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ECOLOGICAL RESEARCH AND SURVEYS

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HEARING
BEFORE THE
COMMITTEE ON
INTERIOR AND INSULAR AFFAIRS
UNITED STATES SENATE
EIGHTY-NINTH CONGRESS

SECOND SESSION

ON

S. 2282

A BILL TO AUTHORIZE THE SECRETARY OF THE INTERIOR TO CONDUCT A PROGRAM OF RESEARCH, STUDY AND SURVEYS, DOCUMENTATION, AND DESCRIPTION OF THE NATURAL ENVIRONMENTAL SYSTEMS OF THE UNITED STATES FOR THE PURPOSE OF UNDERSTANDING AND EVALUATING THE CONDITION OF THESE SYSTEMS AND TO PROVIDE INFORMATION TO THOSE CONCERNED WITH NATURAL RESOURCES MANAGEMENT, AND FOR OTHER PURPOSES

APRIL 27, 1966



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CONTENTS

	Page
S. 2282-----	2
Departmental reports:	
Agriculture-----	6
Bureau of the Budget-----	9
Interior-----	4
National Science Foundation-----	8
Smithsonian Institution-----	7

STATEMENTS

Alderson, George, Washington, D.C.-----	145
Auerbach, Stanley I., Ecological Society of America-----	138
Ayres, Dr. Robert U., the Hudson Institute, Harmon-on-Hudson, N.Y.-----	105
Bayh, Hon. Birch, a U.S. Senator from the State of Indiana-----	10
Bennett, Hon. Charles E., a U.S. Representative in Congress from the State of Florida-----	12
Bormann, Dr. F. H., professor, Dartmouth College, Hanover, N.H.-----	72
Cain, Stanley A., Assistant Secretary for Fish and Wildlife, Department of the Interior-----	13
Calhoun, Dr. John C., Jr., vice chancellor, Texas A. & M., College Station, Tex-----	48
Cantlon, Dr. John E., Program Director, Environmental Biology, National Science Foundation-----	37
Clement, Dr. Roland C., New York staff biologist for the Audubon Society-----	56
Cole, Dr. Lamont, Cornell University-----	63
Darnell, Dr. Rezneat M., Marquette University, Milwaukee, Wis-----	81
Defenders of Wildlife, Washington, D.C.-----	143
Ecological Society of America-----	135
Fosberg, Dr. F. Raymond, special adviser to the Smithsonian-----	95
Galler, Dr. Sidney, Assistant Secretary for Science, Smithsonian Institution-----	32
Goodwin, Dr. Richard, president, the Nature Conservancy, Washington, D.C.-----	54
Ketchum, Dr. Bostwick H., president, Ecological Society of America, and associate director, Woods Hole Oceanographic Institution-----	41
MacLeod, Dr. Colin M., Deputy Director, Office of Science and Technology-----	28
Netting, Dr. M. Graham, director, Carnegie Museum, Pittsburgh, Pa.-----	76
Nickerson, Eugene H., Nassau County executive-----	140
Norris, Dr. Kenneth, chairman, Natural Land and Water Reserves System, UCLA-----	60
Pough, Richard H., president, Natural Area Council-----	46
Revelle, Prof. Roger, chairman, U.S. National Academy of Sciences Committee for the International Biological Program-----	142
Ripley, Dr. Dillon, Secretary, Smithsonian Institution-----	33
Ross, Dr. Philip, Potomac, Md-----	103
Siehl, Dr. George, on behalf of the National Parks Association-----	101
Sill, Dr. Richard C., on behalf of the Wilderness Society-----	118
Smith, Dr. Spencer M., secretary, Citizens Committee on Natural Resources-----	53
Train, Russell E., president, Conservation Foundation-----	57
Udall, Hon. Stewart L., Secretary of the Interior-----	10
Whittaker, Dr. Robert, Brookhaven National Laboratory, Upton, Long Island, N.Y.-----	69
Zimmerman, William, Jr., Washington representative of the Sierra Club-----	53

COMMUNICATIONS

Alexander, Donald B., executive secretary, National Conference on State Parks: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 26, 1966.....	Page 150
Brainerd, Dr. John W., the American Nature Study Society: Letter to the Chairman, Interior and Insular Affairs Committee.....	150
Calder, William A., Duke University: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 25, 1966.....	159
Caldwell, Lynton K., professor of government, Indiana University: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 23, 1966.....	154
Dennis, Robert T., assistant conservation director, IWLA: Letter to Hon. Henry M. Jackson, chairman Interior and Insular Affairs Committee, dated April 28, 1966.....	149
Douglas, Philip A., executive secretary, Sport Fishing Institute: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated July 15, 1966.....	148
Dustin, Thomas E., president, Indiana Division, IWLA: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 2, 1966.....	149
Force, Roland W., director, Bernice P. Bishop Museum: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 25, 1966.....	155
Gates, David M., director, Missouri Botanical Garden: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 25, 1966.....	155
Kimball, Thomas L. executive director, National Wildlife Federation: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 22, 1966.....	147
Klotz, John W., president, ACREs, Inc.: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 26, 1966.....	160
Kormondy, Edward J., associate professor of biology, Oberlin College: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated September 8, 1965.....	154
Kruckeberg, Arthur R., professor, Department of Biology, University of Washington: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 7, 1966.....	153
Lamson, Dr. Robert W., Washington, D.C.: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated July 1, 1966.....	156
LaZelle, Mason, general manager, Matanuska Electric Association, Inc.: Letter to Hon. Ernest Gruening, U.S. Senate, dated May 2, 1966.....	152
McCloskey, Michael, conservation director, the Sierra Club: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated December 29, 1965.....	151
McKeon, Louise H., the Garden Club of America: Letter to the Interior and Insular Affairs Committee dated April 20, 1966.....	151
Mueller-Dombois, Dieter, assistant professor of botany, University of Hawaii: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated May 4, 1966.....	155
Norwood, Gus, executive secretary, Northwest Public Power Association: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 18, 1966.....	145
Rouse, James W., Community Research & Development, Inc.: Letter to Hon. Gaylord Nelson, U.S. Senate, dated April 26, 1966.....	151
Schaal, Herbert R., Megatech, Inc.: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated June 10, 1966.....	160
Tanton, John H., M.D., Burns Clinic, Potoskey, Mich: Letter to Hon. Philip A. Hart, U.S. Senate, dated March 28, 1966.....	153
The Planters, Tacoma, Wash.: Telegram to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 27, 1966.....	160
Woke, Paul A., Bethesda, Md.: Letter to Hon. Henry M. Jackson, chairman, Interior and Insular Affairs Committee, dated April 22, 1966.....	159

ECOLOGICAL RESEARCH AND SURVEYS

WEDNESDAY, APRIL 27, 1966

U.S. SENATE,
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C.

The committee met, pursuant to call, at 10 a.m., in room 3110, New Senate Office Building, Senator Gaylord Nelson (acting chairman of the committee) presiding.

Present: Senators Gaylord Nelson (Wisconsin), Clinton P. Anderson (New Mexico), and Len B. Jordan (Idaho).

Also present: Jerry T. Verkler, staff director; Porter Ward, professional staff member; and E. Lewis Reid, minority counsel.

Senator NELSON. The committee will come to order.

The purpose of the hearing this morning is to consider S. 2282, the ecological research and surveys bill, to authorize the Secretary of the Interior to conduct a program of research, study and surveys, documentation, and description of the natural environmental systems of the United States for the purpose of understanding and evaluating the condition of these systems and to provide information to those concerned with natural resources management, and for other purposes.

It is a very great pleasure to be here today to conduct a hearing on this important bill.

We are all passengers on a rather small spaceship wheeling about the sun and hurtling through space. This observation has been made by poets for some time. However, it is only recently that we have come to realize how very limited are the resources available to us on this planet.

The grave dangers of overpopulation and environmental pollution have driven home to us the need for the most careful and watchful planning in the use of our natural resources.

Americans have generally taken an exploitative view of their environment. Our early experience as a small nation of colonists on the edge of an immense wilderness encouraged such an attitude. But now it is absolutely crucial that we change. We must extend to all our resources—water, land, and air—the conservation concepts that have in the past been limited largely to securing and saving a few bits of wilderness and spectacular natural scenery.

The purpose of this hearing is to take expert testimony from this impressive group of witnesses from all over the Nation on the state of ecological knowledge and to gather ideas on this bill and how it might be improved.

In summary the bill would authorize the Secretary of Interior to—
Conduct studies of natural environmental systems in the United States and to make grants and contracts for such studies to be

made by universities, museums, botanical gardens, and qualified individuals.

Establish a clearinghouse for information on ecological problems and studies, a center for information for those making land use and resource use decisions. For this purpose the Secretary would gather information about ecological activities from other Government agencies as well as from private sources.

Establish a program in which representative natural environments on Federal lands could be set aside for scientific study—and assist and encourage the setting up of similar preserves on State and private lands.

Participate with other governments and international bodies in environmental research.

There is a considerable amount of ecological research now being carried out by agencies of the Federal Government—about \$90 million a year, I understand. Let me emphasize that it is not the purpose of the bill to have the Interior Department encroaching on this work in any way. Nearly all of the work currently being undertaken is mission oriented as opposed to basic ecological research. The research program contemplated in this bill would be designed to focus on those areas of ignorance regarding basic processes that make wise resource use decisionmaking so difficult.

The bill provides for the establishment of advisory committees (see section 7) whose role it would be to help define those areas for research.

Again let me say that any thoughts or suggestions for improving the bill will be most welcome and will receive careful consideration by the committee.

The bill and the agency reports will be included at this point.

(The data referred to follow:)

[S. 2282, 89th Cong., 1st sess.]

A BILL To authorize the Secretary of the Interior to conduct a program of research, study and surveys, documentation, and description of the natural environmental systems of the United States for the purpose of understanding and evaluating the condition of these systems and to provide information to those concerned with natural resources management, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Congress finds and declares that as a result of population pressures, the development of transportation systems, agricultural practices, numerous natural resource developments, and other technological advances, the status of native plant and animal systems and their natural environment in the United States has changed markedly; that serious losses in valuable species of fauna and flora and gains in unwanted species have occurred and continue to occur; that valuable elements of natural communities have disappeared or have become so restricted in area and numbers that they may never recover; that many areas of outstanding interest, scientific value and scenic beauty have been protected but through lack of knowledge and inadequate management practices their value has been lost or has waned; that, in fact, this storm of modern change, in blighting and destroying what has been cherished for generations in this country, is degrading man's environment and threatens his very existence; that it is desirable that studies be conducted to describe, understand, and evaluate these natural and man-caused changes or trends in our natural environmental systems and to provide the information to the public or private agencies, or persons responsible for planning and developing our future resource projects. It is, therefore, the purpose of this Act to authorize a comprehensive program of research, studies, and surveys in order to produce an understanding of our natural resources and the environmental forces responsible for their development and well-being and to provide a basis

for the future protection, enhancement, and proper utilization of the natural environmental systems of the United States. It is not the purpose of this Act to encroach upon or otherwise restrict authorized Federal programs in the fields of agronomy, forest and range management, public health, flood control, wildlife management, or soil conservation other than as an advisory or coordinating activity.

SEC. 2. The Secretary of the Interior (hereinafter referred to as the "Secretary"), in order to carry out the purposes of this Act, is authorized—

(1) to conduct investigations, studies, surveys, research, and analyses;

(2) to document and define changes in the natural environment, including the plant and animal systems, and to accumulate necessary data and other information for a continuing analysis of these changes or trends and an interpretation of their underlying causes;

(3) to develop and maintain an inventory of natural resource development projects, engineering works, and other major projects such as, but not limited to, eradication projects contemplated or planned by public or private agencies or organizations which may make significant modifications in the natural environment;

(4) to establish a system of collecting and receiving information and data on ecological research and evaluations which are in progress or are planned by other public or private agencies or organizations, or individuals;

(5) to evaluate and disseminate information of an ecological nature to public and private agencies or organizations, or individuals in the form of reports, publications, atlases, and maps;

(6) to initiate and utilize ecological information in the planning and development of resources oriented projects;

(7) to encourage other public or private agencies planning development projects to consult with the Secretary on the impact of the proposed projects on the natural environment;

(8) to encourage and assist public (non-Federal) or private agencies or organizations, including educational institutions, museums, and botanical and zoological gardens and other scientific or conservation organizations, or individuals to acquire, designate, and maintain representative samples of important natural environmental systems, including natural areas for observation and for manipulation, and to encourage such agencies, organizations, and individuals to utilize existing areas under their control or jurisdiction for such purposes; and

(9) to establish through interagency coordination, on federally owned lands, a Federal system of natural areas for scientific purposes and develop the means and methods for withdrawal of such areas from nonconforming uses, and provide for their management and protection to serve the natural research needs of all agencies, both public and private.

SEC. 3. The Secretary is further authorized for the purposes of this Act (1) to make grants and enter into contracts or cooperative agreements with public or private agencies or organizations, or individuals, (2) to accept and use donations of funds, property, personal services, or facilities, (3) to acquire selected areas of lands or interests in lands by donation, acquisition with donated funds, devise, or exchange for acquired lands or public lands under his jurisdiction which he finds suitable for disposition, (4) to administer such lands or interests for experimental purposes, including the observation and manipulation of natural areas, and (5) to issue such regulations as he deems necessary with respect to the administration of such lands.

SEC. 4. Activities authorized by this Act may be carried out on lands under the jurisdiction or control of other departments or agencies of the Government only with the approval of the head of the department or agency concerned.

SEC. 5. The Secretary shall consult with and provide technical assistance to departments and agencies of the Government, and he is authorized to obtain from such departments and agencies such information, data, reports, advice, and assistance as he deems necessary or appropriate and which can reasonably be furnished by such departments and agencies in carrying out the purposes of this Act. Any Federal agency furnishing advice or assistance hereunder may expend its own funds for such purposes, with or without reimbursement by the Secretary.

SEC. 6. Nothing in this Act is intended to give, or shall be construed as giving, the Secretary any authority over any of the authorized programs of any other

department or agency of the Government, or as repealing, modifying, restricting, or amending existing authorities or responsibilities that any department or agency may have with respect to the natural environment. The Secretary shall consult with the heads of such departments and agencies for the purpose of identifying and eliminating duplication of effort.

SEC. 7. (a) The Secretary is authorized to establish such advisory committees as he deems desirable for the purpose of rendering advice and submitting recommendations to him relating to the carrying out of the purposes of this Act. Such advisory committees shall render advice and submit recommendations to the Secretary upon his request and may submit recommendations to the Secretary at any time on their own initiative. The Secretary may designate employees of the Department of the Interior to serve as secretaries to the committees.

(b) Members of advisory committees appointed by the Secretary may receive not to exceed \$100 per day when engaged in the actual performance of their duties, in addition to reimbursement for travel, subsistence, and other necessary expenses incurred by them in the performance of their duties.

SEC. 8. The Secretary is authorized, pursuant to such terms and conditions as he deems desirable, to make grants to public and nonprofit private universities and colleges, as well as to museums and botanical and zoological gardens and other scientific or conservation organizations in the several States and possessions of the United States, for the purpose of training persons, including scientists, technicians, and teachers, needed in the field of ecology and related fields.

SEC. 9. The Secretary is authorized to participate in environmental research in surrounding oceans and in other countries in cooperation with appropriate departments or agencies of such countries or with coordinating international organizations if he determines that such activities will contribute to the objectives and purposes of this Act.

SEC. 10. There are authorized to be appropriated such sums as may be necessary to carry out the provisions of this Act.

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., April 26, 1966.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

DEAR SENATOR JACKSON: Your Committee has requested this Department's report on S. 2282, a bill "To authorize the Secretary of the Interior to conduct a program of research, study and surveys, documentation, and description of the natural environmental systems of the United States for the purpose of understanding and evaluating the condition of these systems and to provide information to those concerned with natural resources management, and for other purposes."

S. 2282 gives to the Secretary of the Interior broad authority to initiate and carry out a comprehensive program of research, documentation, and description on the natural environmental systems of the United States for the purpose of gaining a better understanding of our living natural resources and the forces responsible for their development and well-being and of providing a basis for the future use and development of these systems. In carrying out this program, the Secretary may, among other things, (1) establish a system of collecting and receiving information on ecological research and evaluation from various public or private agencies, organizations, or individuals, (2) evaluate this data and information and disseminate it as widely as possible, (3) initiate and use ecological information in the planning and development of natural resource projects, (4) encourage others to consult with him on the potential impact of proposed projects on the natural environment, (5) establish a Federal system of natural areas for scientific purposes on federally-owned lands, (6) make research and training grants, (7) accept and use donated real and personal property and funds, (8) establish advisory committees, and (9) participate in environmental research in the oceans and foreign countries.

The President in his Natural Beauty message of February 8, 1965, said:

"I have also asked the Director of the Office of Science and Technology and the Director of the Bureau of the Budget to recommend the best way in which the Federal Government may direct efforts toward advancing our scientific

understanding of natural plant and animal communities and their interaction with man and his activities."

While this Department wholeheartedly supports the objectives of S. 2282, we believe that further consideration of this legislation should be deferred until after these recommendations are made. We understand that they will be made before the close of this session of Congress.

This Department now conducts many research programs in the environmental sciences. Most of these, however, are oriented toward pressing management programs. The basic research authorized by this bill is directed toward fundamental questions about our natural environment. It would enable this Department to provide a focus in the Federal Government for ecological matters. In particular, it offers a mechanism for assuring systematic coverage of those aspects of the total living environment that are not now covered, or are not adequately covered by existing mission-oriented programs within the Department of the Interior and other Federal agencies.

Ecology: the scientific study of the dynamic interrelations of living organisms with each other and with their immediate physical and chemical environment—has lacked organized and relatively intensive attention that other environmental sciences have received in the Federal Government. Intensified ecological research of the kind provided in this bill would be able to draw on the striking advances that have been taking place in such physical environmental fields as meteorology, physical oceanography, geology, hydrology, and soil science. It would also be able to supply an essential body of information for further research and application in fields involving environmental manipulation, such as agriculture, public health, natural resources management, transportation and urban development.

The program would promote the identification, maintenance, and intensive study of representative natural areas now relatively unaltered by human activities. Deeper understanding of the structure and dynamics of undisturbed plant and animal communities would be sought. With study of the response of such communities to human activities, through controlled experiment and systematic comparison with modified communities, valuable insights could be gained into the ways in which natural processes are altered and how they may be directed so as to maximize desirable effects and minimize undesirable ones. In addition, a special effort could be launched to obtain necessary basic data from natural plant and animal communities to serve as "baseline" or "control" standards against which the effects of human actions, whether beneficial or detrimental, may be compared and evaluated.

The primary research emphasis contemplated by the bill would be upon gaining basic knowledge of ecosystems that are maintained or used without extensive alteration and how they are modified by human activities, often as a result of actions to achieve other purposes. Applied studies in such fields as agronomy, wildlife and fisheries management, economic entomology, forest and range management, disease vector control, and soil conservation represent a different research emphasis and would be excluded from the program.

A major purpose of the bill is to develop and improve a capability for furnishing to public and private agencies, upon request, advice on the probable ecological consequences of proposed large-scale construction projects, resources management activities, or other environment alterations that are of sufficient magnitude to affect the living environment significantly. Most of man's activities, of course, have some effects on communities of plants and animals. Some of these effects are beneficial, some are detrimental. Some detrimental effects can be avoided, some cannot; some can be mitigated, some cannot. Unfortunately, detrimental effects are often apparent only after a project or program is underway, or, perhaps even completed. For this reason we need to develop a sharpened capacity for ecological foresight by which changes induced by human activities may be anticipated, evaluated in advance, and dealt with rationally.

We are in an era of change and complexity. Through technological advance we are continually gaining new powers to alter our environment for better or for worse. At the same time, we are developing a deeper awareness of the importance of maintaining attractive and healthful surroundings if we are truly to enjoy full human existence. To realize the benefits of modern civilization without simultaneously eroding the fundamental physical and biological bases for our tenure on earth is a problem whose complexities we can now only dimly perceive.

We in the Department of the Interior believe that a program of ecological research would be of material assistance in advancing our Nation's efforts in the

challenging task of reversing the trend of deterioration of our environment, and in elucidating scientifically the conditions on which successful and satisfying human existence on this earth must be predicated. The recommendations requested in the President's Natural Beauty message should suggest the best way to accomplish this objective.

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

Sincerely yours,

STEWART L. UDALL,
Secretary of the Interior.

DEPARTMENT OF AGRICULTURE,
Washington, D.C., April 27, 1966.

HON. HENRY M. JACKSON,
*Chairman, Committee on Interior and Insular Affairs,
U.S. Senate.*

DEAR MR. CHAIRMAN: We wish to thank you for your letter of August 4, 1965, giving us the opportunity to report on S. 2282. The bill is entitled "To authorize the Secretary of the Interior to conduct a program of research, study and surveys, documentation, and description of the natural environmental systems of the United States for the purpose of understanding and evaluating the condition of these systems and to provide information to those concerned with natural resources management, and for other purposes."

The bill would authorize a comprehensive program of research and study to describe, understand, and evaluate the natural and man-caused changes or trends in our natural environmental systems. In order to carry out these provisions, the Secretary of the Interior would be authorized (1) to conduct investigations, studies, surveys, research, and analyses; (2) to document and define changes in the natural environment, including the plant and animal systems, and to accumulate necessary data and other information for a continuing analysis of these changes or trends and an interpretation of their underlying causes; (3) to develop an inventory of natural resource development projects, engineering works, and other major projects such as, but not limited to, eradication projects contemplated or planned by public or private agencies or organizations which may make significant modifications in the natural environment; (4) to establish a system of collecting and receiving information and data on ecological research and evaluations which are in progress or are planned by other public or private agencies or organizations, or individuals; (5) to evaluate and disseminate information of an ecological nature to public and private agencies or organizations, or individuals in the form of reports, publications, atlases, and maps; (6) to initiate and utilize ecological information in the planning and development of resource oriented projects; (7) to encourage other public or private agencies planning development projects to consult with the Secretary on the impact of the proposed projects on the natural environment; (8) to encourage and assist public or private organizations, including educational institutions, museums, and botanical and zoological gardens and other scientific or conservation organizations to acquire, designate, and maintain representative samples of important natural environmental systems and to encourage such agencies and organizations to utilize existing areas under their control or jurisdiction for such purposes; and (9) to establish through interagency coordination, on federally owned lands, a Federal system of natural areas for scientific purposes, and develop the means and methods for withdrawal of such areas from nonconforming uses, and provide for their management and protection to serve the natural research needs of all agencies, both public and private. In addition, the Secretary of the Interior shall consult with and provide technical assistance to Federal agencies and obtain from them whatever information, data, reports, advice, and assistance are needed and can reasonably be furnished in carrying out the purposes of the bill. Any Federal agency furnishing advice or assistance hereunder may expend its own funds for such purposes, with or without reimbursement. The Secretary would be authorized to make grants to public and nonprofit private universities and colleges in the several States and possessions of the United States for the purpose of training persons, including scientists, technicians, and teachers, needed in the field of ecology and related fields.

While this Department agrees that there is a need for further and continuing research into the national environmental systems of the United States, we believe

that study and research under the broad scope of S. 2282 might, to a large extent, overlap and unnecessarily duplicate and complicate activities now carried out by this Department.

This Department has many programs in research on soil and water conservation and forestry that deal with the problems discussed in the bill, the research program of the Forest Service presently includes studies of the natural environmental factors affecting most of our renewable natural resources, including forests, forested and related range lands, wildlife habitat, recreation, and water conservation and watershed management. Such research embraces all aspects of the ecology of most of the organisms that make up or effect the whole or any part of these resources. Study of related sociologic and economic factors are also a part of this research. The research activities of the Agricultural Research Service also involve ecology and our natural environmental systems. The Soil Conservation Service has the national leadership for the National Cooperative Soil Survey which is actively engaged in classifying and mapping the soils of the United States. The soil survey reports include interpretations of the basic soils information for all suitable uses of the land including natural vegetation and wildlife. Broader ecological studies could overlap or duplicate this effort.

Section 2(3) of the bill would authorize the Secretary of the Interior to develop and maintain an inventory of both public and private projects which may make significant modification in the natural environment. Adequate inventory records are now kept by many agencies. The inventory proposed by S. 2282 might duplicate these records. It would appear to require the establishment of an extensive new records and reporting system covering numerous public and private activities, large and small. Concomitantly, such a program would appear to require a large organization to assemble, analyze, clarify, and record the inventory information. Furthermore, so many known and unknown activities or related factors make, or may make, significant modifications in natural environment systems that definitions and criteria for inventory subjects would be a task of major proportions in itself.

The research organization and programs of this Department extend to both public (Federal, State, and local) and private lands. We cooperate actively with other public and private research organizations, including the schools and universities of our Nation. The results of our research program, and the benefits therefrom, are disseminated or available to and used by both public and private land owners in the management of their natural resources. Research of natural environmental systems as S. 2282 would authorize does not appear to lend itself to area limitations such as National Forests, National Parks, or other political or administrative jurisdictions.

We believe that the program proposed in S. 2282 could result in unnecessary duplication of public research activities.

Unnecessary duplication should be avoided. In part in recognition of this problem the President, in the natural beauty message of February 8, 1965, asked the Director of the Office of Science and Technology and the Director of the Bureau of the Budget "to recommend the best way in which the Federal Government may direct efforts toward advancing our scientific understanding of natural plant and animal communities and their interaction with man and his activities."

Therefore, while we offer the above comments for the consideration of the Committee, we believe it would be best to defer further action on S. 2282 pending completion of an OST-BOB study which is under way pursuant to the President's directive. The recommendations made as a result of that study should offer the best way to accomplish the objectives of improving and expanding our understanding of ecological problems.

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 yours,

ORVILLE L. FREEMAN, *Secretary.*

SMITHSONIAN INSTITUTION,
Washington, D.C., April 26, 1966.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs, U. S. Senate, Washington, D.C.

DEAR SENATOR JACKSON: Thank you for your requests for the views of the Smithsonian Institution on S. 2282, a bill "To authorize the Secretary of the Interior to conduct a program of research, study and surveys, documentation, and

description of the natural environmental systems of the United States for the purpose of understanding and evaluating the condition of these systems and to provide information to those concerned with natural resources management, and for other purposes."

This legislation would authorize the Secretary of the Interior to conduct a program of research into our natural environmental systems. In brief, it would authorize the Secretary to (1) conduct studies of natural environmental systems in the United States and to make grants and contracts for such studies to be made by universities, museums, botanical gardens, and qualified individuals; (2) establish a clearinghouse for information on ecological problems and studies and to disseminate information about progress in the field; (3) establish a program in which representative natural environments on Federal lands could be set aside for scientific study, and to assist and encourage the setting up of similar preserves on State and private lands; and (4) participate with other governments and international bodies in environmental research.

The Smithsonian Institution favors the objectives of S. 2282 and would be pleased to send a representative to testify at your Committee's hearings on this legislation.

This legislation is concerned with a program that is vital to the future of the United States. Throughout the history of the world, various nations have risen and fallen in accordance with overexploitation and deterioration of their resource bases. If we are to avoid the same pitfall, we must provide a scientific foundation for conservation, development and effective use of our forests, grasslands, watersheds, and animal resources. The ecological knowledge we gain may be useful also in improving the practices of nations we rely on for essential raw materials, experimental organisms, and field research opportunities. This bill comes at a crucial time in our history when we still have the potential resources to support a vigorous nation. A marked expansion in the Nation's ecological research is considered to be essential to our economic survival and international leadership.

The President, in the Natural Beauty Message of February 8, 1965, asked the Director of the Office of Science and Technology and the Director of the Bureau of the Budget "to recommend the best way in which the Federal Government may direct efforts toward advancing our scientific understanding of natural plant and animal communities and their interaction with man and his activities."

While we offer the above comments for the consideration of the Committee, we believe it would be best to defer further action on S. 2282, pending completion of an OST-BOB study which is under way pursuant to the President's directive. The recommendations made as a result of that study should offer the best way to accomplish the objectives of improving and expanding our ecological programs.

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 yours,

S. DILLON RIPLEY, *Secretary.*

NATIONAL SCIENCE FOUNDATION,
OFFICE OF THE DIRECTOR,
Washington, D.C., April 27, 1966.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: This is in further reply to your request for the views of the National Science Foundation on S. 2282, a Bill "To authorize the Secretary of the Interior to conduct a program of research, study and surveys, documentation, and description of the natural environmental systems of the United States for the purpose of understanding and evaluating the condition of these systems and to provide information to those concerned with natural resources management, and for other purposes."

It is, of course, highly important that the deterioration in our environment be recognized and that research information be developed which can be utilized to help minimize such deterioration. S. 2282 is couched in such general terms, however, that it is difficult to determine the exact means being proposed under the Bill to achieve these objectives. Moreover, it should be recognized that there

are various Federal programs in existence whose activities are concerned with the natural environment and which should be continued. We, therefore, believe that Section 2 of the Bill needs to be clarified with respect to the activities which would be authorized.

In addition, we question the desirability of Section 8, which would authorize grants to universities and colleges for the training of persons needed in the field of ecology. In our view, there is already a sufficient number of fellowship, training grant and other similar programs covering the various scientific fields. In any event, we consider it undesirable to orient one such program to a particular field of science.

The President, in the Natural Beauty Message of February 8, 1965, asked the Director of the Office of Science and Technology and the Director of the Bureau of the Budget "to recommend the best way in which the Federal Government may direct efforts toward advancing our scientific understanding of natural plant and animal communities and their interaction with man and his activities."

While we offer the above comments for the consideration of the Committee, we believe it would be best to defer further action on S. 2282 pending completion of an Office of Science and Technology-Bureau of the Budget study which is underway pursuant to the President's Directive. The recommendations made as a result of that study should be of major assistance in arriving at the best way to accomplish the objectives of improving and expanding our understanding of ecological problems.

The Bureau of the Budget has advised us it has no objection to the submission of this report from the standpoint of the Administration's program.

Sincerely yours,

LELAND J. HAWORTH, *Director.*

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D.C., April 26, 1966.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: This is in reply to your request of August 4, 1965, for the views of the Bureau of the Budget on S. 2282, "To authorize the Secretary of the Interior to conduct a program of research, study and surveys, documentation, and description of the natural environmental systems of the United States for the purpose of understanding and evaluating the condition of these systems and to provide information to those concerned with natural resources management, and for other purposes."

In his Natural Beauty message of February 8, 1965, the President asked the Director of the Office of Science and Technology and the Director of the Bureau of the Budget "to recommend the best way in which the Federal Government may direct efforts toward advancing our scientific understanding of natural plant and animal communities and their interaction with man and his activities."

In order to develop such recommendations, the Office of Science and Technology and the Bureau of the Budget have engaged in a study with the aid of the affected Federal agencies. A major step in this study has been to identify relevant ecological activities now being conducted by Federal agencies and to determine the adequacy of existing statutory authority for the conduct by appropriate agencies of needed efforts in this area. With the help of the Federal agencies that have supplied information on existing programs together with their evaluations of the adequacy of current statutory authority relative to their own agencies' activities, this portion of the study is essentially complete.

Using this information as a base, OST and BOB staff are completing a draft study report which includes proposed recommendations as requested by the President. We expect to circulate copies of the draft to the agencies for their comments and recommendations shortly.

After receipt of the agency comments and following whatever adjustments may be necessary in the report, a final report, with recommendations, will be prepared. Every effort will be made to complete the report before the end of the current session of Congress.

The results of the study should prove useful to the executive agencies and the Congress in considering appropriate steps to deal more effectively with the

challenging problems of ecology. Accordingly, we strongly recommend that further consideration of S. 2282 be deferred until the report has been completed and its recommendations considered by the President.

Sincerely yours,

WILFRED H. ROMMEL,
Acting Assistant Director for Legislative Reference.

Senator NELSON. We have now the Secretary of the Interior, who has some immediate commitments elsewhere.

Secretary Udall, would you like to comment?

**STATEMENT OF HON. STEWART L. UDALL, SECRETARY OF THE
DEPARTMENT OF THE INTERIOR**

Secretary UDALL. Mr. Chairman, I do not have a prepared statement. Secretary Cain, who is with me, does have and he will testify in detail with regard to the Department's position on this legislation. I am keenly interested in the legislation, however, and I wanted to make a brief statement indicating my own views with regard to it.

There is one thing I think has come through very plainly in recent months. The complexity of modern conservation problems has become more and more clear to all of us, and it is the interrelationship of all resources that is increasingly important in understanding them.

Therefore, the development of what we might properly call the ecological approach, I think, is more and more vital in terms of mastering these new conservation problems. This is the reason I hope we can perfect legislation that is similar to this and enact it. Ecology is a word that I think was largely familiar only to the members of the scientific community a few years ago. It has now become a rather common word. I hope it becomes more common because of its importance to those of us who are not scientists. This is, as I regard it, the science of the web of life and of its interrelationship to the whole of resource or to all of our resources.

Therefore, I think that the legislation the chairman has proposed and the discussion which will take place here with regard to formulating legislation are very timely and I simply want to indicate my own applause generally for the interest that has been aroused in this type of legislation.

Senator NELSON. Thank you, Mr. Secretary.

Do you have any questions?

Senator JORDAN. No questions.

Senator NELSON. Thank you.

Senator Birch Bayh of Indiana has a statement for the record.

**STATEMENT OF SENATOR BIRCH BAYH, A U.S. SENATOR FROM THE
STATE OF INDIANA**

Senator BAYH. Mr. Chairman, it is a pleasure for me to support S. 2282, Senator Nelson's ecological research and survey bill. The general purpose of this measure is to authorize a comprehensive program of research, studies, and surveys of our natural resources and environment. Its goal is the development of a basis for the future protection, enhancement, and proper utilization of the natural environmental systems of the Nation.

It is my understanding that S. 2282 represents the first comprehensive, nationwide approach to analyzing the problem of the interdependence of our natural environment. To accomplish this it would authorize the Secretary of Interior to take the following actions: conduct investigations of natural environmental systems in the United States; make grants and contracts for such studies; establish a clearing-house for information on ecological problems; disseminate information about progress in the field; establish a program in which representative natural environments on Federal lands could be set aside for scientific study; assist and encourage the setting up of similar preserves on State and private lands; and participate with other governments and international bodies in environmental research.

Mr. Chairman, this bill is greatly needed. It promises to fill a significant gap in knowledge about our total community. Only partial studies of the problems of our natural environment have been available. We have failed frequently to consider how the pollution of one river affects the balance of life on others with which it is connected. We have failed to explore the effects of air pollution in a small area in the surrounding territory.

As Senator Nelson pointed out when S. 2282 was introduced, the rapid development of civilization has brought about a widespread abuse and destruction of natural environmental balances. The effects of this are not well understood and their implications for the future are unknown. It is essential that we gain a basic understanding of the interrelationship of the natural community and the changes that have occurred and are occurring as a result of our agricultural practices, resource exploitation, and technological advances.

Although man-made communities grow larger and more remote from the world of nature every day, that very growth has profound consequence upon nature itself. The air and water pollution of many cities and industrial communities greatly affect the natural balance of animal and plant life throughout the country. As civilization has "advanced," man has many times been a destroyer and a polluter, upsetting the natural balances of nature.

This need not be so. An adequate comprehension of ecological principles and basic knowledge of the present situation would enable man to utilize the many natural resources of this country with little impairment or without depriving future citizens of their enjoyment.

In the past whole populations of animals and birds have been slaughtered for their food, fur, or feathers. Grasslands have been ruined, forests completely cut down. Besides direct devastation of much of our natural vegetation and wildlife, we have wrought even greater harm by causing serious pollution of lakes, rivers, and harbors, and by irreparable damage to the soil and loss of ground water reserves.

The sad story of Man's destruction of his natural environment throughout the world has been effectively told. The application of an intelligent understanding of our natural communities is necessary to help avoid these mistakes. Man is inescapably a part of his environment. With intelligence he may help guard against the development of danger spots, but without intelligence man accelerates destruction.

In conclusion, Mr. Chairman, it seems to me that this bill is worthy of serious consideration by the committee and that its basic features should be reported favorably to the Senate.

Senator NELSON. I have a statement from Congressman Bennett of Florida who has introduced a companion bill in the House. His statement will be included in the record at this point.

(The statement referred to follows:)

STATEMENT OF HON. CHARLES E. BENNETT, A U.S. REPRESENTATIVE IN CONGRESS
FROM THE STATE OF FLORIDA

Mr. Chairman, I appreciate the opportunity to present a statement to your Committee, considering legislation to authorize the Secretary of the Interior to conduct a survey of our natural environment which will lead to a more beautiful and enjoyable place in which to live.

Today our nation faces a great problem which occupies much headline and radio and television time—the population explosion. The challenge confronting us is an expanding population in a static area. People are taking up all the space and what is left of our open areas, particularly the naturally attractive areas. What we need today is planning for this dilemma of too many people in not enough space. I like what Don Marquis wrote: "If the world were not so full of people, and most of them did not have to work so hard, there would be more time for them to get out and lie on the grass, and there would be more grass for them to lie on."

What we are considering today is where the grass is, and can we save some for our future generations to lie on.

In order to do this we need planning. The legislation before the Committee today would give the Secretary of the Interior the authority to make an extensive survey to see what is left of our natural environment and if there is some way of keeping plants and animals around for our children to enjoy.

I have lived in Florida for over 50 years and in my state we have a prime example of what can happen if wide areas of outdoors are not protected by public spirited people or the local, state or federal governments. In Florida, ninth largest state in the nation and the fastest growing large state in the country percentage-wise, all lands not protected by conservation-minded people are destined to become fifty-foot lots. In the last decade Florida has grown in population by fifty-five percent, and, of course, our land area has remained the same. There are not many wide open, interesting outdoor spots left in my state, and that is the important reason why I have been a prime sponsor of the Wilderness Preservation Act and the Land and Water Conservation Acts, the landmark conservation bills, passed in the 88th Congress and earlier legislation like the Key Deer Refuge. I have seen our beautiful outdoor areas dwindle and turned into asphalt highways and acres of shopping centers. These things are necessary to take care of our expanding population, but the planning and the thought behind them has been dreadful.

Vice Admiral H. G. Rickover (U.S. Navy) has outlined our responsibility in this: "... government has as much a duty to protect the land, the air, the water, the natural environment of man against such (technological) damage, as it has to protect the country against foreign enemies and the individual against criminals . . ."

Most of the open land in our country today is where the people aren't. We have an obligation to protect what plant and animal life and natural environment we have left in this country. We can do that by adopting this bill, which will document and define changes in the natural environment, maintain an inventory of projects and developments in our land, and establish a system of collecting and receiving information and data on ecological research. When we have started this survey we will have taken a giant step forward to preserve for generations to come what is left of our outdoors.

Mr. Chairman, my bill, H.R. 9955, was adapted from S. 2282. I would like to suggest one change in the Senate bill. On the first page of the bill it refers to "transportation systems" as one of the elements effecting change in our country. In my bill, I have inserted on page three, line four, the word "transportation" which seems to be an appropriate inclusion in respect to the other Federal programs mentioned. If it is omitted it might be erroneously inferred that approved transportation projects would be accidentally endangered.

Mr. Chairman, I congratulate the sponsors of this legislation. It is an important step in preserving conservation resources in our country. Future generations will applaud this effort.

Senator NELSON. Now we have fortunately a very fine response that has come with respect to this legislation and very fine response from a substantial number of distinguished scientists and conservationists around the country. It is so fine a response in fact we have listed 22 witnesses. It will be difficult to go through all of this testimony in great detail. It would be helpful in terms of getting our hearings concluded today, since we do have a session for this afternoon it would be helpful if you could summarize your statements if it turns out it would be a more economical use of time.

All statements presented will be printed in full in the record. So those of you who find that you can summarize the main points of your testimony more quickly and as effectively as though reading the testimony, then we would appreciate it if you would proceed in that fashion although you are authorized to handle it in any way you wish.

Senator NELSON. I now call upon Dr. Stanley A. Cain, Assistant Secretary of the Interior for Fish and Wildlife and Parks.

