological factors on such chemical activity.

Basic research on insect development and behavior has led to the identification of naturally occurring chemical agents in insects that have profound effects on insect development and behavior. Similar basic investigations on the interaction of plants and insects have also identified the presence of these naturally occurring chemical agents in plants. Such natural chemicals may represent the natural protective mechanisms that have evolved in plants to prevent their destruction by pests. Recent developments in these fields open up new areas of research that should be fully exploited in the search for more effective, more economical and safer ways to control plant and animal pests. Pests destroy up to 30 percent of the world's food production. They are responsible for some of the most devastating and dreaded diseases of man and animals.

Current chemical agents for controlling insect pests are not selective in their action. They destroy beneficial as well as destructive insects. They create hazards in the environment that can adversely affect fish and wildlife resources. Pesticide residues in foods represent problems of concern to many people. Available information on the action of juvenile hormones, ecdysones and other naturally occurring chemicals derived from plants and animals indicates that such agents can be expected to be highly selective in controlling target pests without hazard to man, animals and most other organisms in the environment.

A conference of experts in the field of insect-plant interaction recommended an IBP research program that would involve the isolation, identification and structural determination of biochemical agents that occur naturally in plants and animals, and continued basic research on the effect and mechanism of action of these agents on insect development and behavior. Research on organic synthesis of natural products possessing pesticidal action, including analogs and antagonists, was considered valuable for the program, along with laboratory and field tests aimed at the practical development of such selective agents for pest control. Studies would also be included to determine the ecological impact of the use of such agents on other organisms in the environment.

Biological control of pests by use of their natural enemies offers another valuable possibility for managing agricultural pest problems with proper con-

cern for the quality of the environment and long-term human needs. This method requires sustained and concentrated efforts along sound ecological lines, circumstances that have been lacking for the most part in conventional pest control programs.

The IBP has set up internationally four core programs for the biological control of aphids, spider mites, scale insects and rice pests. The U.S. program will coordinate with this world-wide effort and in addition, try to increase the number of highly trained specialists in this field. It will demonstrate the utility of this method in exemplary areas and establish a supportive information and communications center.

This program will not only lead to a more natural and efficient way of controlling pests which year after year decimate agricultural crops, but will also help prevent the pollution of the environment which so often occurs when non-specific, manmade chemicals are used for pest control.

APPENDIX C—GOALS OF THE INTEGRATED RESEARCH PROGRAMS *

(1) HUMAN ADAPTABILITY COMPONENT

(A) *General.*—The broad goal of this component of the US/IBP is to advance knowledge of (a) the genetic, and (b) the physiological and behavioral adaptations of man. It now includes five integrated research programs—others may develop. They supplement those on-going researches that already provide a wide array of information. Each IRP will attempt to exploit certain unusual opportunities to understand critical aspects of the adaptive process. These programs, their goals and target dates are:

(1) *International Study of Eskimos*

(a) *Goals.*—To elucidate biological and behavioral processes responsible for the successful adaptation and the continuous but slow population growth of 70,000 Eskimos in an arctic environment.

(2) *Population Genetics of American Indians*

(a) *Goals.*—To acquire from primitive tribes of South American Indians baseline information on mating patterns, control of fertility, birth and death rates, genetic characteristics, food utilization and disease pressures, and to link studies in time with studies on the much more changed Indians of the United States. From these quantitative studies of primitive and transitional groups can issue an understanding of the changing stresses of modern man and possibly some insight into their consequences. U.S., Venezuelan and Brazilian participation is involved.

(3) *The Biology of Human Populations at High Altitudes*

(a) *Goals.*—To study selected populations living at altitudes above 3,000 meters for (1) physiological adaptations to chronic hypoxia from before birth to old age, (2) medical and obstetrical problems which are direct consequences of maladaptation, and (3) modifications of diseases. (Some recent observations indicate that high altitude may protect against degenerative cardiovascular disease.) It is planned to study (1) a North American population at 3,100 meters, (2) a South American population at 3,100–3,500 meters, and (3) an Andean population at 4,000 meters.

(4) *Nutritional Adaptation to Environment*

(a) *Goals.*—To coordinate studies of the effects of nutritional stresses on selected population groups in the Arctic, Subarctic, Temperate and Tropical areas, and to assess the development and performance of these groups within the ecological systems in which they are components. The diets of polar populations approach the limit of physiological tolerance to protein and fat. Tropical diets appear very deficient in protein and high in starch and sugar. Temperate diets appear more balanced and yet frequent deficiencies in vitamins and essential trace elements, and excessive caloric intakes are observed.

(5) *Ecology of Migrant Peoples*

"The typical Chicago rioter—1968 version—was a 23-year-old Negro migrant from the South."—*Chicago Daily News*, April 27, 1968.

*Appendix C consists of paragraphs taken verbatim from the material submitted to NSF by USMC; only typographical errors are corrected.

In discussions and reports on the recent outbreaks of violence in America's cities, not much attention has been paid to one of the very basic, underlying causes of the problem—non-adjustment of ghetto residents, both physically and socio-culturally, to a highly stressful urban environment.

Many Negroes now living in northern cities have migrated from rural areas in the South. They experience many environmental changes which have great bearing on their behavior in the northern ghettos—decreased physical activity; increased living-space, congestion and noise stresses; confrontation with impersonal routines and authority; exposure to deviant behavior; changes in mate choice and fertility.

(a) *Goals.*—To measure adaptability responses to migration and urbanization, the program in Ecology of Migrant Peoples will concentrate on populations living under highly stressful conditions. Certainly one of the most significant populations under stress in the United States today is that of the Negro. Therefore, as the major focus of the program, Negro populations in both rural and urban areas will be measured for adaptation trends. The rural population study will be in Holmes County, Mississippi, the poorest county in the United States with a mean annual income for Negro families of \$900 per year. Chicago will be the site of the urban studies since the majority of Holmes County migrants live in the Maywood and West End sections of the city—centers of violent unrest during 1968.

In the Mississippi portion of the study, a thorough biomedical and demographic assessment of the population will be made by specially trained residents of Holmes County under scientific supervision. It is hoped that this survey will identify needed medical treatments and will also serve as a means of training residents for future jobs. Experimental questions will also be considered—how much more developed are children who are enrolled in a Head Start program; how much of an effect will more adequate education and prenatal care have on reducing the very high fetal and neonatal death rates in the county?

The studies in Chicago will be used to determine what attributes predict successful adaptation among young adults ages 15 through 35. The degree of education, acquisition of employment, maintenance of family relations, development of new relationships and social behavior will all be evaluated for their effect on successful or non-successful adaptation. Studies will be made of street gangs and of the incidences of narcotic addiction, prostitution, chronic alcoholism and criminal convictions among the migrants, and how these rates compare to the native city dwellers in the same area. Efforts will be made to illuminate the part non-adjustment to an urban environment plays in Negro discontent.

In later stages of this program, adaptation of Negro populations migrating from Evans County, Georgia, to New Rochelle, New York, and residents of four races in the subarctic city of Fairbanks, Alaska will be investigated. Work is also planned on Spanish-American and Indian populations. Coordination will be maintained with similar programs under the IBP in Israel, Yugoslavia, Australia and Canada.

This work will yield basic data on the phenomenon of migration. It will also help develop an adequate biosocial characterization of the nation by providing intensive research on "nonwhite", "poor" and "rural" populations. It will help develop assessments of interactions of genetic and environmental components in human adaptation and provide a better understanding of adaptation to an urban and industrialized habitat. But most important of all, it will contribute directly to the urgent search for social justice and tranquillity called for by the President's Commissions on Rural Poverty and Civil Disorders.

(II) ENVIRONMENTAL COMPONENT

(A) *General.*—The broad goals of this second component of the US/IBP are (1) to formulate a basis for better understanding of the interactions of all components of selected and representative biological systems, (2) to extend this understanding toward an increased biological productivity, (3) to provide bases

for accurately predicting the consequences of environmental stresses, both man-originated and natural, on the performance of biological systems, and (4) to enhance our ability for better management of our natural resources. Within this component are 6 integrated research programs (IRP) and additional IRP's may develop. All are supplemented by researches that provide a wide array of information. These integrated programs, their goals and target dates are:

(1) *Ecosystems Analysis*

(a) *Goals.*—(1) To understand how ecological systems operate with respect to both short-term and long-term processes (systems disturbed to varying degrees by man are included); (2) to analyze interrelationships between land and water systems, so that broad regions may be considered as wholes; (3) to estimate existing and potential plant and animal production in the major climatic regions of this country, particularly in relation to human welfare, as our contribution to the world-wide goals of the IBP; (4) to add to the scientific basis of resource management, so that optimization for multiple use and for long-term use can be improved; and (5) to establish a scientific base for programs to maintain or improve environmental quality.

In this program an intensive team effort will be made to study six kinds of ecosystems—grasslands, tundra, desert, coniferous forest, deciduous forest, and tropical forest. Each of these six intensive studies will involve many scientists of varying disciplines and each study has its own management structure. In turn, efforts in the six studies are coordinated through a program director and staff. Also, there are some research projects and services at the ecosystem program level. Strong modeling and synthesis projects are characteristic of this program.

In effect, the program on intensive analyses of ecosystems provides a structure or framework which references and utilizes information from all the integrated programs on plants and animals as described in subsequent paragraphs.

(2) *Convergent and Divergent Evolution*

(a) *Goals.*—(1) Understanding of the processes and results of both convergent and divergent evolution in structure, behavior, and physiological adaptation of various kinds of organisms of the New World and understanding of the puzzling relationships between various South American and Australian groups, (2) understanding of the composition, ecological niches, and functioning of ecosystems that have evolved in similar environments of the Southern and Northern Hemispheres, and (3) understanding the native and invading biotas of the land areas of the Hawaiian Islands.

Selected biologists from several American countries and Australia have planned a cooperative research program with six subprograms on specific groups: (1) Amphibia, (2) Fish, (3) Mammals, (4) Reptiles, (5) Insects, and (6) Plants. Each has investigators and institutions named to a limited extent that will expand as the program proceeds. Two subprograms are directed to the question of convergence in ecosystem structure or to convergence in physiological adaptation: (1) Ecosystems, involving investigators representing UCLA and Stanford in the U.S., University of Chile, Central University Venezuela, and INTA (Argentina); (2) Physiological Adaptation, involving investigators of Cornell University, University of California at Riverside, University of Rhode Island, Fullerton State (California), and Universidad Nacional de Cuyo (Mendoza, Argentina).

A third subprogram is directed toward an understanding of the evolutionary and ecological phenomena of the Hawaiian Islands.

(3) *Biogeography of the Sea*

(a) *Goals.*—To develop the ecological and physiological knowledge required to predict how environmental factors limit or enhance the abundance and productivity of selected marine organisms of interest to man. Studies will be in the U.S. and other IBP countries.

Knowledge gained on the mechanisms of marine productivity is basic to: (1) an identification of the environmental factors and stresses which limit the distribution of organisms and help explain evolutionary diversity; (2) a definition of optimal environmental and functional conditions useful for assessing aquacultural potentialities for selected species; (3) an understanding of the significance of selected marine organisms in trophic chains important to man's welfare; and (4) a definition of the adaptive capacity of organisms for life in modified or disturbed environments.

Program coordination will be accomplished by the co-directors and a full-time research coordinator. An advisory committee of senior scientists will provide scientific guidance and evaluation. The research will be conducted in terms of "packages" of separate projects, all dealing with a particular organism or group of closely related organisms. Investigators representing different disciplines will study various physiological parameters on a coordinated cooperative basis. Training will be accomplished within individual *projects* by investigators engaged in direct research participation.

(4) *Phenology*

(a) *Goals.*—(1) To conduct detailed studies on plant and animal species, both aquatic and terrestrial at a number of sites within the United States in order to prepare phenological maps; (2) to obtain clues to the physiologic limitations that determine climatic limits of species and explain the biological basis for phenological timing; (3) test the hypothesis that such studies will aid in understanding evolutionary mechanisms; and (4) to contribute to understanding the role of phenologic phenomena in the structure and productivity of ecosystems.

The program provides for overall coordination, and three subprograms on mechanisms, phenology within communities, and phenologic maps. Broad studies will be conducted with the aid of a large network of stations and observers. They can be done at several levels of sophistication, providing participation by all people with all levels of scientific training. Special sites will be selected and intensive multidisciplinary studies made of measurements of environmental parameters and population structure, breeding behavior, and physiology of organisms. A chief aim will be development of phenologic maps that would predict planting and harvesting dates for crops and outbreaks of plant and animal diseases as well as other biological events.

(5) *Aerobiology*

(a) *Goals.*—(1) To organize, integrate, and extend present investigations of airborne spores, pollen, microbes, insects, and other small organisms, and biologically significant non-living materials such as toxic gases; (2) to identify critical problems not yet under investigation and initiate new projects to meet those needs; (3) to cooperate with other nations in aerobiological studies and relate those studies to global monitoring of environmental conditions, such as the monitoring by WMO under the United Nations.

The program will comprise segments for research technology, phytopathology, allergenic particles, transport of genetic material, human and animal disease microbes, wind-carried insects and other small animals, and gases toxic to organisms. Much of the needed research is already underway, especially by Federal and State laboratories, and the Aerobiology Program will provide the leadership and communications to build the projects into an integrated program. The American Phytopathological Society, which has for many years fostered international cooperation for study of plant diseases and amelioration of resulting losses, has placed its IBP steering committee within the framework of this Program to assist in the prosecution of three related areas within phytopathology: (1) mode and places of origin of organisms causing plant diseases in major crops; (2) processes by which plant disease organisms are dispersed; (3) assessment of world-wide plant disease losses.

The atmospheric dispersal program will share efforts with several other IBP programs, primarily Ecosystems Analysis and Phenology. Various Federal agencies, three scientific societies, and numerous private and university laboratories have requested opportunity to participate in and assist this program.

The program will increase the quantity and improve the quality of research on atmospheric dispersal of biologically significant materials, while taking full advantage of the new opportunities for working in the full context of world-wide investigations.

(6) *Physiology of Colonizing Species*

(a) *Goals.*—(1) To understand the characteristics of species that are able to expand their distribution; (2) to determine the role of habitat alteration in promoting these species invasions; and (3) to determine the degree to which invading species have diverged physiologically and biochemically under the pressure of new selective forces in a variety of habitats. Comparative studies will yield insight into the factors of population adaptation.

A range of species will be studied, varying from those possibly representing local expansion of a specially adapted type to broad expansion of a type with generalized adaptation. The habitats that will be evaluated include those from a broad latitudinal and altitudinal diversity in the western hemisphere. From these studies should come a fuller understanding of the interplay of the disturbance of habitats and the physiological adaptation of invading species.

The basic characteristics of invading plant species may include the following: opportunistic ability to expand or contract a life cycle to fit growing seasons of varying length; the production of chemical inhibitors; the ability to survive in relatively pure stands; broad tolerance of temperature, light intensities, photoperiods, etc.; less palatability; less dependence on a particular insect for pollination; regulative propagation and/or other asexual reproduction; self-fertility. The studies will determine if certain characteristics promote invasion of a given habitat and/or at a given latitude.

(7) *Conservation of Ecosystems for Scientific Purposes*

(a) *Goals.*—(1) To provide registries of protected natural areas and areas requiring protection on:

- (a) Federal lands,
- (b) Non-Federal public lands,
- (c) Private lands;

(2) to provide for descriptions of these areas; (3) to provide guidelines useful in managing and protecting the areas; (4) to provide registries of experimental areas necessary and used for scientific purposes such as experimental forests, watersheds, ranges, etc.:

- (a) On Federal lands,
- (b) On State lands,
- (c) On privately owned lands, e.g., university areas;

(5) to cooperate with other countries of this hemisphere in providing for scientific reserves, specifically, to prepare a list of needed reserves and to stimulate establishment of these; (6) to catalog freshwater areas valuable for scientific purposes; and (7) to catalog existing reserved marine areas and to contribute to devising a suitable mechanism for selecting and protecting marine areas.

