

A Contribution Toward a World Program in Tropical Biology

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Fig. 1. Barro Colorado Island, Lake Gatun in the Panama Canal, showing field headquarters of the Smithsonian Tropical Research Institute.



Fig. 2. Fort Amador and Bay of Panama, on outskirts of Panama City, where the Smithsonian Tropical Research Institute has facilities for research in marine biology.

By comparison with North Temperate Zones, knowledge of biology in the tropics is in an incipient stage, yet this region seems to hold greater promise for the emergence of new biological principles and concepts than any other. With this thought in mind, 60 scientists from the United States and Latin America met for a Conference on Tropical Biology,¹ in Panama, November 10-12, 1966, and urged the Smithsonian Institution to use its unique attributes to lead in the development of a world program in tropical biology. Such a program is relevant to the International Biological Programme theme of broadening the productivity base for human populations. In 1965 approximately 1.1 billion people ($\frac{1}{3}$ of the world population) made their home in about 70 sovereign nations in the world's tropics. Despite the natural richness in variety of species and the high rate of conversion of solar energy to plant and animal life, tropical ecosystems (living communities, including man, and their total environments considered as functional wholes) are readily destroyed through overexploitation by man. Degradation of most tropical ecosystems is now a world concern, since all nations are ultimately affected. Soil erosion on overgrazed savannas in Kenya and bedrock washing of steep mountain slopes denuded of tropical forests in Ecuador illustrate the deterioration of environments under the pressure of expanding human populations.

The most urgent world problem today is the establishment of harmonious relationships between human

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societies and the environmental resources upon which they depend. Most tropical ecosystems are energy-rich compared to ecosystems elsewhere in the world; therefore, preservation of the productivity of tropical environments is a matter of world concern. In view of the rapidly increasing demands on tropical environments, a world program in tropical biology is urgently needed to provide the scientific foundation for the management of tropical resources. It would be a mistake, for example, to apply our technological power to the building of a sea-level canal in tropical Central America without also attempting to increase our scientific understanding of the effects of the new canal on nature, including the world's human societies. Such a foundation in science depends on new knowledge gained through research in the tropics. The application of principles derived from temperate-zone ecosystems has already contributed to the deterioration in the productivity of the tropics. Management of tropical environments must be approached through studies of the components, structure, energy conversion, cycling of nutrients, and the processes underlying temporal changes in ecosystems altered by man within the tropics, rather than through the application of temperate-zone concepts. The foundation of knowledge required for sound decisions on limiting human populations and technological modifications of environments in the tropics, as elsewhere in the world, must emerge from an integration of ideas from both the natural and behavioral sciences.

The Smithsonian Institution is in a key position to encourage the coordination of the interests and efforts of universities, private foundations, corporations, national scientific laboratories, and governmental agencies, both within the United States and abroad, in developing an effective cooperative program of research and education in the biology of the world's tropics. Such an interinstitutional, multidisciplinary effort is basic to a world program aimed at achieving rational use of tropical natural resources. The Smithsonian's role would be principally to catalyze the program and help coordinate worldwide activities. It was noted that by virtue of its vast collections the Smithsonian Institution already has the potential capacity for identification of

plants and animals that form the components of tropical ecosystems, but a realistic increase in the staff of scientists and supporting help would be required for an expanded world program in tropical biology. Extensive educational programs in cooperation with universities are needed to train young scientists in the systematics of tropical organisms at the Smithsonian. In addition to the systematic base that already exists, the Smithsonian Institution is currently evolving a comprehensive program in ecology. However, this program is at its inception, having started July 1, 1965. The capability for sophisticated research in the ecology of tropical ecosystems will require additional staff and financial resources. It was recommended that the Smithsonian serve as a focal point for the many different organizations that must cooperate effectively if a world program in tropical biology is to succeed in achieving harmony between human societies and their tropical environments.