**STATEMENT OF STANLEY A. CAIN, ASSISTANT SECRETARY FOR
FISH AND WILDLIFE AND PARKS, DEPARTMENT OF THE IN-
TERIOR**

Mr. CAIN. Mr. Chairman, members of the committee, one striking feature of modern civilization is the development of means to anticipate and avoid natural and man-caused disasters and unfavorable events, and to mitigate conditions we do not like. We have weather forecasting, traffic lights, flood control, market predictions, interest regulation, and a host of other highly developed systems for anticipating and influencing changes, trends, and future events. This capability is accepted as one of the highest functions of our technology.

But in this country and most others, our concern has been confined largely to specific expected events. We have paid precious little attention to what is happening or will happen to the total environment. One has only to look at the landscape and the general environment with a perceptive eye and an historic appreciation to read warning signs that we need to devote effort also to forecasting changes in our living environment. Our capability to effect massive changes in our environment has not been accompanied by an equal capability to assess the consequences of these changes in terms of man's total needs.

Man does not, in fact, could not, live in a biological desert. We depend directly on many kinds of living things for our subsistence and for many of the pleasures of our lives. Our forestry and agriculture are based on a deep-rooted knowledge that if the environment is favorable these resources will renew themselves. Yet the line between favorable and unfavorable is often very thin, and may be markedly different between species and from place to place.

In altering environments, deliberately or unintentionally, we must recognize that we may make conditions either more or less favorable for any given species. We must also recognize that, just as man depends on an assortment of natural resources, so too does each other living organism depend on an assortment of its own.

Obviously, then, the species of plants and animals we depend on indirectly are many times more numerous than those we use directly.

They include seemingly insignificant micro-organisms that turn bits of organic material into inorganic nutrients that can be used again by plants. They include invertebrates that reduce dead plants and animals to smaller organic pieces. They include invertebrates that are food for birds and fish, and insects that pollinate flowering plants.

These interacting living systems serve to capture and store energy from the sun, to recycle mineral nutrients, to purify our air, land, and water by decomposing pollutants; and to convert plant-stored energy to foodstuffs man prefers. The living and nonliving parts of our surroundings are thus inextricably bound together.

Together, they constitute man's environment. And no one, wherever he may live, is independent of this environment. When we alter this environment, we must take care that we do not decrease its efficiency and hence its capacity to fill our needs. On the other hand, with the application of new knowledge we can enhance the productivity of nature.

On intensively managed areas we can see incipient problems and take necessary steps to guard against unwanted changes. On our less intensively managed lands and waters, such changes are harder to detect, less easy to correct, but may be no less important.

As a result of technological advances, urbanization, population growth, communication and highway systems, agriculture, irrigation and other natural resource developments, the distribution of plants and animals and the communities they form in the United States shows striking differences from years gone by.

There have been losses in interesting and valuable species and overall increases in weeds, pests, and other unwanted species. Valuable elements of natural communities have disappeared or become so restricted in area and in numbers that they may never recover. Many places of outstanding interest and beauty have been set aside for protection, but through lack of knowledge or sometimes indifferent management, their value has waned or may have been lost.

Some examples of unwanted environmental changes and their probable causes are—

Over 500,000 acres of scarred landscapes in populated and scenic areas and 2,500 miles of streams polluted with acid water because of strip and open pit mining—in the Eastern States.

Loss of fish and wildlife from pollution such as that caused by drainage of agricultural chemicals into streams and rivers, and by temperature changes resulting from use of water for cooling.

Desiccation of the Florida Everglades and intrusion of salt water which have combined to endanger waterfowl, fish, grasslands, and endemic trees, resulting from mismanagement of water.

Some changes in today's environment are the result of the cumulative impact of many single and sometimes unrelated events. Although the managers for each single action may know what takes place in their sphere of immediate interest, there is no total evaluation that will consider the cumulative effects. Thus, one dam may do little to alter the environment of a stream, but many dams may completely change the natural situation. Filling 1 acre of estuarine marsh may cause little change, but filling many acres may eliminate necessary nursery grounds for valuable marine resources.

These examples show that a complex variety of seldom recognized and often unbelievably subtle changes are associated with resource development. Actions which appear sensible and desirable may have far-reaching and unpleasant consequences not readily foreseen and possibly not even appreciated over a span of many years. Many of these result because changes are distant in time or place from the factors that caused them. Furthermore, any single change may be so slight as to be almost undetectable. Some are irreversible. A slowly dropping water table or a change in the balance of numbers between small organisms, the very existence of which may be unknown, are often potent factors in the deterioration of a countryside.

The trend of the past has been toward deterioration in the quality of much of our environment. A half century from now new balances of natural forces will exist. They will be caused by the course of natural events and interactions with man's activities. If we fail to make an assessment now, the changes of a half century will be impossible to document. Wherever possible, every effort must be made to recognize and to predict the changes to come. Wherever possible, lessons learned from past experience should be used to advantage in decisionmaking by planners, managers, engineers, and conservationists—in fact, by all who are concerned with the manipulation of our environment.

Ecological understanding—that is, knowledge of interrelations among things—is basic to the optimum development of our natural resources. Without such knowledge we are neither able to exact the greatest gain from our surroundings nor to avoid loss to one resource in the process of using another. In short, ecological understanding is necessary to assure that environmental manipulations undertaken for the benefit of man are in fact beneficial.

Much of the ecology of the past has been directed to understanding the requirements of single species. We need more of this. But even more, we need to understand populations and communities of plants and animals as they interact in nature. The need today is for systematic study of whole ecological systems, for no species is independent of the ecosystem in which it exists.

Present patterns of support of ecological research tend to provide highly useful pieces of information, but the picture they provide may be distorted or blurred. Methods akin to those of systems analysis and operations research would help us assure that the right pieces are available at the right time so that understanding of the system may be more complete.

Because wise use of natural resources depends on ecological knowledge, it is essential that each agency responsible for natural resources in Interior and elsewhere conduct such research. But because ecology does underlie so many programs, it is equally essential that some means of coordination be established to assure that all of the necessary research is supported.

We, in Interior, are deeply concerned with ecology as a basis for management of water, fish and wildlife, parks, and other public lands. Because so many of our bureaus have needs in ecology, and because these needs extend beyond specific bureau missions, we intend to provide a central focus at the Department level. In this way, Interior can

provide a sort of infrastructure of basic ecological research which will provide the understanding on which applied ecology in all fields can stand and grow.

The time has come when the United States should no longer concentrate only on solving parts of indivisible problems. The time has come when we can no longer afford to proceed on a basis of uncoordinated specialties. A means of looking at the entire environmental complex, and integrating the results of partial approaches has become essential. The increased rate in the use of processes that influence the environment makes this mandatory if we are to anticipate and avoid unfavorable consequences, as well as take full advantage of our ability to effect desirable environmental change.

In sum, we are in an era of change and complexity. Through technological advance we are continually gaining new powers to alter our environment for better or for worse. At the same time, we are developing a deeper awareness of the importance of maintaining a sound, attractive, and healthful environment if we are truly to enjoy full human existence. To realize the benefits of modern civilization without also eroding the fundamental physical and biological bases for our tenure on earth is a problem whose complexities we can now only dimly perceive. Broad ecological research has a central role in attacking this vital problem.

It is a pleasure to have this opportunity to appear today for the Department of the Interior. We will do our best to answer any questions you may have.

Senator NELSON. Thank you, Dr. Cain. Do you know how much money is spent on ecological research by the Federal Government now?

Mr. CAIN. The answer to that will have to be qualified. Let me give you some figures which I had gathered on this for Interior and then make the qualification afterward. It seems that in Interior the Bureau of Commercial Fisheries, which is heavily a research bureau, will spend about \$13.6 million for fiscal 1966. This includes studies of environment and environmental effects and ecological processes and factors as they affect essentially commercial fisheries or species.

The Bureau of Sport Fisheries and Wildlife spends about \$8.9 million. The Bureau of Reclamation spends about point \$1 million.

Senator NELSON. Point \$1 million?

Mr. CAIN. Yes, \$100,000. National Park Service spends about \$40,000.

The Geological Survey spends about half a million dollars. I don't have any figures from the Bureau of Land Management, but I know for range management they are involved in ecological research and, in some connections, forest management.

This totals a little over \$23 million.

Then, Interior also is involved in grants and contracts in the ecological field and this is particularly heavy in the Bureau of Sport Fisheries and Wildlife, where, through Pitman-Robertson and Dingell-Johnson authorizations about \$7.6 million in fiscal 1966 is being extended to the States largely for the same kinds of purposes as represented in this bill.

BLM, Reclamation, Park Service, and Commerical Fisheries also have grants. The total is about \$9.5 million.

Senator NELSON. Total for what? I thought you gave a figure of \$23 million.

Mr. CAIN. For grants. Interior agencies are spending \$23.3 million for their own work, and, in addition, for grants about \$9.5. So the total is some \$32 million, roughly speaking.

Senator NELSON. These grants are to institutions, educational institutions, is that it?

Mr. CAIN. Well, the largest part of the grants is by the Fish and Wildlife Service to the States under Pitman-Robertson and Dingell-Johnson authorizations.

Senator NELSON. Do you have any grants or contracts with research organizations, private research organizations, or with universities, in the ecological field?

Mr. CAIN. I would say about a third of the total which I mentioned.

Senator NELSON. A third of what total?

Mr. CAIN. \$9.5 million. About a third of the total grants is to individual scientists, usually connected with colleges and universities.

Senator NELSON. Now, this research that is being done by Fish and Wildlife and the Bureau of Land Management and Parks and so forth within the Interior Department, is all of this money you mentioned spent on what you would classify as ecological research?

Mr. CAIN. Yes; but this is the reason I prefaced these figures with the remark that I think they need explanation.

Now, if we go back to Secretary Udall's statement when he said he understood "ecology" to be the study of the web of life—I think it is quite clear that all of the mission-oriented agencies whenever they are dealing with living organisms in relation to environment they are in the ecological business. So when the Bureau of Commercial Fisheries is dealing with the management and the harvest of commercial species in the sea or fresh waters; when the Bureau of Sport Fisheries and Wildlife is dealing with the management of game species and other organisms; or when land managing agencies have the quality of the forests and the pastures and the waters to maintain for whatever purposes, they are all in ecology.

Now, most of this ecology is mission-oriented in the sense that there are specific, defined objectives involved with relation to certain species at certain times—like certain relations to migratory waterfowl or game animals, or certain relations to the quality of pasture with respect to wildlife or cattle in BLM. Well, this is all ecology by our definition.

Senator NELSON. So that you would consider that the moneys spent for research in forestry, or moneys spent on research on trout gill disease or money spent on any of that type of direct mission-oriented research, you would consider that ecological research?

Mr. CAIN. It depends a little bit on whether the money is spent for, let's say, a physical facility which would be used for a certain biological purpose, or whether the money is spent to acquire the information or knowledge which permits you to manage with respect to certain goals. I am close to claiming too much for ecology. Yet, if you are dealing with a problem of physiology, or a problem of pathology, or problem of structure and composition of a community, these may provide the kinds of information which bear upon the success in management of whatever resources you are concerned with.

Maybe I can make this clear by saying that ecology includes what any organism's environment is—not only its physical environment, like moisture relations and heat relations and chemical relations, but also its relations to all other kinds of life—because the whole thing is an interacting system.

I think the big deficiency at the present is that too little attention is paid to the system within which individual actions occur, or individual species play out their life roles.

Senator NELSON. That is what I was really getting at. If I understand you correctly, by your definition of the appropriation spent by the various agencies in Interior, any and all and every study that they make, no matter how limited, of the flora or fauna or any particular species is ecological research just by definition. Yet it is not a study of a whole system or the whole relationship between living organisms; is that correct?

Mr. CAIN. Yes. That is a very good distinction. Because interrelations are so all pervasive, there is a great temptation to claim much too much for ecology. I don't want to do that, but I think it is fair to say that within the field of forestry, management of forest lands as complex communities is based on what the foresters call silviculture, but they are applying forest ecology.

This is what it amounts to: It would be the same thing with range management whether for domesticated livestock or wildlife; it is the same thing for agriculture, that is, the knowledge which has been gained about species or varieties of crops in relation to environment forms the scientific basis for modern agriculture. Well, this is the field of crop ecology, a perfectly respected field in agriculture. So the applied field and the management field in living natural resources have their roots in ecological science.

Furthermore, I think it is clear that there is an ecology of microorganisms and there is an ecology of the world—geochemistry—the field of the interrelations of things on a global basis.

I think what we are talking about is this: How can we improve the capacity of the Government to secure fundamental knowledge about the systems to provide an underpinning or scientific foundation upon which the applied sciences can build with greater security?

Senator NELSON. In the Forest Service or Interior Department it is decided that they have to spray the forest after making a study, say, in order to get rid of Dutch elm disease or moths that are attacking the forests, so they have made an ecological study by your definition and they have to get rid of the particular insects or moths, and that is qualified as an ecological study, so they spray it with DDT and kill everything else in sight.

As I watch the use of the pesticides, in the forestry field particularly, it seems to me the ecologists, if they are the ones that are advising it, are not making a study of the whole system of the relationship of the living things, plant and animal, or at least considering that factor, are they?

Mr. CAIN. Well, there have been, I am sure, many instances in which a pesticide has been applied without either knowledge or very much concern about what might happen to the environment of others in the target area in which the pesticides are directed.

Now it is known in many cases that in application of a pesticide, particularly in aerial application, only a small percentage, maybe 3 or 5 percent of the chemical, will hit the target organism. We must ask ourselves what happens to the 90-plus percent in the environment as a whole, because such chemicals, like any other chemicals, move through the system as one organism lives upon another. The ramifications of an applied pesticide through the dozens or even hundreds of organisms that make up a community we may not know, and we may not know where the surplus pesticide goes in the physical environment—the soil, water, or air. Sometimes we do know some has gone in the air because we get sued for damage we caused somewhere else.

Actually, I think you put your finger on the critical point: We have had a very narrow specialized approach to our problems in general, whereas each of these approaches should be put in the frame of reference of nature as a whole.

What is happening? What are we doing inadvertently, unthinkingly, out of our ignorance to the rest of nature? We sometimes only discover this when we run into trouble.

Senator NELSON. So that the record would be clear as to your testimony on this, do I understand you correctly or would this be a correct statement of the expenditure of some \$32 million that are made for ecological research, that they are mainly or almost totally a specific mission-oriented ecological project rather than a broad system study, so to speak; is that correct?

Mr. CAIN. I would say so, largely. It is impossible for me to give you a percentage. It should be said, in all fairness that all of the bureaus feel the need for basic knowledge and seek it, if they can. If you would like, I can give you a telling illustration. I don't want to take too much of your time.

Senator NELSON. Yes.

Mr. CAIN. The Bureau of Commercial Fisheries is interested in very important stocks of mid-Pacific fish such as tuna species. Their study under what they call their "trade wind zone" program, is of individual water masses—the physical characteristics of water masses of the mid-Pacific. They are discovering that these water masses may be characterized like air masses. That is, they have characteristics of temperature and salinity and so on, and throughout the year they move in space and shift from surface to depths and so on, much as air masses move.

The reason for studying this physical environment is that they are discovering that certain species of fish move as the environment moves, and it helps to know where to seek and catch the fish for commercial production. Well, they are relating the commercial species to environment and this is ecology. In order to know about this, they have to study the physical environment of the ocean within this limited scale. To draw the line between mission and applied ecology on the one hand, and this fundamental search for information on the other hand is almost impossible. I think in this case it is not necessary.

So I am sure in these figures that I have given you as approximate figures, there is quite a bit of what one would call "fundamental ecological research."

Senator NELSON. Are any other agencies or departments in the Government doing ecological research?

Mr. CAIN. Yes, sir. The Department of Health, Education, and Welfare, is concerned with human health and conditions of the environment that affect health, so they are certainly in this field. As a matter of fact the medical people now have a field they call human ecology which is the environmental aspects of human diseases.

Agriculture is in it, of course, the Atomic Energy Commission is also concerned.

Senator NELSON. Of the things that this bill directs the Secretary to do, how many, or how much of this is the Secretary accomplishing without the authority of any legislation? How much could he accomplish?

Mr. CAIN. Well, we have been considering for some time—sort of incubating, because we have had no action yet—the idea of organizing our own competence in the Department of Interior with regard to, let's say, fundamental ecology, without any additional funding. There are certain things we can do in terms of reorganization and shifts of emphasis. We have had increasing coordination among the several bureaus of the Interior.

I think my testimony touched on the fact that irrespective of what legislation may be passed, we can do something ourselves to increase our attention to ecological problems and to focus our interests on systems.

For example, we have recently established in the Fish and Wildlife Service two interbureau committees between the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife. One is on estuaries, because the interests of these bureaus meet with the fresh and salt water. Another is on anadromous fish. What we are doing is increasing our capacities with the two committees to coordinate our abilities on problems that each alone would not be able to attack. This sort of thing we have under study, but have not moved in terms of reorganization. It would not be extensive in any case because we would not want to take away from any of our bureaus what they have to do and what they have been doing.

Senator NELSON. Mr. Anderson?

Senator ANDERSON. This is somewhat news to me. You said quite a bit of the money of this \$32 million was being spent for ecological research. Quite a bit, isn't it? Wouldn't you also say that.

Mr. CAIN. Quite a bit is.

Senator ANDERSON. Well, isn't there quite a bit that is not? The figures you used there, it seems to me there is some work that is being done that is not actually research but it is applied work, isn't that right?

Mr. CAIN. I didn't mean to give you the impression this many millions was spent this way.

Senator ANDERSON. You said "quite a bit." How big a bit?

Mr. CAIN. Well, this is very difficult, Senator Anderson. I don't really know what the percentage is. A good deal of research in the sense of seeking knowledge about new relationships must be based on a sort of inventory and data-gathering effort. This is one level of research. It is quite different from another level which might be called experimental. I would say these figures which I have had given to

me from the Bureaus are their estimates of what they are spending on ecological work. A considerable portion would be research by anyone's definition. But some of it comes under data-gathering, leaving research in a strict sense to analysis of the data and interpretation of it.

Senator ANDERSON. A statement was made that quite a bit could be done without legislation. Why don't you do that?

Mr. CAIN. We intend to do a little bit. As a matter of fact, we now have in the Office of the Science Adviser in the Department of the Interior one man who was brought in particularly for the purpose of studying ecological problems faced by the Department. He has some assistance but one man does not give us a great deal of capacity, no matter how good he is. I think the problem is more for us to explore the possibilities by minor reorganizations within Interior. To do very much, I think we must have legislation and an appropriation to support this kind of work.

Senator ANDERSON. There was some discussion of a Dutch Elm disease. Would you characterize that as research? In other words, don't you try to find out what causes it and then spray?

Mr. CAIN. It takes research to find out what causes the disease. It takes research to understand the life history and requirements of a disease-producing organism. It takes research to find out the possible technique of control. Then you get to the point where you go ahead and put your control in. That is not research any more. That is operations.

Senator ANDERSON. Have you any idea of how much you spent on research of the Dutch Elm and how much on control?

Mr. CAIN. No, Senator Anderson, I simply do not know; this is not really in the Department of the Interior.

Senator ANDERSON. Don't you think it is important to find out?

Mr. CAIN. Yes; I think so.

Senator ANDERSON. How would this affect that?

Mr. CAIN. Sir?

Senator ANDERSON. How would this bill affect what is now being done in Dutch elm disease?

Mr. CAIN. Well, I, myself, had not conceived that Interior would be directly involved in a problem like the Dutch elm disease problem.

Senator ANDERSON. So those things are in the Department of Agriculture, would not be touched by the bill?

Mr. CAIN. They could be.

Senator ANDERSON. Well, I thought you said you couldn't see where the Department was involved in the Dutch elm disease and if it is a problem that had to do with ecology, why wouldn't it be?

Mr. CAIN. Well, let me say that I think forest pathology is certainly, perhaps preeminently, a responsibility of the U.S. Forest Service from the Federal point of view.

Senator ANDERSON. Well, the Department of the Interior handles lands?

Mr. CAIN. We have many acres of land in forests and we do perform considerable forest management, this is true.

Senator ANDERSON. I found out from the Department of Agriculture that Interior has a lively interest in forest control.

Mr. CAIN. I don't know why I am arguing here for the Department of Agriculture, but I am. They have the Agricultural Research Service, and the Forest Service which include a large and competent forest pathology research staff. I don't, myself, see any reason why the Department of the Interior should be doing forest pathological research. I see many reasons why we should be applying this knowledge to the management of forest lands that Interior is responsible for. I draw that difference.

Senator ANDERSON. I just wanted to know why this money is necessary to get that sort of work done.

Mr. CAIN. I don't think it is.

Senator ANDERSON. Thank you.

Senator NELSON. Mr. Jordan.

Senator JORDAN. Dr. Cain, under what authority are you presently doing the \$32 million of ecological research in the Department of the Interior?

Mr. CAIN. Well, I think all of the agencies, or nearly all of them in Interior, have authority for research in their organic acts and the term "ecology" may or may not be used.

For example, the Fish and Wildlife Act of 1956, the Fish and Wildlife Coordination Act give this Service responsibilities. I guess the oldest is the Geological Survey, which has, through its history, been involved in studies of the vegetation in relation to land form and geological facts in relation to soil formation and so on. Geological Survey today has several biologists working for it.

The National Park Service Act in 1916, the Public Lands Act and Reclamation Act all give some degree of authority to the Federal agencies to (a) manage lands and natural resources, and (b) do research in relation to the management problems. Now, some of the research becomes ecological, depending on what kind is being done.

Senator JORDAN. Well, I understood you to say you needed legislation in order to change the emphasis or to properly emphasize pure ecological research, or words to that effect, and I wondered if you need this legislation to pursue ecological research further as you outlined here or if the authority is already inherent in the enabling legislation that you have enumerated here.

Mr. CAIN. I think it would be a very great help to the Department of the Interior for there to be congressional recognition of the historical fact that the way the bureaus have operated under their organic acts has resulted in their not paying adequate attention to the whole ecological systems in which they may have only a partial direct concern. I think, also, that the time in history has come when we are beginning to realize that scientific analysis, as necessary as it is, isn't all that we need. We need synthesis of the information from the many disciplines, we need to attack the systems as a whole. I rather suspect if we went for any one bureau to the Bureau of the Budget with a significant line item to do fundamental research, we would be asked: "Well, how does this apply toward a certain goal, certain ends, and how many dollars are you going to get out for these dollars of input?" And it is not in the nature of basic science that you can produce a bookkeeping like this.

I think the big advantage in recognizing the need for competence in fundamental ecology is the accompanying advantage that we have in producing funding for such necessary research.

Senator JORDAN. Well, I agree with you to a certain extent. But I wonder why the Department of the Interior is the proper department for this. It would seem to me that Health, Education, and Welfare, for instance, would have a more vital interest in it, having to do with the ecology as it affects humans and that is what we are studying finally and I just wonder why you think the Department of the Interior has a special designation or should be specially designated to do this system of research over and above, we will say, HEW—well, let's say HEW.

Mr. CAIN. Well, we were careful to say in the testimony which I presented, and I believe also in the Department's report to Senator Jackson, that there is no purpose here to preempt the field of ecology for one department. Obviously, it is impossible and is not needed. I think I can clarify the difference for you.

Certainly, the Department of Health, Education, and Welfare is deeply concerned with the quality of the environment as aspects of human health. However, there are also many other aspects of the environment which do not directly affect human health which the Department of Health, Education, and Welfare will not be concerned with paying attention to, such as fish and wildlife measures, or scenic values or water. They will be interested in whether the quality of water is such as to influence human health. I must say also that the interest in human wealth is wider than I have just intimated but, nevertheless, they cannot encompass and should not encompass the whole field of environmental relations to man's interest.

On the other hand, the Department of Agriculture is deeply and legitimately in this field because they are concerned with the production of farm and range and forest products and the use of these plant and animal communities by people under multiple use. But they don't have concerns that go beyond their described objectives.

Now, Interior's interest, I believe, is very much broader because it does deal with fish, it does deal with wildlife, and it deals with them both in relation to products and in relation to services such as recreation. It deals with all kinds of lands and water, because the Department has responsibilities for more than half a billion acres of lands, nearly two-thirds of all Federal lands, with their attendant animal and plant life. We have the general requirement for quality of environment of all kinds of organisms, many of which are not commercial products. So, I think far and away we have the broadest responsibility in the natural resources field and consequently the greatest need for fundamental ecological knowledge.

Senator JORDAN. Do you have any idea of how much money is being spent on ecological research by other agencies, non-Federal public agencies?

Mr. CAIN. I know that a great deal of money is being spent, I don't know how much, by the State universities in ecological research. A great deal of money is spent by State departments of natural resources or conservation in forestry, game management, fish management, and so on. Some of this money is for research, but I would say the total national ecological effort was not very great.

Senator JORDAN. Would you have any idea of what percent is supplied by the private sector in ecological research, those people directly in industries involved?

Mr. CAIN. I would say that it is very difficult to tell.

Senator JORDAN. All I am trying to do, Doctor, is establish the scope of the effort, the magnitude of the ecological research effort that is presently going on throughout the Nation in the Federal sector, in the non-Federal public and in the private sector.

Mr. CAIN. Yes, sir. I can't give you anything but a general impression. The private sectors of our economy in agriculture, the private farms, are progressively becoming more and more scientific in their management. And they are making more and more utilization of ecological kinds of information among others. The same thing is true with respect to privately owned industrial forests.

Private investment in agricultural economic research is almost negligible, but private investment in forest ecology is very considerable. I think today about half of the graduate foresters in the United States are employed by industry. The other half are employed by State and Federal Governments.

I would say, however, that industry, including mining and manufacturing industries, is almost completely without an ecological philosophy or concern. I would also point out that this is not true of oil and gas because the oil and gas people in most States in the interstate compact are very much concerned about the interrelations among the various phenomena that affect their oil and gas production, including protection of the quality of the environment both underground and above ground.

Senator JORDAN. Do you feel in the Department of Interior as the coordinator, that agency of the Government which would stimulate and coordinate all of this research activity by various other agencies of the Federal Government and by the non-Federal public agencies and by the private agencies, are you setting the Department of Interior up in that kind of category with this legislation?

Mr. CAIN. No, sir. I think what Interior is in a position to do or could be in a position to do, is to attempt to coordinate and integrate a rather vast amount of information which has been and is being derived from ecological and other scientific studies. I think it is in a position to study whole systems on a program basis which would be impossible for a university or individual investigator, because these are extremely complicated systems that require the technical input of many disciplines. I think Interior is the ideal place to do this. I don't think that any other agency of Government that I know, at State or Federal level, is really even interested in doing this.

So I would say that gathering and the collating of information and the production of new information on systems as a whole would be logical for Interior but not to coordinate for the Government. I don't know of any agency that would stand still for Interior coordinating its efforts.

Senator JORDAN. Section 10 says there are authorized to be appropriated such sums as may be necessary to carry out the provisions of this act. How much do you calculate would be necessary to carry out the provisions of this act?

Mr. CAIN. I am sorry, sir; I don't have a satisfactory basis for answering that. I think the initial appropriations, if this program is authorized, should be reasonable but not large; let the effort demonstrate its value, if it can, and grow as it convinces Congress that it should be furthered.

Obviously the bill authorizes doing a very large number of things which, if pursued on a very broad basis, would be very expensive and would need a great deal of time. Actually, if many millions were authorized for fiscal 1967 or 1968, I don't know where we would find the people competent today to do all of these things.

But this is quite different from saying that we shouldn't get a start. I would like to see a program funded to the tune of several million dollars over the very near future in order to enable us to get a start on the problem that I believe is fundamental to our capacity to serve our national needs.

Senator JORDAN. Before it gets out of committee, Dr. Cain, some of us will insist there will be a dollar sign on section 10. If you would care to make a recommendation, I would be glad to have it and precisely what that item should be.

Mr. CAIN. Mr. Chairman, we will be glad to study this problem. Could you give a suggestion of how long the record will be open?

Senator NELSON. We will keep the record open for 10 days.

Mr. CAIN. We will be glad to submit an estimate of what we think is feasible and practical for a start. This is what you wish, sir?

Senator JORDAN. Yes; thank you.

(The information requested is as follows:)

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., May 6, 1966.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate,
Washington, D.C.

DEAR MR. CHAIRMAN: On April 27, 1966, I presented oral and written testimony on the ecological survey and research bill (S. 2282) before your committee. Senator Jordan asked me to provide estimates of the costs of carrying out the program authorized by the bill.

The bill would authorize the Secretary of the Interior to (1) conduct, intramurally or extramurally, in the United States, its surrounding oceans and in other countries, basic research directed at understanding ecological systems; (2) accumulate information on the status of the natural environment and to maintain an inventory of programs, actions or events which may significantly change it; (3) make available ecological knowledge in suitable form to such agencies and individuals as may find it useful in considering actions that will affect the environment; (4) make grants available for training manpower necessary in the fields relevant to ecology; (5) establish a Federal system of natural areas for scientific research on Federal lands; and (6) assist in the establishment of natural areas for scientific research on non-federal lands.

Estimated costs for items 1 through 5 are as follows:

Year:	Cost
1st -----	\$2,000,000
2d -----	4,000,000
3d -----	6,000,000
4th -----	7,500,000
5th -----	9,000,000

With regard to item 6, there will undoubtedly be some types of natural areas not available on public lands, or not located in appropriate juxtaposition to institutions needing them. However, until an inventory of needed areas and an inventory of areas available on public lands has been completed, the extent of the need for assistance to non-federal agencies will not be known. Our estimate of cost is therefore somewhat uncertain, and is based on the expectation that future authorizations could be based on inventories of needs and availability.

Year :	<i>Cost</i>
1st -----	\$1, 000, 000
2d -----	1, 000, 000
3d -----	2, 000, 000
4th -----	3, 000, 000
5th -----	4, 000, 000

This breakdown is based on the assumption that authorization could be provided separately for the two categories shown in the above cost estimates.

Sincerely yours,

STANLEY A. CAIN,
Assistant Secretary of the Interior.

Senator NELSON. Now, you stated that there was a considerable amount of ecological research being done by scientists around the country. Is there an example, a good example any place that demonstrates the use of the ecologist's studies for the planning and development of any project? For example, I notice that they have now filled in 200 square miles of San Francisco Bay. It was about 520 square miles and it is now down to 300-and-some square miles of water. Has any study by anybody been made as to the ecological consequences of filling in all of these spawning grounds and marshes and filling in of that bay? Or if the Government engages in large projects—dams up a huge river, or builds a huge reclamation project—have we used the scientific knowledge of the ecologist to tell us in advance what are the ecological consequences of this vast reclamation project or this large dam or the filling up of the canyon and so forth; do we use any of this knowledge?

Mr. CAIN. I think the answer is a sort of qualified or limited "yes." I will explain. Under the Coordination Act, the Fish and Wildlife Service reports on proposed construction by the Corps of Engineers and Bureau of Reclamation, dams, channel dredging, spoil deposits, and so on. So the effects on fish and wildlife are reported. Now, we have no capacity to come in on actions of the States in, say dredging and filling of estuaries and bays or what may be accomplished by local government.

Senator NELSON. What about the Corps of Engineers?

Mr. CAIN. Under the act we come in and tell them. They may or may not take our advice.

Senator NELSON. But would you say that ecologists looking at the evaluation that is made of a dam that fills up the Grand Canyon or a reclamation project that affects a vast area, would you say that an ecologist looking at the study that we make of it would say this is a fine ecological study which tells us the effects on the total environment, the whole system of the relationship of the insects and animals, and all other living things—would you say that we do anything of that nature?

Mr. CAIN. I think your question is bringing out a distinction between what the bureaus with their mission orientation can and nor-

mally do do and what they don't do. For example, with respect to a proposed dam or with respect to a proposed nuclear powerplant that needs a lot of water for heat dissipation, we will report on the fish and wildlife problems essentially in the sense of a huntable species and what would be necessary to mitigate losses or perhaps what could be done to enhance wildlife values because you get some values gained and you get others that are lost.

But to report on the effects of the environment as a whole on the ecological system as a whole, the answer is, "No." We may not know whether there is an endangered species of fish that might be exterminated by the construction; so it is a limited thing which the mission-oriented bureau comments on. It is important but limited.

Senator NELSON. Is there any place in the United States where the ecological research that is done is collected and classified and available? I don't refer to that that may be published in scientific journals and therefore indexed in libraries, but I refer to all of the research going on, much of which is not published.

Mr. CAIN. To my knowledge, there is no single governmental or nongovernmental center for the collation and integration of ecological information. It does not exist.

Senator NELSON. Would you consider that it would be important that there be such a place where this scientific knowledge is collected?

Mr. CAIN. I certainly think it is important and that I think is the import of the testimony.

Senator NELSON. Would you think that the Department of Interior would be a logical place to collect and index and collate that scientific research?

Mr. CAIN. I do. Now, I didn't really completely answer your former question about San Francisco Bay. To my knowledge there is no general ecological study being made of the bay and the damage of this filling. I can say, however, that the Bureau of Commercial Fisheries has been engaged for a few years now on a study of Tampa Bay, where perhaps between 15 and 20 percent of the bay has been filled behind bulkheads and, in producing the material for the fill, there has been about an equal percentage of the bay that has been dredged. These studies reveal that after 10 years of dredging the bottom is, in effect, a biological desert. Here is at least a third, perhaps more, of Tampa Bay that has been completely destroyed from the point of view of natural estuary conditions. Here is a bay in which there must be two dozen species of commercial fish and shellfish that spend part of their life. This is a loss in an estuary smaller than San Francisco that is being studied thoroughly.

Senator NELSON. So after it is all filled, the ecologists will be able to tell us what happened to it?

Mr. CAIN. That brings us to the other point. We have no present means of control over what State and local governments do with respect to endangered habitats.

Senator ANDERSON. Since the San Francisco Bay situation has just begun you do recognize that the San Francisco people are interested in what they call "saving the bay"?

Mr. CAIN. I do.

Senator ANDERSON. Commissioner Kerr, I think the wife of the president, a woman I can't tell her full name, her first name is Peggy.

her husband is a doctor, but they are very much interested in saving it. If you presented the problem to them, couldn't they find the whole Berkeley campus and other campuses, find there some people that would make the study for you?

Mr. CAIN. Certainly, the scientific capacity to study almost every aspect of San Francisco Bay exists in the University of California. The problem there is that scientists are very free in universities, they are individuals, and they determine to a large extent what kind of research they will do. The advantage the Government has is that it can program research and assign appropriate people to the solution of the problem.

Senator ANDERSON. These are the most militant campaigners in this State that I have ever seen and persistent letter writers and I can't believe if they are asked to do it they would refuse. I think they are doing everything they can and I commend them highly for it. They are a wonderful group.

Mr. CAIN. Many citizen groups have arisen in the last few years around the country concerned with the preservation of bays and estuaries and wetlands in general. There is a very important citizenship interest in this matter.

Senator ANDERSON. Thank you.

Senator NELSON. I have no further questions. Thank you very much.

Mr. CAIN. Very well.

Senator NELSON. The next witness is Dr. Colin MacLeod, Deputy Director of Office of Science and Technology.

STATEMENT OF DR. COLIN M. MacLEOD, DEPUTY DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY

Dr. MacLEOD. Yes.

Senator NELSON. Senator Anderson has to attend the swearing-in of the new head of the Bureau of Indian Affairs and he will be gone, but go ahead. You have your statement that you will submit and it will be printed in full in the record at the end of your oral presentation, so it will be available to all of the members of the committee and the Congress. If you can summarize the main points without impairing the testimony, and you feel you can, we would appreciate it because we are going to have difficulty getting to all of the witnesses.

Dr. MacLEOD. I shall attempt to summarize the main points, Mr. Chairman.

I need not emphasize the importance of the subject because Dr. Cain has already done this. I should say it was both clearly and eloquently done.

The Office of Science and Technology and the present Science Advisory Committee have had a deep interest for a number of years, sir, in questions that relate to ecology.

There have been three reports issued from the present Science Advisory Committee, for example, during the past three and a half years that relate to this topic. The first of these is the report on the use of pesticides. The second is the report on cotton insects and the last of these, which was issued in November of 1965, is entitled "Restoring the Quality of Our Environment."

As I said, all of these are fundamentally ecological documents because they do deal with factors and influences that modify.

In the message on natural beauty in 1965, President Johnson asked the Director of the Office of Science and Technology and the Director of the Bureau of the Budget to recommend the best ways in which the Federal Government may direct its efforts toward scientific understanding of natural plant and animal communities and their interactions with man and his activities.

We have been engaged with the Bureau of the Budget in this study and we hope that we shall be able to complete it before too long. The agencies were requested to describe their activities relating to improved understanding of natural communities and the objectives for undertaking this work. Interagency arrangements were made for cooperative studies and the funds expended both for what you may call in-house research and for grants.

There are eight agencies concerned with ecological research. We have had responses from all of them, but we are in the position of having to go back to complete our information in the case of two of the agencies and this is being done at the present time.

As soon as we have completed this what I may call preliminary review and analysis, we shall refer our analysis to the agencies for their comments prior to preparing a final version.

The following agencies of the Government are concerned with natural plant and animal communities, also the relationship to man: Department of Agriculture, Atomic Energy, Department of Commerce, Department of Defense, Department of Health, Education, and Welfare, Department of the Interior, as we have heard, the National Science Foundation, and the Smithsonian Institution.

In fiscal 1965 these eight agencies expended approximately \$87 million for their in-house activities, plus about \$261½ million in grants and contracts. This figure, however, does not give the complete expenditures, because we have become aware recently that we have not included in our survey all of the expenditures that are directed specifically toward human health.

As one would expect, and as Dr. Cain has already described, much of these activities are strongly mission-oriented. Both the in-house and sponsored research deal mainly with economically valuable species such as those used by man for food and fiber, the foods of domestic and game animals, and pests and disease organisms. There is a fair amount of attention being given to recreational facilities and to game species of birds and mammals.

Now, on page 5, sir, of this brief statement, we have broken down the total expenditures for fiscal year 1965 into a number of categories. You will note the third one down, which is research on native plants and animals and their interactions with man. We have a figure of 14 percent of the total of \$113.5 million in that category.

Depending upon how one makes his definitions, this figure could be a little higher or it could be considerably lower and there is a real problem of definition that comes into it. In any case, if one accepts the figure of 14 percent, this is roughly \$16 million that is being expended by all of the agencies on natural plants and animals and interactions with man.

Senator NELSON. This is not mission-oriented research?

Dr. MACLEOD. Part of it is mission oriented; it has to be, sir.

This breakdown, and what I have told you, really highlights the need for improved collection and distribution of information related to ecological subjects.

I should say that most, as I said earlier, of the work is strongly mission oriented. The largest part of what might be called "basic ecological research" is being supported by three agencies, the National Science Foundation, the Atomic Energy Commission, and Smithsonian, and this would be, in the purest sense, not mission oriented but most of the research that is supported by the various other agencies is strongly mission oriented.

Thank you, sir.

Senator NELSON. Would it be correct to say, then, that we are not using ecological studies in the broadest sense of the word to assist us in making decisions about actions that affect the environment? Would that be correct?

Dr. MACLEOD. It wouldn't be entirely correct, sir. I think we do use ecological research to a degree in making many of our decisions. I think it is quite true, however, that we don't make enough use of ecological research before we introduce large modifications into our environment. We have not in the past. I would hope we would do more in the future so we know what we are doing when we do it.

Senator NELSON. Thank you very much, Doctor. I appreciate your coming. Your full statement will be included at this point.

Dr. MACLEOD. Thank you.

(The statement referred to follows:)

STATEMENT OF DR. COLIN M. MACLEOD, DEPUTY DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY

Mr. Chairman and Members of the Committee: It is a pleasure to appear before the Committee to discuss the status of research on the understanding of natural plant and animal communities.

In the past the natural environment was capable of withstanding much of the impact from human populations. During modern times, however, population growth and advances in technology have resulted in dramatic increase in exploitation of our natural resources to support our expanding agricultural, domestic and industrial developments. Man has become the dominant influence and stress on the earth's bioenvironment.