APPENDIX D—ICC OPINIONS ON THE MANAGEMENT OF IBP

DOD (AF).—Overall authority should be given to NSF. If IBP is exposed to haggling between agencies, it is dead. With its unique character, and if it is worth doing, it should depend for its existence on complex interagency coordination. Multiagency management problems should be avoided by giving to NSF the funds and responsibility for IBP. ICC should be largely for coordination and advice.

HEW.—Instead of ICC there should be an IBP Federal Council or Board with executive, administrative, and management authority assigned to it. Each agency's representative should have complete access to the agency head to discourse on immediate problems. The Council would be the apex for monitoring, supervising, and coordinating IBP support.

HUD.—"All of us realize the inherent shortcoming of the committee approach to monitoring, supervising, and coordination."

Interior.—Panels should be formed within ICC for each major study supported by more than one agency. Members would be "over and above" the regular ICC representatives. Each panel member would be responsible for his agency's involvement. The *panel*—not the agency—should dictate the terms of the award. Authority to assign and reassign proposals must be administered by NSF. This can be best accomplished if all funds are made available through NSF.

Smithsonian.—Discussion of a proposal within ICC provides an opportunity to enlist agency support. Once approved for funding by ICC and NSF, NSF should be able to assign all or parts of a proposal to ICC agencies, but it should have special IBP funds available to assist the agencies in complying. What actually is supported needs to be the responsibility of NSF. Multiple agency support of a project can be effectively organized and integrated only if funds from each supporting agency are transferred to a pool in the lead agency. In all management-administrative matters NSF should have final responsibility.

USDA (ARS).—Each IRP should have its own subcommittee operating under ICC. Ultimate authority for management should reside in NSF which will follow the advice of ICC. Interagency letters of understanding on policies would be followed by each agency.

USDA (FS).—NSF and ICC jointly should be able to handle management responsibilities through discussion and coordination. The designer of an IRP proposal would direct parts to appropriate agencies and indicate priorities. ICC would function as intermediary between program directors of IRPs and the agencies.

NSF should maintain a contingency fund and provide support to fill serious gaps in IRPs left by other agencies.

AEC, Commerce, DOD (Army and Navy), HEW (OE), OEO, NASA, State, and USDA (CSRS) did not respond.

APPENDIX E—TABLES
TABLE 1.—FUNDING REQUIREMENTS FOR FISCAL YEAR 1970 AND PRIORITIES AT VARIOUS LEVELS OF FUNDING
[in thousands of dollars]

Integrated research programs	—80 percent		—40 percent		—20 percent		Baseline		Federal		Baseline		+40 percent		Desirable	
	NSF	NC	NSF	NC	NSF	NC	NSF	NC	Total		NC		NSF	NC	NC	NC
Total.....	1,600	3,080	4,800	9,250	6,400	12,300	8,000	18,022	15,400	11,200	21,560	28,700				
Human adaptability component:																
Eskimos.....	10	100	10	145	20	145	50	225	145	120	160	177				
American Indians.....	0	50	0	50	20	100	50	225	150	120	150	176				
High altitudes.....	10	15	160	350	260	400	300	400	400	400	500	600				
Nutrition.....	0	15	0	500	40	750	40	2,440	1,000	40	1,700	2,440				
Migrant peoples.....	10	1,000	50	2,000	100	2,700	200	400	3,500	300	3,500	3,500				
Environmental management component:																
Convergent/divergent evolution.....	30	250	375	500	500	600	700	700	700	700	900	1,050				
Biogeography of the sea.....	10	100	50	200	200	300	300	500	400	300	700	1,107				
Aerobiology.....	10	50	25	250	60	400	160	660	400	160	700	1,107				
Phenology.....	10	25	30	100	100	150	100	310	180	235	310	310				
Conservation of ecosystems.....	0	15	0	30	0	30	0	55	30	0	30	55				
Colonizing species.....	10	180	100	260	250	260	400	400	260	400	360	400				
Ecosystems analysis.....																
Central.....	40	10	300	50	350	50	350	350	50	350	50	55				
Grasslands.....	1,000	1,200	1,500	1,300	1,500	1,300	1,500	1,500	1,300	1,500	1,700	1,439				
Deciduous forest.....	400	15	500	1,000	700	1,500	900	1,200	2,000	1,250	2,000	2,214				
Coniferous forest.....	15	15	400	500	700	750	900	1,000	1,600	1,250	1,600	2,214				
Desert.....	15	15	300	500	500	750	600	900	1,000	1,100	1,600	2,214				
Tundra.....	15	15	300	400	350	450	400	600	800	400	800	2,214				
Tropical.....	15	15	600	400	600	500	600	900	600	1,500	1,400	2,214				
Potential IRP's:																
Biological control.....	0	0	50	300	100	550	200	3,200	1,000	500	2,000	3,201				
Nitrogen.....	0	15	50	200	50	250	100	600	270	350	450	620				
Marine mammals.....	0	0	0	100	0	150	75	500	200	100	450	720				
Crop stress.....	0	15	0	100	0	200	75	640	300	100	560	642				
Gene pools.....	0	15	0	15	0	15	0	17	15	10	15	17				

Note: Baseline, as determined by the U.S. National Committee (NC) is an acceptable level of funding that represents approximately 1/3 of a desirable level of funding. The NC baseline does not take into account the fact that some IRP projects (e.g., some in nutrition, biological control, crop stress) will be funded regardless of the existence of IRP. Baseline, as determined by NSF, represents actual needs based on estimates of stage of planning, available manpower, and justifiable rates of spending.

NC figures throughout cover both new and existing activities. NSF figures represent only additional funding for IRP.

In most instances sums of \$15,000 or less can be assumed to be only for maintaining readiness to start in a later year. Sums of less than \$100,000 in most instances can be assumed to be largely for planning purposes.

TABLE 2.—FUNDING REQUIREMENTS, FISCAL YEARS 1970-73
[In thousands of dollars]

Integrated research programs	Fiscal year 1970			Fiscal year 1971			Fiscal year 1972			Fiscal year 1973			Total		
	NSF	Other Federal	Total	NC	NSF	Other Federal	Total	NC	NSF	Other Federal	Total	NC	NSF	Other Federal	Total
Total.....	8,000	10,022	18,022	28,700	11,300	15,195	26,495	33,500	12,150	15,345	27,495	33,600	11,200	16,475	27,675
Human adaptability component:															
Eskimos.....	50	175	225	177	100	125	225	100	100	125	225	212	350	550	900
Indians.....	50	175	225	176	150	500	650	650	150	750	900	750	450	2,025	2,475
High altitudes.....	300	200	500	600	100	500	600	600	100	500	600	600	600	1,700	2,400
Nutrition.....	40	2,400	2,440	2,440	50	4,250	4,300	4,315	50	4,100	4,150	4,150	190	15,200	15,390
Migrant peoples.....	200	200	400	3,500	400	400	800	3,500	400	400	800	3,500	1,400	1,400	2,800
Environmental management component:															
Convergent/divergent evolution.....	700	0	700	1,055	700	0	700	1,161	700	0	700	1,105	700	0	2,800
Biogeography of the sea.....	300	200	500	1,107	300	200	500	1,750	300	200	500	1,789	300	200	800
Aerobiology.....	160	500	660	1,107	100	700	800	1,675	100	900	1,000	2,010	100	200	2,000
Phenology.....	100	210	310	310	100	250	350	350	100	350	450	450	100	400	3,460
Conservation of ecosystems.....	0	55	55	55	0	20	20	20	0	20	20	20	100	0	1,210
Colonizing species.....	400	0	400	400	300	100	400	285	300	100	400	285	1,300	300	1,610
Microsystems analysis:															
Control.....	350	0	350	55	350	0	350	483	350	0	350	483	1,400	0	95
Grasslands.....	1,500	0	1,500	1,439	2,000	0	2,000	2,775	2,000	0	2,000	2,000	1,400	0	1,255
Deciduous forest.....	300	1,200	1,500	2,214	1,500	500	2,000	2,000	1,500	500	2,000	2,000	5,400	0	1,400
Coniferous forest.....	900	300	1,200	2,214	1,500	500	2,000	2,000	1,500	500	2,000	2,000	1,800	800	7,000
Desert.....	600	300	900	2,214	1,000	1,000	2,000	2,000	1,250	750	2,000	2,000	5,400	1,800	7,200
Tundra.....	400	200	600	2,214	800	800	1,600	2,000	1,250	750	2,000	2,000	4,100	2,000	6,900
Tropical.....	600	300	900	2,214	1,300	700	2,000	2,000	1,600	1,400	2,000	2,000	3,200	2,000	8,214

Potential IRP's:																				
Biological control	200	3,000	3,200	3,210	200	3,000	3,200	3,222	200	3,300	3,500	3,544	100	3,700	3,800	3,898	700	13,000	13,700	13,874
Nitrogen	100	500	600	620	200	500	700	734	200	550	750	752	100	550	650	659	600	2,100	2,700	2,765
Marine mammals	425	500	75	625	70	500	720	1,190	150	550	700	1,250	100	550	700	1,150	450	2,150	2,600	4,710
Crop stress	75	565	640	642	75	525	600	600	100	500	600	600	100	500	600	600	350	2,900	2,440	2,442
Gene pools	0	17	17	17	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17	17

EXPLANATION

NC figures throughout include both existing and new programs. NSF figures represent additional IBP funding only.

NC figures are based on desirable funding, levels; i.e., about twice fiscal year 1970 baseline. NSF figures are based on actual needs; i.e., the baseline level of activity.

Eskimos: NIH should fund a major portion.
American Indians: AEC is funding part of South American portion will

High altitudes: Relevance to NIH seems clear. Assumed that NIH will provide major support, at least to raise budget substantially after 1970.

Nutrition: NC states mostly funded through 1970 and partially for remaining years. Support is sup-

posed to be a mix from USDA, HEW, AID, DOD, and several universities and private foundations. Migrant peoples: \$3,500,000 is unrealistic for fiscal year 1970 considering the planning now evident. Government officials: 100,000.

Convergent/divergent evolution: All support expected from NSF.
Biogeography of the sea: Program needs further development. \$1,017,000 is unrealistic for fiscal year 1970. Most support expected from NSF but not indicated.

year 1970. Most support expected from NSF, but substantial in-house involvement by Interior is probable.

Aerobiology: \$1,107,000 may be realistic for fiscal year 1970, but presumably represents several existing programs. Additional support appropriate from USDA and HEW.

Phenology: About $\frac{1}{6}$ is USDA in-house activity.
Conservation of ecosystems: Apparently fully funded for fiscal year 1970; no justification for additional funds known to NSF.

Colonizing species: Program developing rapidly. Most support expected from NSF.

Ecosystems analysis:

Central: \$350,000 required to meet minimal needs for coordination, services, and analysis. Grasslands: \$1,500,000 is realistic for fiscal year 1970. A USDA contribution will be in-house and concealed; the rest will come from NSF.

Deciduous: Moderate contributions from regular funds of USDA and AEC.

Coniferous: Same as deciduous.

Desert: About \$300,000 in fiscal year 1970 is from regular funds of AEC.

Tundra: Program not fully developed: \$600,000 only is realistic for fiscal year 1970.

Tropical: \$600,000 is considered minimal for fiscal year 1970.

Biological control: \$3,210,000 may be realistic; USDA claims \$3,000,000 as ongoing regular program. Tropical: \$600,000 is considered minimal in fiscal year 1970.

Crop stress: Strong USDA relevance. Need for funds from other agencies not adequately known.

Gene pools: Apparently fully funded by USDA.

TABLE 3.—EXPRESSED AGENCY INTERESTS IN INTEGRATED RESEARCH PROGRAMS

	AEC	USDA	Com- merce	DOD	HEW	USDI	NASA	OE0	Smith- sonian	State	NSF
Human adaptability component:											
Eskimos.....	?			+	?	()			?		+
American Indians.....	*					()					+
High altitudes.....				?	()						
Nutrition.....		?		()	()					()	+
Migrant populations.....					?			*			
Environmental management component:											
Convergent/divergent evolution.....	?	?		?		()			?		**
Biogeography of the sea.....	?			?	()						*
Aerobiology.....	?	?			()						*
Phenology.....	?	+			()						*
Conservation of ecosystems.....	?	?				?					*
Colonizing species.....	?	?									*
Ecosystems analysis.....	?	?		?	?	()					*
Central.....											*
Grasslands.....		()									**
Deciduous forest.....	()	()									**
Coniferous forest.....	()	()									**
Desert.....	()	()									**
Tundra.....											**
Typical.....		()									**
Potential I RP S:											*
Biological control.....		?				()					*
Nitrogen.....		?									*
Marine mammals.....						()					+
Crop stress.....		?									+
Gene pools.....											+

Explanation: ** signifies major interest; * signifies moderate interest; + signifies minor interest; see text for further details. — signifies moral support, see text for further details; ? signifies interest expressed, but level of interest unknown; () signifies no expressed interest, but relevance seems

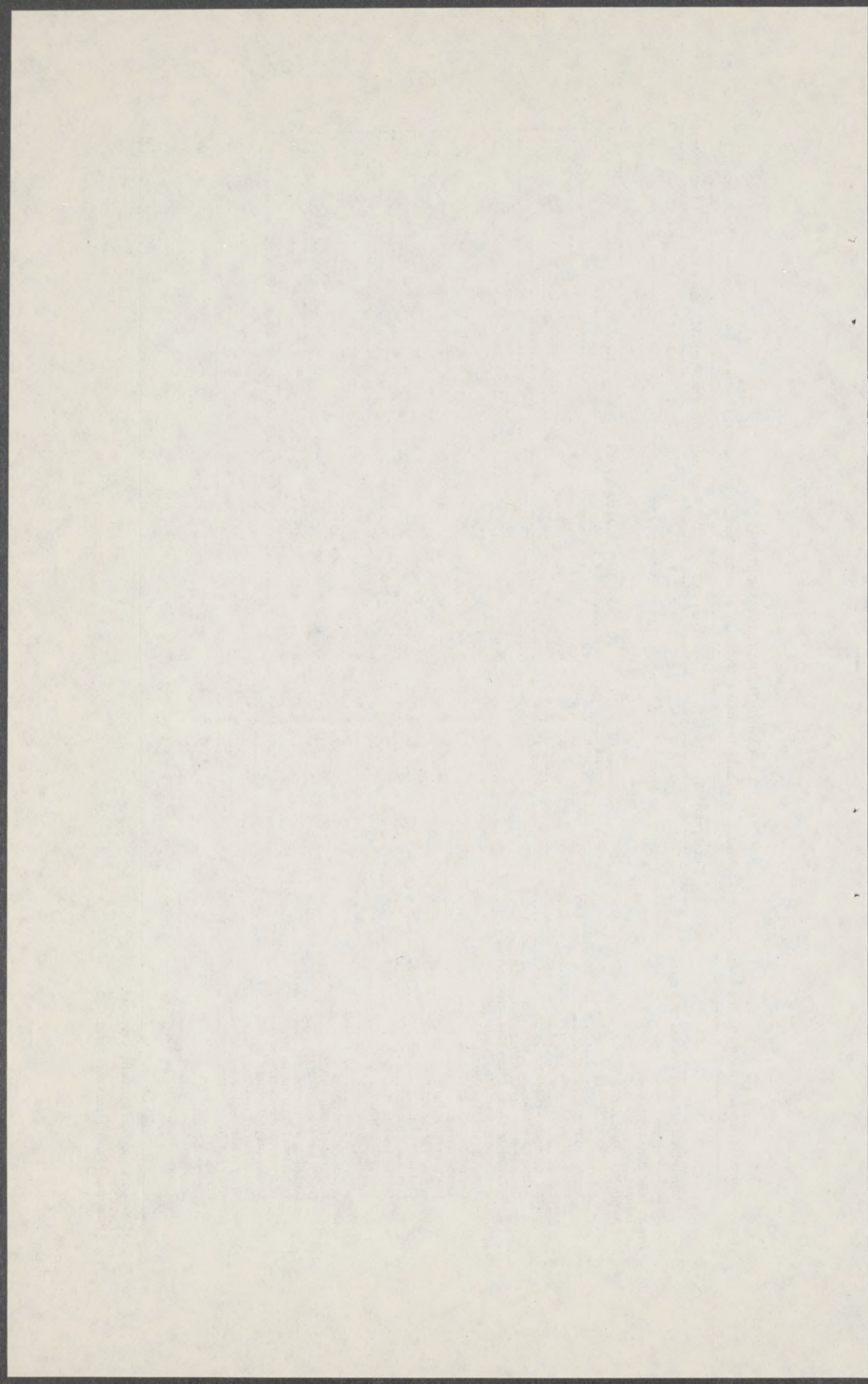
clear. Interests are not known for State (AID), Negative interest is expressed by DOD (A.mv), HEW (OE), HUD, State (Science and Technical Affairs)