The Conference was held in Panama because this is one of the most exciting tropical areas of the world and because the Smithsonian Tropical Research Institute (STRI) is located there. Formerly known as the Canal Zone Biological Area, STRI is responsible for maintaining Barro Colorado Island in Gatun Lake as a biological preserve. The research program is concerned with principles of evolution, behavior, and ecology in tropical ecosystems. Recent emphasis, under the directorship of Martin H. Moynihan, has been on comparative behavior of primates, the evolution of interspecific relations, the significance of social signal systems, social organization and behavior of tropical birds, and isolating mechanisms in marine fishes. STRI provides a strategically located base from which to develop programs of biological research in the New World tropics.

Panama is of special significance to marine biology because nowhere else in the world can one compare ecosystems of the world's two largest oceans within a distance of 40 miles. The simultaneous role of the isthmus as a bridge and a barrier to distribution of organisms makes Panama a significant area in which to study evolutionary processes. The planned construction of a sea-level interoceanic canal somewhere on the isthmus increases the potentialities for an effective program in

marine and terrestrial tropical biology in the region of Panama. The opportunities provided by this major environmental manipulation can contribute substantially to the advancement of biological knowledge in the tropics, particularly if a long-term program of investigation is broadly planned to include all levels of biological integration from the molecular level through the organismal level to the total human ecosystem.

The general chairman of the Conference was Sidney R. Galler, Assistant Secretary (Science) at the Smithsonian Institution. The first day of the meeting was devoted to discussions of existing projects and programs, including: tropical biology and oceanography at the University of Panama (Octavio Sousa and Luis Howell-Rivero, respectively), the interoceanic canal studies of the U.S. Army Corps of Engineers (Brigadier General H. G. Woodbury), the Atomic Energy Commission interests in the tropics (Richard Hamburger), bioenvironmental and radiological safety studies of Battelle Memorial Institute (Richard S. Davidson), the Army Tropic Test Center programs (Robert Hutton), Middle America Research Unit programs in tropical disease ecology (Merle L. Kuns), tropical biology at Gorgas Memorial Laboratory (Graham B. Fairchild), anthropology in Panama (Reina Torres de Arauz), the program of the Guama Ecological Research Area at Belém, Brazil (Philip S. Humphrey), the Organization of Tropical Studies (Emmett T. Hooper), research programs at the Smithsonian Tropical Research Institute (Martin H. Moynihan), tropical oceanography (Giles W. Mead), and proposed Smithsonian activities in the tropics in connection with the International Biological Programme (F. Raymond Fosberg). Preceding these discussions S. Dillon Ripley, Secretary of the Smithsonian Institution, gave the keynote speech that appears in the following article. On the morning of the second day, participants visited various biological facilities, such as the Army Research Tower, the University of Panama, Gorgas Memorial Laboratory, Barro Colorado Island, the Navy Pipeline Area, and the marine facilities at Galeta Point and Fort Amador. Panel discussions on ecology, oceanography and limnology, anthropology, tropical botany, mammalogy and ornithology, rep-

tiles and fishes, and entomology held during the afternoon and evening of the second day resulted in reports given the following day. Resolutions and recommendations were presented at a final plenary session.

Panel Reports

Résumés of the panel reports are presented here in the belief that they represent digests of important thoughts that emerged at the Conference.

Ecology

moderated by H. K. Buechner

Under the impact of exploding human populations, tropical ecosystems are rapidly disappearing. From a theoretical point of view we are in a position of needing to discover biological principles and concepts that can emerge only from studying existing tropical ecosystems before they disappear. From a practical viewpoint there are compelling economic and social reasons for studying tropical ecosystems to achieve harmonious adjustments between human societies and the tropical systems in which they live. This is of importance not only to the tropical countries involved but also to temperate-zone countries whose economies will suffer from increased demands of growing populations in tropical nations. As the high-energy tropical ecosystems deteriorate, more and more economic assistance will be required from countries with the more limited resources of the comparatively low-energy temperate ecosystems.