Ecological processes govern the success and fate of all living organisms. The distribution of species and the vigor and size of their populations is controlled by many factors such as availability of food, by disease, by properties of soils and water, and climate. Some natural bioenvironmental processes build fertile soils and others control the cycling of nutrients and energy on land, in fresh water and in the oceans.

Our present state of knowledge of these and other important ecological processes is not sufficient for our welfare. For example, a better understanding of the normal distribution and abundance of native plants and animals, and of the role of bioenvironmental processes in controlling the distribution of populations would assist in determining how specific land areas could be best used and provide a baseline for detecting and measuring future bioenvironmental changes. Research on the causes and controls of fluctuations in natural populations and knowledge of the factors which cause populations to endure in a stable fashion have obvious importance relative to our use of both native and domestic plants and animals and for improving our understanding of problems of human populations.

The Office of Science and Technology is keenly interested and has been actively assessing various aspects of our Nation's needs in the bioenvironmental sciences

for several years. A report on problems of pollution has recently been issued which was prepared by a Panel of the President's Science Advisory Committee. It is entitled "Restoring the Quality of Our Environment". This study focused on the problems of pollution of air, water and land. It recommends actions to prevent and control contamination of the environment.

This report of the President's Science Advisory Committee recommends that the Federal Government expand substantially its in-house and sponsored research in a number of broad areas including the metabolism, environmental cycling, natural degradation, and long-term deposition of pollutants. It suggests that more objective techniques be developed to measure the tolerance levels of different organisms to pollutants and to identify and assess the changes in abundance and distribution of organisms making up biological communities under pollution stress. It notes the need to assess the population structure of certain natural populations in diverse, relatively unpolluted habitats by systematic sampling in order to establish a basis for comparison with populations under pollution stress.

The report notes that at the present little is understood concerning the structure and function of most plant and animal communities. Studies are therefore needed of the composition of natural communities, of the interactions among organisms which make up these communities, and of the effects that various physical, chemical and biological factors may have upon them. To adequately conduct these studies, there is need for the development of techniques which will enable more accurate sampling of organisms in the natural environment.

The report also notes the need for a center for gathering and distributing ecological information.

In the Message on Natural Beauty, President Johnson "... asked the Director of the Office of Science and Technology and the Director of the Bureau of the Budget to recommend the best way in which the Federal Government may direct efforts toward advancing our scientific understanding of natural plant and animal communities and their interactions with man and his activities".

This study, which is currently nearing completion, will include evaluation of topics relative to S. 2282. It will include a summary of the activities of Federal agencies which contribute to the advancement of understanding of natural plant and animal communities. The present legislative authorizations and the Federal organizational structure that pertain to this subject are being reviewed as well as the needs for further ecological research and suggested priorities.

In conducting this study the agencies were requested to:

1. Provide a description of their activities which contribute to improved understanding of natural communities and of the effects of environmental change on indigenous organisms.
2. State the objectives for undertaking the work.
3. Describe significant interagency arrangements for making cooperative studies.
4. Estimate the level of effort for FY 1965 and 1966 in terms of expenditures.
5. Estimate in-house professional staff resources currently employed in the studies.
6. Indicate the total number of grants let during FY 1965 and the overall amounts of such grants.

We have received response from eight agencies and the results have been summarized and analyzed. Additional information is currently being sought from two of the agencies.

The next phase of the study will be to submit our analysis to the agencies for review and comment which we plan to do shortly. Following this step the final version of the report will be prepared.

The following agencies of the Federal Government are concerned with natural plant and animal communities and their interactions with man: the Department of Agriculture, the Atomic Energy Commission, the Department of Commerce, the Department of Defense, the Department of Health, Education and Welfare, the Department of Interior, the National Science Foundation, and the Smithsonian Institution.

Expenditures reported by the agencies for their research and survey activities during FY 1965 amounted to about \$87,000,000 for in-house activities plus about \$26,500,000 for grants and contracts. This totals about \$113,500,000. Analysis of the scope and objectives of the programs show, as could be expected, that most

of these activities are strongly mission oriented. In general, both the in-house and sponsored research are concerned with economically valuable species, such as those used by man for food or fiber, foods of domestic and game animals, and pests and disease organisms. Considerable attention is being devoted to recreational facilities and game species of birds and mammals and a large part of the expenditures is utilized for studies of soil stability and hydrologic processes.

The total expenditures are distributed approximately as follows:

	Percent
Surveys and inventories.....	33
Research relative to the production of foods and fibers (forestry 9 percent, agricultural products and food fish 14 percent).....	23
Research on native plants and animals and their interactions with man....	14
Research on soil and water usage and conservation.....	12
Taxonomy and other supporting activities.....	7
Ecological research related to health, pollution and pest control.....	5
Ad hoc evaluations.....	1
Miscellaneous.....	5

A considerable portion of the 14 percent classed as *research on native plants and animals and their interaction with man* is indirectly mission oriented such as studies of the food organisms of fish and game birds and mammals. Most of the basic ecological research is supported by the National Science Foundation, the Atomic Energy Commission and the Smithsonian Institution.

It is planned that this report will be completed before the end of this session of Congress.

Senator NELSON. Next is Dr. Sidney Galler, Assistant Secretary for Science of the Smithsonian Institution.

STATEMENT OF DR. SIDNEY GALLER, ASSISTANT SECRETARY FOR SCIENCE, SMITHSONIAN INSTITUTION

DR. GALLER. Mr. Chairman and members of the committee, in behalf of the Board of Regents and the Secretary of the Smithsonian Institution, we thank you for the privilege of appearing before this committee this morning.

Secretary Ripley asked me to extend his apologies and regrets for not being able to appear this morning. There are compelling reasons for his absence. He is a member of a steering committee dealing with ecological problems on a worldwide basis that is meeting today.

We have a rather lengthy statement for the record, and if it is acceptable, I would like to summarize the salient points.

Senator NELSON. We appreciate it very much, and your statement will be printed in the record in full.

DR. GALLER. Thank you, sir.

I will defer comments on the organization proposed in S. 2282 pending the completion of the study that is being conducted under the auspices of the Office of Science and Technology and the Bureau of the Budget pursuant to the President's message of February 1965.

However, I wish to state for the record that the scientific principles recognized and enunciated in S. 2282 are both sound and most encouraging to those of us sitting in what I call the "gray world" of basic science management and administration, who, on the one hand, discern the unfortunate consequences of an ecological laissez-faire in a rapidly shrinking world and in our country in particular; and who, on the other hand, are aware of the intellectual resources and the research tools that could be marshaled and collated to produce a body of basic ecological knowledge that would serve mankind in the

management not only of his resources but in the management of himself in relation to his changing environment.

No single institution and no single faculty in this country has either the full spread of technical competence or scientific resources necessary to develop a full and comprehensive ecological program of the kind that is enunciated in S. 2282.

For example, we, in the Smithsonian Institution, as mentioned by Dr. MacLeod, have been engaged in ecological and taxonomic economic research for many years. However, we feel that we would be unable to cope with more than a part of the total basic ecological effort in the event that there was established a full-blown program in ecology. Nonetheless, the sense of this bill is such that it would permit institutions such as the Smithsonian Institution and universities and nonprofit organizations throughout the country to reexamine their roster of specialists and facilities in systematic biology and environmental biology to determine what needs to be done to reinforce their intellectual and scientific contributions to the orderly development of an ecological program as comprehensive and important as the one enunciated in S. 2282.

I think, for the record, there needs to be made a clear distinction between fundamental research in ecology, which I consider to be the search for and the discovery of the basic ecological principles and what I would call mission-oriented ecological research, which is essentially the exploratory development and application of ecological principles to the management of our resources.

I know that I may be challenged by some of my colleagues sitting in other agencies in presenting you with my own personal estimate of the dollars that are being invested in fundamental non-mission-oriented ecological research. It is my personal considered estimate that less than \$5 million in 1965 were invested in the acquisition of basic knowledge and the discovery of new ecological principles in contradistinction to an estimate of well over \$200 million for what I call the mission-oriented exploratory development and application of ecological principles to the management of resource problems already identified.

In summary, Mr. Chairman, I feel that members of the scientific community—and I do not propose to serve as a spokesman for the scientific community, but merely to articulate the views that I have already received from colleagues in universities and elsewhere—are much encouraged by the fact that our legislative bodies are recognizing the importance of discovering new and augmenting our existing body of basic knowledge in ecology and applying it in a systematic way toward the solution of some of our ever more urgent resource management problems. Thank you.

Senator NELSON. Thank you very much, Doctor; we appreciate your coming this morning. We will include Dr. Ripley's statement for the Smithsonian Institution at this point in the record.

(The statement referred to follows:)

STATEMENT OF DR. S. DILLON RIPLEY, SECRETARY OF THE SMITHSONIAN
INSTITUTION

When European settlers first established themselves on the shores of what is now the United States of America they found a continent of such richness and variety as had not been dreamed of by the inhabitants of a Europe left impover-

ished by the Glacial Period as well as crowded and overused by the competitive civilization that had developed since that Period. The exploitation and development of this continent at the same time led to the evolution of the traditional American character and culture and provided the stimulus and material means for formation of the unprecedented technological civilization of today. During the rise of what we now proudly refer to as American civilization we were too busy to give much attention to any effects this progress had on the continent that gave it birth and nourishment, or even to pay very much attention to acquiring knowledge of our environment other than that directly necessary for its effective exploitation. American science acquired a reputation abroad for heavy over-emphasis on the applied aspects and for parasitic dependence on Europe for the basic knowledge utilized in practical technology.

So long as the required basic science was mostly in general fields that had no geographic aspects and so long as the wiser and older European science could provide what was needed, few people worried about this state of affairs. It was only when we began to need information that directly concerned our own American environment that the situation had to change. The few decades before and after 1900 saw these requirements develop, and this was when the Geological Survey and the Biological Survey were established by the U.S. Government, and when the science of ecology developed in America. The Geological Survey, dealing with a science of obvious practical importance, was strong enough to maintain itself as an agency principally concerned with fundamental research. Ecology was not so clearly practiced nor so easily understood, and the Biological Survey was, during the depression days of the 1930's, absorbed into an agency preoccupied with the easily understood task of providing better hunting and fishing for those who needed these resources as recreation or as means of livelihood.

During the last 75 years there has been a scattering of people who were able to look beyond the unprecedented burst of growth and prosperity and worry about what our exploitative economy was doing to the environment and to the apparently bottomless cornucopia of free natural resources on which it was founded. A few of these voices have been strong enough, and a few of the inroads on the environment serious and obvious enough in their economic efforts, so that such major breakthroughs occurred as the establishment of the U.S. Forest Service and the Soil Conservation Service. Both of these have recognized that ecological research is necessary to their functioning. Their missions, however, have been strictly economic and their research mainly of an applied nature.

It is only in the last 10 or perhaps even only the last 5 years that there has begun to be a public awakening to what has been happening to our environment as a place to live, rather than merely as a place to make money. Perhaps it was the smog in Los Angeles that was the triggering mechanism. Southern California had for three quarters of a century prided itself and advertised itself, with ample reason, as the pleasantest place in the U.S. to live. That this had at least a considerable element of truth is obvious from the hordes that migrated there to spend their lives. When they began to wake up in the morning with eyes brimming with tears and with parched and choking respiratory systems, to look out on a gray smoky sky, and to notice that their beautiful green orange trees were looking sick, a protest arose.

Encouraged by this protest, those who were becoming afraid to swim in the rivers and streams that they had enjoyed as boys, and dismayed that their children could not be allowed to enjoy the same pleasures because of the reek of raw sewage and industrial wastes, began to speak up. Those bothered by the accumulations of solid wastes joined in. And people began to realize that the ugliness that had been increasingly obvious to them was not merely a local affair, but a blight that is afflicting the entire country.

Alarm over the dangers of increasing radioactive fallout was reinforced by the mounting suspicion that the succumbing of birds to pesticide poisoning might merely be a precursor of what would soon be happening to people. Rachel Carson's book, *Silent Spring*, dramatically brought this to the attention of millions who had never even thought of such things before. Even the screams of anguish and rage from those whose pocketbooks were hurt by this awakening public consciousness helped to focus public attention on the fact that what was happening to the environment in which we all must live was not clear, and was possibly bad. Such attention could scarcely avoid the discovery that many more things were wrong than had previously gained attention. The more intelligent among the public began to look to science to answer their worried

questions. It did not take long to find out that the old-line, traditional sciences were incapable of providing anything approaching complete or adequate answers. Almost immediately it became evident that only ecology, a timid, relatively obscure newcomer in the company of major branches of science, by its own frame of reference, could conceivably furnish answers to such questions involving the total environment and the relations of organisms, including humans, to it. The Ecological Society of America, in 1962, took its courage in its hands and abandoned its former position of "no comment" on matters of public interest and established a Committee on Public Affairs.

In the course of ten years, the word *ecology* has changed from a relatively obscure scientific term to a household word—it is even seen in newspaper headlines. Enormous sums of money are allocated to projects that are essentially ecology—though almost all of an applied nature. Practical answers to a great many specific ecological questions are readily available, especially if the questions touch on economic or medical problems. The science of ecology, probably largely because of this preoccupation with practical questions, is a very healthy and active one. By its very nature its interests are very diverse and scattered, and it is hard even to formulate a rigorous definition of ecology, and even harder to describe succinctly what ecologists do. Most of them are busy trying to fit the enormous array of information produced by many sciences, including ecology, into a picture of the relationships between organisms and their environments. Certainly 90% of ecologists would say that ecology is the study of these relationships. Most of them, if pressed for a fuller answer, would probably reply by describing what they, themselves, were doing.

It is only very recently that the concept of ecological systems, more and more commonly called *ecosystems*, has begun to be recognized as the central idea of ecology. It is difficult, but clearly necessary, to look at nature as a whole—as an incredibly complex interacting system, a system of systems, if we are ever going to be able to understand it. And until we understand it, we are inevitably going to continue to make mistakes in our attempts to modify and manipulate it to our advantage. We will continue to learn the hard way, by our mistakes, each of which results in a more impoverished and more unfavorable habitat for ourselves and our descendants.

At the present time there is no place to go for answers to these major questions about the system of which we are a part. Partial answers are easily acquired. If we compare them we will find that they do not agree at all in many respects with each other. They are answers derived in certain particulars, usually practical contexts, biased by the aims of the researchers and their sponsors who have worked them out. Since they only have asked the questions dictated by these aims, they have gotten answers only in these terms. The right questions concerning the total environmental system have not been asked, since there has been no agency whose task was specifically to ask these questions.

The problems raised by these questions are incredibly complex and difficult. The problems of the behavior of the components of the nuclei of atoms are simple by comparison. We think nothing about providing \$375,000,000 for a 200-Bev accelerator and the laboratory to use it. We hope that many of the fundamental questions of ecology can be solved for much less than this order of magnitude of figures. However, as we look at the future of our shrinking world and the geometrically expanding numbers of people that will inhabit it, it seems clear that even though the costs could be several or many times this, we cannot much longer delay starting to develop the necessary understanding of our eco-system to enable us to deal with coming problems.

The problem is too big to be faced in its entirety by any private or local institution or organization. It is too important to be left to a Federal agency that has something else as its main mission. And it is too difficult to be entrusted to the hands of any except the best brains available at any price.

The Smithsonian Institution, which I represent, has within the past year initiated a program of environmental biology designed to shed light on certain of the problems discussed above. It has, already, capability to work with advantage on certain of the aspects involved, and to provide essential support activities. Recognizing the urgency of developing an unbiased understanding of what is happening to the world ecosystem, and of some of the ecological processes contributing to our continued welfare in it, the Smithsonian has determined to place a substantial share of the resources at its command into an investigation of certain of these aspects of ecology. It has no illusion that it,

or any other institution, can alone find solutions to even the most urgent problems in time for them to be of most use in halting the degradation of our environment. Therefore, it would welcome a well planned and effective Federal effort to stimulate and foster the necessary action to cope with this situation.

The goal of the new Smithsonian program in environmental biology is to form a small group of some of the best research scholars who will integrate their efforts to (1) contribute to theory in population biology and (2) provide information essential to the Federal Government in the evolution of our society in the critical years ahead. Population biology means the study of groups of living organisms, including man, particularly with reference to their environmental inter-relationships. Major breakthroughs in population biology are vital to establishing a harmonious relationship between man and his environment. To ensure rapid advances, the Smithsonian Institution is provided with a level of freedom in research, travel, consultation, and postdoctoral education difficult to match in Government agencies or in the nation's universities.

The core of the Smithsonian's own program emphasizes a concentration of talent and effort on the three most important growing points in environmental biology, identified as:

- (1) Systems analysis of populations by computer simulation.
- (2) The cycling of energy and materials in ecosystems.
- (3) The role of social behavior in the natural regulation of animal numbers.

These three areas are the most likely to contribute effectively to the evolution of conceptual unity in environmental biology, and they hold the greatest promise for significant advancement in the science. They point the direction in which the Smithsonian Institution will commit its program in ecology. The program envisioned would provide scientific background for problems concerning the human population explosion, environmental health, and production of food. In keeping with Smithsonian tradition, the program is designed for research on the fringes of knowledge and concentration on international studies.

S. 2282 reflects the growing concern about ecological problems. One of the most urgent national needs, as pointed out by the Ecological Society of America, is for a clearinghouse for evaluation and dissemination of information on ecological problems. An interagency committee on ecology to coordinate Government programs will be required soon. The need for setting up special areas for scientific research cannot be overemphasized. We have already lost much information of significance to environmental and evolutionary biology by failing to document the changes taking place in plant and animal communities under man's impact. The provision for grants to universities, other organizations, and individuals is essential for encouragement and education of ecologists, who are already in short supply.

The President, in the Natural Beauty Message of February 8, 1965, asked the Director of the Office of Science and Technology and the Director of the Bureau of the Budget "to recommend the best way in which the Federal Government may direct efforts toward advancing our scientific understanding of natural plant and animal communities and their interaction with man and his activities."

While we offer the above comments for the consideration of the Committee, we believe it would be best to defer further action on S. 2282, pending completion of an OST-BOB study which is under way pursuant to the President's directive. The recommendations made as a result of that study should offer the best way to accomplish the objectives of improving and expanding our ecological programs.

In summary, we at the Smithsonian Institution find increased efforts in ecology to be worthy of strong support. This is a program that is vital to the future of the United States. Throughout the history of the world, various nations have risen and fallen in accordance with overexploitation and deterioration of their resource bases. If we are to avoid the same pitfall, we must provide a scientific foundation for conservation, development, and effective use of our forests, grasslands, watersheds, and animal resources. Consideration of this subject comes at a crucial time in our history when we still have the potential resources to support a vigorous nation. It is essential to our survival as a nation to take effective action on these problems.

Senator NELSON. The next witness is Dr. John Cantlon, Program Director, Environmental Biology, National Science Foundation.

Doctor, we appreciate your coming and your testimony will be printed in full in the record and you may either read or extemporize from it, whichever suits your purpose best.

**STATEMENT OF DR. JOHN E. CANTLON, PROGRAM DIRECTOR,
ENVIRONMENTAL BIOLOGY, NATIONAL SCIENCE FOUNDATION**

Dr. CANTLON. All right, I will extemporize from it.

I would like to make clear for the record that this is a statement of an individual scientist who happens to be on the staff at a national science foundation rather than the official position of the foundation.

I have asked myself several questions about the bill. The comments of Dr. Galler relative to the encouraging signs represented by this awareness on the part of the U.S. Senate on problems of this nature is indeed encouraging.

There is no doubt in my mind but what the current situation does warrant an increase in attention to the matter of ecological activity based on studies as to our need for preserving inventory and studying the functions of natural and seminatural biological communities. The application and reasons for this I leave as the written record stands.

I would like to address myself to the more specific aspects of the bill as a personal consideration.

Does not the National Science Foundation now support research in this area and therefore could it not fill this need by augmentive funds? This requires a relatively complex answer. First of all, we do support research in this area. Our own environmental biology budget is between \$4 and \$5 million a year, only approximately half to two-thirds being directly related, however, to the areas considered by this bill.

In the disbursement of funds by the Foundation, we support only the most meritorious research proposals. The scientific merit, of course, is judged by a panel of peers and therefore we end up supporting through the years less than half of the proposals that come in. Usually it is nearer a third.

It is no more realistic to expect the National Science Foundation to support all of the research in this ecological area than it would be to expect it to support all of the research in health or in agriculture or forestry or oceanography or any other particular area.

Where the Federal mission agencies have missions, they should, in my judgment, support the applied and basic research which their particular task does require. We do not, of course, fight specific wars or attack specific plagues by hoping that outstanding scientists will address themselves to these specific problems. Rather, we marshal our forces, as one of the previous witnesses pointed out, and we proceed with the task at hand.

Now for this particular question, then, as to whether NSF could do this job, it is my personal feeling that inventory of the general U.S. picture and characterizing the fundamental aspects of specific biological communities for specific purposes will progress most rapidly if such a task is assigned to mission-oriented agencies rather than left to the National Science Foundation.

I would be completely remiss in my obligations to the National Science Foundation, however, if I were not also to note that past and

future research supported by the Foundation will be valuable, if indeed not indispensable, to the long-range path.

Now this, then, brings us to the question as to whether the Department of the Interior appears to me as a logical candidate for the mission-oriented Federal agency. I am inclined to believe that it is, in at least this respect. The Interior Department has jurisdiction over vast public lands that harbor natural and seminatural environments. They also include the Bureau of Commercial Fisheries and understanding and surveying natural environments should not, in my estimation, end at the shoreline. Further, this agency is charged to protect for posterity certain public monuments, national parks, national seashores, and so forth. This charge clearly calls for the protection of the entire natural array in its working conditions, in its normal functioning relationship.

I would like to ask, in connection with the bill: Is an extramural contracting or granting mechanism such as is called for here a favorable or unfavorable one for accomplishing the task that is here? I think it is prudent here to point out my obvious bias in this regard. I feel very strongly the extramural technique has two strong ingredients in its favor. It permits the utilization of a relatively more talented pool of scientists than would be the case if an entirely new array of biologists had to be recruited to do this task of inventorying, recording, and preserving. The available manpower pool in ecology is very small. The source for new personnel tends to be the universities and at the present time removal of any of these people from their training function would be a disservice to our present state.

The extramural mechanism also, in contracting for this work, could actually augment training by the use of young people, by the use of supporting research assistants and research associates and so on. Therefore, this direct use of the extramural mechanism for accomplishing specific tasks in this regard could augment the training.

However, in the bill there is a statement that the Secretary of the Interior be permitted to administer funds for the purpose of training grants. I think this is open to question. Although the health agencies in HEW have been productive in this area, I am not really persuaded that the Department of the Interior would necessarily increase our efforts in this regard.

I would like to close my formal remarks with that and I thank you.

Senator NELSON. Excuse me. Are you referring to section 3(1)?

Dr. CANTLON. On training grants?

Senator NELSON. Yes.

Dr. CANTLON. Yes.

Senator NELSON. Is that page 5 of the bill?

Dr. CANTLON. Well, there is more specific reference to training grants. Maybe I had an earlier copy of this. Is that possible?

Senator NELSON. No. Top of page 7, section 8.

Dr. CANTLON. Yes, line 14, page 7, "for the purpose of training persons, including scientists, technicians, and teachers needed in the field of ecology and related fields."

Senator NELSON. All right. I thought you were referring to another section. Thank you very much.

(The prepared statement referred to follows:)

STATEMENT OF DR. JOHN E. CANTLON, PROGRAM DIRECTOR, ENVIRONMENTAL BIOLOGY, NATIONAL SCIENCE FOUNDATION

This statement is that of an individual scientist it does not represent an official National Science Foundation position on Senate Bill S. 2280. My remarks will be addressed to four questions I have asked myself concerning the Bill. I will amplify one of these at greater length.

1. Does the current situation warrant an increase in this country's efforts in preserving, inventorying and studying the functioning of natural and semi-natural biological communities? My reply is a clear "yes" which I shall amplify later.

2. Does not NSF now support research in this area; and, therefore, could it not fill the need if more funds were appropriated for this purpose?

The answer here is complex. First, we do support research in this area; and if we had more funds in the Environmental Biology Program, we could support a larger percentage of the meritorious proposals. Regularly over the years we have been able to support less than half of the investigators requesting funds. However, it is no more realistic to expect NSF to support all research activity in this particular area than it would be to expect the Foundation to be the sole source of support for research in the medical, atomic, space, oceanographic, agricultural or geological fields. Where Federal agencies have missions, they should, in my judgment, support the applied and basic research which supports that mission. Only in this way can we expect to marshal adequate research capability at particular places and times to solve specific problems. We do not fight specific wars or specific plagues by hoping that outstanding scientists will choose appropriate problems and solve them. However, the inter- or extramural scientific competence which the Public Health Service or Department of Defense brings to bear upon specific problems does draw on the accumulated fundamental knowledge gathered by scientists, many of whom had no, or quite different, applied problems in mind when the discoveries were made.

For question number 2, then, my personal feeling is that the task of inventorying the general U. S. picture and of characterizing the functional aspects of specific biological communities will progress most rapidly if such a task is assigned to a particular mission-oriented federal agency. I would be completely remiss in my obligations to NSF, however, if I did not also note that past and future research supported by the Foundation will prove valuable indeed, if not indispensable, to the long-range task.

3. Is the U.S. Department of the Interior a logical candidate for the mission-oriented Federal agency to which these tasks should be assigned?

I am inclined to believe that it is. Indeed, the present mission of the Department of the Interior would appear to me to demand by inference what is in this bill. They have under their jurisdiction vast public lands harboring natural and semi-natural environments. They also include the Bureau of Commercial Fisheries; and understanding and surveying natural environments should not, in my estimation, end at the shoreline. Further, this agency is charged to protect for posterity certain public monuments, national parks, national seashores, etc. This charge calls for the protection of entire natural arrays of biota and their sustaining habitat solely for their intrinsic characteristics.

4. Is an extramural contracting or granting mechanism a favorable or an unfavorable one for accomplishing this task?

Here I am undoubtedly biased. But I feel strongly that the extramural technique has two ingredients in its favor:

(a) It permits the utilization of a relatively more talented pool of scientists than would be the case if an entirely new array of biologists had to be recruited. The available manpower pool in ecology is very small, and to remove any significant number from the universities would reduce the training capability at a time when it needs increasing.

(b) The extramural mechanism for contracting much of this work could augment the training of new ecologists at a time when more are needed in other areas in the Federal science establishment. Whether the Department of the Interior is the best agency for administering grants solely for this purpose of training, I think, is open to question. Although the health agencies of HEW have been productive in this arena I am not persuaded that it should be repeated in the Department of the Interior.

To amplify my assertion that increased attention is warranted in the area of preserving, inventorying, and studying the operation of natural and semi-

natural ecological systems, I choose the purely practical argument that these arrays of organisms harbor vast amounts of potentially useful information. It would be utterly repugnant to all except the hard-core anti-intellectual to encourage a madman to tour world libraries randomly destroying books. Such a practice permitted to continue unabated would surely result in the total loss of some works and the disappearance of the local translations of others. The genetic information contained in species populations as well as the ecological information content of the total functioning array of organisms in an ecological system represents an irreplaceable resource. It is a resource not as well used by modern scientific man as it was by preceding cultures and a resource that is still pitifully poorly known. In today's technologically advanced thinking, we are inclined to consider man's destiny related to a relatively small portion of the total number of other organisms on earth.

All of the important plants and animals used by man were domesticated before he began to write history. The ancestors of each of these organisms were, of course, components of natural biological communities which, together with the non-living environment, we call an ecological system.

We have come to appreciate that, in natural biological communities, each organism is genetically programmed to respond to most other organisms in his community, i.e., he has genetic information that tells him how to capture, or how to avoid, or how to out-compete, or how to steal from, or how to resist, or how to invade almost every other critter he has to live with. The domestication process can be thought of as the brain-washing of the domesticant. In this process man does for the domesticant many of the things it used to have genetic information to perform and for which task it expended parts of its energy and materials. As mutations resulted in the loss of this information, the losses were not lethal as they were prior to domestication. As still other mutations occurred which permitted materials and energy, formerly used to perform the lost function, to be converted to increased yield, man selected and perpetuated these. We have ended up with fat, dumb, highly efficient and highly dependent domesticated organisms.

The increase in complexity of things man does for his domesticants and the increase in breeding in the scientific era has accelerated this process enormously. Pesticide problems, high fertilizer and water requirements, changes in disease susceptibility alert us that we dare not jettison the non-domesticated close relatives of our useful species. Further, understanding more about how natural arrays can so effectively retain such nutrients as phosphorous and potassium and sulfur suggest that we could profitably study the cycles of these materials in natural ecological systems. On a long-term basis, man may have to reincorporate more genetic information into his domesticated species, as well as use biologically more complex ecological systems. The only source both for genetic information in species and ecological information on how these natural ecological systems function is to be found in the remnants of the earth's formerly vast natural landscapes.

Accelerating population growth and the recent trend toward genetic uniformity and vast field size in agriculture combine to restrict the natural arrays to an ever more insular character. Recent study suggests that islands cannot retain as high a biological diversity as a comparably diverse piece of mainland. This seems to relate to the now rather obvious situation that species with small population sizes disappear locally for various reasons, such as disease, competition, etc. Migration to islands is slower than migration overland for terrestrial species. The increased stress placed upon the insular preserve by man makes local extinction even more probable, e.g., the transport of diseases and pests via man's transportation system as in the case of the chestnut blight fungus from China, or the unintended impact of pesticides, atmospheric pollution or climate modification. All these represent more stress for some local populations. The preservation of one island of a type is frightfully poor insurance against the loss of its constituent species. Further, we know essentially nothing about the minimal size necessary to maintain the natural biological diversity of particular ecological systems. We feel reasonably certain that it takes more area of suitable habitat to keep a viable population of puma than of jumping mice, but our hard knowledge is discouragingly inadequate.

One final point should be made. Preservation of natural and seminatural habitats, harboring the highest biological diversity, is not incompatible with many uses to which man may put these areas. In fact, with improved ecological

knowledge, such utilization may enhance rather than degrade both the genetic and ecological information content of the systems as well as its other values to man.

In summary, then, my argument for this bill has not been one stemming from aesthetic criteria, although I personally feel that these also deserve great weight. Rather, my argument is that we have an irreplaceable resource of genetic and ecological information, much of which we cannot prevent from losing unless we take specific steps soon. The relative priorities need to be established and the tasks initiated to guarantee that our descendants will inherit an earth, hopefully, as rich and, potentially, biologically richer than our own.

Senator NELSON. The next witness is Dr. Ketchum, president of the Ecological Society of America, and associate director of the Woods Hole Oceanographic Institution.

Dr. Ketchum, your testimony will be printed in full in the record, and you may read or extemporize, whichever may be more desirable. We will run into the pressure of time and I don't like to crowd anybody. We will have two rollcalls this afternoon, and it will be necessary for me to leave when the rollcalls start. This way we hope to be able to get everybody on the record here before that time.

STATEMENT OF DR. BOSTWICK H. KETCHUM, PRESIDENT, ECOLOGICAL SOCIETY OF AMERICA, AND ASSOCIATE DIRECTOR, WOODS HOLE OCEANOGRAPHIC INSTITUTION

Dr. KETCHUM. Mr. Chairman, I will be happy to give an abbreviated statement concerning my report which you have before you.

I am honored to have this opportunity to speak before you today concerning the need for a program of research, study, and surveys of the natural environmental systems of the United States such as is proposed in the bill S. 2282.

I earnestly believe that this bill provides a service for the benefit of mankind which is essential and is long overdue. The great engineering developments of the present century are modifying the natural environment at a rapidly increasing rate. Our expanding population will require further industrial production, and the further concentration of the population in urban areas will inevitably force an ever-increasing acceleration of these changes in our natural environment. Unfortunately many of the modifications of the environment are made without any clear understanding of what the effects will be.

Nature has a vast capacity to recover from the minor modifications of the environment which have been characteristic of the development of our present civilization during most of recorded history. Because of this capacity for recovery, man was lulled into a false sense of security, feeling that he could continue to use the water, the air, and the soil as an unlimited resource for exploitation and for the disposal of the waste products of our civilization.

There is, however, a limit to the ability of nature to recover from continuous abuse, just as there is a limit to the recuperative capacities of man himself. Because of our ignorance of the fundamental laws which govern and control the ability of natural populations to grow and survive under adverse conditions and also because the use of our environment has all too commonly been governed by immediate expediency and a very short-range economic point of view, we are now

faced with heavily polluted rivers, streams, and estuaries, with contaminated air and with devastated landscape.

Man's modification of his environment is proceeding at an ever-accelerating pace and it is essential for the protection of mankind that we now look at the total problem of our environment so that we may permit intelligent exploitation of our natural resources and, at the same time, provide for the preservation of these resources and natural beauty.

One of the most important results of the technological developments and progress of this century is our affluent society with the wealth to provide our people with leisure and the opportunity to enjoy the beauties and recreational advantages so abundantly provided by nature to a degree never before known to mankind. Unfortunately these same technological advances carry the threat of destruction—destruction of the very beauty and natural resources that man at last has the chance and the time to enjoy. Potentially, progress carries within it the threat of destruction of the health and welfare of man himself.

The problem facing civilization today is: "How can we enjoy the fruits of progress and at the same time preserve our natural resources and the beauty of our environment?" Technological advances will inevitably proceed, carried forward by the momentum of our great industrial development. There is no similar economic pressure for the study of the fundamental ecological laws which control the development and survival of natural populations; indeed the preservation of the environment cannot be achieved without additional expense.

In the long run, however, the very survival of mankind may depend on what we do today and in the near future to use and exploit our environment. There is a very real need for Federal support of ecological research if we are to use our environment to the best advantage not only for the present but for future generations.

I would like to discuss briefly some problems in my own area of scientific competence, namely the ecological problems associated with the pollution of our estuaries and coastal marine waters. There can be no doubt that the estuaries and harbors along our industrialized seaboard are heavily polluted. Today many communities and industries are making valiant and expensive efforts to correct some of the abuses of the past. However, many productive shellfish areas have been closed because of pollution or destroyed by man's thoughtless and careless activities. Many species of fish have been decimated or eliminated from their earlier homes. The recreational use of many areas has been seriously curtailed or eliminated completely.

Is this destruction of our natural resources necessary? I do not believe so. We have been careless and thoughtless in our approach to the problems of the disposal of the waste products of our technology but I believe that we can have our affluent society and still preserve the natural resources so essential to man's survival on this planet.

Pollution of the environment by an active, vigorous, and affluent society is inevitable. Indeed, I accept as one of the proper uses of the marine environment its capacity to dilute and disperse the waste products of society. However, this is not the only use which must be considered. The marine environment provides, of course, food resources such as commercial and sport fisheries, the clams, shrimp, lobsters, and

crabs of our estuaries, and recreational opportunities such as swimming and boating, surfing and water skiing.

All of these are not only a natural resource which should be protected but are also an economic resource of the country. The fisheries may be used as an example of the economic value of marine resources. During 1964 the fish landings in the United States produced an income to the fishermen of \$390 million. Since the cost of fish on the table is about triple the amount that the fisherman receives, this amounts to roughly \$1 billion of our gross national product. This is not an inconsequential part of our total affluent society. Boating and other recreational activities in the marine environment form a rapidly growing economic resource of our nation.

The basic problem in providing for waste disposal in an aquatic system is the evaluation of the quantity of waste which can be added without detriment to the populations living therein. Many of our waste products act as fertilizers and, if used sensibly, could increase the productivity of the sea rather than destroy it. The ability of a fresh-water stream to recover from the addition of domestic pollution has been well documented, but similar knowledge is largely lacking in estuaries, where the river meets the sea.

It is the role of the ecologist to study these problems and to develop the understanding of the factors which control the development and survival of populations so that reasonable and sensible limits for the contamination of these waters can be established.

The problems that we face in the contamination of our harbors and estuaries today can be traced, in part at least, to a lack of fundamental understanding of the circulation in these areas. For the first several decades of this century the ability of estuaries to dilute pollution was grossly overestimated because the engineering calculations were based upon a misinterpretation of the mixing and circulation processes within the estuary. I have, myself, made some contributions to the study of these problems, since a better understanding of the circulation and mixing within estuaries was essential for the assessment of the survival of planktonic and bacterial population.

Thus, research which started as a purely ecological study, contributed to the understanding of circulation which is essential for engineering developments and for the evaluation of the effects of the disposal of wastes in estuaries.

I mentioned above that there is a great need for Federal support of ecological research because there is no short-range economic incentive to support research of this type. I would like to emphasize another reason which makes Federal support desirable and necessary. Pollution of our streams, harbors, estuaries, and coastal waters have far-reaching effects and a pollutant added by one industry or municipality will be carried to another location, and even across State boundaries. Having been carried far from their source, waste materials may have direct effects on citizens who have no immediate stake in their production and no voice nor vote concerning their disposal but cannot escape their influence.

Thus the quality of the environment of these citizens is being impaired or destroyed without their knowledge or consent. The problems are, thus, of widespread importance and cannot be adequately treated by local communities.

A clean environment of high quality without excessive pollution should be recognized as one of the rights of mankind. This cannot be provided without cost. Since the benefits of an environment of high quality are widespread, the total costs can probably not be assessed solely against the producer of the pollutant. It seems inevitable and reasonable that the mass of the population which enjoys the benefits of an environment of high quality must be willing to support, financially, the development and maintenance of this quality.

I have emphasized in this presentation the pollution of the marine environment as one of the reasons why an ecological survey and study bill is required. It is clearly not the only reason, but it is the one on which I feel that I can speak with some professional experience. All of our efforts to restore and preserve the quality of our environment must be based upon sound, fundamental ecological studies in order to insure that our natural resources may be used with the minimum damage to our environment.

Ecological research has made rapid progress during the present century, but it is a young subject and the problems are truly complex. Each organism must have the proper environment in which to grow and survive; each organism modifies the environment and affects other living organisms with which it comes in contact. Man excels all other living things in the effects which he can produce because of his concentration in urban areas and because of his ability to harness vast sources of energy and thus to modify his environment more drastically than he could by his own unaided efforts. We have developed the ability to modify our environment; we must now develop the will, the understanding, and the ability to preserve our environment.

(The prepared statement referred to follows:)

STATEMENT OF DR. BOSTWICK H. KETCHUM, PRESIDENT, ECOLOGICAL SOCIETY OF AMERICA, AND ASSOCIATE DIRECTOR, WOODS HOLE OCEANOGRAPHIC INSTITUTION

I am Bostwick H. Ketchum, Associate Director of the Woods Hole Oceanographic Institution and Lecturer in Biological Oceanography at Harvard University. I have been engaged in research and teaching in the field of marine ecology since the mid-1930's. I am a Past President of the American Society of Limnology and Oceanography and am President of the Ecological Society of America. I am honored to have this opportunity to speak before you today concerning the need for a program of research, study and surveys of the natural environmental systems of the United States such as is proposed in Bill S. 2282.

I earnestly believe that this Bill provides a service for the benefit of mankind which is essential and is long overdue. The great engineering developments of the present century are modifying the natural environment at a rapidly increasing rate. Our expanding population will require further industrial production and the further concentration of the population in urban areas will inevitably force an ever increasing acceleration of these changes in our natural environment. Unfortunately many of the modifications of the environment are made without any clear understanding of what the effects will be.

Nature has a vast capacity to recover from the minor modifications of the environment which have been characteristic of the development of our present civilization during most of recorded history. Because of this capacity for recovery, man was lulled into a false sense of security, feeling that he could continue to use the water, the air, and the soil as an unlimited resource for exploitation and for the disposal of the waste products of our civilization. There is, however, a limit to the ability of nature to recover from continuous abuse, just as there is a limit to the recuperative capacities of man himself. Because of our ignorance of the fundamental laws which govern and control the ability of natural populations to grow and survive under adverse conditions and also because the use of our environment has all too commonly been governed by immediate expediency

and a very short-range economic point of view, we are now faced with heavily polluted rivers, streams, and estuaries, with contaminated air and with devastated landscape. Man's modification of his environment is proceeding at an ever accelerating pace and it is essential for the protection of mankind that we now look at the total problem of our environment so that we may permit intelligent exploitation of our natural resources and, at the same time, provide for the preservation of these resources and natural beauty.