TABLE 4.—PLANNED TIMING FOR MAJOR STUDIES

[Key: a—proposal preparation begins; b—proposal preparation completed; c—submission to national commission; d—submission to Federal agency; e—work on study begins; f—work completed]

Integrated research programs and subprograms	Fiscal year 1968				Fiscal year 1969				Fiscal year 1970				Fiscal year 1971				Fiscal year 1972				Fiscal year 1973			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Human adaptability component:																								
Eskimos—	a	b	c	d	e	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
American Indians—	d, e	c																						
High altitudes—Central—																								
Colorado—																								
Andes—Huancayo—																								
Andes—Nuncho—																								
Nutrition—																								
Migrant populations—Central—																								
Mississippi—Illinois—																								
Georgia—New York—United States—Alaska, California, Chicago, New York—New Jersey)																								
Environmental management component:																								
Convergent/divergent evolution:																								
Central—																								
South America—																								
Hawaiian terrestrial—																								
Biogeography of the sea:																								
Central—Fungi—																								
Crustacea—Bacteria—																								
Other—Training—																								
Aerobiology—Central—																								
All subprograms—																								
Phenology—All parts—																								
Conservation of ecosystems:																								
Registries of natural areas:																								
Description of natural areas—																								
Guidelines for management—																								
Registries of experimental areas—																								
International coordination on reserves—																								
Catalog freshwater areas—																								
Catalog marine areas—																								
Colonizing species—All parts—																								
Ecosystem analysis—Central—																								
Grasslands—																								
Deciduous forest—																								
Coniferous forest—Desert—																								
Tundra—Tropical forests—																								

¹Some work underway before IRP developed.²Plan only.³Presumably Federal funds not needed.



APPENDIX E

PROGRESS REPORT ANALYSIS OF ECOSYSTEMS, SUBMITTED BY EXECUTIVE BOARD ANALYSIS OF ECOSYSTEMS, MARCH 1969

A summary of progress in the development of the Analysis of Ecosystems Program, a part of the US contribution to the International Biological Program. It begins with the objectives of the IBP, and traces this particular program from its inception in October 1966 through the end of 1968. Major support for program development has been provided through two grants from the National Science Foundation. This document serves as a progress report for NSF GB 7840 and a final report for NSF GB 6215.

INTRODUCTION

Concern with problems of the environment is growing throughout the world. This increase has been dramatic in the U.S. The following list of national and international activities within the last year summarize the scope and intensity of action:

GOVERNMENT REPORTS

The International Biological Program, Its Meaning and Needs.—Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, House of Representatives. 124 pp. 1968. Based on Hearings on the IBP. 449 pp. 1967.

Managing the Environment.—Same Subcommittee. 59 pp. 1968. Based on Hearings on Environmental Quality. 555 pp. 1968.

A National Policy for the Environment.—A Special Report to the Committee on Interior and Insular Affairs, Senate. 35 pp. 1968.

From Sea to Shining Sea, a Report on the American Environment—Our Natural Heritage.—President's Council and Citizen's Advisory Board on Recreation and Natural Beauty. 300 pp. 1968.

LEGISLATIVE PROPOSALS IN 1968

HR 6698. To establish a Technology Assessment Board.

HR 7796. To create a 3-member Council on Environmental Quality.

HR 13211, 14605, 14627. To create a 9-member Council of Ecological Advisors. S. Res. 68. To establish a Select Committee on Technology and the Human Environment.

S. 3031. To establish a Council on Environmental Quality.

INTERGOVERNMENTAL ACTIVITIES

In September UNESCO sponsored an Intergovernmental Conference of Experts on the Scientific Basis for Rational Use and Conservation of the Resources of the Biosphere, a 10-day working session with 63 member states participating. Their final report, 71 pp., was issued in January 1969.

A report, *Conservation and Rational Use of the Environment* (the "Dasman Report"), was submitted in March 1968 to the 44th session of the UN Economic and Social Council. At that same time a Swedish proposal to the UN entitled "Question of Convening an International Conference on Problems of the Human Environment" was referred to ECOSOC for consideration.

At its 45th session ECOSOC approved and sent to the UN a resolution calling for an International Conference on the Problems of the Human Environment, to be held in 1972.

In December 1968, at the 23rd session of the UN General Assembly, the above resolution (#2398) was unanimously approved, and planning for the 1972 Conference was begun.

The Economic Commission for Europe (in which the US participates) at its 23rd session in April 1968, scheduled a Meeting of Governmental Experts on Problems Relating to Environment, to be held April 26-May 8, 1971.

Other Activities:

A group of about 90 US Congressmen and Senators formed in 1968 an Ad Hoc Committee on the Environment. They are aided by an Advisory Board of 98 distinguished citizens.

The Conservation Foundation and the Center for the Biology of Natural Systems sponsored a Conference on the Ecological Aspects of International Development. 53 papers in a 3-day session. December 1968. To be published.

Stewart L. Udall and 25 associates announced the formation of The Overview Group, an international consulting firm to create a better environment for man. January 1969.

In all of these activities the need for expanded research on ecosystems is recognized. The U.S. House of Representatives report, *Managing the Environment*, recommends that "Baseline ecological information should be obtained by adequate funding and organization of the International Biological Program and the environmental sciences and biology programs of the National Science Foundation". The same report finds that "The second requirement is accurate mathematical models of the interrelations in the biosphere". Similarly, the final report of the UNESCO Biosphere Conference recommends the planning of "a world programme of ecological, ecophysiological, and bioclimatological research on a range of ecosystems, both natural and semi-natural, artificial or cultural, on land and in water, selected from both temperate and tropical zones, in wet or arid countries". It also finds that "Research into the working of ecosystems calls for the training of teams of physicists, physiologists, experimental biologists, taxonomists, soil scientists, micro-biologists and micro-meteorologists and for the development of methods and models specially adapted to such research", and recommends "the involvement of mathematicians, systems-analysts, and other appropriate specialists in studies of ecosystems".

Recent progress in ecology relevant to human environmental problems includes the development of two approaches that will greatly improve the analytic and predictive power of research. Both the progress and the need for further development are demonstrated by two new texts. One is by K. E. F. Watt, *Ecology and Resource Management* (1968), an introduction to the use of systems techniques in basic and applied ecology. The other includes 37 papers edited by P. Shepard and D. McKinley, *The Subversive Science, Essays Toward an Ecology of Man* (1969). These emphasize two promising approaches: the use of systems techniques in the solving of complex problems, and the involvement of many disciplines in the solution of such problems. They also emphasize remaining needs. In the first text, applications of systems techniques are limited to sub-systems such as those oriented around single populations, because adequate data on whole ecosystems do not exist. The second book presents *collected* efforts, not *collective* efforts, because team research on ecosystems is still in the early stages of development.

The Analysis of Ecosystems, a part of the U.S. contribution to the IBP, is addressed to these needs. Its success depends upon the support of large numbers of scientists in many disciplines. So far, this support is not lacking. Agreement on the value of this approach makes possible the progress that is reported on the following pages.

OBJECTIVES

1.00 The objectives of the Analysis of Ecosystems Program and its sub-programs have been developed within the framework of the overall objectives of the International Biological Program and those of the US contribution to the IBP. The theme of the IBP, "The Biological Basis of Productivity and Human Welfare", has been paraphrased in the US Program to "Man's Survival in a Changing World". The Analysis of Ecosystems Program has been designed to produce basic ecological knowledge of a scale and kind useful to problems of human welfare.

1.10 *Overall objectives of the IBP* (from IBP News No. 9, June 1967).

.11 The worldwide study of organic production on the land, in fresh waters, and in the seas, and the potentialities and uses of new as well as of existing natural resources.

.12 The worldwide study of human adaptability to changing conditions.

1.20 *Broad objectives of the US contributions to the IBP* (from report by US Exec. Comm. to Interagency Coord. Comm., July 1968).

.21 To advance the knowledge of the genetic adaptations of man.

.22 To advance the knowledge of the physiological and behavioral adaptations of man.

.23 To formulate a basis for better understanding of the interactions of all components of selected and representative biological systems.

.24 To extend this understanding toward an increased biological productivity.

.25 To provide bases for accurately predicting the consequences of environmental stresses both man-originated and natural.

.26 To enhance our ability for better management of our natural resources.

1.30 *Objectives of the US Analysis of Ecosystems Program.*

.31 To understand how ecological systems operate with respect to both short-term and long-term processes (systems disturbed to varying degrees by man are included).

.32 To analyze interrelationships between land and water systems, so that broad regions may be considered as wholes.

.33 To estimate existing and potential plant and animal production in the major climatic regions of this country, particularly in relation to human welfare, as our contribution to the worldwide goals of the IBP.

.34 To add to the scientific basis of resource management, so that optimization for multiple use and for long-term use can be improved.

.35 To establish a scientific base for programs to maintain or improve environmental quality.

1.40 *Additional objectives of sub-programs.*

.41 Principles of Ecosystems.

a. To derive broad principles of ecosystem structure and function through an integration of the results of six Biome Studies.

b. To relate these principles to characteristics of ecosystems such as persistence, stability, maturity, and diversity.

c. To develop and refine a generalized adaptable simulation model suitable for use in planning studies for new development projects.

.42 Each of Six Biome Studies.

a. To elucidate productivity, nutrient cycling, energy flow and other characteristics of ecosystems in a set of distinct environments.

b. To determine the driving forces, the processes causing transfers of matter and energy among components, the non-concentration characteristics, and the controlling variables in each Biome.

c. To determine the ecosystem response to the natural and man-induced stresses appropriate to each Biome; for example: large herbivores in grassland, extreme and rare weather patterns in desert, periodic fluctuations of rodent populations in tundra, commercial use of timber in the coniferous forests, urbanization in the deciduous forest, and nutrient retention in the wet tropical forest.

d. To understand the land-water interactions characteristic of each Biome: prairie ponds and reservoirs in the grasslands, the abundance of shallow waters in wet tundra, springs and temporary waters in deserts, river systems with anadromous fish populations in coniferous forest, pollution and eutrophication in the deciduous forest, and large river systems in wet tropical forest.

e. To synthesize the results of these and previous studies into predictive models of temporal and spatial variation, effects of pollutants and of exploitation, stability, and other ecosystem characteristics necessary for resource management in each Biome.

GUIDELINES

2.00 A number of policies, restrictions, and procedures have been adopted at the international, national, and program levels. Taken together they shape the general features of this program.

2.10 *International Program* (From IBP News No. 9).

.11 Overall IBP. The program does not range through the entire field of biology, but is limited to the basic biological studies, related to productivity and human welfare, which will benefit from international collaboration, and are urgent because of the rapid rate of changes taking place in all environments throughout the world.

Several common principles apply to all sections:

a. The program sets out to obtain internationally comparable observations of the basic biological parameters.

b. There is an urgent need to bring all parts of the program into operation; many situations will soon no longer be available for scientific investigation.

c. There is a widespread need for elaboration and intercalibration of, and for agreement on, suitable methods.

d. The function of the organizers is to co-ordinate rather than direct.

e. An early need of the program is the training of research workers.

f. To avoid unnecessary duplication of work, collaboration has been arranged between the IBP and other national and international organizations.

g. The planning phase will end 1 July 1967, to be followed by five years of operation.

h. The IBP will have a stimulating effect on biological research in the fields under consideration.

i. Special facilities for the storage and retrieval of data will be created as required.

j. Results will be published through existing international and national channels. Special publication of IBP results will be considered only if the capacity of these channels is exceeded.

.12 The International Section on Terrestrial Productivity (PT). Studies of production at different trophic levels provide a unifying factor and should be a fundamental part of every PT project. Purely descriptive studies should not be considered as IBP/PT projects, unless they are clearly preliminary to productivity studies. The section recommends that:

a. As far as possible, studies of primary and secondary production should be undertaken in the same sites.

b. The biological productivity of wild and man-modified ecosystems in the same environmental conditions should be compared.

c. Comparative studies should be made of widespread organisms in different environments.

.13 The International Section on Freshwater Productivity (PF). Section PF should be so oriented as to lead to an increased knowledge of the factors governing biological productivity. At the same time, the information sought should point the way to methods for obtaining more food (by increasing productivity) and additional clean water (by reducing productivity and pollution).

Particular care will be needed to achieve results that are as comparable as possible. Projects should be selected to stimulate pre-existing local research and thereby achieve maximum results with minimum expenditure.

2.20 *The U.S. National Program*. The central and actively supported core of the US contribution is a series of Integrated Research Programs (IRP). These are based upon the use of coordinated, interdisciplinary research teams that focus integrated attacks on carefully defined problems. The US National Committee has endorsed the four criteria for an IRP that are offered by the National Science Foundation:

.21 Each IRP proposal should demonstrate that it is necessary to group a set of research projects in space and time in order to achieve the scientific goals of the program. That is, convincing arguments must be presented to show that support of individual, independent research projects would not achieve those goals. The whole, in this case, must be greater than the sum of its parts.

.22 Substantive, operational questions of general ecological significance must be posed in order to give coherence and direction to the suite of research

projects in the program. Without such questions the projects will tend to go their separate ways, thus placing the ultimate goal of the program in jeopardy. Management proposals must also clearly indicate a means of shifting direction and emphasis as new information and ideas dictate.

.23 Each proposal must describe a system for rapid exchange of information and data among investigators so that each participant will profit from the efforts of others as the work proceeds. This is obviously essential for coordination. Without it, much of the advantage of simultaneous support of projects will be lost.

.24 Each IRP proposal must provide a means of synthesizing the results of the several projects. Otherwise, the hoped for higher-order goals of the program will elude.

2.30 *The Analysis of Ecosystems Program.*

.31 Research.

a. This Integrated Research Program will be focused on intensive, multidisciplinary analyses of ecosystems.

b. Concentrated studies are to be made in a limited number of sites representing the following ecosystems: deciduous forests, western coniferous forests, grasslands, desert, arctic tundra, and tropical forests (in cooperation with Latin American groups). (From October 1966 Program Statement.)

c. Additional contributions can be made through less intensive investigations on related communities at other locations.

d. The systems analysis approach is a necessity in a program as large and complex as this. It is the key to the synthesis of results necessary to reach higher-order goals.

e. In an integrated study, synthesis of results depends on the rapid exchange of all data. Conventional sharing of data via publication is hopelessly slow. All data will be *immediately* available to all participants.

f. Synthesis also demands complete intercalibration or standardization of measurements. IBP handbooks will be used as much as possible to assure comparability of data.

g. A high level of coordination is essential to successful conduct of the Program.