Although the panel recommended a concentration of effort in Panama, it recognized the importance of an extensive world program involving selected sites of a wide variety to advance knowledge through comparisons of tropical ecosystems. The panel recommended Barro Colorado Island, the Navy Pipeline Area, and the Darien Area as sites in Panama for a concentration of activity designed to understand the structure and functioning of humid, lowland tropical ecosystems. Moving out from these centers of concentrated effort, additional studies of a specific but less comprehensive nature were recommended for other parts of Panama and neighboring countries. These recommendations were predicated on the assumption that Panama and neighboring countries would wel-

come the proposed studies and cooperate actively in the program.

The panel discussed the need for a foundation in systematics for ecological studies. It was suggested that consideration be given to developing a Terrestrial Sorting Center, comparable to that of the existing Smithsonian Oceanographic Sorting Center. It was also suggested that task forces be developed with teams of professional and subprofessional personnel to carry out expeditions to selected sites to develop the necessary knowledge of the systematics of the flora and fauna as a basis for ecological studies.

The panel recommended that the Cape Thompson study in Alaska, which was carried out by the U.S. Atomic Energy Commission in preparation for the proposed harbor development using atomic explosives, become a model for studies required in connection with the sea-level canal. This study demonstrated a basic approach to the study of whole ecosystems, starting with geology, hydrology, soils, and climatology on the physical side of the system and extending through flora and vegetation, fauna and animal population studies, and anthropology. Sophisticated ecosystem ecology studies involving mineral cycling and energy conversion extend well beyond the baseline studies illustrated by the Cape Thompson report.

Interinstitutional cooperation between universities in the United States and in tropical countries, national laboratories, government agencies, and corporations was considered by the panel to be essential to obtain sufficient talent for the study.

Oceanography and Limnology

moderated by I. E. Wallen

The panel concluded that a long-term study of marine organisms on both sides of the isthmus is necessary and of urgent priority. The most desirable geographic extent of the study was not established, but the initial studies should extend from the bulges of South America to the Yucatan Peninsula on the east and to the Mexican coast on the west and for about 800 miles to sea.

The following were advanced as reasons for the study:

1) This would be an ideal experiment, consisting of the mixing of two mature ecosystems with the jolt of introduction of exotic elements.

2) Recombining of many biotic species that have not been mixed since the Pliocene offers a 1 in 5 million chance to learn about evolution. This would be a chance to see evolution and to participate in it.

3) The study of the effects of major construction on marine organisms would assist in the development of a prediction capability, useful in future planning. The experiment would permit hypotheses to be tested and refinement of study techniques to be developed.

4) The advancement in learning probably would be as great as that coming from landing a man on the moon, with at least equally valuable technical fallout. The study could contribute to the harvesting of food from the sea.

5) The study would be a demonstration of ecosystem studies which are needed to understand the general biology of the ocean. Carefully designed projects would be developed to provide test series of various shallow to deep-water ecosystems.

6) There is an imbalance in world knowledge, tilted toward temperate zones. These studies would move toward a better equilibrium of effort. A paucity of information about marine tropical species exists. We can only move toward the understanding of their significance for world application by such studies as are proposed.

7) The study would lead to an understanding of many marine processes peculiar to the tropics. Highly complex marine ecosystems could be identified for the pursuit of studies in biological principles, as well as for management.

8) The study would make a useful contribution to the International Biological Programme. Concentrated study in the area proposed and its application to marine productivity are of a nature that is already a part of the International Biological Programme.

9) A special by-product should be contributions to fish culture in the shallow mid-American ocean. Marine fish culture is still in a primitive stage.

10) An obligation exists to our scientific posterity to assemble baseline information for future evaluation of the biogeographic, biotic, and ecological consequences of the canal construction. We collected material before the Bikini nuclear experiments and this has

been valuable as a baseline to note changes. It is urgent that samples be collected from the waters that would be affected by the transisthmian canal.

11) A possibility exists of modifying the present situation with regard to seasonal upswelling and its accompanying biological productivity. This must be studied. Upwelling areas are anticipated to have high fish production. If flow continued through the canal, rather than receding after reaching the shore, major effects could appear.

Tropical Botany

moderated by F. R. Fosberg

Tropical botany comprises those aspects of botany that are regionally relevant in the tropics, as contrasted with those which are generally significant regardless of the climactic zone of the earth. Omitted from this context were those parts of botany that may be investigated without reference to the geographical area or are strictly nontropical in their regional interest.