One of the most important results of the technological developments and progress of this century is our affluent society with the wealth to provide our people with leisure and the opportunity to enjoy the beauties and recreational advantages so abundantly provided by nature to a degree never before known to mankind. Unfortunately these same technological advances carry the threat of destruction—destruction of the very beauty and natural resources that man at last has the chance and the time to enjoy. Potentially, progress carries within it the threat of destruction of the health and welfare of man himself.

The problem facing civilization today is: "How can we enjoy the fruits of progress and at the same time preserve our natural resources and the beauty of our environment?" Technological advances will inevitably proceed, carried forward by the momentum of our great industrial development. There is no similar economic pressure for the study of the fundamental ecological laws which control the development and survival of natural populations; indeed the preservation of the environment cannot be achieved without additional expense. In the long run, however, the very survival of mankind may depend on what we do today and in the near future to use and exploit our environment. There is a very real need for Federal support of ecological research if we are to use our environment to the best advantage not only for the present but for future generations.

I would like to discuss briefly some problems in my own area of scientific competence, namely the ecological problems associated with the pollution of our estuaries and coastal marine waters. There can be no doubt that the estuaries and harbors along our industrialized seaboard are heavily polluted. Today many communities and industries are making valiant and expensive efforts to correct some of the abuses of the past. However, many productive shellfish areas have been closed because of pollution or destroyed by man's thoughtless and careless activities. Many species of fish have been decimated or eliminated from their earlier homes. The recreational use of many areas has been seriously curtailed or eliminated completely. Is this destruction of our natural resources necessary? I do not believe so. We have been careless and thoughtless in our approach to the problems of the disposal of the waste products of our technology but I believe that we can have our affluent society and still preserve the natural resources so essential to man's survival on this planet.

Pollution of the environment by an active, vigorous, and affluent society is inevitable. Indeed, I accept as one of the proper uses of the marine environment its capacity to dilute and disperse the waste products of society. However this is not the only use which must be considered. The marine environment provides, of course, food resources such as commercial and sport fisheries, the clams, shrimp, lobsters, and crabs of our estuaries, and recreational opportunities such as swimming and boating, surfboarding and water skiing. All of these are not only a natural resource which should be protected but are also an economic resource of the country. The fisheries may be used as an example of the economic value of marine resources. During 1964 the fish landings in the United States produced an income to the fishermen of \$390 million. Since the cost of fish on the table is about triple the amount that the fisherman receives, this amounts to roughly \$1 billion of our gross national product. This is not an inconsequential part of our total affluent society. Boating and other recreational activities in the marine environment form a rapidly growing economic resource of our nation.

The basic problem in providing for waste disposal in an aquatic system is the evaluation of the quantity of waste which can be added without detriment to the populations living therein. Many of our waste products act as fertilizers and, if used sensibly, could increase the productivity of the sea rather than destroy it. The ability of a fresh-water stream to recover from the addition of domestic pollution has been well documented, but similar knowledge is largely lacking in estuaries, where the river meets the sea. It is the role of the ecologist to study these problems and to develop the understanding of the factors which control the development and survival of populations so that

reasonable and sensible limits for the contamination of these waters can be established.

The problems that we face in the contamination of our harbors and estuaries today can be traced, in part at least, to a lack of fundamental understanding of the circulation in these areas. For the first several decades of this century the ability of estuaries to dilute pollution was grossly over-estimated because the engineering calculations were based upon a misinterpretation of the mixing and circulation processes within the estuary. I have, myself, made some contributions to the study of these problems, since a better understanding of the circulation and mixing within estuaries was essential for the assessment of the survival of planktonic and bacterial populations. Thus, research which started as a purely ecological study, contributed to the understanding of circulation which is essential for engineering developments and for the evaluation of the effects of the disposal of wastes in estuaries.

I mentioned above that there is a great need for Federal support of ecological research because there is no short-range economic incentive to support research of this type. I would like to emphasize another reason which makes Federal support desirable and necessary. Pollution of our streams, harbors, estuaries, and coastal waters have far reaching effects and a pollutant added by one industry or municipality will be carried to another location, and even across state boundaries. Having been carried far from their source, waste materials may have direct effects on citizens who have no immediate stake in their production and no voice nor vote concerning their disposal but cannot escape their influence. Thus the quality of the environment of these citizens is being impaired or destroyed without their knowledge or consent. The problems are, thus, of widespread importance and cannot be adequately treated by local communities.

A clean environment of high quality without excessive pollution should be recognized as one of the rights of mankind. This cannot be provided without cost. Since the benefits of an environment of high quality are widespread, the total costs can probably not be assessed solely against the producer of the pollutant. It seems inevitable and reasonable that the mass of the population which enjoys the benefits of an environment of high quality must be willing to support, financially, the development and maintenance of this quality.

I have emphasized in this presentation the pollution of the marine environment as one of the reasons why an ecological surveys and study bill is required. It is clearly not the only reason, but it is the one on which I feel that I can speak with some professional experience. All of our efforts to restore and preserve the quality of our environment must be based upon sound, fundamental ecological studies in order to insure that our natural resources may be used with the minimum damage to our environment. Ecological research has made rapid progress during the present century, but it is a young subject and the problems are truly complex. Each organism must have the proper environment in which to grow and survive; each organism modifies the environment and affects other living organisms with which it comes in contact. Man excels all other living things in the effects which he can produce because of his concentration in urban areas and because of his ability to harness vast sources of energy and thus to modify his environment more drastically than he could by his own unaided efforts. We have developed the ability to modify our environment; we must now develop the will, the understanding, and the ability to preserve our environment.

Senator NELSON. Is Mr. Russell Train here?

Our next witness is Mr. Richard H. Pough, president of the Natural Area Council.

STATEMENT OF RICHARD H. POUGH, PRESIDENT, NATURAL AREA COUNCIL

Mr. POUGH. Mr. Chairman, I did not bring a prepared statement, thinking that a good deal of my statement would be covered, and I find that much has already been covered. I would like to comment, though, on one point that I think is important to make and that is: in the terms in which we are talking about ecology the applied research that we have heard described is not really ecological research; it is applied ecology in a very narrow sense and narrow framework.

I know much research is designed to cope with this specific problem and that is the basis on which most of the appropriations are made for this research, but this actually does violence to the principle of preserving and utilizing environmental research correctly because it is in a narrow frame of reference.

We say they are concerned with getting rid of a starfish, say, which is affecting the oyster beds and that under the terms that we heard today what would be described as ecological research, all they will end up with is some solution for getting rid of the starfish without any real knowledge of the ramifications of that and the repercussions that the starfish may have on other elements in the dead state.

I think it is very important and I hope the bill will lead us in this direction; that is, a true understanding of the ecosystems such as in order to understand the human body, we have to know better about its nervous system, circulation of blood and so forth, and in terms of the ecosystems we must analyze in terms of dealing with the body in terms of flow of blood through the system and how it passes from one organ to another and the allocation, say, of energy through the system by virtue of nutrients through the system and then we will begin to have a real understanding of the problem.

We do not have that kind of knowledge for any of our ecosystems in this country. The amount of money being spent on that kind of ecological research is trivial.

Now just to go beyond that we have an obligation to help countries in other parts of the world to understand how to use their biotic communities more intelligently. We are sending technicians today all over the world that are doing more damage than good when being translated into environments in nature that are involved where we have a higher community with large biotic masses with no knowledge of how man is to exploit that.

It is quite obvious, I think, to all of us, if nature can evolve communities where a high mass of living material is maintained per acre, there must be ways and techniques of beginning to make some of that land produce products of value to man. Today we have not come up with the answers and are not going to come up with them through applied ecology and simply the application of known techniques.

The reason we are in trouble today is their climate and their conditions are not suitable for growing the handful of crop plants that man and civilization depend on. If we are going to train men with the sort of knowledge that is going to be required to truly help the country solve the problem and not do irreparable damage, and we can see appalling damage done all over the world by well-meaning technicians that try to take our technology and use it in a completely unsuited way to the training part of this, which is an integral part of the whole effort which is of vital importance.

I might refer to my papers, one on the ecologic development of the tropics, and the tropics are a misunderstood ecosystem and this indicates today we are destroying these environments and not turning them into long-range productive source of products that we need.

I think this bill is very important and the place to begin, of course, is at home. It is to truly understand the things so that the fish and wildlife people, when they want to do something such as dike off a salt

marsh, will not do more damage than good. Are they adding more water power in this case? This research is simply to find out how to make a better habitat for ducks, and what would happen because of the diking off, what happens to fish that would migrate for a great distance—and we are gravely concerned in terms of migratory birds, about what happens to the environment when they spend half of the year in Central and South America, which we don't know—and these are all things tied together which, until we really begin to understand the nature of these ecosystems and study them in the same terms we study our living, whether it is animal or plant, the ecology, we are going to continue, in my opinion, to make serious mistakes.

So my plea, on behalf of this organization, is the authorization of some agency to delve into it as pure science.

We in America have a reputation all over the world of taking fundamental knowledge and applying it. I think research is seeking for knowledge and not just seeking for answers to questions. I don't think we should consider that type of research in the same context as the research that this bill envisions. Thank you.

Senator NELSON. Thank you very much. We appreciate your coming and appreciate your testimony.

Out of order, I will call Dr. John C. Calhoun, vice chancellor, Texas A. & M., College Station, Tex. He has a commitment shortly and I understand will summarize his testimony. You have a prepared text?

**STATEMENT OF DR. JOHN C. CALHOUN, JR., VICE CHANCELLOR,
TEXAS A. & M., COLLEGE STATION, TEX.**

Dr. CALHOUN. I do. Senator Nelson, I have given out copies and ask that it be placed in the record and I will make a few points extemporaneously.

Senator NELSON. It will be printed in full at the end of your oral presentation.

Dr. CALHOUN. You realize that I don't appear here with any professional competence as an economist. I was in the Department of the Interior when Secretary Udall named a task force on the question. What I have to say to you are points which I observed in serving as adviser and I think Secretary Udall himself placed this entire question in perspective in an article he wrote for "Biosciences," and I want to take time to read the initial paragraph of that article and I am quoting:

History will give a name to the time in which we live just as it has for the Ice Age, the Iron Age and other periods of the past. Our time has already been labeled the Atomic Age and the Space Age. To my way of thinking it will more likely be known as the Era of Ecology. As history moves on, our times will be known as the age in which man learned to admit that he is part of the balance of nature—the age in which man began to assess the negative as well as the positive sides of his actions—the age in which man joined his perspective on technology with a perspective on his environment.

Senator NELSON. My commentary on that is when modern man learns he is part of the natural environment and not over and above it, he will have then caught up with the Indian.

Dr. CALHOUN. Senator, I think this is the point that is before us. Man is only one part of the biological system of this world. He is,

however, the primary manipulant of this world and we must recognize that the manipulations which we make bears not only on our economics or upon our standards of living or upon our comforts but they also bear upon the whole biological network. It seems to me that is what we are really looking at.

I see three points that need to be emphasized. We are at the present in the position that we have no record of what has been done. We are today trying to assess whether or not we have made any money or are worth any more than we were in the past, but we don't know what our balance was before we started. It is true that we can assess the conditions of estuaries or rivers now or of plants after we have applied pesticides or built dams or polluted them, but we don't know what we had before, so even after we make the measurements we will not be able to say whether we have a plus or a minus score.

Now, lest the future generations be in the same fix that we are in now, we had better make a start. That is the first point I think that is important.

The second thing I think needs to be emphasized is that we don't really know what we have to protect. All the arguments which I hear—arguments pro or con for a dam, for instance, as we are talking about with the Navasota River, in Texas, are in terms of increased water supply, land that had been inundated, recreational values—no one poses any arguments either pro or con concerning the species that will be obligated or the impacts that will ensue upon the biological system. They may be positive or may be negative, I don't know, but the point is neither does anybody else.

We need some kind of an inventory, some kind of a record. We do this in other areas, in geological survey with respect to geology, in manpower, in census, and in weather and why shouldn't we do it with respect to our biological systems.

The third thing I see that we lack is the ability to make any prior predictions of where we might go and this gets to the relationships of ecology, which I heard mentioned earlier, and the need for basic research.

We cannot really predict the future of any system unless we know the components of the system, the parameters that control it, the relationships that obtain within the system.

So far, we make all of our decisions, our prior judgments on whether we feel better or how it strikes our emotions. We are in the position of the man who takes a drink without realizing or asking himself at all what this may do to his system in the long run. We only know what it will do for us in the immediate near future.

Now, I would like to make two points about the place for this, or its focus, or the authorities that exist. As I see what we have now in the area of ecology in the Federal structure there is a piecemeal approach. Everything we do is mission oriented. Our effort is not focused and it is the staff that falls between the chairs, as the saying goes, that we need to pay some attention to.

I think we see here an operation of a bandwagon principle. Ecology is a word that people have started to use and we ask for summarization of what people are doing and they all tend to aggrandize their own effort, so you ask for a listing and you find out that you get

10 times what is actually going on because everybody will use this definition to try to cover their effort, if they can.

I saw this operate in the area of water resources and I saw it operate in other areas. I think somebody already made this point but I think our total effort in ecology is actually very small if one really gets down to an understanding of the biological basis which controls us and everything around us and the things we need to know in order to make our decisions.

I appreciate the opportunity to be here and I appreciate your taking me out of order.

Senator NELSON. Thank you very much. Your prepared statement will be printed at this point.

(The statement referred to follows:)

STATEMENT OF DR. JOHN C. CALHOUN, JR., VICE CHANCELLOR, TEXAS A. & M., COLLEGE STATION, TEX.

Mr. Chairman and members of the Senate Committee on Interior and Insular Affairs, I welcome this chance to give a statement endorsing Senate Bill 2282 to authorize the Secretary of the Interior to conduct a program of research, study and surveys, document and description of the natural environmental systems of the United States.

My name is John Calhoun and I am employed by the Texas A&M University System, College Station, Texas, as its Vice President for Programs. I am appearing here today to express my personal views on this legislation. No endorsement on the part of my employer is intended.

In 1964, as Science Adviser in the Department of the Interior, I chaired a task force, created by Secretary Udall, to study and report to him what needed to be done to fill the gaps of understanding concerning our living environment and to make the use of that knowledge more effective. The task force study concluded that there were indeed many piecemeal concerns in the federal government for natural environments, but that the whole was covered only in a minor way. The task force could see no existing mandate for anyone to carry on a program which would give decision makers the kind of information needed for accurate assessments of the environmental consequences of their decisions.

The task force assembled a list of desirable actions and with the assistance of legal counsel drafted proposed legislation very similar to that which is before you in S. 2282. Consequently, I am very pleased to see this matter come before the Congress for consideration, and I wish to speak in favor of its passage.

The November 1964 issue of *Biosciences*, a monthly publication of the American Institute of Biological Sciences, carried a "Message for Biologists" by Stewart L. Udall, Secretary of the Interior. I think that article ought to be a part of your record. In it Secretary Udall wrote a paragraph which places this entire question in its right framework. He said:

"History will give a name to the time in which we live just as it has for the Ice Age, the Iron Age and other periods of the past. Our time has already been labeled the Atomic Age and the Space Age. To my way of thinking it will more likely be known as the Era of Ecology. As history moves on, our times will be known as the age in which man learned to admit that he is part of the balance of nature—the age in which man began to assess the negative as well as the positive sides of his actions—the age in which man joined his perspective on technology with a perspective on his environment."

It is a basic fact that man's welfare is tied to nature and to the total system of life. Our major attention has been directed to the use of nature for building our economy, for raising our standard of living, and for overcoming the hardships of existence. These goals we must continue to pursue, but our goals must also include the welfare of man as it is linked to the welfare of the totality of living things.

The most elemental thing about our present situation is that we do not know the record of what we have done. We are faced with situations that are assessable only after the fact. It is as though we wanted to establish whether

we had made money on an investment, but knew only how much money we had after the fact, not how much we were worth before the investment.

So, with man's manipulation of his environment, we may be able to evaluate the present aquatic life in a stream or reservoir where a dam has been built. We may be able to count the birds after pesticides have been applied. We may be able to assess conditions of an estuary which is now filled with pollution. But, we have nothing to use as a comparison because we did not make any measurements before these events took place. We do not know what has really happened to life around us as a result of these steps we have taken to advance our economy.

Each of us recalls in the context of his own experiences and we have a very definite tendency to glamorize our memories. I remember as a boy, snow much greater in depth than it was, I am sure; and fish seem to have been more plentiful within the streams of my childhood than, I am sure, they were. We need to get away from such individual assessments. Although they are meaningful to the individual, they do not constitute a scientific measure. As we try to assess today the effects of dams upon rivers and estuaries, or of pesticides upon birds and wildlife, we are usually at a loss for the simple reason that no one bothered to make and record the facts against which we could compare our present situation. Lest the generations of the future continue to find themselves with respect to the past in the same situation we are now, let us begin to make an inventory and a record. Let us gain the ability to make an accounting.

The second thing that strikes me about our existing problem is that we do not know nearly enough about what there is to protect nor where it is. We need an inventory of existing resources as a basis for identifying the desirable and positive assets of living systems.

Close to my home on the Navasota River in Texas there has been talk about building a dam for some years. The arguments heard have been primarily the advantages to water supply, the added recreational values or the loss in land values due to inundation. At no time during the discussion have I heard arguments pro or con concerning the effect of this installation upon the natural biological system. At this stage it would be very difficult to list the positive and negative values and have them entered into the decision making process, because the biological resources have not been mapped. Is there anything worth protecting in the living world that would be affected by this dam? I don't know and apparently neither does anyone else.

Inventories are done in other areas of activity and are recognized as being very fundamental. Thus, we carry out censuses, we keep labor statistics. We make a complete record of monetary values, we carry on economic analyses, and we examine economic relationships so that we will be able not only to assess the future, but give reasons for change.

In another area of environmental knowledge, the field of geology, we acknowledge the need for basic topographic maps and for the gathering of fundamental geological information. Such data have been of tremendous value to us in assessing resources and in evaluating the effects of earthquakes, erosion and similar natural events. In weather data the record of past years is of inestimable value in assessing current trends. Our need in the biosphere of living things is similar to these accepted programs.

How do we determine whether the manipulations of our environment will yield us positive or negative values so far as biology is concerned. Most of man's activities will have an influence of some sort on living organisms. Before we can enter these influences into the equation to balance the pluses and minuses, we must know in fact what the changes are likely to be. We cannot determine these changes solely by measuring something in the future. Just as we today are not able to assess adequately what has happened to our actions of the past, neither will our descendants be able to assess the results of our present day actions unless we provide for them a base from which they can make comparisons.

Another element to this problem which I saw clearly during my service as Science Adviser in Interior, is that decision makers need prior analysis of the effects which will follow from resource development and construction projects. We recognize the necessity of making predictions in an economic sense. We do a prior analysis of the added economic values expected to result from constructing a reservoir or a public road. We make predictions as to uses for public works, and in dealing with some of our planned construction projects we are able even to assess the amount of waste products or other undesirable effluents.

What we are not able to predict, and hence are unable to evaluate, are the biological consequences of the actions we take. Such predictions should not only be made but they should be added to the considerations which attend the making of decisions for embarking upon public works. We cannot necessarily avoid biological changes, but we should know that they are likely to happen. In order to do prior analyses we must make study of things that are now happening or that have happened in the past. Why for example has the armadillo moved north into Kansas during the last 50 years? Why, as another example, do we now have an invasion of large grackles in Texas? What is the cause of the brushland moving north and east into good grasslands in Texas?

Let it be understood that I am not arguing that we should stop any public works or the economic development of our resources. The acquisition of ecological knowledge may not change our decisions in the least. If we obtain the facts about our living systems and the relationships that control their dynamic quality, we may find many positive values where we now think negative ones exist. And, vice versa. My thesis is that we should be able to assess, by way of prior analysis and by later actual measurement, the impacts of our actions on the living world around us. Only after we know definite and measurable things about these impacts can we use this kind of knowledge in our policy planning.

It is true that some ecological work is being done now in government programs. Most of this is a fire fighting kind of work, such as the work pertaining to pesticide movements, or it is work pertaining to controlled biological systems such as cultivated crops. Although many agencies have an interest in ecology, their interests are specialized and rapidly applicable to natural systems. For example, the ecologists with whom I have talked at Texas A&M University tell me that we do not know animal population dynamics for most of the species of wildlife in Texas. They also tell me that whereas they know about tolerances of cultivated plants for pesticides, virtually nothing is known about the tolerances of native species.

This area appears to be another example demonstrating the principle of that which is everyone's business being nobody's business. The need for action which I see can be met only by giving a mandate, which S 2282 does, to one agency for a program to give us the three things I outlined—the present status of what we have to protect, a baseline for assessing changes, and knowledge of relationships for making prior analyses.

This bill provides for doing much of this program through universities and local groups. It wisely provides for recognizing natural areas for scientific purposes and for maintaining representative collections. It seems incongruous that we would spend billions of dollars to collect, preserve, and analyze samples from other bodies of our planetary system and not be willing to do the same for our own planet.

There are many ways in which this legislation would be of value to Texas. Within the State of Texas there are numerous undertakings which can have long range ecological implications. At present there is very little research underway to guide decisions on this work. Examples of these are (1) extensive water impoundments which change stream flow rates, bottomland availability and plant and animal life in and adjacent to the area, (2) proposed transfers of water from one stream basin to another, along with the construction of large reservoirs, which alter the flow rates and balance of fresh water in bay areas and in turn affect the marine life in the bays, and (3) extensive brush control practices without the necessary management to reestablish a grass cover or to measure the subsequent effects on both the controlled areas as well as adjacent areas.

A state that is as agriculturally oriented as Texas has a great need to understand better the complex components of the biological and physical systems which make up the various ecosystems. Rangeland and forestland resources have not always been utilized in a way which would lead to perpetuation of the resource. At present, scientists indicate that grassland resources are greatly in danger of an irreversible woody plant invasion. Permanent belt transects need to be established on the migrating fronts of these invading woody plants to determine rates of movement and, if differential migration rates occur, to determine what factors are involved. Also a study must be established to determine the effect of various brush control practices on the ecology of the area treated as well as adjacent areas. Studies of this nature should be designed to measure interactions and coactions of the various organismal components of the ecosystem so that long

range effects can be predicted. It may be that the responses are such that brush control is not practical or feasible due to deleterious effects on the total ecosystem.

Measurement techniques must be developed to provide the broad scale information necessary to make judgment decisions in the future. Many decisions are now made on very limited information and rarely on a scope relative to total impacts of any activity on the total ecology of an area. This bill provides a basic structure for the development of information and experience to make these decisions so far as we are concerned in Texas.

In summary, we believe in Texas that this legislation will mean much to us and will aid us in meeting more effectively the challenges for improving the quality of living. If we are, in fact, to maintain the kind of economic, population, and standard of living advances to which we have been accustomed and also enhance the complex net of living systems of which we are a part, we must take some bold steps. The most fundamental are the steps outlined in S. 2282. Alone, they cannot do the job, but without them we have no place to start!

Senator NELSON. I will submit statements for the record on behalf of Mr. William Zimmerman, representing the Sierra Club, and Dr. Spencer Smith, of the Citizens Committee on Natural Resources, since they have each submitted a brief statement. The statement will be printed in each case in full in the record.

(The statements referred to follow:)

STATEMENT OF WILLIAM ZIMMERMAN, JR., WASHINGTON REPRESENTATIVE OF THE
SIERRA CLUB

My name is William Zimmerman. I am Washington representative of the Sierra Club, founded in 1892 by John Muir and a group of friends. The Club now has about 36,000 members. The Club's stated purpose is to help people explore, enjoy and protect parks, wilderness, waters, forests and wildlife.

The Sierra Club has formally approved the purposes of Senator Nelson's bill, and urges that it be enacted. It would be a first step toward adequate Federal recognition and support for ecological studies. Our understanding of the natural world has been lagging far behind our technical ability to alter natural conditions and patterns. It is imperative that ecologists develop the basic knowledge in their field which will make it possible for them to forecast the results of man's continuing interferences and changes in the natural world.

The Nelson bill would authorize ecological research, under the direction of the Secretary of the Interior, in four major categories: (1) to conduct studies of natural environmental systems and make grants to individuals and institutions to carry on such studies; (2) to set up a clearing house for information on ecological problems and studies; (3) to establish a program for the scientific study of natural environments, examples of which would be selected from Federal lands to be set aside for this purpose; (4) to encourage the States and private owners to establish similar preserves.

The Sierra Club regards the Nelson bill as a path-breaker. It is the first attempt, so far as we know, to give Congressional approval to an over-all study of man in his environment. In his statement introducing the bill, Senator Nelson said that we must move beyond the stage of trial and error, beyond guesswork and intuition, in dealing with the natural community in which we live. Sierra Club heartily concurs in Senator Nelson's views.

STATEMENT OF DR. SPENCER M. SMITH, JR., SECRETARY, CITIZENS COMMITTEE
ON NATURAL RESOURCES

Mr. Chairman and Members of the Committee:

I am Dr. Spencer M. Smith, Jr., Secretary of the Citizens Committee on Natural Resources, a national conservation organization with offices in Washington, D.C.

Some years ago a graduate student in Engineering from China was listening to the proceedings before one of the Agriculture Committees of the Congress, which had under discussion the problem of coordination between a number of Govern-

ment agencies involving the prevention of soil erosion. His comment related to the history of his own country when he said, "The seeking of synthesis to understand the interrelated uses of man's environment usually comes after a realization of the damage to that environment and is much too late." We can only hope that the reflection of this young man on the agonies of his ancient culture is not an augury for our own future.

More books have been written recently and more anguish has been manifested in almost every means of communication available to us regarding the despoliation of much of our natural bounty. The misuse of our land, the spoiling of our streams and rivers, and the pollutants in our air give ample evidence to our misjudgments of the past. If the quality of man's environment in the future is to improve or not retrogress, the consequences of man's actions must be viewed with the greatest care.

It is not always wise to stress what a legislative proposal will not do, rather than to suggest the positive feature of it. Our departure from the usual norm today is dictated by what a number of individuals, inappropriately I may add, feel this measure represents. It is suggested that this is a measure to prevent development projects such as dams, highways, subdivisions, and the like. Quite the contrary. The measure neither seeks to espouse or to prohibit the course of development. Rather, the function of this proposal is to make sure that whatever decision is rendered be rational and fully cognizant of the effects of any particular action. Most of the disasters of which we now are remorseful have been due to the failure in considering the consequences of a particular activity or a particular program. In the hardest kind of economic fact, the mistakes of yesteryear haunt us. Presumed conservation programs and/or development and improvement programs have on more than one occasion been more expensive and harmful to society as a whole, than if they had not been undertaken, or if different programs accomplishing much the same thing had been substituted in their place.

S. 2282 would authorize the Secretary of the Interior to carry forth a program of basic ecological research and to ultimately make applicable these research results to much of our land and water use. This study and training of personnel would be used in consultation with other Federal agencies which have responsibilities for many of our land and water programs. The making of such information available to those with such responsibilities would offer great opportunities for better and more effective planning of our various and sundry programs.

Another significant feature of the measure would enable the Government to assist non-Federal, public, and private institutions, and concomitantly to establish a system of natural areas for scientific use, much of which could be achieved on lands already owned by the Federal Government. These natural laboratories could have great and expanding scientific value.

We offer every hope that this measure will find favor with the Committee, for it is our feeling that our efforts toward synthesis of our many activities in the relationship between man and his environment are dangerously late.

Senator NELSON. Now, we will call upon Dr. Richard Goodwin, president of the Nature Conservancy, Washington, D.C.

You may read your statement or extemporize from it, whichever suits your purpose.

STATEMENT OF DR. RICHARD GOODWIN, PRESIDENT, THE NATURE CONSERVANCY, WASHINGTON, D.C.

DR. GOODWIN. My comments are only in one copy here and I will read it, if I may.

Senator NELSON. All right.

DR. GOODWIN. As a nation we have reached the point where we can no longer afford the luxury of permitting developments that unnecessarily destroy our resources. We need a far more coordinated and controlled approach to our resources problems than we are taking at the present time—one based on sound ecological principles that can

only be derived from knowledge generated through a program such as might be developed under the ecological research and surveys bill.

At the present time we frequently plunge into enterprises without taking the effort to bring existing ecological knowledge to bear on the problem or attempting to develop the information when this is lacking.

Let me give two examples to illustrate the point. The Rampart Dam proposal in Alaska is one that would involve some very sweeping changes in the ecology of central Alaska. It was one that aroused sufficient concern among a number of conservation agencies, among them the Nature Conservancy, the organization I represent, so that they took steps to appropriate private funds to finance a fairly broad study of the proposal.

The results of this study clearly indicate that this plan is not well conceived to fill our present and immediate future economic requirements, while at the same time it would be extremely destructive to our fisheries and wildlife resources. The development of this kind of information might be the responsibility of the Federal Government.

The problem of heat pollution is another area that has received inadequate attention. Traditionally, utilities have been permitted to avail themselves of water for cooling purposes. The impact of small generating plants has not been severe, but now, with the increased magnitude of operations, especially the new atomic plants, the picture has changed. We now have clear evidence of the impact of heat pollution on the fisheries and other aquatic life downstream from some of our big reactors, yet inadequate steps are taken to avoid these unfortunate effects elsewhere.

The Yankee atomic plant on the lower Connecticut River is very likely to destroy the highly productive shad run in the river. What provisions have been made to avoid this? A study to be made only through the industry, whose profits are involved, to determine whether damage is done. Only then will cooling towers be installed. By this time, it is not at all unlikely that remedial action will be too late.

I could go on at some length on other issues. As a nation we should stand in shame over the loss of Lake Erie as an attractive unpolluted body of water, and the incipient loss of our collective investment in the Everglades National Park as a spectacular wildlife area through an inadequate approach to the deployment of Florida's water resources.

One of the very urgent tasks that lies ahead of us, as a nation, is the preservation of remaining samples of natural habitat. This is the particular objective to which the Nature Conservancy is addressing its efforts through private action and in cooperation with Government agencies both Federal and State. These areas are vitally needed as a research resource for ecological work as well as for educational, aesthetic and other human needs.

Our organization has often lacked sufficient scientific data properly to assign priorities to its efforts and thereby most efficiently deploy the limited resources at its disposal. The ecological research and surveys bill could develop this scientific information which should put focus on the whole national program of which we hope to be a part and could accelerate the urgently needed program of preservation.

Senator NELSON. Thank you very much.

Next is Dr. Roland C. Clement, New York staff biologist for the Audubon Society.

**STATEMENT OF DR. ROLAND C. CLEMENT, NEW YORK STAFF
BIOLOGIST FOR THE AUDUBON SOCIETY**

Dr. CLEMENT. Mr. Chairman, I thank you for this opportunity. There is always a danger that as a hearing like this goes on one would increasingly deal in platitudes but I might make an additional point to the effect that in addition to being a science, ecology is a point of view and perhaps I can emphasize this in abridging my notes.

Ecology, the ultimate science, the science that must underlie the new conservation if this is to help us awaken our fellow citizens to the importance of preserving a healthful and diversified environment, one in which Nature's processes and the living end-products of Nature's 2-billion-year experiments in evolution should be part of man's enrichment.

This planet is the only home we are likely to have, no matter how much dreaming about interplanetary migration our space enthusiasts may indulge in. We must take care of it, and this bill would provide the basis for a more orderly approach to studying its needs, to eliminating the roadblocks in the way of a wiser use of our planet.

In a democracy the chosen instrument of change is persuasion, and knowledge is essential to guide our choices. But men are short lived, and in sore need of some new agency to serve them as social memory. Ecology, since it is concerned with interactions in space and time, can begin serving in this capacity. Its findings can help our Federal and State legislatures set limits to man's manipulations of the planet, and thus help man become a better steward of his planet.

We need to have in mind that man is, by nature, inclined to over-exploit his environment. This is a biological trait shared with most animal species. It is this trait that allows populations to explore and colonize new territory. For all species but man, however, the adventuring individuals are normally "written off" by the parent population, and those which fail to establish themselves are snuffed out.

But man can no longer allow human exploiters of marginal environments to struggle and die by themselves. Society assumes the burden, not merely of supporting them, but of bringing their standard of living up to the level of the rest of the population. This is a measure of our humanitarian progress but it poses a tremendous burden on society.

Having developed the ability to do almost anything we care to do by way of remaking the landscape, we are tempted to overcommit our resources to such exciting pursuits. Man is still a little boy who likes to do things for the sake of "doing" and without considering whether these activities are a reasonable investment of time and resources. Too often, developers, reclamation specialists, farmers, ranchers, recreationists, and ordinary citizens looking for a place in the sun open up marginal habitats, then call for public funds to protect them from flood, drought, wildlife, and insects.

In addition, this undisciplined invasion of every former wilderness by modern technology is destroying fragile habitats and threatening

the extermination of species that the conservation movement of the last half-century thought it had assured for the future. It is, in short, robbing the earth of much of its interest and attractiveness, and robbing man of the spiritual re-creation he could and should derive from these natural resources.

It is largely ignorance of the ecological consequences of his actions that causes man to be so destructive in our day, since the desire to use wisely is stronger than ever. Powerful tools, such as modern technology has given us, require a sensitive conscience in the user if they are not to become instruments of destruction. It is, unfortunately, much easier to design, manufacture, sell and use our new tools than it is to inculcate perception and self-discipline in the people who use them. Industry has not yet done its share in this task of public education.

We are at last face-to-face with the indispensability of conscience in the use of the atom, but the destructive potentialities of lesser tools—whether bulldozers, draglines, or chemical pesticides—in the hands of inperceptive people are no less dangerous because their effects are delayed effects instead of exploding in a single holocaust.

This is why we need to set about studying our environment in much greater detail than has heretofore been done, and why we of the National Audubon Society feel that S. 2282, if passed, would contribute to a more orderly American civilization.

I thank you for this opportunity.

Senator NELSON. I thank you very much for your statement.

I understand Judge Train is here and, Judge, all of the statements will be printed in the record, and you may extemporize or read whichever suits your purpose.

STATEMENT OF RUSSELL E. TRAIN, PRESIDENT, CONSERVATION FOUNDATION

Mr. TRAIN. Thank you, Mr. Chairman. I apologize for my lateness but for the record I am Russell E. Train, president of the Conservation Foundation, a nonprofit organization located in Washington, D.C., and chartered to promote better understanding of our environments and natural resources.

Mr. Chairman, I welcome this opportunity to present the views of the foundation on S. 2282, the ecological research and surveys bill.

Throughout its history, The Conservation Foundation has placed particular emphasis in all its programs upon ecological approaches to environmental problems—whether these involve regional planning, education, pollution, or population, among many others. Indeed, the concept of “ecology” is a touchstone of the foundation’s activities which are directed in a broad fashion toward sustaining and enriching the quality of our human environment.

We congratulate Senator Nelson for the farsighted concern which has led him to introduce S. 2282 for the consideration of the Congress and for public discussion. We strongly endorse the principle embodied in this bill of bringing ecological criteria into the decision making processes of the Federal Government, both at home and in its activities abroad. We likewise endorse efforts on the part of the Federal Government to increase the sum of our ecological knowledge.

An especially lucid description of the meaning and relevance of the science of ecology was contained in a recent communication to the Conservation Foundation by Dr. Samuel T. Dana, the distinguished dean emeritus of the School of Forestry and Conservation of the University of Michigan. His statement, in part, was as follows:

Ecology is the science that deals with the relations between all of the elements in an environment—the ecosystem.

It rests upon all of the biological and physical sciences—botany, zoology, chemistry, physics, geology, soil science, meteorology, etc., with their innumerable ramifications—and when man is a part of the environment, the social sciences are also involved. Its distinguishing characteristic is that it uses these sciences in their relations to each other to determine what happens in a given environment, under both natural and modified conditions, and why it happens. In comprehensiveness and complexity, it is unique.

It is important that these principles be made part of our normal planning activities. Every modification of the physical environment brings about many other modifications, sometimes beneficial, often adverse, all too often unforeseen.

A sea level canal in Central America may well alter marine life in the Caribbean and the Pacific Ocean. A dam in the Northwest will affect the salmon. Agricultural techniques affect what flows into our rivers. The controlling of the flooding of the Nile River by the Aswan Dam has altered the salinity of the Nile estuary and reduced the flow of nutrients into the Mediterranean Sea immediately off the river mouth.

These changes have apparently had a profound effect upon the plankton in the area with consequent and very dramatic effects upon fish populations, both in terms of quantity and quality. These changes in turn are having important effects upon commercial fisheries and, therefore, upon human nutrition. Thus was set in motion a chain of events largely unforeseen and unconsidered in connection with the Aswan project.

The effects I have described are ecological in nature, including those directly affecting the well-being of man.

None of this is to say that such projects should not be undertaken. The lesson is clear, however, that we should make every reasonable effort to understand and predict the results and implications of our own actions.

S. 2282 authorizes four major groups of programs within the department of Interior.

First, the Department would prepare surveys and maps of natural communities and maintain a clearinghouse of ecological data. Second, the Department would encourage, in an advisory or consulting capacity, the use of ecological analysis in resource development projects. Third, the Department would conduct basic ecological research and would support such research outside the Department. Fourth, a system of natural lands would be preserved for research uses.

I shall concentrate my specific comments upon those portions of S. 2282 which confer certain consultative and advisory functions upon the Department of the Interior.

The Department of the Interior has important responsibilities for our natural resources, but it does not have exclusive responsibility for these resources. Forests, farmland, air, and important aspects of water management are the responsibilities of other Federal agencies.

Public works construction which modifies the environment is scattered among many agencies. S. 2282 is entirely unclear as to what mechanism the Department of the Interior would employ in making an ecological comment on the programs and projects of such other agencies. If the Department of the Interior comments only at the request of another agency, I suspect it will receive few such requests.

If the Department comments on its own initiative, it will doubtless be regarded as a meddlesome intruder by other agencies. On the other hand, if other agencies should be required to submit requests for ecological analysis and comment to the Department of the Interior, the changes in existing administrative procedures would go far beyond what S. 2282 seems to contemplate.

I certainly would not oppose the location of the ecological functions authorized by this bill in the Department of the Interior. It may well be the most logical location. However, the mechanism provided by the bill in its present form for the exercise of those functions, wherever located, seems imperfect and very probably ineffective. We badly need a method for assuring that ecological principles and criteria receive appropriate weight in all Federal decisionmaking. S. 2282 does not do this in a sufficiently effective fashion.

An alternative approach might provide the needed coordination and oversight through the Executive Office of the President. I proposed in a speech last September "that the President establish a Council of Ecological Advisors, or alternatively, an interdisciplinary group of environmental advisors having a strong ecological orientation. And let me make it clear that I am not just talking about an interdepartmental committee. With one such bold stroke, concern for the quality of the environment would be given an important new status in planning and policymaking at the highest level of Government. It would give ecology a new posture in public affairs, and a new sense of responsibility for making its knowledge applicable and relevant to the practical needs of our day."

Well over a year ago in his message to the Congress on natural beauty, the President requested the Director of the Office of Science and Technology and the Director of the Bureau of the Budget "to recommend the best way in which the Federal Government may direct efforts toward advancing our scientific understanding of natural plant and animal communities and their interaction with man and his activities.

These officials—and the National Academy of Sciences-National Research Council could be of great assistance also—should actively study the question of ecological administration and should submit the recommendations called for by President Johnson. Perhaps this committee could encourage the implementation of those recommendations.

In conclusion, Mr. Chairman, this bill should be considered in the context of the enormous forces which modern man, by his technology and wealth, is able to unleash in efforts to improve his environment.

In addition, communications, technology, and education all contribute to an interrelated world in which actions and events have consequences and iterations with profound significance for the future well-being of mankind. As probably the prime instrument of environmental change in the world, the United States has a very special

responsibility to exercise its power with ecological wisdom. It has an unparalleled opportunity for world leadership in this regard.