.32 Management.

a. The management system must attract and maintain *volunteer* participation, since most of the scientists will depend upon academic institutions and government agencies for their major salary support.

b. The coordination and integration of research performed by nearly 800 scientists in many disciplines, and from many institutions and agencies, is required.

c. Communication systems are needed to maintain the team approach at several levels; within groups of projects, within biome programs, throughout the Analysis of Ecosystems program, with other US Integrated Research Programs, and with relevant programs in other countries.

d. The immediate free exchange of data in so large a program creates unprecedented needs in the areas of data processing, storage, retrieval, and transmission.

.33 Funding.

a. Funding procedures must be consistent with the program needs in terms of coordination and integration. Three constraints are paramount:

(1) Simultaneity of research. Within any one ecosystem, *concurrent* research is required on all important components. Reduced rates of funding, associated with the usual concept of stretch-out in time, cannot be invoked to the degree that research on some essential components is postponed.

(2) Maintaining critical mass. Once a group of scientists has begun to work together, their momentum must be maintained through adequate support. Funding delays will cause disintegration of the group, and may produce a permanent disaffection with the program.

(3) Coordinated effort. The close teamwork demanded within each ecosystem requires strong central management and hence central funding for each major program.

b. Proposal development includes a process of internal review defined by PROCOM, the Program Coordinating Committee of the US National Committee. The Analysis of Ecosystems Program Director and the six Biome Directors are members of PROCOM, and are thus available for this review. The steps included are:

(1) Proposals will be reviewed by PROCOM before a final draft is submitted to an agency for funding. The circulation of relatively early drafts is recommended.

(2) Each PROCOM member will receive copies of all proposals from IRP's in which he has some interest. For every new draft proposal, a group of at least 4 PROCOM members (or their designates) will be selected by the PROCOM Chairman to form a review panel. Criticism and constructive change are to be offered freely and openly, so that their contribution to the further development of the proposal is maximized.

(3) At the time of the internal review, one copy of each proposal will be forwarded to the appropriate funding agency on an informal basis.

(4) A number of IBP-related projects may later become incorporated into an IRP. Such projects should remain IBP-related until they are in fact integrated into an existing design for the IRP.

MANAGEMENT

3.00 A management structure for this Program has evolved to meet the needs of coordination and communication with a large and geographically wide-spread research effort. Mechanisms have also been provided to facilitate international cooperation.

3.10 *General organization.* The present management structure has seven major sections, one for the Central Program and one each for the six biomes. They are interrelated as shown in FIG. 1. The Program Director and Coordinator are responsible for the development and management of the entire program, under the guidance of the Program Coordinating Committee of the US National Committee. Authority for the development and management of each Biome Program rests in each Biome Director, under the joint guidance of the Central Program and the US Program Coordinating Committee. In addition, within the Central Program a series of Technical Coordinating Committees is being established whose members are participants in Biome Programs. These will ensure direct communication and coordination between biomes within disciplines, as a supplement to organizational coordination through the administrative staff.

3.20 *Central Program.*

21 An Executive Board assists in the development and operation of the program. Its present composition is as follows:

*Program Director: Frederick E. Smith (Michigan).

Program Coordinator: John A. Kadlec (Michigan).

*Grassland Biome Director: George M. Van Dyne (Colorado).

*Tundra Biome Director: Frank A. Pitelka (California).

*Desert Biome Director: David W. Goodall (Utah).

*Coniferous Forest Biome Director: Stanley P. Gessel (Washington).

*Deciduous Forest Biome Director: Stanley I. Auerbach (Tennessee).

Tropical Forest Biome Director: (to be selected).

Planning and Analysis Director: Robert H. Ellis (Connecticut).

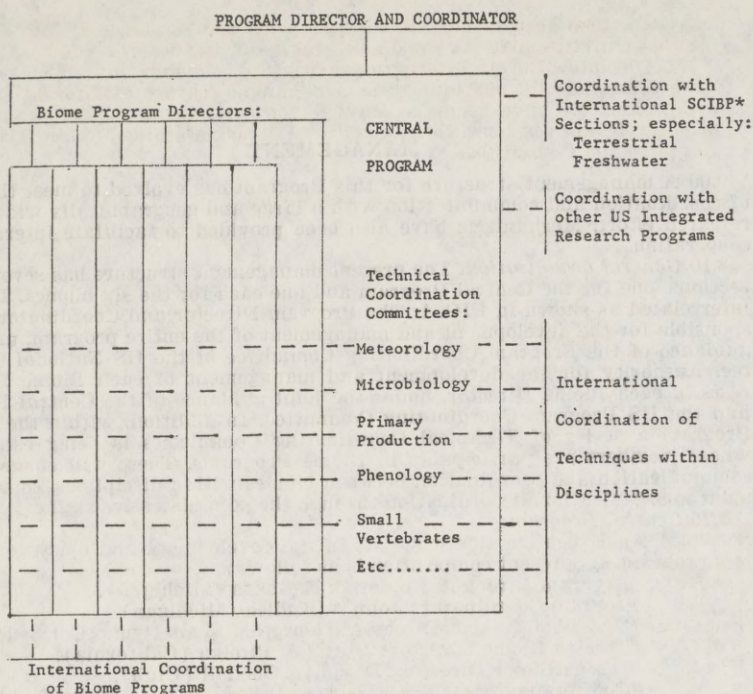
**Terrestrial International Coordination: Jerry S. Olson (Tennessee).

**Freshwater International Coordination: Arthur D. Hasler (Wisconsin).

The Executive Board serves as a review panel for all proposals, especially during the early stages of such proposals. Final review is the major responsibility of those members who are also of PROCOM.

*Members of PROCOM (Program Coordinating Committee).

**Members of INTCOM (International Coordinating Committee).



* Special Committee for the International Biological Program.

FIGURE 1.—Organizational Chart, Analysis of Ecosystems Program.

.22 Technical Coordination Committees. These are in the process of being set up, as it becomes possible to identify appropriate personnel in at least several of the biomes. Each committee will be responsible for maintaining comparability of methods, rapid utilization of improved techniques, etc. Organizationally, their activities are cross-classified with those of the biome directors. The Central Program will promote and support their activities. The following have been identified as an initial set of technical groups: modelling, phenology, remote sensing, aquatic, meteorology, microbiology, primary production, hydrology, chemical analysis, information processing, invertebrates, small vertebrates, and large vertebrates. Phenology will be closely coordinated with the IRP on Phenology. Meteorology will be developed in close coordination with the Biometeorology Panel of the US IBP.

.23 Research and Services. F. E. Smith, J. A. Kadlec, and R. H. Ellis, co-directors.

a. Principles of ecosystems.

b. Methods of systems analysis, statistical analysis, information storage and retrieval, and management planning.

3.30 Biome Programs. Each biome will require a management system much more complex than that of the Central Program, since it is in the biomes that most of the personnel and research are located. As an example, the current organization in the Grassland Biome is presented in Figure 2.

3.40 International Relations.

.41 Program Level. This program is interrelated with the terrestrial and freshwater programs of many countries. Coordination is supplied directly through the presence on the Executive Board of two of the US INTCOM members. These representatives (J. S. Olson and A. D. Hasler) are both very active internationally.

.42 Biome level. Each biome Director is responsible for promoting international coordination with programs in other countries in the same biome.

They are also responsible for working with the established IBP working groups on arctic-subarctic, woodland, grassland, and desert studies.

.43 Discipline level. International working sessions in technical areas have been and will continue to be a dominant feature of international coordination. We have begun to arrange for participants in the program to attend relevant sessions. Such activities will be maintained by the Technical Coordination Committees.

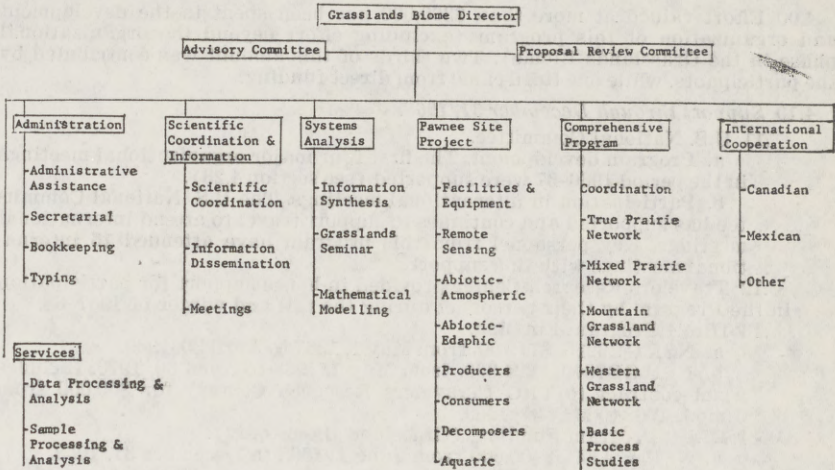


FIGURE 2.—Organizational Chart, Grassland Biome Program.

FUNDING

4.00 Effort valued at more than \$300,000 has been spent in the development and organization of this program (excluding effort beyond the organizational phase in the Grasslands Biome). Two thirds of this amount was contributed by the participants, while one third came from direct funding.

4.10 Support through December 31, 1968.

.11 U.S. National Committee.

- a. Program development. The first four major organizational meetings in the period 1966-67 were supported (see section 4.23).
- b. Participation in international meetings. The U.S. National Committee has supported and continues to support travel to attend international meetings. Key personnel from this program have attended 15 international meetings with this support.

.12 Travelers Research Center provided in-house support for participation in the Program by their personnel during the fall and winter of 1967-68.

.13 Direct Program Funding.

- a. NSF GB6215, \$71,400, from May 1, 1967 to April 30, 1969.
- b. NSF GB7840, \$224,300, from May 1, 1968 to April 30, 1970. Includes a sub-contract to TRC (Travelers Research Center) for \$50,000 from June 1, 1968 to May 31, 1969.

.14 Direct Program Funding, (Grassland Biome only).

- a. NSF & AEC, \$400,000 from June 1, 1968 to December 31, 1968.
- b. North American Rockwell supported a remote sensing flight of the Pawnee site in September 1968.

.15 Additional support expenditures.

- a. Time for people to participate in organizational meetings. There were 975 man-days of time contributed to major organizational meetings (listed under 4.23) by senior scientific personnel. The value of this contribution, at a consulting rate of \$100/day, is \$97,500.
- b. Travel expenses. More than one-half of the people who attended major organizational meetings traveled on funds from non-IBP sources. If local scientists are omitted, the proportion is slightly less than one-half. In general they did not travel as far as those whose expenses were charged to IBP. Taking these factors into account, the non-IBP support for travel expenses is estimated at \$10,000.
- c. Additional effort spent on the development of the Program. Several hundred scientists have attended one or two day local meetings. About 50 have worked considerably longer on the organization of meetings and the preparation of reports. A few have given as much as one-fourth or more of their time to the program. The value of this contribution is well over \$100,000.

4.20 DIRECT EXPENDITURES BY THE CENTRAL OFFICE
.21 TOTAL EXPENDITURES

Code	1967	1968	Total
.01 Salaries and wages.....	\$1,992	\$23,879	\$25,871
.02 Fringe benefits.....	88	2,113	2,201
.03 Equipment.....	0	405	405
.04 Supplies.....	675	2,745	3,420
.05 Travel.....	4,166	33,480	37,646
.06 Printing costs.....	0	1,498	1,498
.07 Other costs:			
Contract to TRC.....	0	14,753	14,753
Communications.....	96	2,367	2,463
.08 Total direct costs.....	7,953	92,802	100,755

.22 EXPENDITURES APPORTIONED AMONG THE 6 BIOMES AND THE CENTRAL PROGRAM

Biome	Total
Analysis of ecosystems.....	\$71,308
Grasslands.....	5,111
Tundra.....	6,162
Desert.....	7,385
Coniferous forest.....	2,704
Deciduous forest.....	4,459
Tropical forest.....	3,626
Total.....	100,755

Note: Funds for the Biomes include travel to major organizational meetings and support for some Biome directors and committees. This latter support was not anticipated in the original grant proposal. The change was made with the advice and consent of NSF.

.23 COST OF MAJOR ORGANIZATIONAL MEETINGS

	Attendees	Cost ¹
1966		
Oct. 28-31..... Williamstown, program.....	24 (0).....	
1967		
February..... Chicago, program.....	10 (0).....	
June 1..... Ann Arbor, systems.....	55 (0).....	
Oct. 4-5..... Fort Collins, grasslands.....	35 (0).....	
1968		
Jan. 26-28..... Atlanta, deciduous forest.....	51 (24).....	\$3,020
Feb. 2-5..... Seattle, coniferous forest.....	56 (13).....	1,983
Feb. 23-25..... Logan, desert.....	74 (31).....	2,707
Mar. 1-3..... Washington, D.C., tundra.....	32 (15).....	3,695
June 27-28..... Manhattan, Kans., grasslands.....	38 (16).....	2,164
Oct. 9-11..... Alaska, tundra.....	57 (5).....	1,635
Oct. 18-19..... Ann Arbor, tropical.....	48 (20).....	3,626
Total.....	480	18,830

¹ Costs include all travel charges to the analysis of ecosystems grant, excluding the expenses of the program director and coordinator. The number of attendees supported by these costs is shown in parentheses in the preceding column.

4.30 BUDGET ESTIMATES (AMOUNTS IN THOUSANDS OF DOLLARS)

	Granted, fiscal year 1968	Granted, fiscal year 1969	Requested, fiscal year 1969	Planned, fiscal year 1970	Anticipated, fiscal year 1971
Central program.....	¹ 224.3			² 275.5	¹ 1,050
Grasslands Biome.....	³ 400.0	⁴ 300.0	⁴ 150.0	⁵ 2,209.3	¹ 4,000
Tundra Biome.....				⁶ 200.0	¹ 1,500
Desert Biome.....			20.0	¹ 1,700.0	² 2,000
Coniferous forest Biome.....			31.4	⁶ 900.0	¹ 1,500
Deciduous forest Biome.....			230.0	⁶ 2,275.0	² 2,750
Tropical forest Biome.....				⁸ 80.0	¹ 1,500
Total.....	624.3	300.0	431.4	7,639.8	14,300

¹ 2 years.

² To be submitted before June 1969.

³ 7 months.

⁴ 8 months.

⁵ Submitted in January 1969, for 16 months.

⁶ To be submitted by fall 1969.

MANPOWER

5.00 The voluntary participation of at least 500 scientists is needed in the biome intensive studies. Several hundred scientists are needed to develop the comprehensive studies. Despite early fears that such a commitment from the scientific community would not develop, we find that manpower has not yet been a limiting factor.

5.10 *Participation in major organizational meetings.* A total of 306 individuals were involved in these meetings (Section 4.23). About 95 academic institutions and government agencies in 36 states, Washington, D.C., and Puerto Rico were represented.

5.20 *Additional contacts with the scientific community.*

.21 Local meetings. Local interest in the program has stimulated many meetings of scientists within academic institutions and in regional groups of institutions and agencies. The total number of people involved is unknown. As an example, within the Deciduous Forest Biome a group met at Lake George, New York, to consider studies of the Lake and its drainage basin. It was organized as result of the attendance of 3 people at the major Deciduous Forest Working Session. A total of 62 people from the region attended, representing 17 institutions or agencies and 7 states.

.22 Mailing Lists. The Central Office maintains a mailing list composed of over 1700 people who have indicated an interest in being informed about the program or some segment of it. Each Biome also maintains such a list. The Grassland list, for example, is now over 450 names.

5.30 *Research participation within biomes.*

.31 Grassland Biome. In the first 7 months of a funded program (June-December 1968), 55 scientists were involved in field research of the intensive site and the information synthesis project. Commitments to work in the program, as evidenced by inclusion in the current proposal for work beginning in 1969, have been received from 105 scientists.