The broad fields of investigation that seem to make up the more interesting and urgent part of tropical botany are as follows:

1) Monographic investigations in tropical systematic botany, leading to usable classification, as well as understanding of the evolution of tropical plant groups (both phanerogamic and cryptogamic); and their geographical distribution.

2) Systematic anatomy and palynology of tropical plant taxa.

3) Tropical paleobotany and paleopalynology.

4) Tropical floristic work, leading to the preparation of floras and contributions to plant geography.

5) Autecology and phenology of tropical plants.

6) Studies of adaptive features, ecological anatomy, and the origins and significance of growth forms of tropical plants.

7) Description and analysis of tropical vegetation and its chorology.

8) Relation of tropical plant communities to environmental factors and patterns.

9) Dynamics, utilization of resources, productivity, and other functional aspects of tropical plant communities.

10) Cytoecology of tropical plants (relation of chromosome number and configuration, as well as other cytological features, to environment).

11) Tropical ethnobotany and archeological botany.

Proposed activities in tropical botany regarded as of special or immediate importance or urgency (some of which are already initiated and in progress):

1) Monographic studies of tropical plant groups, both those which form parts of the Flora Neotropica and some of neglected groups in other parts of the tropics.

2) Floristic investigations, resulting in the preparation of regional floras and local ecological floras.

3) Ecological studies to provide the botanical information required for the description and understanding of important tropical ecosystems.

4) Development of means of exploring the canopy of tropical forests and pursuit of such explorations.

5) Intensive emergency botanical exploration and collection of material and data on threatened tropical areas.

6) General botanical exploration of little-known tropical areas to fill gaps in knowledge and material.

7) Botanical aspects of IBP site development. This involves the following types of specific activities:

a) Physiognomic, or structural-functional, description of vegetation in general areas.

b) Detailed sampling and analyses of vegetation of preserved areas, establishment of permanent plots and photo-points, and marking of specific trees.

c) Phenological studies.

d) Annotated check-lists of ecological floras, with keys to genera and species.

e) Special keys to identify fruits, seedlings, and other items of ecological interest.

8) Small field conferences. It was suggested that small field-trip type conferences of 5-10 carefully selected participants interested in a particular problem, ecosystem, or methodology would be productive. These would be conducted in the field, in the areas where the subjects of the conferences were well illustrated. The objectives would be mutual stimulation and generation of new ideas, approaches, and methods. An example of such a conference might be one on methods of exploring the canopy of the tropical forest.

9) Of special pertinence to Panama and the proposed sea-level canal investigation, the panel recommended giving

every support and encouragement to the carrying to a successful conclusion the "Missouri Botanical Garden's Flora of Panama," now estimated to be about 55% finished. Five volumes and 3000 pages have already appeared. Activities ancillary to this, and to the work of the Smithsonian Tropical Research Institute (STRI), would be the preparation of a new ecological flora of Barro Colorado Island and adjacent mainland areas under STRI control.

For this, cooperation between the Smithsonian, Missouri Botanical Garden, University of Panama, Army Tropic Test Center, and as many other organizations as could be interested in participation, should be encouraged and supported.

With great satisfaction, the panel received the information that a bilateral cooperative arrangement is being set up for botanical work in Panama between the University of Panama and the Missouri Botanical Garden. This is in line with a recommendation made by the UNESCO visiting committee for Tropical Herbaria, and will certainly be a matter of great satisfaction to that committee and its parent organization, too.

Of the proposed activities listed, the panel found it difficult to select any to which priorities could be assigned. Because the selection and development of IBP sites necessarily must be done in time for their use by the IBP, this activity should be initiated promptly. The exploration of threatened tropical areas also must be viewed with more than casual urgency, as the areas are likely to be changed and vital information lost. Likewise, the exploration of little-known regions is more than ordinarily urgent, as it may well yield data essential to other aspects of the program.