S. 2282 provides a valuable focal point for discussions leading to the development of policies directed to this objective.

That completes my statement. Thank you, Mr. Chairman.

Senator NELSON. Do you have any specific suggestions for modifying that part of the bill to which you have reservations?

Mr. TRAIN. I think, Senator, both with respect to the portion of the bill to which I directed my specific comments and as well as in other areas of the bill, the primary problem is that of interagency relationships; at least that is as I see it. I think this is true with regard to all of the figures reposed in the Department of the Interior by the bill and for this reason it is my belief that the best solution for the problem is going to be found outside of one of the traditional resource departments, probably in some office, at least initially, in the Executive office of the President. I think perhaps the best coordination can be achieved by that approach.

Senator NELSON. Are you talking only about interagency relationships or are you suggesting that all of the activities proposed to be done in the bill should be these?

Mr. TRAIN. Not the latter. I believe that the support and financing of ecological research, for example, could well be reposed, as this bill does, in the Department of the Interior. I believe my major concern lies in the appraisal of major Federal programs from an ecological standpoint.

There, I believe, a judgment independent of the operating agencies should be brought to bear in much the same fashion that the Budget Bureau brings an independent judgment to bear.

Senator NELSON. Thank you.

Mr. TRAIN. Thank you.

Senator NELSON. Dr. Kenneth Norris of the University of California at Los Angeles, chairman of the natural land and water reserves system, and associate professor of zoology.

STATEMENT OF DR. KENNETH NORRIS, LOS ANGELES, CHAIRMAN, NATURAL LAND AND WATER RESERVES SYSTEM, UCLA

Dr. NORRIS. I would like to correct a notation on the agency I represent. The University of California Natural Land and Water Reserves System, which is statewide and not just limited to the University of California at Los Angeles.

In the past 100 years the science of biology has changed society in many ways through such unfolding stores of information as medicine, genetics, and evolutionary theory. Like all sciences biology has moved by revolutions of activity spurred by a few key circumstances or ideas. I see three such revolutions at present, one extant and two in the wings, just beginning. With us is all the excitement of seeing for the first time a new and incredibly intricate level of life structures and processes spurred by chemical, and crystallographic techniques and the electron microscope. This is the active revolution of today—molecular biology. On its heels the study of development—how molecular structures and cells gather, reproduce, and are regulated to produce the whole organism—is rising.

The other revolution is one I might call "the reluctant revolution of ecology" because in many cases it is being forced upon its reluctant practitioners by the overwhelming forces of society. Society faces incredibly complex problems and most of them can be understood and predicted in ecological terms. Ecologists know many things about how populations are controlled, how their energy is used, what happens when populations grow too large, and most of these facts can be applied to people, or lizards, or lichens. It's more comfortable to study lichens than people usually, so many ecologists are reluctant to enter the hurly burly of society in an attempt to get their ideas across.

Ecology is being thrust forward, not because it is pop biology, but because it is at the very heart of our most difficult social problems, and ecologists are being asked for answers they cannot, as yet, give.

We humans have always been governed and continue to be governed by the same ecological laws and interactions that control the lives of wild plants and animals. This may seem remote, and perhaps may seem untrue to a man in a city where pavement covers the soil and buildings blot out any view of the horizon, but it is not remote. We are all faced, though we may not realize it, with dependence upon maintenance of soil nutrient cycles which control our food production, upon air and water replenishment, upon control of parasites, and we are especially dependent upon our understanding of controls of population size and growth.

In many cases the city man pushes these natural controls away from him by intricate means such as automated agriculture, transportation webs, and electrical systems. But when the generator fails he quickly reverts to organizing his activities around the day and night cycle.

The natural controls remain, as inexorable as the coming of night and day. We must know how natural systems operate and how human society can function within their limitations. We must come to understand what effect we will produce throughout human society when we tamper with natural systems.

What, for example, is happening to the normal reconstitution and development of our soils by soil microorganisms when we spread pesticides by the thousands of tons across our agricultural lands?

I am afraid at present we can only guess. We must not guess. It is too deeply vital a question.

Not all ecologists are reluctant though. Recently, the Ecological Society of America formed an advisory group of its most august members to advise the Government on ecological matters, and this advice is to be given not after the fact, but before ecological laws are violated. This is a brave idea, and the use of such counsel may well become a key to our success as a society. Ecology is related cogently to such public political problems as air and water pollution, use of water supplies, and even the construction of cities in relation to energy sources and flow, public recreation, the land use policy. Ecology has frightening things to say about overpopulation and its relation to the incidence of disease.

Not enough ecologists are available though. Furthermore, the very pressures that make their counsel so necessary are destroying the baseline from which they must work and develop new rules—undisturbed nature. This, I believe is what the ecological research and surveys bill

(S. 2282) is all about. I suspect that it is one of those pieces of legislation that may receive little public notice, but whose effects may pervade and direct society very significantly in the years ahead.

We need more ecologists, and articulate ones capable of applying their knowledge to ongoing human events. The bill will significantly aid in training new men, and in attracting the best brains to the field.

The bill will help catalog the baseline research resource of ecology in America. We need to know better than we do, what natural communities of plants and animals are available to us. In a subtle and seldom recognized way, this may be utterly crucial to our survival. Organisms molded in nature over millions of years nearly all survive because they have built wide ranges of variability into their genetic structures. Thus, as climates or other conditions change, the species can draw upon this or that variant, and the species survives. Our crop plants and domestic animals have been derived in the opposite way—by selective breeding for uniformity of specific sorts. Thus, for example, we must change our wheat strains as new pests arise to infest the ones we use, since they themselves cannot change and combat the pest. Often we must look to native stocks for genetic materials from which to draw our variability. Thus, not only is natural terrain an essential resource for the study of whole communities and their processes, but also an essential reservoir for genetic materials as well.

We, in the University of California, are engaged in an independently conceived effort of a similar sort for California, the University of California Natural Land and Water Reserves System. This system, farsightedly chartered by our board of regents and president in 1964, is designed to include samples of the ecological diversity of California, including every major habitat type. This is a large order, both in view of the fact that California is the most ecologically diverse State in the Union and also subject to the greatest population growth and influx of any State. These natural lands are fragile and are disappearing with frightening rapidity in California and we have moved none too soon. It is a complex undertaking to build such a system, but we ecologists know that we must or we will lose our essential teaching and research resource, and our traditional excellence in ecology in the University of California will be lost.

Our steps in building our system, which is very far from complete, started like this. First, we surveyed what natural ecological situations were available in California, and it was surprising to me to find that no one scientist encompassed nearly all this information even for a single State, but the talents of dozens of people were required and are being used. The bill presented here recognizes this and starts with a survey utilizing all available talent.

Next, we attempted to find out what samples of each ecological type were available and wisely left ourselves wide flexibility in the manner of acquisition and holding.

Facilities are essential, and are mentioned in the bill. They need not be expensive or large but modern ecologists must shelter instruments of a wide variety and must have basic opportunities to measure the environment. A simple facility allowing these things will multiply the value of an ecological reserve manifold.

Modern science is manipulative. No longer can a scientist simply observe nature and record what he sees. He must also test and later

check conditions to reveal the details of ecological processes. But since the ecological baseline is nature, much of every reserve must be kept inviolate for control purposes and such alterations carefully judged for their long-term effects on a reserve.

There are important interactions between our growing system and the plans of the ecological research and surveys bill. Establishment of reserves on public land such as are held by the Bureau of Land Management and the U.S. Forest Service is essential. The cooperation of public-spirited private citizens is essential to both efforts. It seems probable to me that other State efforts such as ours will appear with increasing frequency. I can assure you that such efforts have to have Federal help in a variety of ways to be very successful ranging from financial aid in obtaining lands, to cooperative use of Government property, to assistance in maintenance and the long job of cataloging what we save. We in the University of California Natural Land and Water Reserves System watch the progress of this legislation with great interest for it would lend strong impetus to our effort, and to others everywhere.

Senator NELSON. Thank you very much, Dr. Norris.

The next witness is Dr. LaMont Cole of Cornell University.

STATEMENT OF DR. LaMONT COLE, CORNELL UNIVERSITY

Dr. COLE. I would like say, Mr. Chairman, although I have prepared this statement I have permission of the chairman of the Public Affairs Committee of the Ecological Society to express the approval of that committee.

Senator NELSON. Your statement will be printed in full in the record and you may read it or extemporize on it.

Dr. COLE. This bill would increase the pace of ecological research in the United States, establish a clearinghouse for ecological information, lead to an inventory of our living resources, and accelerate the training of ecologists. All of these objectives are long overdue in the opinion of ecologists and each of them has been the object of serious concern by committees of the Ecological Society of America and by various Government agencies.

Many of the most serious problems facing mankind are basically ecological problems but until very recently policymakers, with few exceptions, seem to have been unaware of the existence of a science of ecology. This situation seems to be improving but there are simply not enough qualified ecologists and not enough are being trained at present to conduct the studies and furnish the advice that society urgently needs. As recognition of ecology increases there are going to be more and more urgent calls for ecologists to participate in interdisciplinary studies involving mathematicians, engineers, public health scientists, and social scientists; we must have a means for stepping up the production of qualified ecologists. Earlier this month a group of ecologists met here in Washington to consider the need for an interdisciplinary conference on the quantitative analysis of ecological systems. The unanimous conclusion was that such a conference was not only needed but that it was urgent to establish more communication among these groups of investigators. I hope that by citing a few examples I can convey some of the urgency to this committee.

The most critical problem facing mankind is the unregulated growth of the human population. I shall not here stress the extensive contributions that ecologists have made to population theory and the management of populations but I wish to mention some of the collateral effects of the population explosion.

The world population today stands at 3.3 billion and is growing at 2 percent per year, a rate that if continued would cause the population to double every 35 years. We often hear it said that agriculture must find a way to keep up with the growing population, but this is impossible. Even in the coterminous United States it would take only 90 years at the present rate to bring the amount of land per person to 2½ acres, which is considered by many experts to be the minimum amount of arable land necessary to support one person. This figure includes our deserts and mountains and forests and cities and so is unreasonably optimistic. And population growth at the present rate would just about halve this figure in every generation. Obviously, the population must stop growing in the not distant future, whether by disaster or a rational solution, but in the meantime it is putting alarming pressures on natural resources.

Many species of plants and animals are threatened with extinction. A recent survey by scientists in the Bureau of Sport Fisheries and Wildlife (1965; Circular 223) found over 200 forms of vertebrate animals in the United States and Puerto Rico to be at least threatened, and the numbers of endangered invertebrates and plants must be much larger. I know that there are differences of opinion about the desirability of preserving all species, and this is not the place to open that controversy. Probably everyone will agree that some wild species should be preserved, and anyone who has really studied the matter will realize that many species must be preserved if man himself is to survive and flourish.

In many cases (probably most cases) we do not know what importance a particular species now has or may later come to have for human welfare, and we do not know enough to be certain that we can preserve any given species. The research need here is tremendous. In the best interdisciplinary tradition Dr. Frank Preston, an engineer and glass technologist, has provided ecologists with some provocative mathematical and statistical theories that suggest a definite mathematical relationship between the size of an area and the number of species that can survive there. If he is correct, some of the African game preserves are not large enough to retain all of the species they are intended to preserve.

I have a list from the Bureau of Land Management of over 100 natural areas in this country that had been proposed prior to March 1, 1965, to be set aside and preserved. It is important for us to preserve as many types as possible of natural plant and animal communities. The analogy has been made that medicine made little progress prior to the careful study of the healthy body and, similarly, in order to learn to manage and preserve plant and animal communities, including our synthetic agricultural communities, we must understand the functioning of the natural community. Some proposed natural areas may be too small to preserve the communities occupying them, and some communities owe their character to recurring fires in the past or

to particular types of grazing or similar influences. Communities will vary greatly in the technique required to preserve them and in the amount of pressure from recreation that they can withstand. Much ecological research is going to be necessary and it can scarcely begin until the training of ecologists has been drastically expanded.

I know that people in Washington these days are acutely aware of pollution of the environment with silt, smoke, trash, organic debris, and noxious chemicals so I shall skip to some more subtle and less publicized but no less alarming side effects of the industrialization that is maintaining and expanding our economy even as the population grows.

Man is burning fossil fuel at an ever increasing rate and it is probable that more than half of the fuel ever burned by man has been burned in this century. One result of this is to release carbon dioxide into the atmosphere more rapidly than it can be taken up by green plants or dissolved in the oceans and eventually precipitated. Older measures are subject to some uncertainty but it appears probable that the carbon dioxide content of the atmosphere has increased by at least 10 percent since the turn of the century. Atmosphere carbon dioxide is believed to have drastic effects on climate and there are now two diametrically opposed hypotheses as to what effect this change may have. One hypothesis predicts that world temperatures will increase and melt the icecaps from Greenland and Antarctica, thus raising sea level and drastically altering the world's coastline; for example all of Florida would be under water. The other hypothesis contends that precipitation, including snowfall, will increase so much that glaciers will start to advance and bring on a new ice age.

Obviously, there is a need here for some very basic studies, not only by climatologists and geographers, but also by ecologists studying what factors control the rate at which the earth's vegetation removes carbon dioxide from the atmosphere, and the complex cycle in the oceans which begins with carbon dioxide dissolving in the water and culminates in its being precipitated as limestone by animals.

The only reason the earth's atmosphere contains oxygen for us to breathe and with which to burn fossil fuels is that oxygen is constantly being given off by green plants. If we reach a point at which the rate of combustion exceeds the rate of photosynthesis, the oxygen content of the atmosphere will start to decrease. Almost a year ago I made an intense effort to estimate how near we are to the balance point which will signal the end of expansion of our present type of industrialization, but satisfactory data of the necessary sort do not exist. I suspect that we are close to the critical point but I shall not try to defend this opinion.

We should know the answer to such a vital question, and only accelerated basic research can supply the necessary data. We are going to have to recognize that green plants are doing something essential for us. We cannot afford to give up a million acres of photosynthesizing vegetation each year by paving and by building factories that consume more oxygen. We need basic research to compare, for example, forests with grasslands and to give us the basis for deciding how photosynthesis can be maintained and increased. We must seriously reconsider, on the basis of ecological data yet to be obtained, any sug-

gestions that it might be desirable to industrialize Africa and South America. And at some point—I wish we had the data to estimate how near it is—we must declare a moratorium on any increases in combustion of fuel. Presumably this will mean shifting to atomic energy and facing on a very large scale agonizing problems of safety, pollution, and waste disposal. There are ecologists today working on the problems of the future atomic age but I am confident that the research effort should be increased many fold.

Let me mention just one surprising ecological effect of atomic energy as an example of the type of thing we may expect to encounter as research progresses. Two years after water in the western Pacific was contaminated by radioactive fall-out, certain clams were found to contain very high concentrations of the radioisotope Cobalt-60. This was surprising because Cobalt-60 is not produced by atomic fission; it must have been produced by the action of radiation on some chemical, presumably a stable cobalt isotope, naturally present in the water. This would presumably occur even if a completely "clean" bomb could be built. And everyone except biologists seemed surprised that an animal could accumulate a chemical in its tissues to millions of times the concentration in the surrounding water. This is a common phenomenon and has been an important factor in the killing of wildlife by pesticides. We need a tremendous expansion of research and training and, speaking for myself, I think it would be sheer irresponsibility in our present state of ignorance to use nuclear explosives to dig a new canal across Central America.

Another global problem that is totally unfamiliar to most persons is that of maintaining the natural cycle of the element nitrogen. I shall have an article on this subject coming out in the Saturday Review in a month or so and will merely touch on the matter here. Man's very survival depends on the survival of many types of micro-organisms and perhaps a minimum of a dozen types of bacteria that are involved in the nitrogen cycle are essential to preserve life on earth. Proteins, which are the fundamental building blocks of all living things, are nitrogen compounds but nitrogen is actually a scarce element and about 90 percent of the earth's supply is represented by the molecular nitrogen in the atmosphere. Higher plants cannot use this source directly; they are dependent on certain bacteria and blue-green algae to convert the nitrogen to ammonia which they can use. Two additional types of bacteria, however, convert the ammonia by a two-step process to nitrate which is the form in which most green plants obtain nitrogen. Animals ultimately obtain all of their nitrogen for protein building from plants. This nitrogen would be lost from the cycle and unavailable to later generations of plants were it not for still additional types of bacteria that can attack the often inert nitrogen compounds in dead plants and animals and convert it back into ammonia. And the nuclear nitrogen removed from the atmosphere would gradually be replaced by ammonia—a process which would quickly make man extinct—were it not for additional types of bacteria that can regenerate molecular nitrogen from nitrate.

Within the past year I have heard sincere and educated Americans, thinking about ways of increasing agricultural productivity, seriously propose that we seek ways to block the conversion of ammonia to

nitrate, and thus inadvertently block the regeneration of molecular nitrogen. In this case we know enough so that I am confident that any such move, which would destroy man, can be avoided, but it disturbs me greatly to realize that nitrogen is only one of many elements that must cycle in nature if life is to continue, and that there are probably many such essential processes of which ecologists are as yet totally unaware.

I am also thoroughly alarmed by the haphazard way in which we drastically alter environments without a thought for our microscopic benefactors. I am confident that nobody tested DDT for its effect on the bacteria involved in the nitrogen cycle before it was broadcast over the earth. This chemical has now spread over the entire earth and is found in the snow on Alaskan glaciers and in the fat of Antarctic penguins. If it had happened to be a deadly poison for one of the essential links in the nitrogen cycle this could now be a dying planet. Man's influence is now so dominant on a worldwide scale that we can no longer afford to trust to luck or to remain ignorant of intimate ecological relationships that remain to be discovered by future research.

We are just at the beginning of what I believe must become a strong trend—the policy of consulting qualified ecologists before deciding on major changes of environments. A little over a year ago a meeting brought a major concentration of highly competent ecologists to Washington. Taking advantage of this, the Special Commission for Weather Modification of the National Science Foundation asked this group for a report on probable and possible ecological consequences of weather modification. The assembled ecologists took perhaps an hour considering the names of ecologists with particular relevant specialized knowledge and assembled a working committee that quickly produced an outstanding report, “Biological Aspects of Weather Modification, Ecological Society of America’s Ad Hoc Weather Working Group,” August 15, 1965. The benefits and dangers that ecologists can foresee right now and the areas of ignorance where more research is needed are now on record for this one problem, and this should be a paradigm for all proposals to alter environments. Usually, ecologists are either not consulted or their advice is ignored by the decision-makers. It must be admitted, however, that committees as competent as the one I have referred to could not now be assembled in any numbers or with any regularity. Again, the only way out of a serious predicament is to train more ecologists.

I have referred to the need to set aside natural areas to preserve particular communities of plants and animals. Some of these areas may prove inadequate for the purpose, and the ever increasing pressures from more people using public lands may cause deterioration of communities thus vitiating the purpose of preserving them. For example, the national parks bill of 1916 specifies that the parks shall “* * * conserve the scenery * * * and the wild life therein * * *” but there has been no inventory to determine just what wild life each preserve is obligated to conserve. When ecologists have charged that plant and animal communities on public lands are deteriorating they have often been opposed by persons with vested interests and they have usually lacked scientific data adequate to convince policymakers.

Inventories should be made of the living organisms on public lands, deterioration should be defined, and an adequate staff of persons should receive ecological training to enable them to detect deterioration in its initial stages while it can still be corrected. This is not nearly so easy as it sounds. The staff to do the job would have to be trained to identify and conduct censuses of the plants and animals, and ecological criteria of deterioration will have to be established; a number of statistically inclined ecologists are working on this problem right now.

If we compare a healthy community, say a forest or lake, with one that has obviously deteriorated such as a badly polluted lake, one of the most striking changes is a reduction in the diversity of the biota in the damaged community. The healthy community has a relatively large number of species while the sick community may contain as much total life but only few species which are each tremendously abundant. To measure deterioration, one thing we want is a sensitive way of measuring diversity so that we can detect any decrease in its initial stages before the damage becomes obvious. This is a nontrivial mathematical and statistical problem to which we may or may not now have the ultimate solution. In any case, management of public lands could be greatly improved by employing existing ecological technique to detect incipient degeneration. Parenthetically, I might add that much of the recent and current controversy about pesticides stems from the fact that modern agricultural crops have much in common with "sick" communities. Our monoculture technique produces communities of very low diversity and consequently high vulnerability. I have argued that application of ecological knowledge could improve matters in this case also.

At a much more advanced level we are greatly in need of increased understanding of complex ecological systems that call for multidisciplinary study. To summarize a reasonably simple and well-studied case, let me mention the islands off the west coast of South America where the great deposits of "Peruvian guano" and their potentiality as a source of fertilizer were first discovered in 1804 by a great pioneer ecologist, Alexander von Humboldt.

The very cold Humboldt or Peruvian ocean current moves northward along the coast drastically affecting the climate and causing an overturn of the deep ocean water so that chemical nutrients to support plant growth are constantly circulated up into the surface waters where enough sunlight penetrates to permit photosynthesis. The resulting abundant algal growth supports a high production of small crustaceans which are eaten by anchovies which also are highly productive in the presence of an abundance of food. Cormorants feed on the anchovies and nest in enormous numbers on the "guano islands" where they deposit their excrement, the guano which has long been one of Peru's important natural resources. But Peru now harvests anchovies for the production of fishmeal and the Japanese are fishing the same water. This reduces the production of guano and has a bearing on the price of fertilizer around the world. As if to make things more complicated, the Humboldt current is not completely dependable but in occasional years swings away from the coast; then the upwelling of nutrient-rich water ceases, and the production of both anchovies and guano fails.

I understand that an attempt is underway right now to try out modern techniques of systems analysis on this particular system. There must be some optimum way in which man can derive maximum benefit from any ecological system such as this if he can analyze the situation with sufficient accuracy. But notice what is involved: Ecologists can work out the chain of events that produces anchovies and guano, but chemists, hydrologists, oceanographers, climatologists, and statisticians will have to be involved in determining the optimum strategy for the harvest of these resources. Then come the social scientists, considering the economics of fishmeal versus guano and similar problems on which I am not qualified to comment.

But I submit that every system affecting man's welfare in the real world is of this general type. There is always a basic ecological component that must be understood before there is any possibility of understanding the whole system.

Finally, we desperately need a central clearinghouse for ecological information. I do not keep a tally of the long-distance calls and letters I receive from strangers seeking advice about some proposed local program for flood control, mosquito abatement, or other environmental alteration. I can assure you that the volume is impressive when you realize that it is directed to one unpublicized scientist whose name must have reached most of these people by accident. This is surely indicative of widespread public concern that public policy is being misguided in these areas. To most of these queries I can reply only in broad generalities because I am unfamiliar with the pertinent local conditions and the details of the proposed environmental alterations.

This is surely not the place to recount horrifying case histories, but to me it is clear that there should be some place that the scientist, when asked, could quickly retrieve the data on past experience with a particular type of environmental modification. The Ecological Society of America has actually authorized a committee to solicit in its name funds to establish an information and data retrieval center on environmental pollution. This project has not progressed because of the conviction of some of us that it is but a fragment of a vastly larger and more important project which, ideally, should be global in scope, but which, practically, can become national in scope through passage of the ecological research and surveys bill.

Thank you.

Senator NELSON. Our next witness is Dr. Whittaker of the Brookhaven National Laboratory.

STATEMENT OF DR. ROBERT WHITTAKER, BROOKHAVEN NATIONAL LABORATORY, UPTON, LONG ISLAND, N.Y.

Dr. WHITTAKER. Mr. Chairman, I should like to speak in support of the bill, on bases to which I think my experience in ecological research is relevant. I have had the opportunity in the last 18 years, of carrying out a number of research projects in national parks, monuments, and forests, from which a number of reports on ecological problems have resulted.

Three of these studies were done in Great Smoky Mountains National Park, a magnificent preserve of natural and less disturbed vege-

tation in a wide range of environments. The first project dealt with the way plant populations are distributed in relation to one another along environmental gradients in climax; that is, stable and undisturbed vegetation.

From this study resulted contributions to ecological theory I think fundamental, especially as regards the meaning of plant associations and clines. A second project utilized the wide range of plant communities there to study how animal populations were distributed in relation to plant communities. A third project concerned the study, by methods which did not disturb the vegetation, of the amount of organic material being produced, in the form of wood growth and other components, in the different kinds of forests and bald communities of the Smokies.

A central concern of this study was with the normal level of total production in climax forests, and results on this depended both on the presence of undisturbed forests for study and on the fact that the Smokies offer a wide range of kinds of undisturbed forests which may be compared with one another. All three of these studies could be carried out very much more effectively in the Smokies than anywhere else because of the wide range of natural communities preserved in this national park.

My early work in the Smokies was aided greatly by the presence there of a most experienced and knowledgeable park naturalist, Arthur Stupka, who possessed a mental inventory of the life of the park from which he could tell myself and other investigators where to start their work. It is not possible for all natural preserves to have naturalists of such long experience.

The bill before us proposes to seek more systematic studies of preserved natural communities, and description of favorable areas in which investigators may do their research, and often relate their studies to one another. Important background information would be recorded as a basis for interpreting any future change in the wildlife of the natural areas.

In most cases research in a natural area has interest over a much wider area than the natural area itself, and studies of these would provide much information not now available on natural communities, some of which can be preserved, others of which must in the future be developed and utilized.

From my experience in the Smokies may I suggest two points bearing on the bill: First, the very great, really fundamental scientific significance of such national preserves of natural landscapes; second, the usefulness of the studies of natural areas for which the bill would provide.

More recently, in 1962-63, Drs. W. A. Niering, C. H. Lowe and I investigated the decline of the saguaro or giant cactus population in Saguaro National Monument, Ariz. The monument had been established so as to preserve a once-superb saguaro forest, probably the finest in the world, on the valley plain at the foot of the Rincon Mountains.

This saguaro forest, in the loop drive area of the Rincon part of Saguaro National Monument, is now in a sad, a sick, and degenerate state indeed. There are virtually no young saguaros to replace the older giants as they die; the population is headed toward disappear-

ance in this particular valley plain area, though surviving better on the Rocky Mountain slopes above.

The monument officials and other scientists in Arizona had been concerned with this population decline. By combining studies of size distributions of saguaro populations in the monument with comparative studies of saguaro populations in various environmental conditions—in grazed and ungrazed areas and different kinds of soils and climates, inside and outside the monument—we were able, I think, to establish, on a convincing basis, that grazing had been the cause of the population decline. Heavy grazing through many years, before and after the establishment of the monument, had been destroying young saguaros and the shrubs which provide shelter for them, while also causing the development of high populations of rodents which actively seek and eat the young saguaros. These effects of grazing are most severe on the kinds of valley soils on which the once fine stand below the Rincon Mountain grew. The reason part of Saguaro National Monument was losing the saguaros it had been created to preserve could not have been established without careful research.

Our research at Saguaro National Monument was aided by the existence of an area of mountain slopes with saguaros protected from grazing in the nearby Santa Catalina Mountains. These ungrazed areas, on national forest land, provided controls—study objects like some of the monument vegetation except in freedom from the factor under investigation—without which convincing establishment of the effect of grazing would have been much more difficult.

May I emphasize in the strongest terms the importance of undisturbed natural communities for such controls, importance not only for basic ecological research, but also for study of the meaning of man's use and disturbance of communities, and in the future also for the meaning of more widespread changes in man's own environment produced by pollution effects and possible climatic change. We are often dependent on remnants of natural vegetation to determine what the landscape was like that man has occupied and altered.

The picture of the natural vegetation, before logging and other changes, of the Siskiyou Mountains of southern Oregon and northern California which I developed was dependent on piecing together information from natural vegetation still existing—in California redwood parks, in Oregon Caves National Monument, two wild areas in Siskiyou National Forest, and various still uncut private and national forest lands.

In the future, such natural areas will be, on the one hand, fewer in number, and, on the other hand, of increased research importance, not only for ecology as such, but for their relevance to environmental problems of man himself.

May I, from these experiences, suggest two further points bearing on the bill: First, the importance of studying, and of the Department of the Interior's being able to support study of, changes in natural lands, the meaning of which may otherwise escape us until too late; and second, the very great value of preserving, while it is still possible, other natural areas than the national parks and monuments and wilderness areas, as the bill also proposes to make possible.

Man is encountering progressively intensifying problems in his relation to environment. He must modify his environment at an accelerat-

ing rate to provide for the needs of increasing populations; but he must at the same time pay for this accelerating modification of environment with shrinkage of recreational access to open land and expansion of pollution problems of disadvantage to himself.

Current intensification of these problems results from a phenomenon of compound acceleration—not only does population itself increase at an approximately geometric or compound-interest rate, but the technological power to change environment in the hands of the population increases at an even more steeply accelerating rate.

The product of increasing population combined with increasing mean consumer demand and technological power in that population is the dramatic and disturbing speeding in the rate of change of man's environment. We have only recently begun to realize the costs—the inescapably disadvantageous side-effects—of these transformations as they appear in our problems of population congestion and environmental pollution.

There is a further point to be made about natural areas in this connection. These have value not only as controls to study meaning of man's use of other communities, but also for their potential indicator value for expressing more widespread changes, especially in chemical environment, of concern to man.

The significance of plants killed by atmospheric pollution, or bird populations declining toward disappearance because of food-chain effects of pesticides, is by no means simply the loss in natural life which some of us value. It is also the warning of the significance to man himself, who must receive the same chemicals in air, food, and water and who is not immune though fortunately relatively less sensitive than some other organisms, that is offered by this mortality of wild populations.

Any reasonable projection of the compound acceleration of environmental modification and chemical release implies that man will be increasingly concerned with such problems in the future. The bill is to authorize collection of information and support of research on these inescapable environmental problems.

It is thus my perspective as an ecologist on the ecological research and surveys bill that, first, the provisions on natural areas and research I have been discussing would have scientific justification even without current population and pollution problems, and second that these problems render the purposes of the bill the more urgent in relation to man's own ecology and the search for national policies on man's relation to his environment.

Thank you, sir.

Senator NELSON. Thank you very much for your statement.

We will next call on Dr. Bormann, department of biological sciences, Dartmouth College.

STATEMENT OF DR. F. H. BORMANN, PROFESSOR, DARTMOUTH COLLEGE, HANOVER, N.H.

Dr. BORMANN. Mr. Chairman, I have a statement that I would like to read into the record.

Senator NELSON. You may read it or extemporize.

Dr. BORMANN. Mr. Chairman, the advent of the nuclear age with its population explosion, pollution problems, deterioration of parks

and recreational areas and impending shortages of water, food, and other natural resources has focused attention on the capacity of our environment to sustain both the quantity and quality of human life.

Man's ability to meet and solve these problems of modern society is rooted in a common need to better understand naturally occurring ecological systems. Knowledge of natural systems serves as a biological baseline by which we can judge the success of our efforts to manipulate our environment and, in some cases, it can lead to a change of practice or the development of new practices. For example, research on the movement of pesticides through naturally occurring food chains has resulted in a general review of our overall use of pesticides.

This baseline function of our national ecosystems has been widely recognized. Within the past 2 years, five separate groups of scientists have called for intensified study of our natural environment. The President's Science Advisory Committee, in its report "Restoring the Quality of Our Environment," has called for the study of naturally occurring ecosystems by which we can evaluate the degree of pollution in man-controlled systems (p. 22, 24, 25-526).

The U.S. National Committee for the International Hydrologic Decade has proposed the hydrologic study of natural environments because man needs " * * * to understand natural environments in order to modify, control, and exploit them to better his welfare" (p. 3, International Hydrologic Decade. Phase I, U.S. Program For Period Ending June 30, 1969). Preliminary plans for the International Biological Program call for the study and conservation of various naturally occurring ecological systems (U.S.N.C. for IBP, publ. No. 1).

Biologists concerned with the weather modification program have urged that a full range of environments and major community types should be studied prior to any attempted weather modification in an area (Bull. Ecol. Soc. 47: 67).

Finally, the Ecological Society of America has urged the establishment of biological stations in some of the major biomes to provide much needed basic ecological information (Bull. Ecol. Soc. 46: 78).

Despite the increasing recognition of the need for study of natural ecosystems, there is at present no thoughtfully planned national system of representative ecosystems set aside for the purpose of descriptive and experimental research. Rather we have a potpourri of biologically interesting areas set aside by thoughtful citizens both within and without the government.

Although these reserved areas represent a step in the right direction, they are by no means comprehensive in their coverage of the whole range of our natural ecosystems, and oftentimes they are not extensive enough to permit experimental work necessary to the elucidation of ecological principles. I would like to illustrate this point by reference to a personal experience.

My particular scientific interest is in the study of the structure, function, and development of forest ecosystems. To fully understand the biological potentialities of any unit of land surface it is necessary to study the whole range of biological communities, both natural and man manipulated, that a unit of land can support.

This can be done by following changes that occur in one place over long periods of time, or by studying similar units of land in different

stages of biological development. In a forest area, the full potential of a site may be understood only after study of the whole range of communities that might occur in that area, for example, cultivated fields, abandoned fields in herbaceous stages, shrub stages, successional forests, cutover forests, burned-over forests, and old-age climax forests.

Detailed descriptive and experimental studies of such a sequence of communities reveals basic information on the structure, function, and development of the ecosystems occupying that unit of land. Ideally such studies tell us how the capacity to fix energy, to cycle nutrients, to alter the hydrologic cycle is related to the various communities able to occupy the site; these studies also tell us of the biological or microclimatological mechanisms operating to cause developmental changes within the system, and the types and numbers of organisms that each developmental stage is able to support.

Such basic biologic information provides the land manager with a set of managerial alternatives in the planning of proper land use for such purposes as timber production, disease control, wildlife management, recreation, water yield, conservation of species, etc.

Studies of complete developmental sequences of vegetation are becoming more and more difficult to carry out because of an increasing scarcity of the better developed stages of our forest ecosystems. I cite two examples. During 8 years spent in the Piedmont region of the Southeast, I invested considerable effort trying to locate old-age successional pine stands and undisturbed climax oak-hickory forests.

Not only were good examples of these types hard to locate, but the area of existing examples steadily decreased during the period of my observations. This situation exists despite the fact that pine and oak ecosystems cover much of the Piedmont landscape and are of great economic importance to the region.

The northern hardwood forest ecosystem covers most of the land area of northern New England and is basic to the economy of the region. During the past 10 years, working with State groups in New Hampshire and Vermont, I have attempted to locate good examples of old age, relatively undisturbed northern hardwood forest. Even though several million acres of this forest-type exist (McQuilkin, Northeast Forest Experiment Station, paper 91) practically all of it has been subjected to cutting, grazing, or maple sugaring activities and old-age stands are extremely rare (Lyon, C. J. and F. H. Bormann, ed. 1962, *Natural Areas of New Hampshire Suitable for Ecological Research*, Dartmouth College Biol. Sci. publ. 2; Vogelmann, H. W., 1964, *Natural Areas in Vermont*, Vermont Agriculture Experiment Station). Recently the best stand has been greatly impaired by the construction of a lake conceived and developed by the State fish and game commission.

My experience is not unique. Conversations with ecologists in various sections of the country indicate that good examples of various kinds of biological systems, such as certain forest types, grasslands, bogs, dunes, marshes, and rock outcrops, necessary for research and teaching, are becoming increasingly hard to find or to maintain. This situation is not limited to terrestrial systems, but also applies to aquatic systems, particularly lakes and streams.

Even in northern New England, with its low population density and its thousands of lakes, it is extremely hard to find a wholly natural

lake. This situation is worse in other sections less well endowed in natural waters and with higher population. Destruction or alteration of important biological research areas is unquestionably accelerating as our population grows and as the tools for environmental manipulation become more powerful.

To meet these needs and the more general need to preserve representative samples of our natural environment and the species diversity contained therein, a Federal system of natural areas for scientific purposes should be established as advocated in section 2, paragraphs 8 and 9. I believe this is one of the most important features of the ecological research and surveys bill.

Such a system should be planned by a committee of ecologically oriented scientists appointed by the Secretary from the Federal bureaus concerned with wild lands and from a group of recognized ecologists suggested by the National Academy of Sciences. Provisions should be made to make it possible for State, city, or private groups to add acceptable representative samples of important natural ecosystems to the Federal system.

To serve the best interests of science and the Nation, the Federal system of natural areas for scientific purposes should have two broad functions:

The first function is to preserve for scientific purposes representative samples of the range of biologically important ecosystems occurring in North America. This function could be fulfilled by setting aside biologically important sites throughout the States and Puerto Rico. I should add that many of these sites have already been set aside.

Collectively, these holdings might be thought of as a national biological reserve, or as a system of natural ecosystems held in reserve against the future biological needs of both basic and applied research. An additional and important function of the reserve system would be the preservation of the species diversity of the North American biota.

The species represent genetic information accumulated through eons of time, and the conservation of this information is basic both to scientific progress and to the successful manipulation of our environment. There is no question that the maintenance of maximum species diversity would contribute to progress in biology, agriculture, and medicine.

A reserve of species would provide sources of genes for experimental biology and breeding programs and would maintain the numbers of species from which new organisms could be selected for the production of food, drugs, and shelter, for esthetic purposes, and for other important ecological uses, such as biological control of pests and nitrogen fixation.

Although the reserve system would be used for research and teaching, because of its extent and diversification it would go beyond the capacity of our limited number of ecologically trained scientists to study intensively even a sizable fraction of the eco-systems held within the reserve system. This leads to the second major function.

The second major function of the Federal system of areas for scientific study should be to provide baseline information on the structure, function, and development of our natural eco-systems. To serve this need several eco-systems, perhaps 5 to 10, representative of the major biomes, should be chosen from the biological reserve system, and inten-

sively studied. These systems should be several thousands of acres in extent to allow considerable research pressure and, ideally, should be located near a university or a group of associated universities willing to participate in eco-system research.

Basic biologic, geologic, hydrologic, and meteorologic parameters of these systems should be studied, as well as parameters important to studies of air, soil, and water pollution such as levels, of lead, chromium, pesticides, and herbicides. Data collected should be analyzed and correlated using modern computational techniques, including systems analysis.

Baseline studies of the type described would not only reveal new principles of eco-system dynamics and thereby increase our understanding of the operation of all eco-systems, but these studies would also provide a set of biological baselines by which we could evaluate the changes that man has and will continue to make in his environment.

A Federal system of scientific areas serving the functions of biologic reserve and eco-system baseline studies would do much to meet our current and future needs to better understand our environment.

Senator NELSON. Thank you very much, Doctor.

Our next witness is Dr. Graham Netting, director of the Carnegie Museum, Pittsburgh, Pa.

Dr. Netting, your statement will be printed in full and you may either read or extemporize from it.

STATEMENT OF DR. M. GRAHAM NETTING, DIRECTOR, CARNEGIE MUSEUM, PITTSBURGH, PA.

Dr. NETTING. In the interest of saving time, I will hit only a few points made in my prepared statement and then I will add or I would like to add one illustration not covered in that.

The large museums and botanical gardens, whose systematic colleagues are a national resource are vitally interested in this bill. I cannot speak in any official capacity for any museum except my own, but I have discussed this bill at a recent meeting of the directors of the large systematic colleges and the response of the group was most favorable.

I think that many of those individual institutions have written letters supporting the bill.

Museums believe so strongly that ecological study areas are an essential need for the training of students and for modern systematic studies that many of our institutions have set up such areas at our own expense. We find that these areas are of growing importance and we would deeply appreciate the additional emphasis on the value of such areas that would be brought about by the passage of this bill.

Actually, biologists are much more ignorant than they like to admit. We know relatively little about the flora and fauna of the world if we consider how many species probably occur and how few of these are actually known. If, for example, after a multibillion-dollar investment, the first astronaut to land on the moon should find and bring back as a prize a spore or a pollen grain or even a minute spider, there would be a great clamor for definitive evidence immediately

that this was an extraterrestrial species and not a hitchhiker, and the chances are in the present state of our knowledge that this question could not be answered.