.32 Desert Biome. Since the major organizational meeting at Logan, Utah, over 40 scientists have been actively involved in planning. About 280 scientists have indicated an intent to participate in the research program.

5.40 *International Participation.* A large number of US scientists have participated in IBP meetings at the international level. Some of these have not worked actively within the US IBP. The Central Office of the Analysis of Ecosystems Program is currently attempting to identify these people and the meetings they attended, regardless of relevance to this Program. Their contribution to IBP guidelines is important and their identification for potential consultation within the US should be useful. The admittedly incomplete list now contains 160 names of scientists who have attended international meetings. Of these, 66 were not on the Analysis of Ecosystems mailing list, although of course they may be involved in other US IBP programs.

5.50 *Key personnel associated with the Analysis of Ecosystems Program.*

.51 Central Program.

Director, Frederick E. Smith, University of Michigan

Coordinator, John A. Kadlec, University of Michigan

Planning & Analysis, Robert H. Ellis, Travelers Research Corporation, Hartford, Connecticut

Remote Sensing, Donald S. Lowe, University of Michigan

.52 Grassland Biome.

Director, George M. Van Dyne, Colorado State University

Pawnee Project Director, D. A. Jameson, CSU.

Comprehensive Program Director, R. L. Dix (Temporary), CSU.

Facilities Committee Chairman, R. E. Bement, Agricultural Research Service, USDA, Fort Collins, Colorado

Lab. and Biomet. Services Director, L. J. Bledsoe (Temporary), CSU.

Executive Assistant, P. T. Haug, CSU.

Scientific Coordinators:

C. F. Becker, U. Wyo.

- W. H. Moir, CSU.
 D. H. Knight, U Wyo.
 R. M. Hansen, CSU.
 D. N. Hyder, US, ARS, Ft. Collins
 R. J. Lavigne, U. Wyo.
 K. G. Duxtader, CSU.
 F. E. Clark, ARS, Ft. Collins
 Comprehensive Program Scientific Committee:
 L. C. Hubert, Kansas State U.
 C. H. Herbel, ARS, Las Cruces
 E. H. Reid, Forest Serv, USDA, Ft. Collins
 F. A. Glover, BSWF, Ft. Collins
 J. O. Klemmedson, U. Arizona
 R. L. Packard, Texas Tech. Coll.
 J. H. Grosklags, N. Ill. U.
 C. M. Skau, U. Nevada
 R. Q. Landers, Iowa St. U.
 J. L. Kline, Argonne Nat Lab., Ill.
 T. C. Dorris, Okla. St. U.
 Regional Coordinators:
 C. L. Kucera, U. Mo.
 H. G. Fisser, U. Wyo.
 H. F. Heady, U Cal., Berkeley
 W. L. Mueggler, FS, Bozeman
- .53 Tundra Biome.
 Director, Frank A. Pitelka, University of California, Berkeley
 Advisory Panel:
 L. C. Bliss, U. Alberta
 M. E. Britton, Wash., D.C.
 J. Brown, CRREL, N.H.
 J. E. Hobbie, N. Car. St. U.
 D. M. Hopkins, USGS, Menlo Park
 J. D. Ives, U. Colo.
 G. G. West, U. Alaska
 Temporary Co-directors, Arctic Tundra-Taiga:
 V. A. Billaud, U. Alaska
 H. N. Coulombe, U. Alaska
 K. Van Cleve, U. Alaska
- .54 Desert Biome.
 Director, David W. Goodall, Utah State University
 Committee:
 J. P. Blaisdell, FS, Ogden
 J. E. Deacon, Nev. So. U.
 W. A. Dick-Peddie, New Mex St. U.
 J. W. Hawley, SCS, Univ. N.M.
 W. Keller, ARS, Logan
 W. McGinnies, U. Arizona
 W. L. Minckley, Ariz. St. U.
 W. H. Rickard, Jr., Battelle-Northwest
 F. B. Turner, UCLA
 F. H. Wagner, Utah St. U.
- .55 Coniferous Forest Biome.
 Director, Stanley P. Gessel, University of Washington
 Committee:
 E. W. Mogren, CSU.
 D. R. Wootton, Chico St. Coll., Cal.
 R. Waring, Ore. St. U.
 D. W. Cole, U. Wash.
 A. R. Gaufin, U. Mont.
 F. D. Johnson, U. Idaho
 R. W. Harris, FS, Portland
 D. Chapman, U. Wash.
 R. Burgner, U. Wash.
 G. Staebler, Weyerhaeuser Co.
 K. Van Cleve, U. Alaska
 C. P. Goldman, U. Cal., Davis

.55 Coniferous Forest Biome—Continued

Committee—Continued

P. Zinke, U. Cal., Berkeley

.56 Deciduous Forest Biome.

Director, Stanley I. Auerbach, Oak Ridge National Laboratory, Tennessee

Committee:

F. G. Goff, U. Mo.

N. L. Clesceri, Ren. Poly. Inst.

E. C. Williams, Jr., Wabash Coll., Ind.

H. Lieth, U.N. Carolina

O. Loucks, U. Wise.

S. Stephenson, Mich. St. U.

K. Wenger, FS, Wash., D.C.

.57 Tropical Forest Biome.

Director (un-named)

Committee:

F. B. Golley, Chmn., U. Ga.

R. Cowan, Smith. Inst., Wash., D.C.

C. F. Jordan, P.R. Nuclear Center, AEC

S. Preston, U. Mich.

D. H. Janzen, U. Chicago

R. S. Davidson, Battelle-Columbus

H. Lieth, U.N. Carolina

T. E. Moore, U. Mich.

E. Wadsworth, Inst. Trop. For., PR

T. C. Dorris, Okla. St. U.

.58 IBP Liaison.

Scientific Director, IBP: Dr. E. B. Worthington, IBP-Central Office, 7 Marylebone Road, London NW 1, UK

Section PT

Convenor: Professor F. Bourliere, Faculte de Medecine, 45, rue des Saints-Peres, Paris 6e, France

Coordinator: Dr. M. J. Hadley, Faculte de Medecine, 45, rue des Saints-Peres, Paris 6e, France

Section PF

Convenor: Professor G. G. Winberg, Professor of Zoology, Academy of Science, Leningrad V-164, U.S.S.R.

Coordinator: Dr. J. Rzoska, IBP-Central Office, 7 Marylebone Road, London NW 1, UK

US Coordination with International Sections:

PT representative on INTCOM: Dr. Jerry S. Olson, Oak Ridge National Laboratory, Tennessee

PF representative on INTCOM: Dr. Arthur D. Hasler, University of Wisconsin

Program Directors of related Integrated Research Programs, US IBP.

Phenology, Dr. Byron O. Blair, Purdue U.

Aerobiology, Dr. William S. Benninghoff, U. Mich.

Upwelling Ecosystems, Dr. Richard C. Dugdale, U. Wash.

Convergent and Divergent Evolution, Dr. W. Franklin Blair*, U. Texas

Chairman, Biometeorology Panel, Dr. Glenn R. Hilst, Trav. Res. Corp., Hartford.

*Also Chairman, US IBP Executive Committee.

CURRENT STATUS AND ACCOMPLISHMENTS

6.00 Two problems related to funding have affected program development. First, in early March 1968, serious doubt about prospects for significant IBP funding for fiscal '69 and '70 led to the decision to postpone the major organizational meeting for the Tropical Forest Biome planned for April 5-6, 1968 and a Coniferous Forest Biome Committee meeting planned for March 8, 1968. This action resulted in a considerable loss of momentum in those Biomes. Morale suffered in all biomes.

Second, the imposition of expenditure ceilings on NSF grants in August 1968, forced a virtually complete cessation of planning of new activity and a drastic curtailment of support to Biome Directors and Committees while new budgets were being developed. And after new budgets were approved, severe restrictions were reimposed at the Univ. of Michigan on October 30, 1968. The result of these restrictions has been a general slowing of Biome Program development and the postponement of a series of meetings planned for fall 1968, to coordinate efforts by disciplines among Biomes.

Despite these setbacks organization continued. For example, the Tropical Biome Steering Committee decided it should meet *in spite of* the lack of support, each individual finding support from other sources.

6.10 *Program Development.* Many aspects of program development have been presented in previous sections: organization in section 3.00, funding in section 4.00, and manpower in section 5.00. Section 4.23 lists the major organizational meetings, and section 4.30 presents expected funding needs. Additional highlights of development for each of the seven program components follow.

.11 Central Program. Frederick Smith was nominated Program Director in February 1967. John Kadlec was nominated Program Coordinator in October 1967.

Work has started on ecosystem models, information systems design, and management planning. Substantial progress in the development of principles of ecosystems awaits activation of the six biome studies. Most of the effort so far has gone into program development within biomes.

International relations are promoted through the activities of the INTCOM associates, Jerry Olson and Arthur Hasler. The PF and PT Sections have sponsored more than 20 international working sessions on subjects relevant to this program.

.12 Grasslands. George Van Dyne was nominated Biome Director in October 1967.

An initial research design for the intensive study is complete. Work began in June 1968, in four phases involving 59 scientists: synthesis of available information, ecosystem modelling, preliminary field studies, and site development. Three of five workshops on information synthesis have been held. A preliminary model for a grasslands ecosystem has been constructed. Field research in 11 areas of study involving 25 scientists has begun. A new soil survey of study areas has been completed, and one remote sensing flight over the site has taken place. Field laboratories are under construction, and micro-drainage basin installations have been completed. Planning has begun on the design of the comprehensive program.

The US program is coordinated closely with the existing Canadian Grasslands Study in Saskatchewan, and with the proposed Mexican Grasslands Study in Chihuahua. An international conference to define a minimal grassland program was held in September 1967. The US and Canadian groups are co-hosting an international grasslands conference in Saskatoon, Canada, in September 1969.

.13 Tundra. Frank Pitelka was nominated Biome Director in November 1967.

Following meetings in Washington, D.C. and Fairbanks, Alaska, a research proposal is now being prepared to request support for (1) modeling analysis

of existing data for Point Barrow and related areas, (2) development of the overall designs for arctic research and for alpine research, and (3) integration of existing and future taiga research into an ecosystem approach.

International research design is ahead of that for the US alone. At a series of meetings, but especially those in England (Nov. 1967) and Norway (Sept. 1968) a circumpolar effort has been designed. The systems approach to analysis and synthesis has been incorporated, with the US playing a leading role.

.14 Desert. David Goodall was nominated Biome Director in May 1968. All proposed major sites have been visited by committees from within the biome, and major study sites have been selected. A complex research design combining analytic and synthetic studies has been completed, and an integrated proposal is nearing completion.

The development of international cooperation will be emphasized at the Arid Lands Conference in Tucson, June 1969.

.15 Coniferous Forest. Stanley Gessel was nominated Biome Director in September 1968.

A comprehensive program covering the coniferous forest regions of the northwest, has been outlined. The development of a design for intensive study has begun, with a major proposal planned for the fall of 1969.

An international symposium on the Coniferous Forests of the Northern Rocky Mountains was held in Missoula, Montana, in September 1968.

.16 Deciduous Forest. Stanley Auerbach was nominated Biome Director in June 1968.

A general design of intensive and comprehensive studies has been completed.

A major proposal for research on ecosystem modelling and a few lead-time studies has been submitted and revised. In some regions existing support is being re-oriented and mobilized toward this program, although their complete integration awaits central funding for the biome.

International meetings have been held in Brookhaven, December 1967, and in Gatlinburg, Tenn., July-August 1968. Close coordination is developing with the programs of several European countries.

.17 Tropical Forest. A Biome Director is yet to be nominated.

A general plan has been accepted by the Biome Committee that focuses effort on continental wet lowland forests, with comparative studies extending into other tropical forest systems. The development of IBP programs by tropical countries has been slow, but several now have identified groups with which we can cooperate, including India as well as countries in South America.

Most of this program will be international in the true sense of cooperative teamwork between US scientists and scientists resident in tropical countries. In addition, studies in South America, Africa, and Asia will be coordinated in the more usual way through work sessions.

6.20 Reports and Proposals.

Listed below are the major reports and proposals produced by this program. They contain the details of the progress and plans of the program to date. Not all of them are available for distribution.

Program Statement of the Subcommittee on Productivity of Freshwater Communities and Subcommittee on Productivity of Terrestrial Communities, US National Committee for the International Biological Program. 12 pp., December 1966.

Analysis of Drainage Basins and Landscapes. A proposal submitted to the National Science Foundation (NSF) by F. E. Smith, 25 pp., February 1967.

Systems Ecology and the IBP. A report of the working conference on systems analysis for the International Biological Program. 19 pp., June 1967.

Report of the Working Session on Grassland Ecosystems. Design of research for the intensive study and plans for the comprehensive study. 43 pp., October 1967.

First Annual Report on the Analysis of Ecosystems, an integrated research program of the US IBP. 5 pp., November 1967.

Analysis of Structure and Function of Grassland Ecosystems. A proposal submitted to NSF by G.M. Van Dyne. 373 pp., January 1968.

Analysis of Ecosystems. A proposal submitted to NSF by J.A. Kadlec. 30 pp., January 1968.

A Planning and Analysis Research Project for the Analysis of Ecosystems Program, International Biological Program. A proposal submitted to the U. of Michigan by R. H. Ellis (as a sub-contract to the above proposal). 81 pp., January 1968.

Proposal for Investigation of Multispectral Remote Sensing Techniques for the Analysis of Ecosystems. Submitted to NSF by the Willow Run Laboratories, Inst. of Science and Technology, U. of Mich. 72 pp., January 1968.

Report of the Working Session on Deciduous Forest Ecosystems: Design of research for the comprehensive study. 37 pp. January 1, 1968.

Report of the Working Session on Coniferous Forest Ecosystems: Contributions toward a design of research for the comprehensive study. (Rough draft) 37 pp. February, 1968.

Report of the Working Session on Desert Ecosystems: Contributions toward a research design. 46 pp., February 1968.

Comprehensive Network Phase Organizational Meeting. Grasslands Biome Sub-program. 14 pp., June 1968.

Research Design and Analysis of the Structure and Function of Ecosystems in the Deciduous Forest. A proposal submitted to NSF by S.I. Auerbach. 141 pp., September 1968.

Proposal for Support of Initial Administrative Costs of the Desert Biome Section of the US IBP Program for the Analysis of Ecosystems. Submitted to NSF by D.W. Goodall. 23 pp., September 1968.

Report on a US IBP Meeting for Tundra. 44 pp., October 1968.

Report of Ann Arbor Working Session on Tropical Forest Research Program. 6 pp., October 1968.

Proposal for Support of Initial Administrative Costs of the Coniferous Forest Biome Section of the US IBP Program for the Analysis of Ecosystems. Submitted to NSF by S.P. Gessel. 16 pp., November 1968.

Analysis of Structure and Function of Grassland Ecosystems: a progress report and a continuation proposal. Submitted to NSF by G.M. Van Dyne. 700 pp., January 1969.

A Planning and Analysis Research Project for the Analysis of Ecosystems Program, International Biological Program. Submitted to the U. of Michigan by R.H. Ellis. 97 pp., January 1969.

PRIORITIES

7.00 In 1967 the total cost of operating the Analysis of Ecosystems was estimated at \$12 million/year. This now appears to be about 25% too low; current estimates are \$15 million/year. This is a large sum in comparison with the cost of conventional ecological research, although it is very small in comparison with the cost of restoring and maintaining the human environment.

7.10 Allocation with less than adequate funding.

The type of integrated research program designed for each of the six biomes cannot be executed at a partial level of funding. The work must be complete and simultaneous. It is essential, therefore, that whole biomes be deleted at reduced levels of funding, rather than attempting to run all six partially.

Initially, reduced levels of support can be used to advantage. Some support is essential during the organizational phase. This can be followed by one year of funding at an intermediate level during which program development can be completed and lead projects begun. After this, however, support at less than the full level is severely damaging to the objectives of the program.