The panel concluded its report by pointing out that the urgent problems and needs in tropical botany are so great and widespread that they will require the participation and earnest efforts of all institutions with interests or capabilities in this field. It is suggested that the Smithsonian Institution, in addition to such efforts in tropical botany as its present and anticipated staff are able to make, use its prestige and experience to help secure support for the efforts and participation of any other qualified institution that needs such support to engage in the above listed activities in tropical botany.

Ornithology and Mammalogy

moderated by P. S. Humphrey

In certain tropical areas of the world a critical need exists for general collections of birds and mammals to clarify important details of distribution and classification. Some of this work is already under way in relation to epidemiological surveys in Southeast Asia, the lower Amazon, Venezuela, Africa, and elsewhere. For various tropical regions identification manuals for field ecologists and epidemiologists are required to facilitate field work, encourage collections, and promote solutions to taxonomic and zoogeographic problems.

In Panama, largely through the field work of Alexander Wetmore and Charles O. Handley, Jr., the classification of birds and mammals has been nearly completed. Handley's book on the mammals of Panama, which includes keys, chorology, and ecological information, is expected to be published in 1968. Similar works are not available for most countries in the tropics. Wetmore's first volume on the birds of Panama has been published and two more volumes are forthcoming. A field guide as a supplement to Wetmore's important work is needed to facilitate field identification.

In the last decade increased emphasis has been placed on ecological studies of tropical birds and mammals in relation to problems of public health. Most of this interest has concerned birds and mammals as reservoirs for arthropod-borne viruses and other diseases, and as hosts for various ectoparasite vectors of disease. There is a paucity of knowledge concerning population dynamics, reproductive cycles, predator-prey relationships, food chains, and life histories.

A critical shortage of trained mammalogists and ornithologists exists in the tropical areas of the world. Ultimately, basic work in these fields must be undertaken by citizens of the countries involved, not by visiting scientists. Development of scientific manpower resources in tropical countries of the New World can be encouraged through collaborative programs involving the Organization of American States, the Smithsonian Institution, the Organization of Tropical Studies, and various regional educational institutions.

Future ecological surveys in tropical regions should be planned, at least in part, to include site developments, inter-

disciplinary collaboration, reasonable standardization of techniques for collecting field data, improved processing of specimens, and automatic data processing.

Reptiles and Fishes

moderated by J. A. Peters

A world program in tropical biology should be based on the following statements of organization:

1) There should be a continuous, thorough assessment of the composition of the biota of the tropics upon which further accumulation of knowledge must be based.

2) There should be a continuous focus on those problems in biology that are most likely to be solved by carrying on their investigation in the tropics.

3) There should be an increase in the encouragement of the talents of actual and incipient scholars originating in the countries within the tropics, through training grants, scholarships, fellowships, and grants-in-aid for research.

The panel recommended the development and maintenance of natural areas in the tropics to perpetuate and preserve habitats and species. Such reserves would facilitate comparative investigations throughout South and Central America.

Consideration should be given to the establishment of supported chairs in Latin American universities to encourage the development of scholars with the time, opportunity, and finances to carry on research and graduate instruction in tropical biology. The determination of the occupant of the chair should be under complete control of the university concerned, and it was recommended that the occupant be preferably a citizen of that country.

Entomology

moderated by W. D. Duckworth

The enormous diversity of insects is such that entomologists have a severe problem in systematics, thus making it difficult to coordinate with and to collaborate with more diverse and advanced studies in the tropics all over the world. Programs involving specific type-site studies in various ecological habitats of the tropics seem to be the most desirable way to develop cooperative programs. Large numbers of entomologists are already at work in the tropics, many of whom are located in

mission-oriented operations related to health and agriculture, yet the manpower resources in entomology are seriously inadequate for the task ahead. Insufficient effort has been made to identify entomologists, their places of activity, and their research work as a basis for coordinating programs and collecting information into a useful whole for all persons interested in tropical habitats.

With respect to Panama, the panel regarded the program and facilities of the Smithsonian Tropical Research Institute, and the sites available to it, as adequate in meeting requirements for entomological studies in depth in the lowland tropics of Central America. A concentration of effort should be placed where data can be accumulated in an orderly fashion over long periods of time, such as Barro Colorado Island, and where short-range, mission-oriented projects can be introduced as opportunities present themselves.