I would like to mention a number of points that the bill does not stress or does not allude to which to me seem important. The importance of natural environmental systems such as gene pools is very great indeed and may be an element of real survival for our Nation. I think some reference to this might help to strengthen the language of the bill.

I have included in my statement a quotation from a leading botanist with reference to this element. The importance of studies of what might be call "archeological ecology" might be mentioned as well. It is not enough to set aside areas that are natural in the sense of not having been greatly altered by man. We also have an interest in areas that have been altered by man but which can provide important ecological information on past plants and animals.

Some of the studies that have been made in our own country of dry land agricultural techniques, of early Indian settlers—similar studies that have been made recently in Israel—point up the advantage of knowing something about what the early human adjustments were on certain areas.

I think the language of the bill is broad enough to include such areas, but they might be specifically mentioned. Areas increase in value in direct proportion to the studies made on them. If the bulldozer and the sprays are the great threats to unprotected land, eminent domain land is the great threat to protected areas. I think if Congress sets up a system of natural environmental areas around the country, as I hope it will, that Congress might also provide protective measures so that no noncompatible use of these areas, invasions of them by any agency, governmental or private, would be permitted without specific congressional approval.

It is heartbreaking to see the trustees of a university decide to build a dormitory on a study area that has been productive of many scientific studies over the years and it is equally heartbreaking to see a natural area that may be in the hands of some governmental agency, State or Federal, cut in half by a new highway, simply because this land is cheaper than land outside of the area. So I would strongly recommend some protective wording for areas that are designated as parts of the national environmental system.

In an addendum that is not covered in my statement, it would be possible to light trap 10,000 moths in a week's time on almost any natural area in the United States. It would be impossible to get these 10,000 moths identified. There just are not enough specialists in microlepadocora in the United States or in the world to give identification of every moth that you could easily collect in a week's time. It would be equally difficult for many other groups, so one of the very important features of this bill to me is the possibility that it offers for accelerating the training of students and for employing personnel to get on with the job of studying many of these groups that have been sadly neglected.

Now, I can point this up very quickly by citing a case. I had my eye on a young lady in a graduate school at a great university who has

specialized in spiders. She will be getting her doctoral degree in a matter of 6 or 8 months. She does not want to teach and she should not teach because she is much too valuable to the Nation as an arachnologist.

If she went into a teaching position she would have perhaps 10 or 15 percent of her time to study spiders and there is not a State in the United States, to the best of my knowledge, that knows its spider fauna adequately, much less the ecology of the spiders.

We do not have any staff position at our institution for an arachnologist. Most granting agencies are not inclined to pay the salary of the principal investigator. I have the problem of finding a modest salary for an arachnologist if I wish to get the spiders of Pennsylvania or of our museum reserve studied. Every museum, every botanical garden, many universities, are in exactly the same position. They need to build up a cadre of people who can do the basic studies of the areas that are to be set up.

I wish to express my very great admiration for this bill and my sincere hope that it will be enacted into law.

Thank you.

Senator NELSON. Thank you very much.

I have a lawyer friend who had a scientist friend who spent all of his time studying the spider, and one day the lawyer asked him, "What good are spiders?" and he said, "They are interesting, and may I ask, What good are you?"

Dr. Netting, as previously stated, your full statement will be included in the hearing record.

(The statement referred to follows:)

STATEMENT OF DR. M. GRAHAM NETTING, DIRECTOR, CARNEGIE MUSEUM

My name is M. Graham Netting. I am, and have been for twelve years, Director of Carnegie Museum, a department of Carnegie Institute, a non-profit educational corporation located in Pittsburgh, Pennsylvania. Carnegie Institute, which also includes a Museum of Art and a Music Hall, now derives less than half of its income from endowment, one third or more from contributions of individuals and private foundations, and the balance from modest tax support by the city, county, and Commonwealth, and from Federal grants or contracts for research projects.

Before being kicked upstairs I worked at my trade as herpetologist and animal geographer for 28 years. During this period I made frequent trips to collect salamanders and frogs, snakes, lizards, and turtles for the Museum in various parts of the United States and Latin America. I had opportunity to observe and to study animals in habitats that are now gone forever although some of the species cling to a precarious existence in pockets of their once greater range. I was particularly pleased, therefore, to be invited to testify at this hearing on Senate Bill 2282. This Ecological Research and Surveys Bill introduced by Senator Nelson and co-sponsored by an impressive number of his colleagues, I regard—and I know that many of my fellow directors of natural history museums and botanical gardens also regard—as an excellent and long needed legislative proposal for a comprehensive program of accelerated research on natural environmental systems, for coordination of surveys and results, and for establishment of a system of natural areas, both public and private, for ecological research.

Don't be misled by glamor articles on the marvels of biology. All such discoveries—and there are many exciting ones—hark back to a prosaic foundation, often unhalloved and unsung, but none the less necessary. I refer to the descriptive task of listing and documenting the world's population of plant and animal species, which is Step 1; and the more intriguing and more difficult, but still fundamental task of studying the relationships of living things to others in their lineage and to the wide variety of other species that comprise each design for living, each well-balanced community that has evolved over millions of years of

adjustment to soil and climate and terrain. If the first astronaut who lands on the moon or elsewhere should bring back as one of the prizes of a multibillion dollar investment a lowly fungus or a pollen grain or even a minute spider there would be an immediate clamor for documented proof that this evidence of life represented a species unknown on earth, rather than a contaminating hitchhiker. In the present state of our knowledge, the chances are that no absolute confirmation or denial could be offered. We penetrated the stratosphere before we became fully acquainted with the biosphere.

The task of learning about the living world is a formidable one and much further from completion than any biologist likes to admit. Furthermore, exploding populations, mushrooming urbanization, exploitative land uses, and unchecked chemicalization threaten to alter or destroy many ecosystems and to exterminate many species before specimens are even pressed or preserved. Dr. David D. Keck, a distinguished botanist, writing in 1959 on *The Future of Systematic Botany* (*Systematic Zool.*, 8, no. 2:76-82), stated:

"This figure is hard to arrive at, but my hunch is that we shall know the temperate floras of the world rather thoroughly in another thirty or forty years, and that it will be at least twice as long before we can begin to think we know the tropical floras almost as well."

An equally eminent zoologist, Dr. G. W. Wharton, in a companion article on *The Future of Systematic Zoology* (*l.c.*: 82-87), wrote in even more sobering vein:

"While no one knows how many kinds of animals there are in the world, or even how many kinds have been named, estimates of the total number vary from 2,500,000 to 10,000,000 while estimates of those already described are in the neighborhood of 1,000,000. Systematists have a real challenge here and it is certain that the future will see this challenge met. It is inconceivable that a civilization that aspires to reach the moon can long afford to be ignored of the kinds of animals on earth."

Systematics or, if you prefer, taxonomy, the science of classification of organisms, was all too frequently in the past an indoor study of preserved materials. The modern systematist studies populations in relation to their environments and often spends a goodly portion of his time in the field, happily out of reach of the administrator's directives and in pleasant proximity to the plants or animals that comprise his specialty. The carefully tended collections in museums and botanical gardens are still of paramount importance as they are the final and permanent reference against which field observations must be checked; but they are no longer the sole stuff of taxonomy; and natural areas have become essential for the training of taxonomists and for the performance of their craft. The great systematic collections that constitute a national resource and that are basic comparative material are located principally in museums and botanical gardens, and a large proportion of practicing systematists are employed by such institutions. Museums believe so strongly that ecological study areas are an essential adjunct to their preserved collections that many of them have acquired natural areas at their own expense for the field checking by their own staffs of hypotheses developed in the laboratory. The Smithsonian Institution, the greatest assemblage of systematic collections in the nation, has a growing number of such areas, and the American Museum of Natural History has four: one on Long Island, one in Florida, one in Arizona, and one in the Bahamas. Some other museums and many colleges and universities have biological preserves or stations.

Even my own institution—with a mere seven million specimens in its collections and far more limited financial resources than the two previously mentioned—owns and operates a 1,500 acre field research station, Powdermill Nature Reserve, 55 miles east of Pittsburgh in the Ligonier Valley. This Reserve, specifically intended for long-term studies of life histories, ecological relationships, and population dynamics, has demonstrated its worth in less than ten years' time. In the past six years over 33,000 birds have been banded and a vast amount of data accumulated on bird migration, fluctuations in numbers, longevity, and other matters. Important new knowledge of insect life history and behavior has been gained. Even I, playing hooky from fund-raising and other tasks, have delved into the night life of salamanders and the movements of turtles. No portion of our Reserve has been farmed since the heavy use of agricultural chemicals and sprays began, so it now affords a check area where the teeming soil life of an untreated area may be studied. A cooperative project

with Pennsylvania State University for a soil sample transect from an adjacent agricultural experiment station across Powdermill Nature Reserve is now being planned.

The "Naturalist's Guide to the Americas," prepared by a committee of the Ecological Society of America, was a prelude to the organization of The Nature Conservancy, the only national conservation organization whose primary purpose is the preservation of natural areas having outstanding esthetic or scientific importance. The Nature Conservancy has actually acquired or helped in the acquiring of about 150 natural areas in various parts of the United States some of which have already been transferred to Federal agencies or to colleges and universities with suitable protective restrictions. Federally-owned lands, especially categories administered by the Department of Interior and the Department of Agriculture, encompass many primitive and natural areas, some of which have recently been afforded more permanent protection through the Wilderness Act. In 1962, I published a recommendation that each museum should endeavor to supplement its preserved collections with living populations on a carefully selected preserve. I mentioned that this was already being done by many museums, but I suggested that the practice be expanded not opportunistically but in a coordinated fashion with special emphasis upon endangered species and habitats. Many of the good and necessary things detailed in Senate Bill 2282 are already, therefore, being done to some extent by public and private agencies, but there is a crying need for the coordinating measures incorporated in the bill, and then, after inventorying the resource areas presently available for ecological research, a planned program for further acquirement, for accelerated study of the areas, and for the training of many more systematists and ecologists.

The bill focuses attention most admirably upon the critical need for a great increase in ecological research so that land use decisions affecting our dwindling natural resource base may be made intelligently rather than through trial and error. (If a species that has taken millions of years to evolve is exterminated in a twinkling because of a human error the loss is irreparable and well-nigh unforgivable.) It also affords strong encouragement for the establishment by public and private agencies and by individuals of representative samples of natural environmental systems for research and training needs. With this I am thoroughly in accord but I should like to be more crassly materialistic than Senator Nelson and to point out some additional arguments favoring a national network of representative ecosystems.

Dr. Herbert L. Mason, a great California botanist and a conservationist of broad insight, has stated the case for natural areas as genetic reservoirs most ably:

"The continued advancement of our scientific knowledge has brought into cultural use a constant stream of new plants and animals and of new products stemming from them, and resulting from scientific discovery in the search for the new or for new uses and improvements of the old. In its commodity resources for use as food or for use in the crafts and medicine, human culture has been enormously enriched by these operations. We have scarcely scratched the surface of the full economic potential hidden in the natural landscape. Some of these values are in directly usable commodities, reproducible through agricultural methods. Some will constitute a discovery in nature and the later synthesis of the material artificially. Here the act of discovery is the important value of the natural resource.

"The cultural growth of a people will be measured by what it does with what it has to work with. The more it has to work with, the greater the potential growth. The natural park and natural preserves constitute a prime means of preservation of elements of the natural diversity so important to the cultural advancement of a people. It is therefore important to every people that it preserve representative elements of the natural landscape as the source of the scientific advancement of its culture. Discovery in one land may lead to an item of exchange in another that may further broaden the cultural base of the people." (First World Conference on National Parks, pp. 108-109.)

Dr. Mason does not state categorically that a nation's future survival may depend upon its foresight in establishing and maintaining natural areas, but his examples lend strong support to this thesis.

Another cogent argument for preserving unspoiled natural areas is that no one generation should selfishly usurp the privilege of tampering with every square mile of its national land heritage for its own purposes. Surely our

descendants have a God-given right to walk beneath trees older than our history, to float down rivers devoid of habitation, and to be bitten by black flies in swamps too precious to be drained. And their research needs will be as important, and perhaps even more sophisticated than ours. Much such heritage is already assured in national parks, national forests, wilderness areas, and other sanctuaries already in being, but Senate Bill 2282 provides a vehicle for the inventorying and preserving of representative ecosystems not yet safeguarded in the public interest.

Although there is no specific reference in the bill to man, destructive beast that he is, as a part of the natural environment, he is part of that environment, and the language of the bill is broad enough to encompass studies of archeological ecology, i.e., how did those who lived here before us adapt to the natural environment of their day, whether they were American Indians or our own forebearers of one hundred years ago concerning whose use of land we are surprisingly ignorant. We know from the studies of archeologists the kinds of plants and mammals and birds and reptiles and shellfish that once lived in ecological niches now reft of much of their biota by the works of modern man. The natural inhabitants may yet be restored by careful handling and because we know they did live in those niches. Recent work in our Southwest by Richard Woodbury and in Israel by Michael Evenari demonstrated highly sophisticated water conservation techniques and dry land farming methods developed by so-called primitive inhabitants, techniques we can profit from in solving our arid area problems. Not only natural areas in the purist's sense of without human habitation merit preservation, but also habitations of tiny, isolated, human communities for the ecological and historical study that can lead us to understand the dynamics of human adjustment to living areas so that neither man nor nature suffers.

Once they have been established, natural areas increase in scientific value in direct proportion to the number of studies made upon them. Their value as norms, as controls, as springs of living knowledge, increases with each passing, scientifically productive year. It is tragic indeed to have college trustees preempt a long-used study area for a new dormitory or to have a highway slashed across a preserve just because condemnation costs on the open space will be lower. The bulldozer may be the greatest threat to unprotected land; eminent domain is the greatest threat to nature preserves. I think it would be eminently proper for the Congress to require that any natural environments it may establish are sacrosanct unless legislative approval is obtained for each and every non-compatible invasion.

All vainglory to the contrary, man cannot conquer nature. We are a part of nature, bigger and more noisy and destructive than a mouse, but subject to the same inexorable laws. When the good water is gone, the good soil covered or wasted, the good air tainted, we shall surely perish. This has happened in many times and place. We now send food to peoples whose ancestors failed to realize that without soil and trees on the hillside the town in the valley dies, without recognizing that we ourselves are busily engaged in emulating the ancient error.

Senate Bill 2282 offers life insurance for our nation, assurance of a natural heritage for our children's children. I commend it most highly.

Senator NELSON. Next is Dr. Rezneat M. Darnell.

**STATEMENT OF DR. REZNEAT M. DARNELL, MARQUETTE
UNIVERSITY, MILWAUKEE, WIS.**

Dr. DARNELL. Thank you, Mr. Chairman.

I. THE ENVIRONMENT OF MAN

A. NATURE OF ECOLOGICAL KNOWLEDGE

Every natural community is made up of numerous kinds of species of plants and animals. An oak forest may include several hundred. Each one of these species contains a particular spectrum of hereditary characters which have been perfected through thousands of years of

trial and error experiments, with the winners of each generation surviving to produce the next generation. This process is known as adaptation. Factors which shape adaptation are not the same from place to place, so the hereditary spectrum of a given species varies from one locality to another. This genetic diversity is one of the cardinal points of ecology since it represents the inherent plasticity of the species; i.e., its inborn ability to cope with a mosaic pattern of changing environmental conditions.

Each of the many species inhabiting a given area has become adapted to live in harmony with its neighbors. This harmony is characterized by inherent stability and is often referred to as the "balance of nature." Involved in this balance are many complex interrelations of the different species which in sum total tend to regulate the size and activities of the individual species populations and of the community as a whole.

Since the community exists in the context of a nonliving environment, it influences and is to some extent controlled by this environment. Chemical materials and energy are cycled through the community at considerable rates, and here again there is a certain stability or constancy determined by the regulatory forces of the community. The field of ecology encompasses study of species diversity, species interrelations, and relations with the environment. In its most sophisticated moments ecology attempts to understand the phenomena of adaptation and regulation.

B. THE COMMUNITY UNDER STRESS

Any mild external stimulus applied to a natural community represents a disturbance of the status quo and brings about an adjustment at a new equilibrium level. Due to its diversity and regulatory powers the community often displays great resilience in accommodating to new circumstances. However, there are limits in the abilities of the community to adjust. Drastic environmental change is likely to be followed by breakdown of regulatory mechanisms so that while the stimulus is being applied and for some time after it is removed the community may be in a dangerous state of imbalance as it seeks to adjust to the new rules of the game. Many species depend for their existence upon the original balance, and any disturbance may lead to extermination of such sensitive species. The greater the disturbance the more species are likely to be affected adversely. Unfortunately, the most sensitive species are often the most desirable ones from the human point of view. In this deadly game the ultimate winners appear to be the bacteria, and the runners-up are the forms which can live among and upon the bacteria. The natural allies of man are early losers.

C. MANKIND AS THE CHIEF STRESS AGENT

Man is a species which has, to some extent, become independent of his immediate environment. Through technology he has divested himself of many of his former responsibilities to the natural communities within which he evolved and to which he became adapted. The

nature of man's own adaptations, however, precludes the possibility of his ignoring all responsibility to the natural world so long as he needs food, water, air, and peace of mind. The fact that the human population has been able to achieve high planetary density reflects as much the plasticity of nature as it does his own technological ability. It follows that there is an ultimate limit in the ability of nature to bend and bounce back from man-imposed stress. Whatever the cost, therefore, humanity must strive to understand the factors of nature and the limits beyond which it cannot be pushed without entailing irreparable damage or even human extinction. It is already clear that there is a limit to the numbers of humans which can survive on this planet and that the maximum population for human comfort is well below the level of maximum survival. In any event, the length of time for which such large populations could be supported is at present an unanswerable question.

With the advent of high population density and associated technological development drastic environmental modification has come about at a greatly expanding rate. Simultaneously, society has become more urban and more buffered from the direct results of its actions. Only the outdoorsman and the environmental specialist need directly encounter the mounting tragedy, and most of these are acquainted with only a few local situations. Few, indeed, can view the total dilemma in real perspective.

D. A CASE STUDY—THE DEAD RIVER STORY

For the record the case of environmental deterioration and community adjustment will be documented with a single example based upon some of my own recent studies.

Shortly before 1910 an ecologist, Dr. Victor Shelford, then of the University of Chicago, made a survey of the fishes in small streams of the Chicago area, and for each stream he carefully identified the exact collecting locality and the fish species obtained. Fifty years later I revisited all of his collecting stations on one of the small streams (Dead River) near Waukegan, Ill., hoping to be able to determine what natural changes take place in a stream during a half century. By searching through various museum collections I found Shelford's original fishes as well as subsequent collections made through the years by other scientists. For this one stream I had a reasonable complete picture of the changes which had taken place in the fish populations during the years. Sufficient information was available to allow interpretation of certain environmental changes, as well. Such complete data are quite rare since they depend upon adequate initial surveys.

The record did not reveal progressive changes in response to natural phenomena. Rather, it clearly reflected the deterioration of an aquatic environment in response to gradual encroachment by the human population. Fifty years ago the stream flowed through a forested area which payed out its water gradually and maintained a rather even annual flow. The water was clear and supported a population of fishes characteristic of such environments. At present the

stream flows through treeless lots and suburban backyards. Following heavy rains it rises quickly to torrential flow and as quickly subsides afterward. During dry summer weather the upper reaches dry up completely, and farther down the streambed contains only a series of disconnected pools. At several points along the stream effluent from nearby cesspools seeps visibly into the stream pools. Besides creating a stinking health hazard, this effluent introduces much organic matter so that through bacterial action the oxygen supply of the water is greatly reduced. In this section of the stream only a few sickly fish of two species are able to survive. Where roads cross the stream one encounters a great deal of human litter including paper, beer cans, cardboard containers, glass, old rubber tires, strands of wire, and broken phonograph records. The clear-water community has disappeared from all the upstream areas except from one wooded ravine a few hundred yards long where a small remnant yet survives. The remainder of the headwater is populated by a few pollution (low oxygen) tolerant species. The downstream section of the river flows through a park before entering Lake Michigan, but even here evidence of human handiwork is evident in the additions to and subtractions from the original fish fauna.

Of the 37 species known to have inhabited the stream during the past half century, 15 can no longer be found there. Populations of four other clean-water species have been severely reduced. Populations of about five pollution-tolerant species seem to have expanded, and four species new to the stream are clearly present as a result of human activities. The carp first appeared in the 1925 collections, and in the 1958 collections they constituted 94 percent of the 6,000 fishes taken. Goldfish appeared in 1958 as did the alewife (a recent introduction into Lake Michigan) and the redbfin shiner. The latter species is used by fishermen as bait, and through bait-bucket introductions it is known to have spread widely from its original home in streams of the Great Plains.

Not all the changes in the fish fauna of the stream can be laid directly at the feet of man, largely because we do not have enough knowledge of the complex interactions involved. A number of the changes, however, are directly attributable to human activities, and most of these changes may be thought of as deleterious in the sense of substitutions of a pollution-tolerant garbage feeding community in place of the clean-water balanced community. The elimination and restriction of native species is obvious. In a few years, as the area becomes urbanized, the stream will be replaced by a culvert and then a pipe, and the natural community will have disappeared completely.

Unfortunately, this same story is being repeated daily throughout this and other countries in areas where documentation is not possible. No one is watching. Through a series of accidents the history of the demise of Dead River has found its way into the records of civilization, and, as such, it must stand somewhat alone as a monument to human extravagance, a wretched byproduct of the American way of life.

E. DILEMMA OF THE ECOLOGIST

The practicing ecologist faces a difficult situation. Although much insight may be gained from studies carried on in the inside laboratory, all such studies are de facto unreal oversimplifications of nature. The real situation exists in the field where it is exceedingly difficult to carry out anything resembling a controlled experiment. Natural communities are generally too complex and the interrelations too subtle to provide simple clearcut experimental answers. Preparation of ecological reports is itself a special chore since narratives describing the field variables are of necessity long and involved and since the field ecologist who is adept at mountain climbing, skin diving, or jungle survival is not likely to be equally adept at describing his field experiences. Indeed, from personal observation a great share of our best ecological knowledge has never been published. It still resides in file cabinets of ecologists who for one reason or another have not been able to place all their data into print. The Dead River study is a case in point.

In order to carry out his responsibility to mankind the ecologist clearly needs help. The job of describing and interpreting nature is one of inconceivable magnitude and complexity. Emphasis must be placed upon the value of ecological knowledge in order to attract outstanding young minds equal to the task. Funds must be made available to carry out the analyses. Time must be provided for the experienced ecologist to write what he has discovered about nature.

The ecologist needs help in yet another way. Since his laboratory is nature itself, provision must be made for preservation of intact natural communities from which he can derive the knowledge which mankind needs for comfort, health, and survival. Only through identification and preservation of such natural areas can mankind ever hope to achieve this knowledge. Ideally several representatives of each type of virgin community native to our land should have been set aside long ago. This was not done, and already it is too late to ever know just what certain of them were like. Many near-virgin areas are still left, however, and preservation of these is a matter of national concern: national, because the preservation job has not and simply cannot be handled entirely by local means.

F. PRESERVATION OF SAMPLES OF NATURE

Natural area preservation does not imply just the setting aside of areas for scientific study and manipulation. It also means the permanent protection of our most valuable natural resource, the native species of plants, animals, and microbes which are of enormous potential use to civilization. These forms represent untapped sources of antibiotics, medicines, drugs, natural pesticides, industrial raw materials, foodstuffs, and ornamentals. They include our hopes for successful biological warfare against crop pests. Since these species are already adapted to the American environments they are potential sources of hereditary material for improvement of production and

disease resistance in our crop species. In the future our native fauna and flora will undoubtedly be put to uses wholly undreamed of today. In aggregate these species represent the total hope for environmental stabilization of oxygen for human respiration, clean water for human consumption, and indirectly, perhaps even such factors as planetary temperature.

Already many conspicuous species of our native plants and animals are known to have become extinct, and many others have suffered severe restriction of distributional range with concomitant loss of genetic strains. How many of the inconspicuous forms have silently ceased to exist, no one can say. Recent scientific writings indicate that at least 100 species and subspecies of our native vertebrate animals alone are currently in some danger of extinction, and several are in critical danger. Clearly we cannot afford to preside over the demise of nature. We cannot in conscience deprive future generations of the opportunity of reversing our unwitting mistakes. We must provide for the public trust.

G. SUMMARY

The ecologist sees the ultimate necessity of some sort of artificial control of the human population. He sees the immediate necessity of reducing environmental disturbance, and this involves control of at least the most severe forms of environmental destruction and pollution. In order to manage the environment to the long-range benefit of mankind it is mandatory that a label of urgency be placed upon matters pertaining to the understanding of nature. This understanding can only be derived from study of representative natural areas. Such natural areas would also provide sanctuaries for preservation of our native species in their various genetic strains for potential use by future generations.

II. THE WISCONSIN STORY

A. WISCONSIN'S CONSERVATION TRADITION

The cause of conservation in our age needs little justification in the State of Wisconsin. The scientific, economic, and social need for conservation of our natural resources, and the moral obligation of educators, scientists, legislators, and citizens to demand wise preservation and management have been well established. Indeed, the State of Wisconsin has long been recognized nationally as one of the leaders in the conservation field. Renowned conservation spokesmen and advocates have appeared among our legislators, university presidents such as Van Hise and Chamberlain, and among our naturalists and scientists including Increase A. Lapham, John Muir, Aldo Leopold, Norman Fassett, John Curtis, and a host of others. Wisconsin authors have won acclaim for their conservation writings, and healthy public support for conservation programs has repeatedly been demonstrated.

Most significantly, the State has been the source of new conservation ideas, some of which have created worldwide impact. Aldo Leopold's appeal for the development of a "conservation conscience" in the hearts and minds of citizens has not gone unheeded. The University of Wis-

consin Arboretum and the Wisconsin State Board for the Preservation of Scientific Areas represent significant concepts in conservation thinking in this country. Following our lead several other States have since established university preserves and State natural areas systems, and from coast to coast additional States have expressed interest in initiating such programs. Traditionally the gap between the scientist-educator and the legislator has been smaller in Wisconsin than elsewhere, and support for conservation programs has been mustered on a nonpartisan basis.

B. THE UNIVERSITY ARBORETUM

Only 5 years after Wisconsin became a State one of her early and most distinguished naturalists, noting the encroachment of civilization on the natural areas near the university, pointed out:

It would seem to be peculiarly appropriate for our Universities and Colleges to secure upon the grounds by which they are surrounded, at least one good specimen of each tree and shrub that grows naturally in Wisconsin; and I will venture to predict that the University or College that shall first surround itself with such an "Arboretum" will first secure the patronage and good opinion of the people, and will thus outstrip those institutions that show a lack of taste and refinement by omitting to plant trees. (Increase A. Lapham, "The Forest Trees of Wisconsin." Wisconsin State Agricultural Society, vol. IV, 1853.)

A quarter of a century later another Wisconsin scientist published a more serious view:

The most reliable natural indications of the agricultural capabilities of a district are to be found in its native vegetation. The natural flora may be regarded as the result of nature's experiments in crop raising through the thousands of years that have elapsed since the region became covered with vegetation. If we set aside the inherent nature of the several plants, the native vegetation may be regarded as the natural correlation of the combined agricultural influences of soil, climate, topography drainage and underlying formations and their effect upon it. To determine the exact character of each of these agencies independently is a work of no little difficulty; and then to compare and combine their respective influences upon vegetation presents very great additional difficulty. But the experiments of nature furnish us in the native flora a practical correlation of them. The native vegetation therefore merits a careful consideration, none the less so because it is rapidly disappearing and a record of it will be valuable historically. (Chamberlin, T.C. "Native Vegetation of Eastern Wisconsin." In: Geology of Wisconsin, vol. 2:176-187, 1877.)

From these and other beginnings stemmed the idea of a natural area for use by the university. Through the years much discussion ensued, but it was not until the early 1930's that an organized program of land acquisition got underway. In late 1933 Dr. Aldo Leopold submitted a wildlife management plan in which he recommended that the arboretum serve in four ways:

- (1) As an educational exhibit for wildlife and management methods,
- (2) As a place for research,
- (3) As a place to conserve remnants of rare species, and
- (4) As a source of "outflow" of surplus wildlife populations.

Formal dedication took place in late spring of 1934, and during the three decades of its existence untiring efforts have been devoted by scientists and citizens alike to increase the size and enhance the sci-

entific value of the arboretum. Especial effort has been made to re-establish and maintain within the confines of the arboretum examples of early vegetational communities all but gone from the Wisconsin scene.

Today the arboretum represents 1,500 acres of carefully maintained oak forest, pine forest, maple-beech-hickory forest, savanna, prairie, marsh, fen, pond, and lake. In addition, it includes laboratories, nursery and horticultural areas, gardens, and trails. In this outdoor research area plants, animals, and landscapes can be studied in the natural or near-natural conditions, and during the past few years alone over 90 scientific studies have taken place in the arboretum (appendix A). This area, likewise, performs an educational function providing living dioramas of the native Wisconsin landscapes for the study and inspiration of hundreds of students of art, literature, history, geography, hydrology and other disciplines within and beyond the scope of technical biological science. The value of such an area to the university and to citizens of the State cannot be measured. A detailed history of the development of the arboretum, which has just been published, documents the dreams and efforts which have been invested to bring this worthwhile project to reality. (Nancy A. Sachse, "A Thousand Ages." 151 pages. 1965. Available through: The University of Wisconsin Arboretum, 329 Birge Hall, Madison, Wis.)

C. THE WISCONSIN STATE BOARD FOR THE PRESERVATION OF SCIENTIFIC AREAS

Although pleased with the development of the arboretum for near-campus research and training, the scientists and citizens of Wisconsin have not been content to allow the remainder of the State to disappear down the drain of misuse. In 1951, through cooperative action of university scientists, conservation department personnel, and legislators there was created by statute a State board to, "formulate policies for the preservation, selection, acquisition, and management of areas necessary for scientific research, the teaching of conservation and natural history, and for the preservation of rare or valuable plant and animal species and communities." (Wisconsin statute 23.27). The board was given the power and authority to—

- (a) Determine the acceptance or rejection of areas of special scientific interest that may be offered as a donation by individuals or organizations for preservation.
- (b) Make recommendations to appropriate federal agencies or national scientific organizations of areas in the state that are considered worthy to be listed as scientific areas of national importance.
- (c) Advise the conservation department and other agencies on matters pertaining to the acquisition, development, utilization and maintenance of scientific areas, including determinations as to the extent of multiple use that may be allowed on approved scientific areas that are a part of a state park, state forest, public hunting ground or similar property of the commission.
- (d) Prepare and publish an official state list of scientific areas available for research and the teaching of conservation and natural history, and recommend publication of studies made in connection with these areas.
- (e) Co-operate with federal agencies, other states, counties, or organizations concerned with similar purposes.
- (f) Take such other action as may be deemed advisable to facilitate the administration, development, maintenance or protection of the scientific area system or any part or parts thereof.

The board was to consist of six members representing the State conservation commission, State department of public instruction, University of Wisconsin, State colleges, private colleges, and the Milwaukee Public Museum. Members were to donate their services, and incidental expenses were to be absorbed by the institutions represented.

Lacking operating funds or the power to hold title to lands, the State board began its activities by designating certain publicly owned lands as scientific areas. Through the enthusiastic cooperation of the Wisconsin chapter of the Nature Conservancy other parcels in critical danger were purchased and the titles of ownership given to the university. Through the ensuing years plans were developed for setting aside representative examples of each natural community native to the State. After years of intensive study and survey work, Dr. John T. Curtis, professor of botany of the University of Wisconsin and long time chairman of the State board, published an extensive treatise on the plant communities of the State which is, without question, the most comprehensive treatment of a State flora yet printed (John T. Curtis, "The Vegetation of Wisconsin." University of Wisconsin Press; 637 pages, 1959). In this work he classified and characterized each of the native vegetational communities of the State (simplified in app. B). Furthermore, by studying records of the original State surveyors and early naturalists he was able to construct a detailed map of the distributional patterns of the native vegetational communities of the State (app. C). Articles pointing out the work of the State board and the need for scientific areas were published by several authors (app. D).

By spring of 1965, 37 areas had been designated as scientific areas, and at that time the board approached the State legislature, pointing out the extent of its activities and requested an operating budget for the employment of staff to aid in locating potential sites and assessing their scientific value, and for publication and dissemination of descriptions of scientific areas to the scientists and educators of the State. The legislature and the Governor proved sympathetic to this appeal, and operating funds were provided.

Now, in the spring of 1966, the State board for the preservation of scientific areas is able to proceed more rapidly in discharging its responsibilities to the citizenry of the State. With a full-time ecologist already employed and a State natural areas system already comprising 45 carefully selected sites (8 having been added during the past year), prospects are brighter for the fulfillment of an early dream.

Problems yet remain, however. At present the total system includes less than 5,000 acres, scarcely a fitting representation of the native communities. Most of the scientific areas have, of necessity, been established on lands already in public ownership, and some of the most critical areas yet to be set aside are not publicly owned. Although the State board is prepared to put to good use any funds available for land acquisition, access to such funds has turned out to be anything but a simple matter. Federal support for this specific purpose is urgently needed.

D. SUMMARY

In sharing its experience Wisconsin wishes to stimulate other States to initiate and strengthen their natural area preservation programs. Simultaneously, it wishes to demonstrate a Federal responsibility in the development of centers for environmental training and research and, in cooperation with the various States, a joint responsibility in the establishment of programs of selective natural area preservation. One no longer has to be a professional ecologist to comprehend this need. (The appendixes follow:)

APPENDIX A

RECENT RESEARCH PROJECTS UTILIZING THE UNIVERSITY OF WISCONSIN ARBORETUM

During the past three or four years the Arboretum of the University of Wisconsin has been utilized by at least fifty faculty members and a large number of graduate students to carry out over ninety research projects. A partial listing of these projects by University Department is given below.

A. UNIVERSITY OF WISCONSIN

Agronomy: Effect of Fertilizer on Nitrate

Botany:

- Sand Prairie Establishment
- Effects of Burning on Prairie
- Mast Production by Oaks
- Antibiosis & Autotoxicity in Native Plants
- Selection of Grazing-Resistant Prairie Grass Strains
- Developing Native Plants for Horticulture
- Factors Affecting the Weed Stage in Secondary Succession
- Succession in the Oak Community
- Plant Succession in Permanent Quadrats
- Growth & Yield of Oak Forest Herbs
- Understory Plants and Conifer Growth Cycles
- Intra-stand Forest Composition Variation
- Rate of Leaf Litter Decomposition
- Moss Communities of Different-Aged Pine Stands
- Phloem of Woody Plants
- Monocot Vascular Tissues
- A Fungus (*Emericellopsis*) in Different Environments
- Desmodium*, *Anthraxnose*, and Other Fungi
- Austrian Pine Embryology
- Earthballing Techniques for Transplanting

Entomology:

- Red Pine Sawfly Population Fluctuation
- Jackpine Sawfly
- Larch Case-Bearer
- CO₂-Trapping of Parasitic Arthropods
- Mosquito Biology
- Residual Insecticides in Mosquito Control
- Biological Survey of Arboretum Insects
- Nesting of Native Bees
- Red Pine Attackers

Forestry:

- Red Pine Microsporogenesis
- Conversion of Oak and Pine Forest

Forest Products:

- Fungi in Wood Destruction
- Cambial Marking of Red Pine
- Soil Characteristics and Wood Quality of Red Pine

A. UNIVERSITY OF WISCONSIN—continued

Genetics:

- Compatibility Test on *Pinus*
- Forest Tree Breeding

Horticulture & Landscape Architecture:

- Oak Establishment by Seed
- Lilac Desirability
- Ornamental Crabapples
- Viburnums
- Hardiness & Variability in Small Shrubs
- Phenology of Lilacs

*Medical School-Anatomy: Fetal Membranes of Shrews**Meteorology:*

- Microclimatic Reconnaissance
- Subsurface Soil Temperatures

Plant Pathology:

- Overwintering of Red Clover Mildew
- Red Cedar Resistance to Apple Rust
- Conversion of Nettles to Grass
- Canker on Quaking Aspen
- Selection & Breeding of Poplars

Soils:

- Slow Neutron Counter
- Soil & Climate Factor Analysis Appraisal
- Soil Moisture
- Soil Profile Characteristics
- Incorporation of Organic Matter Under Native Vegetation
- Incorporation of Organic Matter
- Light Interception in two Forest Types

Wildlife Management:

- Bluebird & Tree Swallow Life History
- Woodcock Population
- Ring-necked Pheasant Population
- Cottontail Rabbit Population
- Prairie Propagation
- Spread of Mature Wild Plants After Transplanting
- Spread of Planted Trilliums
- Grass Competition
- Control of Tatarian Honeysuckle
- Growth of Planted Tamaracks
- Foxes
- Tree Swallow Population

Zoology:

- Small Mammal Community
- Environmental Manipulation and House Mouse Populations
- Selection of Chemical Elements by Small Mammals
- Life History of Flying Squirrel
- Predation of *Drosophila*
- Migration of Banded Songbirds
- Utilization of Constant Diet by Pheasants
- Cecropia* on Black Cherry
- Nutrients & Vitamins in Algal Growth
- Frog Populations
- Prairie Small Mammal Populations
- Shelter Construction
- Orientation of Migrant Birds

B. OTHER INSTITUTIONS

- Biology* (Marquette University) : *Parthenocissus* Development & Morphology
- City* (Madison, Wisconsin) :
 - Banding Mourning Doves
 - Lepidoptera

APPENDIX B

List of Wisconsin plant communities

[Adapted from Curtis, 1959]

Distinguishing features	Communities	Representative species	
Mature trees present.	Savannas (scat-trees) -----	Hardwoods dominant:	
		1. Oak barren -----	Black oak; Hills oak.
		2. Oak opening -----	White oak; Bur oak.
		Conifers dominant:	
	Forests -----	3. Pine barren -----	Jack pine.
		4. Cedar glade -----	Red cedar.
		Hardwoods only:	
		5. Southern dry forest -----	Black oak; white oak.
		6. Southern dry-mesic forest -----	Red oak; elm.
		7. Southern mesic forest -----	Maple; basswood.
		8. Southern wet-mesic forest -----	Soft maple; ash; elm.
		9. Southern wet forest -----	Willow; cottonwood.
Mixed conifers and hardwoods:			
10. Northern dry forest -----		Jack pine; aspen.	
11. Northern dry-mesic forest -----		Pine; red oak; maple.	
12. Northern mesic forest -----		Maple; hemlock; Yellow birch.	
Terrestrial -----	13. Northern wet-mesic forest -----	White cedar; ash.	
	Conifers only:		
	14. Northern wet forest -----	Black spruce; tamarack.	
	15. Boreal forest -----	Balsam fir; spruce.	
	Shrubs dominant:		
	16. Shrub-Carr -----	Willow; dogwood.	
	17. Alder thicket -----	Speckled alder.	
	18. Open bog -----	Sphagnum; leatherleaf.	
	Herbs dominant:		
	Closed communities:		
	19. Northern sedge meadow -----	Sedges; bluejoint.	
	20. Southern sedge meadow -----	Sedges; cordgrass.	
Mature trees absent.	21. Fen -----	Bluejoint; managrass.	
	22. Dry prairie -----	Little bluestem; grama-grass.	
	23. Dry-mesic prairie -----	Bluestem; little bluestem.	
	24. Mesic prairie -----	Bluestem; needlegrass.	
	25. Wet-mesic prairie -----	Bluestem; bluejoint.	
	26. Wet prairie -----	Bluejoint; cordgrass.	
	27. Bracken grassland -----	Bracken; povertygrass.	
	Open communities:		
	28. Open cliff community -----	Campion; cliffbrake.	
	29. Shaded cliff community -----	Polypody; fragilefern.	
	30. Sand barren -----	Junegrass; little bluestem.	
	31. Beach community -----	Sea-rocket; saltwort.	
32. Lake dune community -----	Beach grass; beach pea.		
Aquatic -----	33. Emergent aquatics -----	Cattail; burreed.	
	34. Submerged aquatics -----	Pondweed; Eelgrass.	