The Board has long adopted the resolution that, unless support levels rise above \$2 million/year, virtually all of the funds should be allocated to the Grasslands Study. Above this level, additional biomes should receive significant support on a readiness basis, the number so supported depending upon how quickly how many can be supported fully.

Unless several biome studies are fully supported, the continued support of the Central Program is not recommended. Its service value depends upon the number of studies being served, and its research value depends upon the number of biome studies that can be compared and used in generalization. The development of Principles of Ecosystems cannot progress far unless at least four biome studies are fully active, and its value rises rapidly if the number of biome studies is increased to six. Still greater value would result from 8 or 10 biome studies, although the returns in terms of the contribution to general theory may be less for the additional studies.

7.20 Scientific Need for Six Studies.

The decision to begin with studies in six biomes arises from the conviction that this is the smallest array from which generalizations can be made with confidence. Development of all six is vital to the overall objectives of the program. Those that were selected were chosen on the basis of several criteria: intrinsic scientific interest, degree of contrast within the set, and value to human welfare. Nothing scientific has happened to suggest that this decision is in error.

An additional scientific need in program design has now become clear: it is a problem in critical mass, not of the number of scientists from different disciplines working in one integrated study, but of the number of scientists in the same discipline working in different integrated studies. Within each discipline (such as meteorology, microbiology, systems analysis, etc.) the investigators in an integrated study develop new perspectives of their field, which in turn lead to the need for new technologies. Two problems arise: first, help from their professions too often suffers from a lack of experience in this kind of study, and, second, the resulting isolation creates a high risk of premature rigidity in techniques. With more ecosystem studies these problems are reduced. The ideal minimal number of concurrent studies in that for which the rate of conceptual and technical advance is commensurate with the time scale for the integrated studies. Our best guess is that the original design of six studies is certainly not too many. *The new constraint emphasizes that these six must be concurrent.*

7.30 Manpower Needs.

Environmental problems facing society are ubiquitous, large, and costly. Large numbers of trained personnel will be needed to cope with them,

whether the action be federal, state, or private. The source of such personnel lies primarily in educational institutions. Thus, although the design of this program may be adequate from a scientific point of view, it may be inadequate as a means of meeting future manpower needs.

The ability of an institution to produce appropriately trained recruits depends very much on its involvement in a research program such as this one. Its students will be able to execute useful sections of research and at the same time participate extensively in synthesis. They can be trained in the techniques of systems analysis applied directly to the study of ecosystems. They will acquire early experience in team research.

At present more than a dozen educational centers (groups of locally interrelated schools and agency facilities) in this country have the interest and potential to develop this kind of training. Thus, a program nearly twice the size of this Program can be initiated if manpower needs are overwhelming.

The development of additional manpower must take into account the one or two years needed to bring ecosystem research programs into operation, and the several years of training that each student must receive. A total lead time of about five years is needed between the development of training programs and large-scale action programs of environmental improvement.

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APPENDIX F

MAN'S SURVIVAL IN A CHANGING WORLD

(VIEWS OF A U.S. NATIONAL COMMITTEE OF THE IBP CONFERENCE)

The United States International Biological Program

"In our times of unprecedented change, biologists are well aware of the rapidly growing ability of their fellow human beings to alter the face of the earth through technology. But they are equally aware that these alterations can bring about far-spreading and often destructive changes in the web of life that is stretched so thinly over the surface of our planet. Our technology has out-paced our understanding, our cleaverness has grown faster than our wisdom.

"Because of our limited understanding of the relationships among living things, we are limited in our ability to predict the effects of technical change or to help the technologists conserve the values and utilize the abundance of the world of life. Our goal should be not to conquer the natural world but to live in harmony with it. To attain this goal we must learn how to control both the external environment and ourselves. Especially we need to learn how to avoid irreversible change. If we do not we shall deny to future generations the opportunity to choose the kind of world in which they want to live.

"Greater understanding will make it possible for man to respond to opportunity as well as to react to need. To gain such understanding is the underlying purpose of the International Biological Program."

ROGER REVELLE,

Past Chairman, U.S. National Committee for the International Biological Program.

INTRODUCTION

The International Biological Program (IBP) grew out of mounting scientific concern throughout the world for the major problems confronting mankind today—the rapidly increasing population, food shortages and environmental destruction. As early as 1959, scientists began discussing the possibilities of organizing an international program which would deal with increasing food supplies and keeping the earth a fit place in which to live.

In July of 1964, the IBP was voted into reality by the International Council of Scientific Unions (ICSU) which set up a Special Committee for the IBP (SCIBP). Based on the theme of "The Biological Basis of Productivity and Human Welfare," the program was divided into two main phases: the planning stage from 1964 through June of 1967, and the five-year operational phase from July of 1967 through June of 1972.

Possibilities for United States participation in the IBP were explored by an ad hoc committee of the National Academy of Sciences which, upon the recommendations of this group, organized the U.S. National Committee for the IBP in 1965 with Roger Revelle of Harvard University as chairman.

Fifty-three other nations also agreed to participate in the IBP and formed national committees. Each country has developed or is in the process of developing a national program which fits into the broad international aims set up by ICSU, but which also concentrates on special problems within their own nation. Many of the developing nations in the IBP have directed their efforts toward methods for increasing food production and for better population control, while the more industrial nations have concentrated on investigating the problems of urbanization and environmental pollution.

Because of the degree of advanced technology in the United States—which can be harmful as well as beneficial—the U.S. scientists departed from the scheme of trying to reorganize ongoing research as many of the other countries had done.

They decided instead to develop entirely new methods for handling the very complicated ecological problems found within the country. This new type of approach—which has been called the beginnings of “big biology”—involves the use of multidisciplinary teams of researchers working on all components of a specific environment and the interactions that occur between them.

Special concern was also given to man himself and how he fits into and affects his environment—and how it affects him. Man's adaptation to environmental stresses such as cold, high altitude and urbanization was of particular interest to the IBP scientists.

With the advent of the operational phase in July of 1967, the U.S. National Committee found itself with a group of integrated research programs specifically generated by and designed for the IBP. Also a part of the U.S. effort were smaller, individual research projects that were not IBP-originated, but closely related to the aims and goals of the program.

The major effort of the U.S. Committee for the next few months was to interrelate these programs for a better concentration and management of research effort. Along with these actions, the structure of the Committee itself was altered with the chairmanship passing to W. Frank Blair of the University of Texas, and the formulation of plans to streamline the group to meet the needs of the operational phase of the program.

Through these efforts, the large-scale integrated research programs which formed the major core of the U.S. contribution, focused more sharply on the two main centers of international interest—problems of human adaptability and those of environmental management. Although the number of integrated programs in these two areas has been and is still subject to change through the addition of new studies or the merger of others, the contributions to be made over the next few years should be of significant value in helping to “not conquer the natural world, but to live in harmony with it.”

PROBLEMS OF HUMAN ADAPTABILITY

As a result of rapid technological advances and increasing population pressures, man is so seriously disturbing his environment that he is subjecting himself to a wide variety of new stresses and strains. Man is an enormously adaptable animal, but it is clear that his adaptability has limits, and that attempts to exceed them produce a toll in disease and death. Clearly, we must greatly improve our understanding of the processes of human adaptability if we are to cope with the emerging crises of human survival.

The scientific basis of human adaptability has two major components—the genetic, which sets the limit of the organism's capacity to respond, and the physiological and behavioral, which determines the range of responses available to the organism given its genetic set. At one extreme of the spectrum of inquiry that can be brought to bear on human adaptability is population genetics, and at the other extreme, environmental physiology. In between, many aspects of modern medicine and anthropology come into play.

Human behavior, in contrast to the behavior of other organisms, includes a large set of cultural activities, the domain of the arts and social sciences. These establish a context, a pattern of civilization, within which the more biological attributes of human adaptability must operate. It is the limited adaptability of the latter, expressed in genetics, physiology and behavior, that are the central theme of this program.

Each U.S. IBP integrated research program in human adaptability attempts to exploit certain unusual opportunities to understand critical aspects of human adaptability. Some of these opportunities are associated with vanishing cultures and will soon disappear. It can be truly said that this is the last generation of scientists to have the opportunity to study primitive cultures, and the first generation to have adequate tools in genetics, molecular biology and physiology to do it. As an aggregate, these programs will clarify many mechanisms of human adaptation to environmental extremes and to urbanization. They are articulated by a number of common subjects, especially nutrition and population genetics, and by research on the same populations under varying conditions, such as Eskimos in the Arctic hunting and in urban settings. They are also coordinated with the environmental programs through commonalities of place, time and personnel.

International Study of Eskimos

Eskimos, similar in race, language and culture across a distance of 3,000 miles at the top of the world, represent the greatest linear dispersion of one group of people in human history. Their habitat, snow-covered two-thirds of the year, is marked by low temperatures, seasonal extremes in light and darkness and relatively meager resources. The aim of this five-year program is to elucidate biological and behavioral processes responsible for the successful adaptation and slow population growth of 70,000 Eskimos in an arctic environment.

The integrated program involves multidisciplinary scientific teams from the United States, Canada, Denmark and France who are cooperatively and simultaneously studying their own Eskimo citizens (excepting France) in Alaska, Canada and Greenland. Methods to be used, previously approved by IBP working groups following World Health Organization recommendations, will be comparable to simplify synthesis of results.

The research categories are: 1) general health and performance, with special attention to the cardiovascular system, work capacity and the antibodies present in the blood and serum; 2) child growth, including long-term studies of the size, form and composition of the body at different ages, the dentition and bone mineral content *in vivo*; 3) genetics, including genetic markers, the population structure and demography; 4) behavior, including cognition, psychomotor and expressive behavior and behavioral genetics; and 5) ecology, including quantification of nutritional energy flow through the ecosystem of which the human population is a part.

The studies will provide immediate dental and health benefits and growth norms for Eskimos, who are increasing population numbers at about three and one-half percent per year, as well as contribute to basic knowledge of small group population genetics, of human survival in a harsh environment, and of relations within a small isolated population between genetics, stress, environment and disease.

Population Genetics of the American Indian

Scattered throughout South America are still to be found tribes of Indians living by hunting, gathering and simple agriculture, much like the ancestors of most civilized populations a few thousand years ago. These tribes provide a rapidly disappearing opportunity to obtain a baseline on the vital statistics and health patterns of primitive man. At the same time, dispersed throughout the United States, but especially in the Southwest, are groups of relatively pure Indians who are in the mid stream of transition from the primitive state to the Atomic Age. In their lifetime, these Indians are subject to biological adjustments which in the Old World were spread over several thousands of years. Thus, the study of these transitional Indian populations in conjunction with the study of primitive groups should provide important insights into the kind of biological adjustments modern man is being called upon to make and some of the consequences of these adjustments.

This specific investigation at present entails the collaboration of U.S. investigators with those in Venezuela and Brazil. Several very primitive tribes living on tributaries of the Amazon and Orinoco Rivers have been selected for studies of their mating patterns, methods of fertility control, birth and death rates, genetic characteristics, food utilization characteristics and disease pressures. The early effects of acculturation are being explored in the expectation of linking these studies in time with studies on the much more changed Indian of the United States. From the careful, quantitative study of groups such as these, an understanding of the changing stresses of modern man and, possibly, some insight into their consequences can be found. All over the world the remaining primitive societies are being rapidly disrupted; this is probably the last generation of scientists to be able to study them.

Biology of Human Populations at High Altitudes

A significant portion of the world's population, more than 25 million people, live at altitudes above 10,000 feet. This number can be expected to expand as world-wide pressure for living space increases. The former stability of ancient high altitude populations is rapidly disappearing as transportation facilities improve. In some communities, there is a constant influx and efflux, yet the population dynamics of such communities are poorly understood. In particular, the reasons why people leave high altitude have never been examined sys-

tematically. The role of biological inability to adapt to chronic hypoxia in comparison with other environmental stresses such as cold and dryness has not been thoroughly investigated as well as the economic, social, political or cultural factors that affect these populations.

United States participation in the study of man living at high altitudes will be concentrated in the Western Hemisphere, with emphasis on collaboration between scientists in both North and South America. At the same time, the program will integrate with investigations in such countries as Ethiopia, India and the Soviet Union. Three human population groups will be examined in the U.S. program: a North American population at 10,175 feet in the Rocky Mountains; a South American population also living at 10,175–11,500 feet; and a predominantly native Andean population living at the more extreme altitude of about 13,000 feet.

In each of these populations, the human biological investigations will have three main foci—physiological adaptations to the chronic hypoxia of high altitude from before birth to old age; medical and obstetrical problems which are a direct consequence of maladaptation to high altitude such as incidence of fetal wastage and malformations; and modification of disease by high altitude. In this last category, one provocative hypothesis is that residence at high altitude may protect against degenerative cardiovascular disease.

The study of these three populations will allow judgments to be made concerning the relative significance of genetic and physiological processes in human adaptability. The peoples to be studied in the Rocky Mountain communities enjoy such conveniences as central heating, adequate clothing, sanitation, refrigeration, adequate nutrition, good medical care and private transportation. Hence, the primary uncontrollable environmental factor is the reduced atmospheric pressure and the resulting hypoxia. For the Andean populations who have lived at high altitudes for many generations, these amenities are not readily available. A hypothesis that can be examined in these studies is that their adaptation has been primarily genetic whereas the North American peoples have made their adjustments physiologically.

Nutritional Adaptation to Environment

The nutritional studies in the IBP are based on research that is integrated on a national and international basis with other programs of human adaptation. The results will hopefully assist mankind in making adjustments to present and future circumstances in relation to food.

Experience in typical arctic, tropical, and temperate zones has resulted in three extreme ranges of food practices that are in sharp contrast as related to critical margins of success or failure in human adaptability. Limitation to animal sources of food in polar areas of Alaska, Canada and Greenland has resulted in diets that are close to the limit of physiological tolerance in their high content of protein and fat and their low content of carbohydrates and vitamin C. In tropical areas of Latin America, Africa and Asia the reverse is true: diets there tend to be critically low in good quality protein, high in starch or sugar and seriously low in total energy content. Temperate zones as in the United States and Western Europe permit varied and more adequate food production and generally a more favorable economic environment. Nutritional adaptation research in this area is needed to identify requirements for all essential nutrients including vitamins and trace elements such as zinc and chromium, and to investigate the tragic hazards of excess caloric intake.

Within the integrated programs, the Eskimo study includes a nutritional examination of food consumption by different age groups and metabolic measurements to identify the degree of functional adaptation to the restricted and extreme types of diets.

Among the tropical and subtropical populations, protein deficiency is a major hazard to health and human development. There is an urgent need for U.S. cooperation in identifying the degree of protein deficiency and its differentiation from caloric and other dietary deficiencies that may exist concurrently.

In the temperate zone, good quality protein foods are available. Nevertheless, many problems require intensive research on quality, safety and nutritive value of foods in their production and use for domestic and export purposes. Studies will be directed also to impoverished urban and rural areas, to migrant populations and other groups living in stress environments.

The Ecology of Migrant Peoples

The planned research on the ecology of migrant peoples will improve understanding of how people who migrate from a rural to a highly urbanized environ-

ment adapt to change. Involved in migration are various factors including the physical environment (increased congestion, noise, traffic, and climatic differences), the institutional environment (impersonal routines and authority, and conformity to rigid time schedules), and the social environment (changing family patterns, exposure to gangs and to deviant behavior such as narcotics addiction). These factors constitute critical changes in the ecology of migrants.

Work on the ecology of migrants of varied racial and ethnic origins can clarify the broadest common denominator of human response to industrialization. World-wide, at least a billion people have migrated since World War II, yet rigorous bio-social studies of migrants are almost totally lacking.