There is a manpower potential in almost every country in the tropics, and any effort to develop studies in the tropics should be coordinated with local people and local institutions.

Currently, the Smithsonian Institution is cooperating with the U.S. Army in a project on mosquitoes in Southeast Asia. Systematists working in Washington are directly coordinated with a series of biological laboratories in Southeast Asia where ecological studies on mosquitoes and other insects are underway. Similar cooperative arrangements could be established in other tropical areas of the world.

Anthropology

moderated by R. B. Woodbury

Since anthropology is the study of patterned human behavior both in its widest variations and in its central tendencies, and since the living groups of mankind are anthropology's laboratory, therefore every human group is of potential scientific importance as showing particular cultural adaptations to a specific physical and biotic environment.

From the fact of man's worldwide present-day ecological dominance, it follows that the study of tropical biology must take human activities into consideration. This is especially true where man is manipulating the environment by means of major engineering projects. Such projects present to the scientific community great opportunities and

Resolutions

The full text of all resolutions is presented here as a summary of significant conclusions of the Conference. The conferees resolved:

1) That the participants in the Smithsonian Conference on Tropical Biology urge the development of a worldwide tropical biology program, including initially inventories and surveys such as those required in connection with the construction of a sea-level canal and the Bayano Dam.

2) That the Smithsonian Institution, with appropriate advice from a body of recognized scientists from various countries, should:

a) Seek funds immediately for a marine program in the Caribbean and in the Pacific Ocean adjacent to the Isthmus of Panama.

b) Seek funding for worldwide surveys of terrestrial and freshwater environments.

c) Seek funding for intensive ecological studies in the tropics, initially in Panama.

3) That the Smithsonian Institution seek the advice of foundations and Federal granting agencies, such as the National Science Foundation and the National Institutes of Health, in establishing policies governing the distribution of financial support.

4) That administrators of museums and other institutions which maintain systematic collections anticipate the large increases of such collections that will result from any successful tropical biology program, that they accept the responsibility of storing and protecting them adequately, and that they provide space not only for their own staff but for other scientists who need to consult and study these collections.

5) That the Smithsonian Institution consider the establishment of supported chairs of tropical biology at universities in the tropics to encourage the development of scholars with the time, opportunity, and finances to carry on research and graduate instruction in areas of interest to the Smithsonian Institution, the filling of the chairs to be under control of the universities concerned; it is recommended that the chairs be occupied by a citizen of the country in which the university is located as often as possible and practical.

6) That investigators obtaining grants and contracts for research in tropical

heavy responsibilities. Because these projects so greatly accelerate rates of change, they give the opportunity to make extensive baseline studies followed immediately by analysis of subsequent drastic modifications on a scale previously rarely available. Such studies will make fundamental contributions to knowledge, and therefore deserve the application of our best intellectual resources. Observation and analysis of changes, however, are insufficient without accepting the responsibility to apply scientific insights to the task of selecting from alternative courses of action in view of their expectable total impact on the environment in which we live.

Anthropology's role within such interdisciplinary studies is not only to record and analyze the changes that occur but also to assist the responsible agencies in formulating, executing, and evaluating programs for the human occupants of the areas affected. These programs often involve relocation of large numbers of people and their adaptation to new habitats and new socioeconomic patterns. For example, in Africa the Kariba Dam project required the relocation of 50,000 people, the Aswan High Dam project, of over 100,000 people, and the Volta scheme, of some 75,000. In such projects the potential contributions of social science and, indeed, of all the sciences to the immense human problems created have not always been used to full advantage.