(App. E is a map which is in the files of the committee.)

APPENDIX D

WE NEED MANY MORE SCIENTIFIC AREAS

(Excerpt from: Hugh H. Iltis—Wisconsin Conservation Bulletin, Vol 24(9) : 1959)

To the biologist, especially to the research biologist, conservation does not only mean wise use when a use is known. To him, conservation also means preservation when no direct immediate use has as yet been found.

We have come to realize during the last 30 years that preservation of soil or forest for economic reasons is not enough; that to really make advances in proper conservation we have to learn to understand the immense complexities of what the British ecologist, Tansley, called the ecosystem, the interrelationships of plants, animals and their environments. In order to study these, we need to preserve areas containing undisturbed ecosystems for scientific study. These we call scientific areas.

What do we really know about our Wisconsin land and soil, our plants and the animals that feed on them, and the myriads of delicate ecological relationships between all these organisms? The truth is, we know very little, despite the fact that we know more about the natural history of Wisconsin than that of most any other state.

Natural history is in many ways in its infancy. We may know about how many species of plants grow in Wisconsin, but do we know where and why? And if we think of insects, fungi, bacteria, and other small organisms, in many instances we do not even know their names, and less their potential uses, or importance in the schemes of the living world.

There are countless questions that can be asked. For example, what effect do all these organisms have on soil formation, or on the growth of trees? What are the factors that produce the types of soil found in Wisconsin? What effect does selective cutting have on the heredity of tree species? Why are species such as chestnut, elm, or oak so vulnerable to disease, especially now that most of their habitat has been disturbed by man? What is the maximum size of a tree? How many local genetic types of, say, red oak or sugar maple are there here? Are there any strains of oak that are wilt-resistant?

Each woods or prairie has particular forms of each species, each form specially adapted to that particular site. The differences between them may be minute, but they are there and they can be measured. With all this variety, each area is therefore a tremendous storehouse of potential resources, not only for ecological or taxonomic research but also for the source of as yet unknown economic products of plants. What month goes by we do not read of a new antibiotic or a new drug that originated from plant sources? We therefore need to keep inviolate samples of as many types of vegetation in as many situations as possible, to keep from extinction as many species and genotypes as possible. Is there one among us who could evaluate the potential of *Lespedeza leptostachya*? None of us can, for this legume disappeared from Wisconsin with the plowing of the prairies. And once extinct, no human effort can ever recreate this or any other species!

It is indeed a small price to pay, to buy 50 acres of prairie! For from such a prairie as this, which would barely support a family, came streptomycin, or strains of penicillium, which helped save this country billions in man-hours and human suffering, or may come a valuable strain of grass or legume.

There are many more questions for which we do not as yet know the answers. To get the answers, we must carry out basic research. To carry out basic research we must have natural or scientific areas, that is, tracts of land in a natural state, set aside and permanently protected or managed to preserve native plant and animal communities, free from any kind of interference that will destroy the community. Cultivated land or grazed or cut forest has different living things—the complex system has changed and with it, the original value for basic research has been lost.

To quote Aldo Leopold: "The science of land-health (i.e., conservation), needs, first of all, a base datum of normality of how healthy land maintains itself as an organism.

"Paleontology offers abundant evidence that wilderness maintained itself for immensely long periods . . . soil was built as fast or faster than it was carried away. Wilderness, then, assumes unexpected importance as a land laboratory.

"One cannot study the physiology of Montana to the Amazon: each biotic province needs its own wilderness for comparative studies of used and unused land. It is of course too late to salvage more than a lop-sided system of wilderness remnants, and most of these are far too small to retain their normality. All wilderness areas, no matter how small or imperfect, have a large value to land-science. The important thing is to realize that recreation is not their only, or even their principal, utility."

What are, then, the principal purposes of wilderness and scientific areas? First of all, it is here that we can preserve permanently the tremendous complexity of undisturbed natural biotic communities, so that we may further the understanding of nature for the benefit of man by basic research into the ecology, taxonomy, and economic uses of its organisms, and to transmit such an understanding to students of this and later generations.

For advanced students of the land-use sciences, a virgin maple woods or blue-stem prairie is a "living museum," an outdoor classroom, a check or control experiment, and a biological storehouse, whose demonstration value is tremendously important in teaching. Without such a demonstration, no teacher, no

matter how good, can ever transmit to the student the knowledge he needs to properly evaluate the effects of the activities of man on his surroundings or ever hope to know nature. To understand the soil of a plowed field he needs first of all to understand the intact, unplowed soil profile of an oak opening or a prairie. There simply is no substitute!

For that reason *scientific areas must never be disturbed, cut or grazed*, except in the specific cases where management is necessary to preserve a vegetation type (i.g., the burning of prairies). So-called improvements, like a trail building, clearing out over-mature timber, or dead trees, or spraying with DDT, or 2, 4-D are incompatible with their functions.

To the biologist, in addition, the scientific areas may represent in some cases sanctuaries for valuable and rare species of plants or animals (such as the blue aconite in Parfrey's Glen), or of whole communities, such as the wild flowers of the Ridges Sanctuary or the Cedarburg Bog species and communities which give us clues to the past history of Wisconsin's living things.

Now what do we have in Wisconsin in terms of scientific areas? Wisconsin has a number of interesting and valuable scientific areas already set aside. The number is as yet pitifully small, considering the size of the state and the potential value that will be derived from them in the future.

Through the efforts of Norman Fassett, Aldo Leopold, John Curtis, Albert Fuller and C. L. Harrington, just to mention a few, a law was passed in 1951 to establish a State Board for the Preservation of Scientific Areas. This board has worked hard to preserve some 28 of the areas in immediate need of preservation. But in Wisconsin we need not 28, but 280 or even 500 such areas, scattered throughout the state, to give us a full representation of the vegetation mosaic that used to cover the landscape. This is the great need, the urgent problem, for time is running out.

What are the specific problems that we face, in trying to acquire land for such purposes in Wisconsin, we who are convinced of the value of conservation, and who have a deep faith in the over-all concepts of conservation on a scientific basis?

Many of the areas on your map are state property and their acquisitions involved relatively simple transfers of status. This type of acquisition is now coming to an end, for except for some wetlands there are only a few desirable and obvious areas left in state ownership that the board has not recommended and actually set aside for preservation.

Many areas that are of great scientific value are in private ownership and cost money, often *much* money. And unfortunately, many of these which are in the greatest need of being conserved, are also those that are valuable commercially—upland prairies, upland virgin hardwoods, and coniferous forests. Climax communities can only be bought at great expense, for there are few such areas left and these are very valuable, even though often less than 40 acres in extent. Nevertheless, some of these will have to be bought, no matter what the expense.

While money is the big bottleneck in the acquisition of land, there is much that can be done at the "grass root" level. As a matter of fact, it is the conviction of many that this is the real answer to the problem, that the hope of preservation for many local areas lies in the efforts of the conservation leaders of the community, you who are reading this, and in the various organizations, from Garden Clubs to Friends of the Native Landscape, from the Izaak Walton League to the Nature Conservancy.

Senator NELSON. Excuse me, Doctor. I have an amendment over on the floor. Senator Metcalf has kindly agreed to come over and conclude the hearing. I appreciate your very fine testimony. I regret that I have to leave.

Dr. DARNELL. I have four more sentences. May I read them after you leave?

Senator NELSON. Go ahead and finish.

Dr. DARNELL. In order to manage the environment to the long-range benefit of mankind it is mandatory that a label of urgency be placed upon matters pertaining to the understanding of nature. This understanding can only be derived from study of representative natural

areas. Such natural areas would also provide sanctuaries for preservation of our native species in their various genetic strains for potential use by future generations.

I wish to point out that the international biological program, which is somewhat comparable to the international geophysical calendar year, has already established several programs for natural area preservation. The human body maintains a portion of its resources for the carrying forth of wound healing, body maintenance, and taking care of such exigencies then as this, although natural communities are prepared to take care of wound healing and any damage which may occur.

I think human population might well take a note from natural community and by analogy take some care to the healing of its sores and its wounds. I suggest, Senator, in the near future a portion of our Federal budget amounting to at least 1 percent be allocated to such purposes as we are talking about now.

I doubt that the agencies involved, that the scientists available would be able to put that much money to good use immediately. But I think we must look forward to that kind of allocation in the near future.

Senator Nelson, thank you, sir.

Senator NELSON. Thank you, Dr. Darnell.

Senator Metcalf from Montana, who is a distinguished member of the Interior Committee, will conduct the balance of the hearing.

Senator METCALF. If I read this accurately, the next witness is Dr. Fosberg.

Dr. Fosberg, we are delighted to have you before the committee. I am a cosponsor of this legislation but I have been before the education committee, Senator Jackson's committee on NATO, and several others today. I assure you that the rest of us who are sponsors of this will read the statements carefully.

So, you are making a record for many of us and not just for me. Dr. Fosberg, you may go ahead in your own way. You have a prepared statement. If you wish to read it, go ahead.

STATEMENT OF DR. F. RAYMOND FOSBERG, SPECIAL ADVISER TO THE SMITHSONIAN

Dr. FOSBERG. Thank you, Senator Metcalf.

Ladies and gentlemen, it is a great privilege to express some ideas concerning certain aspects of the bill under consideration. We have already heard a great deal about the necessity for this bill. Most, of course, of what we have heard has to do with the situation in the United States and work in the United States. These, of course, are of prime concern. There may have been a time when we were so isolated and self-sufficient, and when man's ability to affect his environment was so limited, that we could afford to be concerned only with conditions in our own country.

These days are now past. We have reached the stage where we are perfectly capable of effecting changes, either good or bad, in the total environment of man. Not only are we able to, we are doing it.

It is entirely likely that before we learn the full extent of this power, we will commit blunders that will injure the entire human race. The

only way we can hope to avoid such occurrences is to gain an effective understanding of our world eco-system, and of our own role in it.

Section 9 of the bill authorizes the proposed agency to participate in environmental research in the oceans and in other countries. This is, in the long run, undoubtedly one of the most important provisions of the proposed legislation. While our need to understand the entire system in which we live may be self-evident, there are a number of specific aspects that deserve attention.

One is a simple matter. Ecology is not a science that can be pursued to a very great extent in a laboratory, though certain laboratory work is essential to it. It is principally studied outdoors, and deals with large scale phenomena. The problems of ecology are, many of them, of vast geographical dimensions. Comparing situations with different combinations of conditions is often the most enlightening approach. Political boundaries frequently do not enclose all of the relevant fact. Sometimes the key to a problem may be in parts of the world that are politically different but ecologically related. The biologists of the world have come to realize this and are presently planning and organizing an international biological program (IBP) to bring to bear cooperative efforts upon those problems that do not respect national boundaries. This program is for the most part ecological in nature. It is a recognition that the big efforts in biology of the near future will be ecological, and that they require international action. We, in the United States, hope to be in the forefront in the IBP, though we have as yet found no very suitable means of carrying on large ecological efforts outside the United States except under military auspices, and consequently in a military straitjacket. Perhaps the proposed agency may help with this. It should be our strongest arm in the whole IBP activity.

Senator METCALF. Wait a minute. What is our responsibility for carrying on these efforts outside the United States? Should we not concentrate our efforts on the United States, itself?

Dr. FOSBERG. Because the problems can only be partially approached in the confines of the United States. We do not have the entire spectrum of the ecological situation in the world within our boundaries. We are a very diverse country but we have only a trace of tropical habitats in the United States. Unfortunately the tropics are coming to be one of our major headaches. The next couple of items in my talk deal with these headaches and they are expensive headaches, too, not just intellectual problems.

Senator METCALF. Do not we have some headaches up in the colder areas?

Dr. FOSBERG. Oh yes, we certainly do. But I think the things that I am going to bring next are most acute headaches at the present time.

Senator METCALF. Here, every time we view any legislation we are concerned with the billions of dollars that we are spending in Vietnam.

Dr. FOSBERG. Just what I was going to say next.

Senator METCALF. Do you not think that we should look to our own problems here?

Dr. FOSBERG. We must.

Senator METCALF. Why should we get into efforts outside the United States when we have only a limited amount of money to spend on this whole problem?

Dr. FOSBERG. I am afraid we are in them whether we want to get into them or not. We are principally under ecological conditions that are not familiar and that we do not well understand. Hence, large sums of money, and I can assure you no one knows just how much—

Senator METCALF. I can assure you that you are right.

Dr. FOSBERG. We have crash programs that are inordinately expensive and inefficient. These are going on all over southeast Asia and in other parts of the tropics too. I can tell you another thing, that there are teams and parties of people being sent out to work on problems and they do not even know that others are working in the same area.

I have had the experience of one or two of these people finding out about each other through my office, even though they were both working for the same agency. This is how confused the situation is. I do not think we should have let it get that way.

Senator METCALF. Are you on the team that defoliates—

Dr. FOSBERG. I am definitely not on this team. I have some opinions about that that I will not express here but I certainly am not on this team at all.

Senator METCALF. Go ahead.

Dr. FOSBERG. I think this waste, you may say, and confusion are unavoidable because we did not take the trouble to learn much about tropical countries between wars, when it could have been done normally. How many billions will be spent in Vietnam alone, both in fighting a war and in carrying on our peaceful attempts to better the lot of the Vietnamese, is anyone's guess. How much of this will be wasted because the efforts are made in a poorly understood environment will never be known, but we can be sure that it will be more than enough to run the proposed agency for a long time.

Second, one of our headaches—maybe some people do not think this is as much of a headache as Vietnam—

Through AID we have been spending upward of \$3 billion a year to better the lot of the less fortunate people of the earth. The success or failure of a vast part of this effort, as well as its cost, depends on environmental complexes and influences on which we have really very little information. I have spent a great deal of time during the last 15 years compiling maps and information on the vegetation of overseas areas for the use of certain Government agencies, and I have ample reason to know the scarcity of reliable recorded data on most areas, especially in the tropics. And I also know that when such information is needed it is often needed right away, with no time or opportunity to go out and get it, even supposing that the areas of interest are at the time open to U.S. scientists.

Our efforts in public health have exerted profound effects all over the world. With practically no knowledge of the long-term, or even the short-term carrying capacity of the ecosystems in which tropical peoples live, we have altered death rates and caused population explosions that are now frightening us. I do not mean to suggest that these humanitarian efforts are not good. However, if we had possessed

a clear understanding of the ecological consequences of exponential increase in population, we would unquestionably have devoted equally great attention to means of regulating birth rates. Now the consequences are beginning to dawn upon us and we are paying frantic and frightened attention to the problem, but we still lack information that could have guided us earlier, and that will be required to avoid other such situations in the future.

I have spent a very considerable amount of time abroad during the last 25 years and have had ample opportunity to observe how many of our well-intentioned efforts to do good are faring. Failure to understand the environment in which a project is being carried out sometimes has appalling results. It is now perfectly within the ability of ecologists to predict the success or failure of many development projects, agricultural or even industrial, if they have studied the environment in which the activity is to be undertaken, and possess the right physical and biological data. There are certain ecological areas, or "life zones" in which certain types of agriculture are predestined to failure. Such areas do not necessarily look very different from others in which success has been achieved in the past. But the same environments which produce lush tropical vegetation may be completely unfavorable to the growth and maturation of certain crops. In the process of learning by trial and error, irreversible changes in the soil may be brought about that destroy large areas for further agriculture, or make such agriculture prohibitively expensive.

I have talked to more than one embittered scientist or ordinary citizen in foreign countries who had protested, to no avail, against projects or methods introduced by our foreign aid people, because they had an intuitive feeling that they were not right. Since they had no hard data on which to base their opinions, they were ignored, only to see the projects fail. There is, of course, no lack on intensive strictly agricultural research after such failures. Frequently, however, the subtle environmental factors responsible still remain undiscovered, and even unsearched for, because of the lack of an ecological approach, or of an ecological framework in which to utilize the information already available.

We are pushing industrialization in tropical countries with great vigor, as the solution to their economic problems. But even here in the United States we are only now discovering the reasons for some of the unpleasant consequences of our own industrialization. Such simple ecological situations as temperature inversions can be responsible for disastrous smog concentrations. We did not know about these when we built the cities and established the industries. We do not know such things and many others about the sites where we are now encouraging factory concentrations abroad. Irrigation projects established 75 years ago are resulting in salinization of hundreds of thousands of acres in West Pakistan, because one of the simple ecological facts of life was unknown or ignored. We do not have this kind of information, either about ecological principles or about local situations, that affect many of our present efforts abroad.

Of course, the mere establishment of an agency with the authority to do ecological work on an international scale, and even the carrying out of such work give no assurance that AID officials would use

ecology as a guide for their planning, but then at least if they wanted to and had the ability, they could. And when they were in danger of making mistakes, those concerned would be better able to show them what might happen.

A very important aspect of our opportunity to work overseas, granted by this bill, is the chance to make critical studies of major undertakings abroad, about which we can be more objective than we can about our own projects. If we were able to send a team to determine the full story of the Aswan Dam, of the Snowy Mountains plan in Australia, or of the African ground nut scheme, their origins, their execution, and their consequences, we would perhaps have some models against which to measure our own projects and to predict their results before the plans were crystallized. We should be able to profit by others' mistakes. This bill will make it possible for us to study their successes as well as errors.

The United States is very definitely looked to for leadership in many, if not most, parts of the world, and as the fountainhead of science and technology. This is true despite widespread anti-Americanism, some of which is brought about by misguided efforts to help, as well as by envy. We are being asked to send teachers and scientists, including ecologists, to countries that are deficient in people with such training. But even here competent ecologists are scarce, even those with only local experience in the United States, and most of them are very busy. Of ecologists with experience in any foreign country we have far fewer since we have had very few ecological enterprises abroad in the past. Those with significant oversea experience can be sent as teachers with much more chance of success than those with only a local background. If we want to maintain our position of leadership in the free world, we would do well to remedy this scarcity. I have met many eastern European ecologists, as well as other scientists, busily observing and carrying on their research in tropical countries. This is not accidental. Only with a substantial corps of well-trained and competent ecologists can we hope to meet this challenge.

Lastly, the American people as a whole seem to have a child-like faith that the apparently impossible problems that face us will be solved by science. There have, of course, been spectacular successes to foster this faith, which almost, at times, approaches a blind worship. However, the only way that science can solve problems is to work on them, long and persistently. The problems that are going to loom larger and larger in our future are those involving our shrinking and deteriorating environment. The science that will be expected to solve them will be ecology. It is the hope of those who support the creation of an Office of Ecological Research and Surveys that this will come in time and be provided with the means to meet the problems foreseen, both in the United States and in our areas of responsibility abroad. Only with the trained people and the necessary data plus understanding can science live up to the confidence the public has in it.

This is a timely bill. Recently, in so many words, the President of Peru insisted on an ecological survey before the establishment of a new national park. Ecology, as Secretary Udall mentioned this morning, is becoming a common word in newspaper headlines and editorials, both here and abroad. We are actually in a situation where public

opinion is getting ahead of our governmental institutions. The ecological research and surveys bill is an inevitable response to such a situation.

Senator METCALF. Dr. Fosberg, do you think we should have an ecological survey here in America before we establish a national park?

Dr. FOSBERG. I think it would be an excellent idea.

Senator METCALF. Should we send a team of ecological scientists down to the Indiana Dunes?

Dr. FOSBERG. I think actually in the Indiana Dunes we probably know enough so that any good ecologist could bring together most of the relevant facts on what we know. That is a very intensively studied area. That is where ecology began in the United States.

Senator METCALF. That is interesting. Would you elaborate on that a bit?

Dr. FOSBERG. The science of ecology in this country probably dates back as an organized science to two people about the beginning of this century. One was Clements, who was a more or less dominating figure in the science of ecology for the first 35 years of this century. The other was Coles, the famous ecologist at the University of Chicago.

He established some of the basic principles on which the rest of us have been working ever since by his studies in the Indiana Dunes area, in the depression, bogs, and lakes between these dunes. This gave him a kind of microcosm, an area that was tangible where he could see process going on and fortunately, there he had illustrations, at that time, of all stages in these processes.

You see, one man does not ordinarily live long enough to see an entire ecological succession go on. But if he can see examples representing all of the different stages of it, arrayed under a single climatic regime, that is a regional climate where climatic variables are not important, then he can see what the soil does, what the different stages in development of vegetation, what influence they have on the environment, and he can arrive at some principles on which ecology can be founded. This is what Coles was able to do in the Indiana dunes area, because this area had not been messed up as it is now.

When I first came to the Eastern United States—I grew up in the West—when I first came to the East, I went by way of Chicago and I took a day to look at the Indiana dunes because I had been reading about the studies that had been taking place there all through my college training. It was an important place for me to go and see. I must say I was a bit disappointed to find the condition it was in even in 1937. But still there is enough interest so that it certainly should be preserved.

This has more than just a recreational significance. Most of the talk has been about recreation for the population that lives around Chicago and places like that. This is an illustration of some of the basic research that has taken place in ecology.

I think it should be preserved from that point of view as well as a beautiful recreation area for the inhabitants of the surrounding cities.

Senator METCALF. I know that Senator Douglas is going to be very grateful for a very eloquent and persuasive argument in support of his legislation.

Dr. Fosberg, we are delighted to have your testimony. It has been helpful.

I am very grateful on behalf of the committee that you have appeared today. Thank you.

Dr. FOSBERG. Thank you very much.

Senator METCALF. I have Dr. Nader, who is one of the outstanding men in Washington right now, on a television program over in the television studio. I am going to ask your permission, if I may, to recess this hearing for a few minutes so that I can go over and participate in that. When I come back we will have the witness from the University of Montana at any time he wants to appear.

When I get back Dr. George Siehl of the National Parks Association will be the first witness. If you want bear with me for a few minutes while I recess this hearing and go over and make this television appearance, I will be right back. Thank you.

(Whereupon, the subcommittee recessed, to reconvene as stated above.)

Mr. WHITACRE. Because of the lateness of the hour and the fact that Senator Metcalf may be delayed, we will proceed with the hearing.

Mr. Siehl, will you come forward, please?

STATEMENT OF DR. GEORGE SIEHL ON BEHALF OF THE NATIONAL PARKS ASSOCIATION

Dr. SIEHL. My name is George H. Siehl. I am assistant to the president of the National Parks Association.

The National Parks Association is an independent, private, non-profit, public service organization, educational and scientific in character, founded in 1919 by Stephen T. Mather, the first Director of the National Park Service.

It has a membership of over 32,000 persons throughout the United States and abroad. It publishes the monthly National Parks magazine, received by all members. The concern of the association is for the protection of the national park system, which includes great national parks and monuments of America, and the protection and restoration of the natural environment generally. The association appreciates the invitation of the committee to appear and present our observations.

It has become a commonplace in this, the most advanced technological society the world has known, to hear of, and accept, each new feat billed as a conquest of nature. Almost monthly man is thrust deeper into space for longer periods of time, defying gravity and vacuum; or plunged beneath the seas to live and work longer and deeper than ever before. Daily, it seems we hear of vast engineering projects being proposed or projected, endeavors which would level mountains, inundate canyons, drain lakes and marshes or divert flowing rivers from their ancient trails.

All these mighty modifications must fall within the category of activity envisioned about a dozen years ago in a book called "Engineer's Dream." In this book the author pointed out a number of instances where engineering effort could result in major environmental changes which in many cases would have readily converted the engineer's dream to ecologists' nightmares.

S. 2282 is a measure which would enable the ecologist to rest a bit easier when he contemplates the fate facing the natural world. The

language of the bill eloquently expresses the areas of ecological concern. Acceptance of Senator Nelson's bill could result in a triumph for the public interest in the fields of conservation and natural beauty as well as ecology.

The intent of the bill is excellent. I would like, however, to suggest that language be incorporated making mandatory a favorable report from the Secretary before any Federal project affecting ecological values be undertaken. This would require a change in the language of section 6 of the bill. Such a stipulation would apply also in any project in which Federal funds are used. The American people are entitled to such protection for the few unravished corners of our land.

Paragraph 9 of section 2, allowing the creating of a system of natural areas for scientific purposes by withdrawal from federally owned lands is a significant and commendable provision. This is certainly true also of section 8, especially in the provision of funds for the training of scientists, technicians, and teachers, needed in the field of ecology and related fields.

Had our Nation been fortunate enough to have such a law in effect since the close of World War II, then today we would not be faced with the spectre of an Everglades National Park drying, dying, and rotting for lack of water while a vast network of waterworks nearby dumped water uselessly to the sea.

Perhaps we would not have wildlife region refuges and parks lying prostrate at a threatening roadhead awaiting the destructive thrust of the concrete lance. Streams, cascading or meandering, and bordering habitat for wildlife would not be summarily inundated behind dams which were built with little or no consideration for the ecological changes which would be effected.

Wisdom cannot be legislated, but tools for the application of wisdom can be provided.

Senator Nelson and the cosponsors of this bill have done a yeoman task in fashioning such a tool. They deserve a strong vote of thanks for their effort.

In closing, I would say that this measure, strengthened as indicated, is long overdue, and a firm decision in favor of the protection of ecological touchstones in this the world's most wondrous land.

Mr. WHITACRE. Mr. Siehl, you heard Senator Metcalf inquire of Dr. Fosberg as to whether or not he would recommend that there be no further authorization for national parks pending the study indicated in this legislation.

What would your response be?

Dr. SIEHL. I believe that one criteria which is used at this time in determining whether an area does meet the criteria or the standards for national parks, that one of these areas of concern is the ecological situation involved. In some cases this is a primary consideration.

In others we find that economic aspects are used to justify parks, to the exclusion almost of the ecological effects. I would certainly think that the ecology should be one of the prime considerations in considering areas for national park status.

Mr. WHITACRE. Do I gather from that then that you do or do not feel that the Department of the Interior, in submitting reports on proposed national parks, does conduct comprehensive ecological studies of the area prior to recommendations for or against?

Dr. SIEHL. It is my impression that they do carry out an ecological study. I think in some cases it could be extended but I believe it is always included as one of the studies which they do carry out and this is as it should be.

Mr. WHITACRE. Don't you feel that possibly the establishment of a national park in an area which may not have received such a study as you indicate might actually protect it from an encroachment of a commercial type that might destroy the things you wish to preserve?

In fact the authorization of the park goes along with protecting the area. I am referring particularly to areas like Assateague, Fire Island, Indiana Dunes, lakeshores or seashores which are close to areas of large population, have a large visitation which is usually not well controlled.

Dr. SIEHL. I believe in areas such as Assateague that an ecological survey was part of it. In fact we have the Chincoteague Wildlife Refuge, which is adjacent to it. In this case we would also have some ecological surveys in a bordering area actually.

Part of this ecological value had a carryover on the mainland of Assateague, itself.

Mr. WHITACRE. Thank you very much for your testimony.

Dr. SIEHL. Thank you.

Mr. WHITACRE. Is Dr. Ross here?

You are from Potomac, Md.?

Dr. Ross. Yes; I am, sir.

STATEMENT OF DR. PHILIP ROSS, POTOMAC, MD.

Dr. Ross. Mr. Chairman, members of the committee, it is indeed a pleasure to appear before this distinguished committee and to testify in behalf of the ecological research and surveys bill.

As a trained ecologist and Government employee, I am acutely aware of the need for legislation such as this bill provides. I helped write a botanical survey bill which Congressman Tupper introduced into the 88th Congress and which started the ball rolling for the development of an ecological surveys bill.

Public awareness of the problems that have beset our lands is now at an alltime high. The newspapers are full of the accounts of floods, duststorms, epidemics, endangered species, pollution, and the effects of pesticides.

These are but a few of the problems caused by mismanagement or lack of ecological knowledge. In order to cure these problems and to prevent a recurrence or new outbreak, the land and its components, including the environment, must be studied and must be described and analyzed, must be investigated for the delicate relationships of the parts.

From research and study envisioned in the ecological research and survey bill can come wise management of our renewable natural resources that will insure use of them and not abuse of them.

Although natural and seminatural vegetation covers all of our land except for agricultural and urban areas, there is no single national agency responsible for making an inventory of that total resource and interpreting it for the present and for the future in a program of land use and land planning. Not only must we gain knowledge of the actual resources including plants, animals, and their distribution, but we must seek knowledge of the basic fundamental mechanisms and relationship of the components of the natural resources to each other, to their environment and to men.

There is no one Federal agency dedicated to studying or coordinating the study of the total environment including man, animals, plants, soil, water, and air.

The concepts outlined in the ecological research and surveys bill are excellent ones: research and analysis, data storage and dissemination, establishment of sample populations, granting mechanism for research and training, and assistance to any agency or organization requesting advice.

These concepts have worked very well in the public health field, as witnessed by the National Institutes of Health. It is high time that we put these concepts to work on the problems that are affecting our land and our natural resources.

I enthusiastically endorse Senator Nelson's ecological research and surveys bill.

Thank you.

Mr. WHITACRE. Doctor, are you an employee of the Federal Government?

Dr. ROSS. Yes; I am.

Mr. WHITACRE. And you have made a study of this in the preparation of the legislation before us?

Dr. ROSS. I have been active in studying, preparing for this; yes.

Mr. WHITACRE. Do you notice section 10 is, in effect, an open ended authorization to carry out this program? I know that members of the committee are interested usually in what this type of program might cost. Do you have an idea as a result of your background and knowledge of this, what the cost may be if this bill should become law?

Dr. ROSS. I think, as was brought out earlier this morning, the program must start out small in order to bring to Washington the scientists necessary to administer and to set up an adequate program.

The program can develop in cost as Congress sees fit. Usually programs of this size that I have seen have been able to get underway for \$1 or \$2 million.

However, I have not gone into the details with the budget people for the Department of the Interior. This is strictly a personal opinion.

Mr. WHITACRE. Thank you very much. I know that those financial matters are always a matter of interest to the members of the committee when they study the record, as they will at the conclusion of the hearings.

Thank you very much, Dr. Ross.

Dr. Ross. Thank you.

Mr. WHITACRE. Is Dr. Ayres present?

You may proceed.

**STATEMENT OF DR. ROBERT U. AYRES, THE HUDSON INSTITUTE,
HARMON-ON-HUDSON, N. Y.**

Dr. AYRES. My name is Robert U. Ayres, I am a member of the staff of the Hudson Institute, which is a nonprofit policy research organization. However, I am here today as a private individual.

I appreciate this opportunity to testify in support of the ecological surveys bill, S. 2282, and for the record I should say I was educated as a theoretical physicist. My concern was environmental problems, relatively recent, since I have been engaged in the last 4 years in the study of environmental effects of nuclear weapons and possibly nuclear war.

However, it is a short step from this to the consideration of the effects of peacetime technological, industrial, and other activities on the environment.

Since I have submitted a complete statement—

Mr. WHITACRE. Doctor, your paper will appear in full in the record. You can summarize it or whatever you wish to do. The material attached will be made a part of the record.

Dr. AYRES. I think perhaps what I will do is just mention a few points briefly.

Mr. WHITACRE. You may proceed in your own way.

Dr. AYRES. A good deal I might have said has already been said, some of the things perhaps better than I could have said them.

The first point I wanted to stress is whether or not the amount of money currently spent on ecological research is \$5 million as the Smithsonian estimates or \$113 million, it still is a very small amount in comparison with the expenditures which are made each year on projects which affect the environment. These are projects ranging from public roads to dams and dredging canals, many things which I have heard mentioned here today. These things run into the tens of millions of dollars.

There are two essential arguments that I would make in favor of this bill or two things which seem to me this bill might accomplish or help to accomplish.

The first is to provide some bulwark or hedge against disasters. We have heard already, and I need not report, examples of many kinds of ecological disasters which have occurred in the past. Further disasters will undoubtedly occur in the future. But there is a large po-

tential leverage in any money which here may be spent under this bill in terms of money which can be saved directly.

One need only mention something like the sea lamprey invasion in the Great Lakes which might have been prevented by very little expenditure or no expenditure, but which after it occurred cost tens of hundreds of millions of dollars in lost fresh water fisheries.

There have been dozens of major insect outbreaks, often because of inadequate ecological studies or poorly applied ecology.

There has been an invasion in the fresh waters of the south, in Florida, for example, of a water hyacinth which has caused enormous damage. I might mention the invasion of the rabbit in Australia, the Klamath weed which invaded California. There are a large number of other examples of this kind. I have listed some of them in the back of this statement.

Mr. WHITACRE. Along that line, Doctor, would you include the soft cedar in the Southwest United States as that type of disaster, or are you familiar with that?

Dr. AYRES. I am. That is an interesting case. I don't think it qualifies as an invasion, but one of the things one might mention, for example, is the fact that certain kinds of range vegetation, let us say unpalatable kind of range vegetation, have prospered greatly in the last 50 years because of fire suppression over a wide area.

It turns out that the Indians had this problem solved. They lit fires which burned down unpalatable shrubs. Of course the grass would then grow the next year, whereas the shrubs required several years to reach the age of maturity and seed themselves.

The fire suppression in large areas of the Southwest has resulted in invasion of mesquite and other kinds of wood shrubs covering something like 13 million acres. I might be wrong about the figure.

But I need not mention, I think, the large numbers of these examples. They are available in the literature. One thing that impresses me, however, is the fact that the pesticide industry in this country has been growing roughly 7 percent per year. Picking your years appropriately you might make that figure larger but between 1950 and 1960 it was about 7 percent a year.

Since a good many of these pesticides are chlorinated hydrocarbons and the whole toxigens group have long lifetimes in the soil it is probably fair to say that the soil burden is also growing roughly 7 percent a year. This will continue to increase until such times as it reaches an equilibrium with the environment at which point as much of this toxic stuff will be washed away into streams each year as we have.

We have not reached that equilibrium point. In terms of the damage these pesticides have done today I rather shudder to think of what the situation may be when we do reach that equilibrium.

So, to summarize this first point, we can hope to repair some kinds of damage and prevent others only if we can predict better than we can today, and this requires knowledge. This bill should do a great deal to increase our state of knowledge.

The second point has to do with hedging against future reevaluations of existing resources. It is an old story that there are many re-

sources which are disregarded, then at some time in history with greater knowledge or greater demand it suddenly becomes very valuable.

I could give a number of examples but there are some spectacular ones which may make the point. Twenty years ago or 30 years ago, natural gas was splendidly burned off at the wellhead. It was not economic to pipe it anywhere, it was just wasted. Today it is the basis of a large industry. Among the things that were even wasted when natural gas was burned off was helium. There was no industry that required helium. Twenty or thirty years ago it was a scientific curiosity. Today it is used in literally hundreds of applications and I believe that the helium industry is growing 20 percent per year. The only source of it is in natural gas wells and it will shortly, if you project the curves, begin to get to the point where demand will exceed supply.

The implication of that remark, I think, is obvious. We have great natural resources, many of them disregarded, in our biological surroundings. Hundreds of thousands of species of birds, animals, insects, fungi, and so forth. We tend to classify these into beneficial pests. There are a few hundred species which we think of as beneficial—the plants we use for food and fiber, and animals we use for domestic purposes, and a few others.

Pollinating insects are an example. There are a few more hundred species, mostly insects and rodents, which we think of as pests. The large majority of the species of plants and animals on the earth we may pay no attention to.

These constitute an unknown resource. One cannot say today what use we may have for these things. They may provide ideal experimental animals for some purpose we have not yet devised. These may be resources of natural insecticides or antibiotics. Our descendants may see beauty where we do not. We cannot say why we want to preserve a lot of these things but we can say, on the basis of past experience, that we will want, in the future, some of the biological resources and in that I include ecosystems as well as individual species which are today dwindling and some of them will be irretrievably lost.

I would like to read a small section of this just to summarize why I think this bill is important. Decisions will be made by the Government to spend tens of billions of tax dollars each year in the next decade to build sewage plants and dams, to dredge harbors, to divert streams, to stock fish, to permit, or forbid, powerplants or strip mines and so on.

Regulations on the purity of water, the killing of animals, the disposal of wastes, the use of pesticides, and numerous other activities will be fixed and as often happens set to some extent in bureaucratic concrete. These decisions may be much better ones if ecological knowledge is brought to bear, as recommended by subsections 6 and 7 of section 2 of the bill.

I would hope that some of the problems raised by the witnesses in regard to coordination or interagency activities can be solved. But

if just one major incident like the sea lamprey invasion of the Great Lakes could be predicted and avoided—and there have been a number of such examples, loss of the chestnut tree for one—if just one major incident could be prevented or counteracted as a result of the research activities and ultimately advice generated by this bill, its cost would be more than justified in the most direct economic terms.

In short, the kinds of basic research which would be stimulated and supported by the provisions of this bill offer the reasonable expectation of a very high leverage factor in comparison with many other research and development activities which are currently fashionable.

There is another kind of leverage which is built into this bill. Apart from benefits we know how to qualify today in terms of dollars and cents, it is quite likely that in 10 or 20 years we shall be putting dollars and cents price tags on quite unsuspected kinds of utilities and/or disutilities.

Water is a good case in point. Not long ago fresh water was so cheap it had no value—only the cost of digging a well or laying a pipe.

Today we are beginning to look at water with different eyes. If it has a market value, as it is beginning to, and as it definitely has in some parts of the country—for instance, people or industries who take water from a river are getting something of value from the public domain, which is tantamount to receiving a form of income.

In due course I have no doubt this income will receive legal recognition in new forms perhaps by being made subject to tax. But that is a speculation I have no right to make. As people are beginning to think of water as a commodity with a market price, so, I believe, they will gradually come to regard air, sunlight, quiet, natural diversity, and beautiful scenery.

The implicit valuations attached to these goods are already clear enough if you look at real estate prices. People pay a premium for them which is determined in the marketplace. In Manhattan, for instance, you pay roughly \$5 a month per story in a luxury apartment building. That is what it costs to get the sun in the morning and the moon at night plus a little less street noise, a little less polluted air, and so on.

The point is that many of the things which this bill will help us to preserve are in the same category: at once priceless and valueless, so to speak. Many people do not think of them as a valuable asset today, but sooner or later, as the land becomes more crowded and our natural resources become scarcer in relation to projected demand, some of these biological resources we are talking about will almost certainly come to be regarded as important components of national and individual wealth.

Today we tend to measure progress in terms of growth in GNP—the sum of all goods and service bought and sold in the marketplace. I regard it as a certainty that in 10, 20, or 50 years, we shall also in-

clude some measures of environmental quality in our standard indexes of national income and national assets.

The present bill may be an important contribution toward creating a mobilization base. One cannot create a science complex like the current high-energy physics or space research establishments overnight, merely by spending a lot of money. Competent people must be attracted, trained, and supported. Centers must be created and nurtured until they reach intellectual critical mass as it were. Theories must be generated and experiments must be performed. This takes time. When the need for expertise is acute enough to be widely recognized, it may be too late to produce it quickly.

Now is certainly an appropriate time to take the first steps. This bill would go far toward creating the necessary institutional interest and financial support, in short the infrastructure which could give ecology a major push toward scientific maturity.

Mr. WHITACRE. Doctor, the committee has recently been holding extensive hearings on weather modifications and weather control. One of the factors that has continually entered into a determination as to whether or not you should proceed is the testimony that qualified people in that particular field, scientific field, are not available. Would you say that the same situation would exist in this particular field or would you attempt to divert some of the many scientists who are now engaged in NASA space activity in a different direction possibly?

Dr. AYRES. I don't know that it is possible to shift people around quite that easily. I think it might be worth making the attempt and might attract some. More likely I think we have a number of people in the country who are working in ecology today, others who certainly would be attracted into the field, if the interest, the "sex appeal" so to speak, were there.

Mr. WHITACRE. And a proper compensation for their efforts?

Dr. AYRES. Exactly.

Mr. WHITACRE. Does the National Science Foundation contribute to any of the studies carried on by people in your activity?

Dr. AYRES. You mean in the activity of the Hudson Institute?

Mr. WHITACRE. I mean in ecology.

Dr. AYRES. I am not entirely familiar with the NSF research program. So far as I know it puts something like \$3 or \$4 million into environmental biology studies, some of which undoubtedly include ecological work. Such as it is, I would guess that it is among the best work being done. It is not tied to a particular mission.