In this program, priority has been given to source populations under high physical and socio-psychological stress in Mississippi and Georgia and in receiving areas like the inner city of Chicago and Fairbanks, Alaska. Specifically, Holmes County, Mississippi, appears to be the most economically deprived area in the United States, and the areas to which Holmes County people migrate in Chicago—Maywood and the West End—have been foci of violent unrest. Consequently, the work proposed would yield basic data on the phenomenon of migration and also contribute directly to the urgent search for social justice and tranquillity called for by the President's Commissions on Rural Poverty and on Civil Disorders. Furthermore, the program's methodology would have world-wide relevance and its field operations would provide a basis for associated programs to alleviate chronic poverty and deprivation.

PROBLEMS OF ENVIRONMENTAL MANAGEMENT

An increasing human population coupled with an expanding technology has placed unprecedented stress upon the biosphere, the world environment in which man lives. More of the productive capacity of the earth must be harnessed for the benefit of man, while at the same time more space is used for other activities and more waste and contamination are released. Improperly managed, these activities become incompatible, reducing both the quality and the productive capacity of the environment. Each local problem can often be allayed with a "quick technological fix," but such a piece-meal approach usually shifts the place or time of the problem rather than eliminating it. Mankind is running out of both places and time.

The scale of these problems is larger than the scale of conventional research. Their solution requires the skills and knowledge of many disciplines, the coordinated efforts of many scientists, the experimental manipulation of large environmental-biological systems, the study of interactions in such systems and the synthesis of large amounts of information into working models. Only by such an approach can the predictive powers of the separate sciences be integrated to reach the needed level of reliability.

FIGURE 1.—SCIENTIFIC BASIS FOR ENVIRONMENTAL MANAGEMENT

- A. Changes in Plants and Animals
 - 1. Evolutionary Adaptations
 - 2. Physiological and Behavioral Adaptations
- B. Changes in Relationships of Plants and Animals
 - 1. Interactions with the non-living environment
 - 2. Interactions with other organisms
- C. Structure and Function of Ecosystems

The scientific basis of environmental management combines a variety of basic and applied problems in several major components (figure 1). A major biological aspect of the environment concerns the changes that occur in plants and animals in response to variations in their surroundings. These areas parallel those in human adaptability. Evolution has produced, for each species, a genetic composition that sets limits to its environmental responses. Within these constraints, physiological and behavioral mechanisms define an array of responses that can be used to cope with environmental change. Both areas, applied to the several thousand species in an ecosystem or the several million in the biosphere, will make use of enormous amounts of information already on file, as well as requiring much more research as this information is integrated and the underlying processes become better understood.

A second major biological aspect of the environment concerns changes that occur in relationships between organisms or between organisms and the non-living environment in response to environmental change. The presence or absence of species in a region is largely determined by such relationships, and for each

species present its many relationships are continually shifting as the composition of the environment changes. The effects of changes imposed by man could be predictable if we knew much more about the mechanisms influencing such relationships. Better control of particular species is certain to result. Here the role of the meteorologist, soil scientist and chemist are as significant as those of the ecologist, behaviorist and molecular geneticist.

The environment as a whole includes both biological and physical-chemical processes. Their interactions in given regions produce complex ecological systems. These ecosystems in turn interact in larger regions producing on the largest scale the earth's biosphere, the total system in which organisms participate. The ecosystem is the smallest unit in which environmental management can be applied if problems are to be solved rather than moved. One goal of this program is to learn much more about the structure and function of such systems.

Most of the IBP integrated research programs in environmental management are concerned with the processes discussed above. In addition, urgent problems in conservation face mankind. The U.S. IBP includes the search for and preservation of representative ecosystems. Areas preserved for long-term scientific use provide natural laboratories for the study of ecosystems in all their variety and complexity including their inherent biological productivity. They can serve as check areas against which the effects of use, protection and management of comparable areas of land and water can be measured. They provide for the continued existence of large numbers of species whose potential use by man is yet unknown, as well as the preservation of many genetic stocks, wild precursors of domesticated organisms, from which breeding of more useful strains may be continued.

INTEGRATED RESEARCH PROGRAMS IN ENVIRONMENTAL MANAGEMENT

Convergent and Divergent Evolution in the Americas

This cooperative research program has three main purposes: the understanding of the processes and results of both convergent and divergent evolution in structure, behavior, and physiological adaptation of various kinds of organisms of the New World as well as the puzzling relationships between various South American and Australian groups; understanding of the composition, ecological niches and functioning of ecosystems that have evolved in similar environments of the Southern and Northern Hemispheres; and the understanding of native and invading biotas of the land areas of the Hawaiian Islands.

Selected biologists from several American countries and Australia have planned a cooperative research program with subprograms on six groups—amphibia, fish, mammals, reptiles, insects and plants. Each has investigators and institutions named to a limited extent that will expand as the program proceeds. In addition, there are two subprograms concerning the questions of convergence in ecosystem structure and convergence in physiological adaptation.

In the Hawaiian Islands, the native terrestrial biotas are most seriously threatened. Many island species have become extinct; but most of the remaining species can be saved with better understanding of the interactions between the plants and animals and their changing environments, especially where man is having a serious influence. The rich Hawaiian flora and fauna evolved from about 700 immigrant species, under conditions of extreme isolation in the course of a few million years. This provides an unsurpassed natural laboratory for the study of evolutionary and ecological phenomena.

Experimental Biogeography of the Sea

This program seeks to develop the ecological and physiological knowledge required to predict how environmental factors limit or enhance the abundance and productivity of selected marine organisms of interest to man. Studies will be in the United States and other IBP countries in the Americas.

Knowledge gained on the mechanisms of marine productivity is basic to an identification of the environmental factors and stresses which limit the distribution of organisms and help explain evolutionary diversity. It would also aid in identifying optimal environmental and functional conditions useful for assessing aquacultural potentialities for selected species and provide an understanding of the significance of selected marine organisms in food chains important to man's welfare. In addition, information would become available on the adaptive capacity of organisms for life in modified or disturbed environments such as polluted waters.

The IBP research will be conducted in terms of "packages" of separate projects, all dealing with a particular organism or group of closely related organisms.

Investigators representing different disciplines will study various physiological parameters on a coordinated cooperative basis.

Physiology of Colonizing Species

Species of plants and animals which invade disturbed habitats will be investigated in this program to first, obtain a better understanding of the characteristics of these species that allow distribution expansion and second, to determine the role of habitat alteration in promoting these invasions. A range of species will be studied varying from those possibly representing local expansion of a specially adapted type to broad expansion of a type with generalized adaptation. The habitats to be evaluated will encompass a broad latitudinal and altitudinal diversity in the Western Hemisphere. From these studies should come a fuller understanding of the interplay of the disturbance of habitats and the physiological adaptation of invading species.

Basic characteristics of invading plant species that will be investigated include: 1) opportunistic ability to expand or contract a life cycle to fit growing seasons of varying length; 2) the production of chemical inhibitors; 3) the ability to survive in relatively pure stands; 4) broad tolerance of temperature, light intensities, and photoperiods; 5) less palatability; 6) less dependence on a particular insect for pollination; 7) regulative propagation or other asexual reproduction; and 8) self-fertility. These studies will try to determine if certain characteristics promote invasion of a given habitat at a given latitude.

The program also seeks to measure the degree to which invading species have diverged physiologically and biochemically under the pressure of new selective forces in a variety of habitats. These comparative studies will yield insight into the factors of population adaptation. Attention will be given to habitat influences since man's disturbance of habitats plays a major role in species invasion.

*Atmospherical Dispersal**

This program is designed to meet urgent problems of airborne diseases, allergenic substances, and biologically harmful pollutants in the air around man. It will organize, integrate, and extend present investigations of airborne spores, pollen, microbes, insects and other small organisms and biologically significant non-living materials such as toxic gases. It will also identify critical problems not yet under investigation and will initiate new projects to meet those needs. The IBP provides unprecedented opportunities for attacking these problems because of the free cooperation between nations and because of concurrent development of schemes for global monitoring of environmental conditions.

The program will include segments for research technology, phytopathology, allergenic particles, transport of genetic material, human and animal disease microbes, wind-carried insects and other small animals and gases toxic to organisms. The American Phytopathological Society, which has for many years fostered international cooperation for study of plant diseases and amelioration of resulting losses, has placed its IBP steering committee within the framework of this program to assist in the prosecution of three related areas within phytopathology: mode and places of origin of organisms causing plant diseases in major crops; processes by which plant disease organisms are dispersed; and assessment of world-wide plant disease losses.

The atmospheric dispersal program will share efforts with several other IBP programs as well as various Federal agencies, scientific societies and numerous private and university laboratories. It will increase the quantity and improve the quality of research on atmospheric dispersal of biologically significant materials, while taking full advantage of the new opportunities for working in the full context of world-wide investigations.

Phenology

Plants and animals undergo rhythmic changes from season to season. These biological rhythms collectively are termed the phenology of the organism. These phenological changes are the response of the organism to regular, seasonally varying meteorological inputs such as light, heat and moisture. Because man has many uses of phenological information about plants and animals, it is important to obtain a broader and more predictive knowledge of these phenomena.

*Previously referred to as the Aerobiology program.

The objectives of the phenology program include detailed studies on plant and animal species, both aquatic and terrestrial at a number of sites within the United States in order to prepare phenological maps; to obtain clues to the physiologic limitations that determine climatic limits of species and explain the biological basis for phenological timing; to test the hypothesis that such studies will aid in understanding evolutionary mechanisms; and to contribute to understanding the role of phenologic phenomena in the structure and productivity of ecosystems.

The program provides for overall coordination and three subprograms on mechanisms, phenology within communities, and phenologic maps. Broad studies will be conducted with the aid of a large network of stations and observers. They can be done at several levels of sophistication, providing participation by people with all levels of scientific training. Special sites will be selected and intensive multidisciplinary studies made of measurements of environmental parameters and population structure, breeding behavior and physiology of organisms. A chief aim will be the development of phenologic maps that will predict planting and harvesting dates for crops and outbreaks of plant and animal borne diseases as well as other biological events.

Analysis of Ecosystems

Plants and animals live together and interact continually with the non-living parts of their environment. These ecological systems or ecosystems are the units of landscape or seascape of immediate importance to man. Understanding or predicting the responses of ecosystems to man's activities requires knowledge of the whole integrated system as well as of living and non-living components.

The purposes of the Analysis of Ecosystems program are: (1) to understand how ecological systems operate with respect to both short-term and long-term processes, including those disturbed to varying degrees by man; (2) to analyze interrelationships between land and water systems so that broad regions may be considered as entities; (3) to estimate existing and potential plant and animal production in the major climatic regions of this country, particularly in relation to human welfare; (4) to add to the scientific basis of resource management, so that optimization for multiple use and for long-term use can be improved; and (5) to establish a scientific base for programs to maintain or improve environmental quality.

In this program an intensive team effort will be made to study six kinds of ecosystems called biomes—grasslands, tundra, desert, coniferous forest, deciduous forest and tropical forest. Each of these six intensive studies will involve many scientists of varying disciplines and each study has its own management structure. In turn, efforts in the six studies will be coordinated by the overall program director and his staff. Strong modelling and synthesis projects are characteristic of this whole program.

Within each of the six biomes, a comprehensive study involving natural gradients or contrasts of climate or sites is planned. These will sample the range of conditions that exist in the biome. For example, the deciduous forest biome includes contrasting forest types (oak-hickory, beech-maple), a variety of geological conditions (granite, limestone, gravel, clay), variations in the steepness of topography and variations in the degree of alteration by man. Many of these will be utilized to improve the power of analysis concerning ecosystem function.

At least one site in each biome will be the location of an intensive study—as complete a study as modern technology permits. All of the components of the system will be studied, and all processes will be evaluated in relation to other variables. On different subareas within the study unit, different treatments will be imposed to stress the system or to shift its configuration into a different state. This general plan will be modified to fit specific situations within each biome.

The synthesis of results toward an understanding of ecosystems will be a major research activity. It will be supported by a staff of planning and analysis experts in each biome who will develop models of ecosystems that incorporate all of the data, attempting to view the system as a whole. This information synthesis will begin with data from the several states of one system in the intensive study, continue with data from system variants in the comprehensive study, and finally include data from markedly different systems in different biomes.

The many benefits that will be derived from this large-scale attempt to understand ecosystems can be divided into three main areas—biological productivity, resource management and environmental quality.

Biological Productivity: Productivity is one measure or capability by which systems as different as the grassland, forests and lakes will be compared. It is a measure of their biological conversion of solar energy—their ecological efficiency. With information from the six biomes, extensive knowledge on total natural plant and animal production as well as economic products in the United States should become available. In collaboration with other IBP countries, actual and unrealized potential production can be assessed also on a world-wide basis, in circumpolar, temperate and tropical zones.

By gaining knowledge of the interactions that occur between green plants, herbivores (animals that eat plants), predators (animals that eat other animals) and decomposers (the micro-organisms in organic matter), levels or allocations of production can become understood. This information is vitally important for agricultural systems and in the field of biological control of pests.

Resource Management: Multiple use of natural resources is increasing steadily: for example, combining timber production, hunting, fishing and recreation. Management programs for this multiple use are already developing but are very complex and cumbersome because of lack of knowledge. The principles and facts about ecosystems that will be produced by this program will establish a theoretical base on which to design the complex management systems needed. Once the principles governing whole ecosystems become familiar, management should become both simpler and less expensive than it is at present. Mistakes should be foreseen and avoided where possible.

Quality of the Environment: A rapid deterioration of the environment is often due to obvious causes that can be corrected if enough people decide to do so. The solution of these problems seldom requires more than the most elementary level of ecology.

But, of growing concern are the less visible, more chronic, insidious changes that take place over decades. Many phenomena of varying importance to man can be listed: the thinning of the soil, the increasing need to spray crops, the increasing abundance of weeds, the dense algal blooms in lakes, the decreasing abundance of sport fish and changes in species of birds in towns. These and many others combine to produce profound changes over long periods of time.

Many of these problems are deeply rooted in ecological systems. They are system responses in which the visible effect appears in one part of the system while the cause lies in another. The relation between cause and effect, and recommendations for improvement would be much easier to determine if the operations of ecological systems were better understood.

In effect, the program on intensive analyses of ecosystems provides a structure or framework which references and utilizes information from all the integrated programs on plants and animals in the U.S. IBP.

Conservation of Ecosystems for Scientific Purposes

Increasing human populations, with their attendant demands upon their surroundings, make increasingly urgent the selection and preservation of representative samples of environments. Already, some of these environments are disappearing while changes in use are affecting many others. Some experimental areas with records of study extending back several decades are threatened by encroachment of buildings or highways. Future generations will find even more urgent the need for natural or near natural areas for comparative study and areas with long histories of study.

The overall purpose of this program is to assure the protection and preservation of a full range of environments—both those relatively little disturbed by man and those that have been appreciably modified by his activities; of those rare or endangered species not subject to protection by reservation of areas; and of those areas, aquatic and terrestrial, with long histories of scientific records.

Specific goals include the provision of registries and descriptions of protected areas and areas requiring protection as well as guidelines useful in managing and protecting them. Assistance will be given to other nations also interested in accomplishing these same purposes.

The program will be accomplished by stimulating and providing a focal point for those activities already underway by governmental or private units. Thus, the Directory of Research Natural Areas on Federal Lands published in 1968, will be updated and additional natural areas added. An assessment and plan of action for publishing similar information on non-federal lands will be carried out by a foundation under the program's direction. An inventory of freshwater and estuarine areas has begun as has a study of mechanisms for assuring protection in marine areas.

PROPOSED RESEARCH FOR THE U.S. IBP

The programs classified as proposed research have also been generated specifically for the IBP but have not yet reached the stage of development necessary for final approval of the U.S. National Committee as an integrated research program. There are several alternatives for each of these programs—they may be considered adequately housed in existing IBP related research, or they may be incorporated into an existing integrated program, or indeed be established as an additional integrated program. As the U.S. Committee continues to examine the spectrum of past, present and planned research in relation to its objectives in human adaptability and environmental management, additional research needs may also be found.