In eastern Panama there now exists an opportunity to greatly improve the effective application of anthropological techniques to situations of enforced drastic change. Three engineering programs have been initiated which will drastically alter the lives of nearly 30,000 people of the region. These are, first, the Pan-American Highway, second, the Bayano Dam, and third, the examination of possible routes for a sea-level canal. Rates of cultural change among the local population are increased as soon as surveys for engineering studies begin, and long before actual construction. This area contains two quite separate Indian groups, a large and rapidly growing Negro or mestizo group, and a smaller number of recent white settlers. All of these ethnic segments live in small and widely dispersed communities. Anthropological studies have already been successfully begun as reported at this Conference by Reina Torres de Arauz. The study of the four

cultural groups in this area should serve as a model for such investigations everywhere; thus it should include the collection during baseline and subsequent studies of the following topics for each cultural group and in each major geographic subdivision of the area:

1) Demography and demographic trends.

2) Systems of resource exploitation, both current and past. This would include archeological surveys and studies, nutritional and medical studies, and also the usual land-use analyses.

3) Social and political systems and patterns of leadership and authority.

4) Expectations, attitudes, and value orientations, with special attention to the reactions to past governmental attempts to induce change.

The baseline study along the lines just mentioned must be sufficiently comprehensive to enable those making subsequent studies to understand the nature of the changes occurring in all sectors of the different cultures. Relocation and rapid social change can be expected to increase stress within the societies involved. For example, relocation usually brings major dietary changes and temporarily increased mortality. It widens social contacts with other groups and increases the number of cultural alternatives among which choices must be made.

The very complexity of changes arising from major engineering projects requires a long-term, interdisciplinary approach. The anthropological aspects of these studies can be appropriately incorporated in biological programs, national resource surveys, and other similar projects. The shortage of qualified personnel makes cooperation between national and international agencies essential. It is especially important that every investigation effectively involve educational and research institutions in the host country and that it bear in mind the development goals of the country involved.

Man has been changing the face of the earth from his earliest beginnings, but the immensity and the rapidity of the changes being made at the present provide both an unparalleled opportunity for large-scale research during the course of these changes and a new major responsibility to apply our best scientific insights and understanding to the direction of these changes.

biology and anthropology include, where appropriate, requests for funds to provide advanced training of students to increase the number of qualified scientists concerned with science in the tropics.

7) That collaboration between scientists of the United States and those of host countries include:

a) Joint planning of research programs from their inception.

b) Development of research programs through government scientific bodies as well as directly with research organizations in the host countries.

c) Publication of at least preliminary research results in the host country's scientific journals, in the host country's language, when appropriate and feasible.

d) Deposition of representative data and specimens in host country institutions.

Conclusions

As a result of the Panama Conference on Tropical Biology, the Smithsonian Institution is revising and expanding its Task Force Report as a statement of need, opportunities, and reasons for a world program in the

biology of the tropics, together with suggestions for implementing such a program. This report will be made available to the scientific community, government officials, and other relevant persons.

Although the Smithsonian Institution will design a program that reflects a world outlook for the study of tropical ecosystems, the results of the Panama Conference clearly indicate the priority that should be given to the Central American tropics because of the unique research opportunity offered by the planned construction of the sea-level canal. There is a high probability that the knowledge acquired from a tropical biology program will buttress the pre-canal surveys currently underway by the U.S. Army Corps of Engineers which are focused on the engineering feasibility, including from the biological point of view studies relevant to radiological safety in the event that nuclear explosions are used to excavate the canal. Under present world conditions of exploding human populations and the limitations of the resources that support them, it is essential that proposed environmental manipulations as significant as the proposed Atlantic-Pacific

sea-level canal be based on a comprehensive background of fundamental information.

It is clear that major sums of money can be made available for imaginative programs of scientific investigation if prestige in international circles is involved—witness the vast and well-funded programs in the Antarctic and space research. Great sums are also provided where major economic benefits are promised—witness the attention being given to oceanography. The profound importance of tropical regions and the biological studies necessary to understand them may actually be more critical than the Antarctic, space, and oceanography with respect to our future tenure as dominant inhabitants of the earth. Unfortunately, most of the required work is outside the experience of most of those in control of large dis-bursable funds. Biologists, at least, should have no difficulty in grasping the urgency of making an effort comparable with the big programs mentioned above. It is hoped that their influence in favor of adequate financial resources for tropical biology will be felt strongly at the levels where decisions are made.