Conservation of Genetic Materials

The genetic resources of plants by which we live are dwindling rapidly and disastrously. Yet these are the very raw materials on which plant breeding and related agricultural research depend for increasing production efficiency.

The United States, with 20 native resources of major crop plants, has programs within government agencies on the introduction, evaluation, and conservation of genetic materials from abroad. There is a national need to assure the protection of these invaluable resources on a world-wide scale through fundamental research. These efforts will provide future generations with one of the most powerful, single weapons for agricultural improvement.

In the international field, IBP is a source of scientific expertise in problems of exploration, utilization and conservation of plant gene resources since these are essential to developing and developed countries alike. On the national scene, IBP is a vehicle for relating research in the academic area to the needs of the governmental programs of plant introduction, utilization and conservation.

These programs will benefit from new inputs in crop evolution, systematics and plant geography as they relate to world centers of diversity. The remarkable changes undergone by cultivated plants in a very short period of time and the projected changes in the future offer remarkable opportunities to study primitive crop ancestors and their weedy relatives as a basis for more effective programs of plant exploration, use and conservation of this essential base of crop variability.

An information center recording the unusually high production levels of selected crops under favorable conditions of environment and cultivation would help summarize the maximum levels of energetic efficiency or protein quality that are possible under conditions of intensive management. These data would be correlated with the results from the Analysis of Ecosystems Program, and studies of natural and managed ecosystems of other countries.

Crop Production Under Stress

The clear necessity of matching food production to the needs of the world's population requires an accurate knowledge of the factors limiting primary production in the various regions and environments of the globe. The objectives of this program are: to identify the environmental factors that limit production of plant materials, particularly foodstuffs, and to encourage and coordinate research on the nature of the physiological responses of plants to environmental stresses.

Recognizing the limitations of time, funds and personnel, this program focuses on certain immediate problems of a specific nature in the Western Hemisphere—increasing plant tolerance to drought and to temperature extremes and increasing rooting zone volume particularly in tropical soils. The program encourages investigations of environmental factors using an international team approach with local and visiting scientists working together. Concomitantly with field studies, laboratory and model studies are encouraged. The end results of this program will provide a logical basis for manipulation of the environment and biological factors involved in plant production.

Productivity and Conservation of Marine Mammals

Marine mammals are largely oceanic, truly international, and represent a large source of protein and fats. Their exploitation has largely been heedless of biological realities so that population after population has been drastically depleted. It is striking that the adaptation, systematics, distribution and abundance of most species remain uncertain or unknown.

Current research on marine mammals in the fields of systematics, behavior, physiology, acoustics and anatomy is urgently in need of expansion and integration so that an intelligent approach to this major resource will evolve on a national and international level. The IBP offers the best opportunity to gather together research-oriented marine mammalogists into a comprehensive, international, non-political program. The U.S. program aims initially at the establishment of a Marine Mammal Coordinating Council to integrate existing programs and at the development of a Central Museum Repository for specimens.

Only by developing a strong U.S. program with international ties, will effective research be developed leading to a full understanding of even a portion of the aquatic adaptation of marine mammals. Only by understanding those adaptations will use and management be approached intelligently on a world-wide basis and the full potential of marine mammals be realized. The IBP represents perhaps the last great opportunity fully to understand these unique and historically important animals for their own sake and for the benefit of man.

Nitrogen Management—Evaluation of Inputs and Outflow

Major factors limiting production in tropical, temperate, and arctic climates are the fixation and changes of nitrogen. Familiar schematic pictures of the nitrogen cycle need to be measured as quantitative budgets to understand these rates. Nitrogen budgets will be studied both in native environments and under agricultural conditions to determine the extent to which this process contributes to the total nitrogen and monetary economy in food production. Research on factors affecting fixation of gaseous nitrogen, from the atmosphere by microorganisms of roots and leaves, is being coordinated in a world study on symbiotic fixation. The U.S. program will further evaluate nonsymbiotic nitrogen fixation and the extent to which this process can be exploited in the production of food will be estimated. Sources of fixed nitrogen will be compared with industrial nitrogen sources as potential contributors to food production in order to pinpoint rations that will have to rely—for social, economic or logistic reasons—on biologically fixed nitrogen instead of industrially prepared nitrogenous fertilizers. The potential effect of large-scale use of nitrogen fertilizers on the quality of the environment and on food quality will also be explored. Mechanisms for avoiding contamination of the environment with excessive quantities of nitrogen and for dealing with inordinately high levels of nitrate in ground waters, lakes and streams will also be considered.

Chemical and Biological Controls of Organisms

A great variety of substances produced by plants or animals stimulate or depress the development and growth of neighboring organisms. Although local concentrations of solid and liquid wastes or other animal excretions may be sufficient to exert measurable influences, chemicals of plant origin are more abundant and generally are more complex so that they are of farther reaching consequence in the natural environment. The same general groups of chemicals are involved in interrelations between plants and animals.

Inhibiting or stimulating effects may be produced by substances released from one plant when they contact another plant of the same or a different type. The active substances may be synthesized in any part of the donor plant and may be released by volatilization, excretion, leaching, leakage or during decay of dead matter. These phenomena appear to be universal in occurrence and of great importance in natural vegetation and in crop growth. They affect productivity including crop yields, nutrient cycling and population density control.

As a part of the U.S. IBP, this program will seek to identify plants which produce such chemicals in natural and managed ecosystems and develop methods to utilize such active species or the substances they produce to obtain greater and more natural control over vegetation and increase the yield of usable plant materials. The pathways of synthesis and movement and sites of accumulation of these chemicals within the donor plant, the manner in which they enter the environment, and the pathways of entry and mechanisms of their action in the receptor plant will all be investigated. Research will also be considered to determine the fate of these substances in the environment when affected by microorganisms, soil conditions, fire, and climatic agents and to discover the influences of these and other environmental, genetic, and physiological factors on such chemical activity.

Basic research on insect development and behavior has led to the identification of naturally occurring chemical agents in insects that have profound effects on insect development and behavior. Similar basic investigations on the interaction of plants and insects have also identified the presence of these naturally

occurring chemical agents in plants. Such natural chemicals may represent the natural protective mechanisms that have evolved in plants to prevent their destruction by pests. Recent developments in these fields open up new areas of research that should be fully exploited in the search for more effective, more economical and safer ways to control plant and animal pests. Pests destroy up to 30 percent of the world's food production. They are responsible for some of the most devastating and dreaded diseases of man and animals.

Current chemical agents for controlling insect pests are not selective in their action. They destroy beneficial as well as destructive insects. They create hazards in the environment that can adversely affect fish and wildlife resources. Pesticide residues in foods represent problems of concern to many people. Available information on the action of juvenile hormones, ecdysones and other naturally occurring chemicals derived from plants and animals indicates that such agents can be expected to be highly selective in controlling target pests without hazard to man, animals and most other organisms in the environment.

A conference of experts in the field of insect-plant interaction recommended an IBP research program that would involve the isolation, identification and structural determination of biochemical agents that occur naturally in plants and animals, and continued basic research on the effect and mechanism of action of these agents on insect development and behavior. Research on organic synthesis of natural products possessing pesticidal action, including analogs and antagonists, was considered valuable for the program, along with laboratory and field tests aimed at the practical development of such selective agents for pest control. Studies would also be included to determine the ecological impact of the use of such agents on other organisms in the environment.

Biological control of pests by use of their natural enemies offers another valuable possibility for managing agricultural pest problems with proper concern for the quality of the environment and long-term human needs. This method requires sustained and concentrated efforts along sound ecological lines, circumstances that have been lacking for the most part in conventional pest control programs.

The IBP has set up internationally four core programs for the biological control of aphids, spider mites, scale insects and rice pests. The U.S. program will coordinate with this world-wide effort and in addition, try to increase the number of highly trained specialists in this field. It will demonstrate the utility of this method in exemplary areas and establish a supportive information and communications center.

This program will not only lead to a more natural and efficient way of controlling pests which year after year decimate agricultural crops, but will also help prevent the pollution of the environment which so often occurs when non-specific, man-made chemicals are used for pest control.

APPENDIX G

A BRIEF SUMMARY AND EVALUATION OF THE IBP GRASSLANDS ECOSYSTEM PROGRESS REPORT AND PROPOSAL

LIBRARY OF CONGRESS LEGISLATIVE REFERENCE SERVICE

April 28, 1969.

To a considerable extent this report and proposal represents an experiment in re-budgeting strategy of the grassland ecosystem program. It reflects an attempt to maintain the interest and participation of a broad group of researchers in spite of a real budget which is only 29.5% of that estimated to be required. The strategy consists of (1) delaying study of the comprehensive grassland network until the intensive site project is fully funded; (2) delaying aquatic phase studies until the major terrestrial system are initiated; (3) concentration on field facilities and instrumentation and on a critical "core" of subprojects; (4) a minimum of new staff and graduate students; (5) and some actual data output and preliminary modeling and synthesis of information on the ecosystem during the next 15 months.

Some 25 scientists from institutions in Colorado and Wyoming and from the Agriculture Research Service have contracted to conduct initial research at the Pawnee grasslands site on various studies of the ecosystem.

Results of Pawnee Site research to date include (1) preliminary surveys of the resident biota; (2) the development of sensors and a 35-channel removable-circuit digital recording system for computer handling of continuous measurements of meteorological conditions; (3) the design of similar systems for handling varied biological data; (4) development and application of the workshop system for maintaining communication among researchers; (4) the synthesis of existing knowledge of ecology as a major project of the IBP; (5) continued organizational development at the working ecosystem level; (6) the application of an ATP system for measuring bacterial biomass in the soil; (7) instrumentation for field measurements of carbon dioxide; (8) the use of PERT systems for prediction of administrative bottlenecks involving the analysis of some 225 jobs; (9) the detection of critical paths, time-sequencing and time critical events in both management and data acquisition (see figures 6.14.1 and 6.15.1 of the Grasslands Report); (10) design of the grasslands laboratory; and (11) aircraft flights by North American Rockwell and the University of Michigan over the Pawnee Site to determine if overall ecosystem productivity and other aspects of the system can be determined by remotely sensed electromagnetic imagery.

While the massive data collection year for the grassland ecosystem is scheduled for 1970, some 33 scientific papers are expected to appear during the field season of 1969. If adequate operating funds are obtained, 1969 will be the final dress rehearsal for the first prime data year for the grassland ecosystem.

Sequential budget reductions now show a resultant detailed cost breakdown totaling \$2,209,334 for 16 months beginning Sept. 1, 1969. Projected cost for completion of the Grasslands Ecosystem Program by July, 1974 indicate a requirement for \$6,500,000 additional funds over this entire period beginning January 1, 1971.

The objectives and research strategy of the grasslands biome project are common to those of the US-IBP environmental program as a whole. These are summarized below (quoted from pages 109-110 of the report) :

OBJECTIVES AND RESEARCH STRATEGY

"It must be recognized that in a program of this magnitude there are several levels of objectives. These relate to international needs, national programs, long-term and broad-project goals, specific operational objects, and fundamental theo-

retical ecological objectives. Each of these categories must be considered in the evaluation of the structure, design, and fund allocation within the program.

"It is also important to consider here potential benefits from attaining these objectives. The benefits are complex and often difficult to measure in dollar values. The potential benefits of the Analysis of Ecosystems Program (see Smith 1968, proposal to National Science Foundation) illustrates four major areas to which this program contributes:

- (1) better scientific understanding of ecosystem operation;
- (2) better understanding of biological production and its relationship to man in both a food and environment sense;
- (3) development of an ecological theory that will be the basis of a new and more intensive resource management, especially encompassing the problems of multiple use optimization;
- (4) the development of a basis for designing more effective methods of evaluation and maintaining environmental quality.

"Although specific figures are hard to obtain, it is well known that federal agencies alone spend at least \$500,000,000 per year on the management of natural resources such as fish, game, forests, rangeland, and soil. Grasslands contribute a large fraction of the land managed by public resource management agencies. Assuming that only one-fifth of this cost is allocated to the management of grasslands, then a minimal 1% improvement in management of natural resources based on information from our proposed grassland ecosystem studies would be worth \$1,000,000 per year! Potentially, the improvement in management as a result from the type of information to be derived in this research would account for a much higher percentage improvement than stated above; thus the costs of our entire proposed program could be repaid in as little as a few years time. The information to be derived from this research, of course, not only has bearing on the management of public natural resources, but also those under private control by small land owners or by corporate control.

Objectives of US-IBP Environmental Studies

"The broad goals of the environmental component of IBP are:

- (1) to formulate a basis for better understanding of the interactions of all components of selected and representative biological systems.
- (2) to extend this understanding toward an increased biological productivity.
- (3) to provide bases for accurately predicting the consequences of environmental stresses, both man-originated and natural, on the performance of biological systems, and
- (4) to enhance our ability to manage our natural resources.

Objectives of the Analysis of Ecosystems Program

"The goals of this program, of which the grasslands study is a component, are:

- (1) to understand how ecological systems operate with respect to both short-term and long-term processes (systems disturbed to varying degrees by man are included),
- (2) to analyze interrelationships between land and water systems, so that broad regions may be considered as wholes,
- (3) to estimate existing and potential plant and animal production in the major climatic regions of this country, particularly in relation to human welfare, as the U.S. contribution to the world-wide goals of the IBP.
- (4) to add to the scientific basis of resource management, so that optimization for multiple use and for long-term use can be improved, and
- (5) to establish a scientific base for programs to maintain or improve environmental quality.

Grasslands Biome Program Broad Objectives

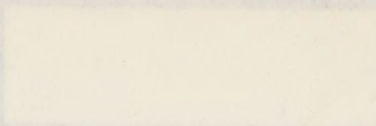
"The broad objectives of our grassland research are to study various states of grassland ecosystems to determine the interrelationships of structure and function, to determine the variability and magnitude of rates of energy flow and nutrient cycling, and to encompass these parameters and variables in an overall systems framework and mathematical model.

Objectives Toward Development of Ecological Theory

"A more fundamental understanding of ecosystem processes and components is necessary for the development of an ecological theory. This theory would include aspects of ecosystem structure and function, such as energy flow, nutrient cycling, trophic structure, spatial patterns, interspecies relations, and species diversity. Further goals include the understanding of how these ecosystem processes are achieved and maintained. By understanding how these processes are achieved and maintained, man will be more able to manage his environment wisely. In attaining these objectives, research must be concerned with population dynamics, ecological processes, environmental interactions, and responses of systems to various natural and induced stresses."

The grasslands ecosystem progress report and proposal is a reflection of scientific competence and dedication to a most difficult task. Moreover it demonstrates a most unusual skill in planning and organizing biologists for systematic study of the environmental complex. We had no idea whatsoever that our ecologists could overcome so much tradition and criticism and produce so much progress and sophisticated scientific design even under favorable circumstances. My own reaction to these unexpected events is that they place the IBP, or at least the ecosystem component of it, at a high priority level in Federally supported R. & D. Other than the direct attack on the problems of human health and on our deteriorating environment with knowledge already available, I am aware of no scientific proposal or program before government officials today which is more important or as deserving or as essential as one which will provide the ecological base lines of the bio-environmental systems of the world. There is much that we can do tentatively to improve environmental quality but we will not know what our future options really are until we understand the ecosystem mechanisms involved. All standoffs in progress in controlling nature, whether they be disease, climate, or earthquakes, rest squarely on this type of limitation.

The re-newed importance of the IBP is not that it recognizes this limitation but that it has become a realistic approach for overcoming this limitation in the field of environmental control and management. It is my judgment that this is what the 700 page ecosystem document is telling us.





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