Mr. WHITACRE. Thank you very much, Doctor, for a very fine statement. I am sure that the members of the committee will read it with a good deal of interest—not only your statement but the many others which have been presented here.

It is unfortunate we can't get a full committee meeting all the time to hear all the testimony, but I assure you that this record will be printed and it will be read with interest by the members of the com-

mittee. I might also advise that when this is printed, everyone who has testified and anybody who desires will be furnished a printed transcript of the record. If there are any further additions, if anybody wants to submit a statement, and they will do so within the next 10 days, we will make sure that that, too, is made a part of the permanent record.

Dr. Ayres, your full statement will be included at this point.
(The statement referred to follows:)

STATEMENT OF DR. ROBERT U. AYRES, HUDSON INSTITUTE, HARMON-ON-HUDSON,
N.Y., RE BIOLOGICAL RESOURCE CONSERVATION

I. INTRODUCTION

Ecology as a field today is undermanned, underfinanced and to some extent undervalued, in any comparative terms—number of scientists, journals, articles, research monies spent, quality of research done, or memberships in the senior scientific community (e.g., National Academy of Sciences). But, of importance to this committee, it is so in relation to the magnitude of the *pressures* which our rapidly expanding population and technology will put on our natural environment and of the *decisions* which will be made in the next decade on matters of national importance—with, or without, competent ecological research inputs.

Of the six billion dollars spent in 1965 by the Federal government on fundamental and applied research, just over \$200 million was allocated to all the biological sciences outside of agriculture and medicine.¹ The fraction of this that goes into environment-related research is hard to estimate, but it is probably much less than half, (depending what one counts), or under \$100 million. This is the only support for research inputs on the environmental aspects of a tremendous range of government and private activities including road building, electric power generation (both conventional and nuclear), sewage disposal, pest control, river and harbor projects, fish and wildlife conservation, and recreation—not to mention broad impacts on agriculture, forestry and health. It is fair to say that this research has an important bearing on the detailed way in which tens of billions of dollars are spent each year. I do not mean, of course, that the big go/no go decisions—whether or not to spend these funds—depend, in general, on the outcome of ecological or environmental research, although in the future this situation may also arise, for example, in connection with “clean air” or “clean water” proposals. But there are many choices affecting the environment to be made within each of the major on-going activities. Shall a dam, a system of locks, a sewage treatment plant, or a road be built in this spot, or that one? Or should another solution for the problem be sought? The more we know about natural systems the fewer expensive blunders we shall make.

II. A HEDGE AGAINST DISASTER

We do not know very much; certainly nowhere near enough, about our environment. As a consequence, our environment is constantly responding to man-made disturbances—which we can hardly help—in unexpected and unpleasant ways, which we are often at a loss to understand or counteract. Yet, in many cases, prediction would make prevention possible. To mention a few examples:

The activities of man have frequently, if unwittingly and unwillingly, introduced new species into environments where they were formerly unknown, and where natural controls do not exist. Thus, the rabbit, introduced into Australia, 150 years ago as a household pet, has become an ineradicable pest which costs the sheep farmers hundreds of millions of dollars per year in lost production.

¹ *Federal Funds for Research, Development, and Other Scientific Activities*, Fiscal Years 1964, 1965 and 1966, Volume XIV, National Science Foundation, July 1965.

In our country, the introduction of a fungus, (*Endothia parasitica*) from Asia in 1904 resulted in the loss of all (100%) of the American Chestnut trees—once the dominant species in the eastern hardwood forests. History is now repeating itself for the American Elm, which once gracefully lined the streets of so many towns throughout New England and the Middle Atlantic States. The fungus (*Ceratostomella ulmi*) which causes the disease came to the U.S. in 1930, via imported elm burl logs. The fungus is spread by the agency of a bark beetle, which arrived earlier from Europe, in 1904. Many of these trees are now dead, and they are continuing to die despite some palliative sanitary measures. The same melancholy fate may soon face the oaks, if a bark beetle (*Xylosandrus germanus*) now spreading westward from the Atlantic seaboard becomes associated in like fashion with a fungus now causing oak wilt in the central states.

The opening of the Welland Canal bypassing Niagara Falls in 1930 may have introduced the sea lamprey into the Great Lakes, where it decimated the trout and bass population and badly hurt the fishing industry. Although partial controls have now been found, the cumulative loss certainly runs into tens, if not hundreds, of millions of dollars.

The accidental introduction of the prolific water hyacinth has literally choked many inland waterways in Florida and the Gulf Coast. This has resulted in heavy controls costs, depreciated waterfront property, health and safety hazards, and sharply reduced recreational value.

There are numerous other instances. Apart from "invasions" such as these, one could cite many cases of ecological imbalances—or population explosions—resulting in serious economic losses: The cotton rat-quail outbreaks which occur every few years in West Texas; the Engelmann Spruce bark-beetle plague which devastated thousands of acres of virgin forest in Colorado for a decade, the periodic Mormon cricket and grasshopper outbreaks, and so on. Or think of the ugly and ill-smelling algae "blooms" which often disfigure our rivers when the conditions of temperature, oxygen and mineral nutrients (from pollution or sewage) are just right—or wrong.

Fish and birds dead from ingesting poisonous chemicals are doubly symptomatic of our national ecological lack of sophistication. In the first place, the "broadcast" use of large quantities of toxic chemicals to kill agricultural pests is a sign of incompetence at finding and maintaining the proper natural controls. Between 1951 and 1961 the rate of use of chemical pesticides in the U.S. increased about 7% each year (about double the growth rate of the GNP during the same period). Some of these chemicals, particularly DDT and the aldrin-taxaphene group of chlorinated hydrocarbons, retain their toxicity in the soil for many years. Hence, the "soil burden" is also presumably increasing at roughly 7% per year, and will continue to do so until an equilibrium is reached where the poisons are leached out by rainfall and ground water at the same rate they are being added. Toxic runoff has already caused tremendous havoc among fish and wildlife populations. We can anticipate that this problem will continue to get worse for a long time to come, inasmuch as pesticides are still only used intensively on about a fifth of the agricultural acreage in the U.S. Unfortunately little is known about the long-term ecological effects of this kind of environmental stress. It may be that the potential ecological problems associated with radioactive wastes and/or nuclear attack have actually received more scientific attention than this obvious and everyday problem. Ecological research could also contribute greatly to the development of economically feasible means of biological control, which would alleviate the pesticide problem at its source. There are some notable success stories which demonstrate what can sometimes be done when ecological knowledge is properly exploited. For instance, the Klamath weed, imported from Europe to California in 1900, had invaded 2½ million acres of rangeland by 1950. The answer turned out to be a couple of imported beetles which feed on the weed in preference to anything else and have successfully brought this particular pest under control. Or, take the case of the prickly pear cactus, which was exported from the

U.S. (for a change) to Australia where it spread over 60 million acres by 1925. Luckily a suitable control was found in this case too, resulting in a 95% decline in the level of infestation within 7 years from the peak. There are quite a number of other noteworthy cases which might be mentioned, several of which have resulted in savings of hundreds of millions of dollars over the years.

III. A HEDGE AGAINST FUTURE REVALUATION

It is a commonplace observation that what is disregarded by one generation may be highly valued by a later one. To take only one example, our ancestors treated the great forest as an enemy to be conquered and laid low by any means possible. Already, we are beginning to regret some of that destruction, which has cost us much that our ancestors never suspected—such as billions of tons of rich topsoil.

As late as 20 years ago natural gas was simply a nuisance, generally burned at the well-head. Today it is a valuable commodity and the basis for a major industry. The element, helium, was first identified in spectroscopic photographs of the sun's corona (whence its name), because it is so scarce on the earth's surface. It is only found in natural gas deposits. Enormous quantities were—and still are—lost irretrievably into the atmosphere because it was not valued much. Yet, today it is an industrial gas with an enormous variety of technological issues, some of them, like the "maser," unimaginable two decades ago. Demand for helium is growing at 20% per year, and will rapidly outstrip all known sources unless it is conserved.

In the more recent past we have regarded air and water as limitless resources—free for the taking—to be used or abused at will. We, in this generation, are beginning to become painfully aware that these resources are not infinite and must be conserved.

These examples are not directly relevant to the purposes of the present bill, but they serve to underline the very important point that tomorrow's "price" for a natural resource may be very different from today's. If we thoughtlessly permit unregarded natural resources to vanish because we have no immediate use for them, we may lose by default something of potential value in the future.

This applies to plants and animals as well as air, water and minerals. Perhaps it is even more important, because each species is an absolutely unique entity. We cannot duplicate the results of billions of years of evolution in a laboratory, nor are we ever likely to. It is, at the very least, shortsighted to label a small number of animals and plants "beneficial," another small number "pests" and disregard the rest entirely. We cannot say, today, what future benefits may be derived from the Anopheles mosquito, the cockroach, the whooping crane or the rhinoceros. They may provide vaccines, food clues to the fundamental nature of life, ideal experimental animals for some special purpose, marvelous pets, explorers of inner space, new vitamins, anti-biotics—or our children's children may simply see beauty where we did not.

The preservation of natural diversity cannot only be done in zoos, botanical gardens, and test tubes. An "ecosystem"—or self-contained natural community—wherein many different species of plants and animals live and interact together, is also a kind of unique organism which has evolved over many millennia. Like Humpty Dumpty, an ecosystem once destroyed may not be possible to put together again. Similarly, we cannot say what benefits our descendants, or even we ourselves, may derive from a dune, a salt marsh, a pond, or a granite-outcrop. But there are plenty of possibilities. We may learn how to control pests without poisoning the environment—whereupon the pests cease to be pests and become acceptable citizens—or we may learn things of interest to many other branches of science, or some of us may derive spiritual benefits by just looking.

The compilation of a catalog of the natural biological resources of this country—and I would hope, in due course, of the continent—is an essential first step toward a rational program of preserving and protecting these resources against the unknown demands which the future may make upon them.

IV. IMPACT OF RESEARCH ON DECISION-MAKING

Let me summarize why I think this bill is important. Decisions *will* be made by government to spend tens of billions of tax dollars each year in the next decade to build sewage plants, and dams, to dredge harbors, to divert streams, to stock fish, permit (or forbid) power plants, or stripmines and so on. Regulations on the purity of water, the killing of animals, the disposal of wastes, the use of pesticides and numerous other activities will be fixed and—as often happens—“set” to some extent in bureaucratic concrete. These decisions may be much better ones if ecological knowledge is brought to bear, as recommended by subsections 6 and 7 of section 2 of the bill. If just one major incident like the sea lamprey invasion of the Great Lakes could be predicted and avoided, prevented or counteracted as a result of the research activities, and (ultimately) advice generated by this bill, its cost would be more than justified in the most direct economic terms. In short, the kinds of basic research which would be stimulated and supported by the provisions of this bill offer the reasonable expectation of a very high “leverage” factor in comparison with many other research and development activities which are currently fashionable.

There is another kind of leverage which is built-in to this bill. Apart from benefits we know how to quantify *today* in terms of dollars and cents, it is quite likely that in ten or twenty years we shall be putting dollars and cents price-tags on quite unsuspected kinds of utilities and/or disutilities. Water is a good case in point. Not long ago fresh water was so cheap it had no “value”—only the cost of digging a well or laying a pipe. Today we are beginning to look at water with different eyes. But if it has a “market value”—as it is beginning to—then, for instance, people or industries who take water from a river are getting something of value from the public domain, which is tantamount to receiving a form of income. In due course, I have no doubt, this income will receive legal recognition in new forms, perhaps by being made subject to tax.

As people are beginning to think of water as a commodity with a market price, so, I believe, they will gradually come to regard air, sunlight, quiet, natural diversity, and beautiful scenery. The implicit valuations attached to these “goods” are already clear enough if you look at real estate prices: people pay a premium for them which is determined in the market place. In Manhattan, for instance, you pay roughly \$5 per month per story in a luxury apartment building. That is what it costs to get the “sun in the morning and the moon at night” plus a little less street noise, a little less polluted air and so on.

The point is that many of the things which this bill will help us to preserve, are in the same category: at once priceless and valueless, so to speak. Many people do not think of them as valuable assets today, but sooner or later as the land becomes more crowded and our natural resources become scarcer in relation to projected demand, some of these biological resources we are talking about will almost certainly come to be regarded as important components of national (and individual) wealth. Today we tend to measure progress in terms of growth in GNP—the sum of all goods and services bought and sold in the market place. I regard it as a certainty that in ten, twenty or fifty years, we shall also include some measures of environmental quality in our “standard” indices of national income and national assets.

The present bill may be an important contribution towards creating a “mobilization base.” One cannot create a science complex like the current high energy physics or space research establishments overnight, merely by spending a lot of money. Competent people must be attracted, trained and supported. Centers must be created and nurtured until they reach intellectual “critical mass,” as it were. Theories must be generated and experiments must be performed. This takes time. When the need for expertise is acute enough to be widely recognized, it may be too late to produce it quickly. Now is certainly an appropriate time to take the first steps. This bill would go far toward creating the necessary institutional interest and financial support—in short, the “infra-structure”—which could give ecology a major push towards scientific maturity.

Periodic insect outbreaks

Species	Dates and places of outbreaks	Conditions for onset	Control measures
Chinch bug (<i>Blissus leucopterus</i>)	1783—First recorded outbreak in United States, \$350,000,000 damage. 1914—13 Illinois counties (caused loss of \$6,000,000 worth of corn, wheat, and oats). 1934—Illinois, \$40,000,000 worth of damage. 1963—(September) Louisiana. The chinch bug has been found throughout the United States, in southern Canada, in Mexico, and in central America. Its areas of greatest destructiveness are in the Mississippi, Ohio, and Missouri River Valleys. 1898—White River National Forest, Colo. 1909—Lincoln National Forest, N. Mex. 1939—1940—Southwest Colorado. 1964—Chibola National Forest, N. Mex. 1962—California (statewide).	70° F. temperature on sunny days. Invades at time of small grain harvest.	Heavy rainfall. Sowing of wheat on fertile soil (bug avoids shade and dampness). Winter burning in hibernating quarters in areas west of Mississippi River. Trapping and spraying barrier strips with dielin or creosote.
Engelmann spruce bark beetle (<i>Dendroctonus engelmanni</i>) Hopk.	1909—Quebec 1910—1925—Forests of Eastern United States and Canada. Almost continuous outbreaks in Canada and United States have spread into Oregon, Minnesota, etc. Epidemic proportions reached in Ontario 1938—some decline since 1948. 1949—New Brunswick. 1962—Warner Mountains, Modoc County, Calif.	Trees blown down. Attracted by fermentation in cambium of unhealthy trees. Lowered resistance of trees due to drought periods.	Woodpeckers, cold winters, sun curing, logging damaged trees. Normally repelled by pitch flow of healthy trees. Predators: clerid beetles. Parasites: braconid wasps and a mite (<i>Pedictoides ventricosus</i>). Oil spray and logging damaged trees. Parasitic wasps and flies, logging damaged trees. Birds. Storms.
Fir engraver beetle (<i>Scolytus ventralis</i>)	1909—Quebec 1910—1925—Forests of Eastern United States and Canada. Almost continuous outbreaks in Canada and United States have spread into Oregon, Minnesota, etc. Epidemic proportions reached in Ontario 1938—some decline since 1948. 1949—New Brunswick. 1962—Warner Mountains, Modoc County, Calif.	Overmatures trees. Dry, sunny summers for about 4 consecutive years.	Mist of 5 percent DDT in fuel oil, logging damaged trees.
Spruce budworm (<i>Choristoneura fumiferana</i>)	1909—Quebec 1910—1925—Forests of Eastern United States and Canada. Almost continuous outbreaks in Canada and United States have spread into Oregon, Minnesota, etc. Epidemic proportions reached in Ontario 1938—some decline since 1948. 1949—New Brunswick. 1962—Warner Mountains, Modoc County, Calif.	Overmatures trees. Dry, sunny summers for about 4 consecutive years.	Mist of 5 percent DDT in fuel oil, logging damaged trees.
Douglas fir bark beetle (<i>Dendroctonus pseudotsugae</i>)	1909—Quebec 1910—1925—Forests of Eastern United States and Canada. Almost continuous outbreaks in Canada and United States have spread into Oregon, Minnesota, etc. Epidemic proportions reached in Ontario 1938—some decline since 1948. 1949—New Brunswick. 1962—Warner Mountains, Modoc County, Calif.	Overmatures trees. Dry, sunny summers for about 4 consecutive years.	Mist of 5 percent DDT in fuel oil, logging damaged trees.

Lodgepole needle miner (<i>Returraria milleri</i>)	1900—Southern Sierra Nevada. 1945—Yosemite National Park. 1955—Tuolumne River Basin, Merced River headwaters, California. 1962—Kings Canyon National Park, Calif. 1933—Coastal forests of Oregon, Washington, British Columbia, and Alaska.	Old, overmature stands. Elevations between 8,000 and 10,000 feet.	Disease: graulosis virus. Aerial applications of malathion or DDT. Logging timber.
Hemlock sawfly (<i>Neodiprion tsugae</i>)	1940—First observed in south Arkansas. 1945-48—3,000,000 acres in that area attacked (loblolly and shortleaf pine). 1920—Observed in the Pacific. 1921-1946—Pacific States—25,000,000,000 board feet of timber killed. 1962—California (heavy in southern portion of State). "Mother Lode" infestation—estimate acreage: 2,400,000—from El Dorado, south to Kern County, Calif. Mostly attacks ponderosa and Coulter pine.	Old foliage	Hymenopterous parasites (<i>Delomeristia diprionis</i> Cuth. and <i>Toplectis Montana Cuth.</i>). DDT and other chlorinated hydrocarbon insecticides. Polyhedral virus (destroys larvae). Aerial spraying DDT in fuel oil.
Sawfly (<i>Neodiprion taedae linearis</i>)	1740—Massachusetts Colony. 1805—Montana. 1818—Minnesota. 1874-76—Swept across Western Plains States. ¹	Several years of drought. Subhumid and semiarid regions. Mountain meadows, and outover land.	Logging damaged timber. Spraying infested trees: 5 percent DDT in fuel oil. Inactive in temperature below 50° F.
Western pine beetle (<i>Dendroctonus brevicornis</i>)	1891-95—(1892 peak) same area. 1894-98—(1898 peak) same area. 1899—Observed in Midwestern States? 1945—Peak in Midwest. 1951—Lower Yellowstone River. 1955—McCone County, Mont. and Sargent County, N. Dak., eastern Kansas.	Above normal precipitation for an area, followed by just growth. High temperatures (above 80° F.) stimulate flying and migration.	Insecticides: aldrin, chlordane, heptachlor, methoxychlor. Thilage and seeding program.
Grasshopper (<i>Dissosteira longipennis</i>)	1848—Great Salt Lake Basin. 1937—Rocky Mountain Region. 1939—Nevada. 1937-49—Nevada, Montana, Wyoming, and Idaho.	Migrations take place on clear days with air temperature 65-46° F. and soil-surface temperature 75-129° F. when wind velocity less than 20-25 m.p.h.	Poison bait. Aerial spraying.
Differential grasshopper (<i>Melanoplus differentialis</i>)			Poisoned bait. Oil and fence barriers. Abnormally cold and wet weather for about a month. Predators and parasites.
Mormon cricket (<i>Anabrus similis</i>)			

¹ The invasion caused over \$200,000,000 damage and was termed a national disaster by Congress.
² Replaced migratory grasshopper in predominance from 1939. Replacement associated with lighter precipitation.

Invasions

Species	Origin and date of first introduction	Extent of greatest damage	Methods of control	Comments
Mosquito (<i>Anopheles gambiae</i>)	1930—Brazil (Native to tropic belt of Africa) Probably transported on a French destroyer from Dakar.	North east Brazil from Natal to Fortaleza and Jaquaribe River Valley.	Insecticides (applied inside houses). Destruction of larvae in breeding grounds, e.g. fuel oil. Completely eradicated in its area of introduction.	Feeds on men and cattle, carries malaria. Caused severe malaria epidemics, over 20,000 died.
Mediterranean fruit fly (<i>Ceratitiscapitata</i>).	1929—Florida—spread over 10,000,000 acres. 1936—Florida. (Mediterranean region).	Hawaii and Florida. Citrus and deciduous fruits	Spraying with insecticides. Vigilance over shipments of horticultural products. Has now been effectively eliminated from the United States. Paris green. Spraying or dusting foliage with DDT, dieldrin or thiodan.	Never found in wild hosts. Thrives best in temperatures of 16°-32° C. and relative humidities of 65-75 percent. Feed by chewing leaves and terminal growth.
Colorado potato beetle (<i>Leptinotarsa decemlineata</i>).	1824—Eastern slopes of the Rocky Mountains from Canada to Texas. 1870—spread across United States at rate of 85 miles per year. (Local—Colorado).	Potato crop areas, now world-wide.	Parasites of the moth (Europe and Asia). Coal-tar creosote over winter egg masses. Spraying trees with DDT, lead arsenate. Cultural control: delayed planting. Spraying foliage and fruit with DDT, Sevin, Methoxychlor.	Pest of shade trees, both deciduous and evergreen. Strips foliage. More destructive in United States than native area (Japan).
Gypsy moth (<i>Portheia dispar</i>)	1869—Medford, Mass., from France. (Native to Europe and Japan).	Confined to New England States and small areas in southeast Canada.	Traps. "Milky disease" or grubs. Quarantine. Spraying with malathion and sevin.	Breeds prolifically. Eats anything that grows.
Japanese beetle (<i>Popillia japonica</i>).	1916—Riverton, N.J. (Japan).	From southern Maine to North Carolina, westward to West Virginia.	Scatter dust: chlordane, dieldrin. Bait of lezone: destroy mounds.	Stings can kill birds and mammals in rare cases. Myxomatosis caused 80-90 percent mortality at first, but has now become endemic in smaller, partially immune population.
Cereal leaf beetle (<i>Ouleta melanopa</i>).	1962—Gallen, Mich. (Brought from Europe aboard a freighter via the St. Lawrence Seaway).	Cereal crops in Michigan, Ohio, and Indiana, expanding rapidly.	Grub coast. 300 persons treated.	Deliberate inoculation with Myxomatosis (1950). Cross-continental fence.
Imported fire ant (<i>Solenopsis sarcivassima richteri</i>).	1929—Alabama. 1956—Fort Benning, Ga.	By 1928 had invaded 2/3 of Australian Continent.		
European wild rabbit (<i>Oryctolagus cuniculus</i>).	1788-1859—Scattered locations on coast of Australia and Tasmania. 1859—Became critical upon entering Victoria.			

Sea lamprey (<i>Petromyzon marinus</i>).	1930—Invaded Lake Erie via Welland. 1937—Infested Lake Huron and Lake Michigan. 1946—Lake Superior. 1900—Observed in Mauritius. (Native of East Africa—in particular, Kenya and Zanzibar). 1938—Established in Hawaii.	Lake Michigan—1945-49, 93 per cent decrease in fish catch—destroyed fish industry in all Great Lakes. Southeast Asia and the Pacific.	Discovery and poisoning preferred breeding grounds. Threat ended by 1950.	
Giant African snail (<i>Achatina fulica</i>).	1890—New York City (Native of Europe). Imported deliberately. 1850—New York City.	Abundant in East Coast. Beginning to appear on Pacific Coast. Greatest abundance in cities where few native birds are found. Entire United States.	(None fully effective) Methods used: (1) Metaldelyde (molluscicide). (2) Some predatory beetles. (3) Giant toads. Discourage nesting.	Spread eastward from E. Africa to Micronesia, India, Ceylon, and Hawaii. Appetite for rotting and decaying matter.
Starling (<i>Sturnus vulgaris</i>).	1727—Entered Russia. (Native of western China).	Spread rapidly over Europe (fully occupied by middle of 18th century) replacing the black rat.	Discourage nesting.	Population increased in direct proportion to the degree of environmental modification by man.
English sparrow (<i>Passer domesticus</i>).	1936 (December)—Willamette Valley, Oreg.	Found from Brazil and Argentina to Chile.	Traps. Bait. Protection of natural enemies of rats. Diminution of the available shelter. Traps.	Carries disease—bubonic plague and trichinosis.
Brown rat (<i>Rattus norvegicus</i>).	1900—Klamath River, Calif. (Native of Europe). 1840—Imported to Australia. (Native of United States) 1930—Imported to United States in elm burl logs (Discovered in Netherlands, 1919) 1904—First reported in New York City. (Imported from Asia).	Rangeland—by 1950 invaded 2,500,000 acres of rangeland. Grazing land; covered 60,000,000 acres by 1925. Northeast United States. Various kinds of elms. Natural stands of elm shade-tree areas. Entire United States (has killed 100 percent of American chestnut trees).	Import insects 1. Import insect 2. None adequate. None effective.	People raising nutria for fur turned the rodents loose when it became nonprofitable. Nutria bred rapidly and now devastating crop fields. Unpalatable to stock.
Nutria rat (<i>Mypocastor</i>).				
Klamath-weed or goatweed (<i>Hypochaeris perforatum</i>).				
Prickly pear cactus (<i>Opuntia inermis</i>)				
Dutch elm disease ³ (fungus— <i>Ceratostomella ulmi</i>)				
Chestnut Blight ⁴ (<i>Endothia parasitica</i>).				

¹ *Chrysolina gemellata* and *C. hyperici* (beetles).
² Argentinian moth; *Catoblastis cactorum*.
³ It is carried by the European elm bark beetle; *Scolytus multistriatus*.
⁴ The beetle was imported from Europe in 1904 and was observed in Boston, Mass. The relationship between the beetle and the Dutch elm disease was not discovered until 1930.

Mr. WHITACRE. Dr. Sill, if you will step to the witness table—we are very happy to have you before us.
Senator METCALF. So right ahead.

**STATEMENT OF DR. RICHARD C. SILL ON BEHALF OF THE
WILDERNESS SOCIETY**

Dr. SILL. Mr. Chairman, I am Dr. Richard C. Sill, Reno, Nev. I am associate professor of physics at the University of Nevada and am also chairman of the board of control of the George Whittell Forest and Wildlife Area of the University of Nevada.

I am representing neither my profession nor my university today, but rather then I have been asked to speak as a representative of the Wilderness Society in behalf of the bill, S. 2282, introduced by Senator Nelson.

The Wilderness Society is a national citizen organization of over 32,000 conservation minded members with its headquarters at 729 15th Street NW. in Washington, D.C. The society's longtime broad purpose is to increase the knowledge and appreciation of wilderness, wherever found, and to see established enduring policies and programs for its protection and appropriate use.

In spite of the fact that I am a University of Nevada professor and head of their wildlife research program and a physics professor, it is inevitable that though I represent the Wilderness Society I shall draw on personal background as relevant materials both from my profession as physicist and my responsibility as head of the Whittell Forest.

I would like to say I feel very strongly about the subject matter of this bill, S. 2282. What the bill seeks to do should be done. And by this I mean the acquisition of knowledge of natural ecosystems and if they aren't natural let them be as nearly natural as possible, the encouragement of both specialized and interdisciplinary research on all the many subjects including physics that enter the natural scene. The encouragement of natural areas and the establishment of them is essential and I speak for this, too.

In a way I believe the bill's purposes may not be strong enough. I must confess to prejudice in that I feel man should conduct himself in such a way that he has a fighting chance to survive indefinitely on this planet and some of the fruits of my profession cause me to question whether this is a real practical possibility.

However, if we manage to avoid blowing or irradiating or otherwise poisoning ourselves to death, we are faced with a long, uncertain future on earth.

One aspect of this is a curious one. I suspect that before long we shall find that man is not adapted to life in a society such as we are building. One example was displayed in John Fischer's recent editorial in Harper's magazine on substitutes for violence. Another is the known fact that gregarious species—and man is one—and the lemming is another—can stand just so many of their own kind about before various nervous and psychosomatic disturbances appear—hypertension some phases of hypoglycemia and so on.

We shall someday find, and since some of us have already, I should say, we shall be able to document that to live in the cities, one must have the wilderness as a subjunctive retreat if not an actual one.

That is to say, then, it makes me feel good Everest is there to climb, even though I know darn well I will never get there.

But the wilderness system is not on review here in a direct sense. It is true we must learn to manage it, but we must also learn to manage the rest of the country for man to live in outside of the wild country. Knowledge from the wilderness can help us immensely.

One of my professional fields includes enough knowledge of—

Senator METCALF. Just why do we have to have a wilderness?

Dr. SILL. I wish I could answer that question. The research this bill fosters may enable us to do so. I am relatively sure that man has not been designed to work in an environment in which he is constantly under restraint, red lights, stop lights, don't do this, constant forms to fill out, and so on.

Senator METCALF. Millions of people live out there—live their whole lives without ever going away from the boulevards and the avenues and red lights you are talking about.

Dr. SILL. That is right. Many of the leaders of the community that have more and more of this type pressure to bear—

Senator METCALF. Don't you think we are taking care of it with a few barbiturates, aspirin, and some tranquilizers, and we don't need wilderness areas?

Dr. SILL. There is a maximum safe threshold level for such things. One would hope we are not running on the ragged edges of everything. I take your statement both seriously and jocularly.

Senator METCALF. Thank you.

And we now have a statutory program to perpetuate the wilderness—I almost said create, but we are not creating any more, we are kind of cutting off a few of them.

Dr. SILL. It might be a little difficult to create one, but it might be possible.

Senator METCALF. But I am wondering, would you give me a little explanation how this affects this bill?

Dr. SILL. I would like to do so. I will give one rather substantial example.

Senator METCALF. That would be fine.

Dr. SILL. I would like to finish this reference though.

Senator METCALF. Certainly, go ahead. I am sorry I interrupted you.

Dr. SILL. One of my professional fields includes enough knowledge of servocontrol theory to devise and use sophisticated pieces of apparatus. Such mathematical physical engineering topics must be brought into the picture of ecological research or we will be throwing away much of our capability.

Ecology is feedback theory applied to biological communities and involves inputs from all other fields, atmospheric physics, geology, hydrology, soil chemistry, and physics, and so on. Hence, I stress the interdisciplinary features of the research that is needed.

Man attempts to alter something. He succeeds invariably and usually in the direction in which he seeks to go. He then finds subsidiary chains he did not suspect.

Sometimes these are undesirable—cutting off the carrying of silt by rivers through the use of impoundments results in the washing away of the Nation's ocean beaches, for example—sometimes they may be

catastrophic—using chlorinated hydrocarbons and worse on insects promotes the development of super insects, or still worse, the wonder drug resistant bacteria.

So far we are ahead of the game and I do not anymore argue elimination of DDT and so forth, than Rachel Carson did, if you read her book carefully—like her I urge caution and as much a priori knowledge as possible.

Most of what man has worked with so far has a closed loop characteristic inherent of stability—so-called negative feedback. Someday he will tangle with something that, pushed too far, will become nonlinear and achieve positive feedback. It may prove his undoing. It is almost certain to prove very disturbing to him.

In addition to scientific research in wildlands and other areas which S. 2282 fosters I notice it speaks of providing information to the public. I wish to urge that this be heavily emphasized and in particular, that the public needs heavy indoctrination. The bill apparently has no specific provisions for this. I urge it.

Safeguards should be built into S. 2282 relevant to protecting the areas studied or at least the elements of the wilderness system when they are studied.

I would like to refer to specific examples. In behalf of the first I have two items I am submitting for the record. One of these, the first, is an excerpt from a report I prepared for the president of the University of Nevada regarding the scientific features of the proposed Great Basin National Park.

The other is a preprint in reality—it has not yet been printed—of a semitechnical paper delineating some of the more technical features of the research problems proposed by the so-called Great Basin National Park and these are severe.

Senator METCALF. Your two inserts, without objection, are going to be introduced in the record and are going to be printed at the end of your oral presentation.

Dr. SILL. What I mean, of course, is that the inclusion of the formal technical reference a technical paper must have has not yet been accomplished nor the final editing. It is a shade rough but not bad. The other example I wish to mention is that due to economic considerations we move in the direction of establishing buildings with nothing but fluorescent lights. This sound fine. There are, of course, minor difficulties with radio astronomy from the noise that develops.

Of course, this can be taken care of one way or the other. There is an interesting example that has a very fine point regarding the feedback problem. It so happens the majority of fluorescent lights put out a considerable amount of energy in the ultraviolet, 3650 group, exactly how much depends on the tube.

It is also odd that not many people can see ultraviolet light but some can. When you talk about a considerable amount of energy in the 3650 group you are talking about ultraviolet. I tested a girl in the optics laboratory the other day who can go down to 3100 Angstrom units. This girl has perpetual headaches. Evidence suggests that as we deal with the younger and younger age group we are dealing with a larger and larger percentage of those whose crystalline lenses will pass ultraviolet light. I ask, then, what happens when we get to the place of building elementary schools lighted, if you will, totally with fluorescent lights?

The answer is an ecological type situation. The kids are already antagonistic to school. They get headaches or they don't like the situation and therefore tend to avoid it still further and end up not having school skills such as reading.

Senator METCALF. Kids have gotten headaches about schools long before industrial fluorescent lights were invented.

Dr. SILL. This is a minor point but it is one which could have ramifications that are rather substantial. A whole generation of children who are candidates for the poverty program.

I would like to get to the place that I may talk about the Great Basin National Park situation as an illustration.

If you wish to bring out then in question how I as a physicist get involved in this it will take more time. Suffice that I am. And I am in it with both feet. The Great Basin National Park is a remarkable situation. I hesitate to use the word unique, however, I mean unique in the full sense of the term.

It contains a glacier. The proponents of the park say it is a glacier and therefore is marvelous. The opponents say it is not. In reality the thing that pertains to this bill is that it is neither. It is a threshold glacier and is a very, very fine indicator of relatively long-term and relatively short-term variations in moisture and glacial characteristics. In addition there is a bristlecone pine stand adjacent to the threshold glacier whose real significance in connection with the glacier is that highly instrumented studies of the so-called glacier—which is the only thing in the vicinity that is on the edge of glacial conditions in the Great Basin—not only tells us what glacial conditions mean in the Great Basin country but also enables us to tell us over a period of time what the tree rings mean.

The tree rings are complete—if one goes to Billings' data—back to 9,000 years and 9,000 years ago Ontario was still under ice. We were still under the ice of the glacial age. We have therefore the opportunity here to interpret the significance of the brittle cone pine and if these can be carried then to a full sense of scientific interpretation one can then move throughout the Great Basin with other stands of bristlecone pines and start to develop rough but still significant average meteorological maps of the Great Basin in this time.

This is of considerable importance if for no other reason perhaps than the scientific inference that increasing the precipitation in the Great Basin by 50 percent might start the reestablishment of the Great Lakes, might start resurgence in the direction of true glacial conditions.

There is another feature adjacent to the glacier, a rock glacier. These are not understood by geologists.

A rough description is a sort of a slurry of ice and rocks that does not act exactly like a glacier and does not act like rocks either. This is not understood. One of these is present. Elsewhere in the basin are rock glaciers. If we can interpret them we can understand still further. Among other things comes an opportunity to evaluate what is happening in these long-range weather modifications studies and activities that are being undertaken.

This in itself is of considerable importance. But there is still something behind that. That is practically enough perhaps. I might note incidentally that some of the ranchers in Nevada are

quite excited about the immediate possibility of increasing the rainfall but if it were realized that by doing so unrestrainedly they might someday have to hire rowboats to get out of their ranches they might not be so happy.

There is another feature. The theory of the Lamont Geophysical Laboratory—I am referring to the theory of Ewing and Donn—needs testing. If you are familiar with this it deals with the relaxation oscillator model in which you move from the one saturation point where the Arctic Ocean is frozen and introducing reduced atmospheric moisture to the other direction where it is liquid and contributing enough moisture to the atmosphere so that there is heavy precipitation as snow on the higher parts of the continent which in turn lowers the ocean level thus starting the system oscillating back and forth.

In the time scale of thousands of years it may be of little significance to man but closed hydrologic basins may be susceptible to varying moisture inputs with a shorter response time.

Professor Gianella is a primary source of the estimate that the 50 percent increase in rainfall might set us back to an earlier period. He is a very eminent and respected geologist from the University of Nevada who has studied Nevada geology all his life. He is still doing so. In any event if this is correct then we find ourselves in a very intriguing possibility that by modifying the weather to the degree that may be within reach of weather modifications activity at this point we might be able to trigger this system whose response has been hypothesized as that of an asymmetric bistable oscillator far enough so that it starts moving in the other direction and carrying on to the state of saturation.

Senator METCALF. Why do we have to create a national park to do this?

Dr. SILL. Who else can administer the lands to do it?

Senator METCALF. We have land management.

Dr. SILL. Senator Metcalf, you are from Montana. I am from Nevada. I think we both know the answer to that.

Senator METCALF. The national forest.

Dr. SILL. The national forest does not then have the opportunity to withdraw land from mineral entry unless they go to U-4 classification and it is too restrictive.

Senator METCALF. Are they going to carve building stone out of these rock glaciers?

Dr. SILL. The mining profession has its own ideas about what should be done in the area. Their interest is in the sedimentary rock area north of the Mount Washington beryllium deposits. It is not impossible that if one can work out a satisfactory compromise it might be a satisfactory compromise. The possibilities of interdisciplinary research here still farther north in a relatively unmineralized region involve among other things, a full use of instrumentation like that used in space technology, building small instrument packages so that you can retrieve data by remote challenge procedures. You can set up a challenge receiver-transmitter in the proper place and it will obtain continuous data from other areas in the Lehman Creek region as well as from the glacier.

I point this out not particularly to plug the area itself but I feel that intensive studies should be made and precipitate action should not be taken—should not occur until we know what we are doing.

Senator METCALF. We have a lot of glaciers in Montana.

Dr. SILL. But they are not in a threshold condition.

Senator METCALF. I don't know what kind of glaciers they are but they are lovely to look at.

Dr. SILL. That is true.

Senator METCALF. Come up and see them.

Dr. SILL. Is that an invitation to quit?

Senator METCALF. No; we have a lot of time here.

Dr. SILL. I would like to urge, in any event, that the bill in question here, S. 2282, is one which recommends, encourages the sort of study that should be done in the areas.

I understand that, Senator. Was it you who asked the question whether all proposed national parks should be subject to ecological studies?

Senator METCALF. Yes.

Dr. SILL. I think the answer is "yes, in a sense." But the danger with these reviews is that in the process of finding out what is there, the barn is sometimes stolen. The review is excellent and it should be done. In the meantime it should not be deferred to such a degree that there is nothing left to study.

This is what might happen in those proposed areas.

Senator METCALF. When there is nothing left to study neither of us will be around unless somebody makes a mistake in another area in which we are concerned and starts dropping nuclear bombs. Then we won't have any problems of wilderness or anything. Of course, as you know, I am a cosponsor of this bill. I have asked you these questions and I think that you have answered them very well. You have pointed out some additional reasons why we should enact this legislation.

Dr. SILL. May I answer a question you have not asked?

Senator METCALF. Surely. I will ask it.

Dr. SILL. Please ask me the question why do we want to preserve things anyway?

Senator METCALF. Go ahead. I have asked it, now you answer it.

Dr. SILL. I will give you the simplest answer, not to close our bridges ahead of us.

Senator METCALF. That is a pretty good answer.

Dr. SILL. As someone else said, I don't recall who it is, we should preserve for the future the opportunity to answer questions we don't even know how to ask.

Senator METCALF. We have a lot of answers around here but several of us don't even know the questions that are going to come up in the future.

It has been really a pleasure to hear you. The two items mentioned previously will go into the record. Do you have anything to add?

(The documents referred to follow:)

EXCERPTS FROM A REPORT ON PROPOSED GREAT BASIN NATIONAL PARK

(By Richard C. Sill, chairman, board of control, George Whittell Forest and Wildlife Area, University of Nevada, prepared for Dr. Charles Armstrong, president of the University of Nevada, April 18, 1966)

The Snake Range, southeast of Ely, Nevada, is in two parts separated by Sacramento Pass through which U.S. 6 and U.S. 50 go. This range is large and

DESCRIPTION

high, possessing half of the highest two dozen peaks in Nevada, four in the north (including peak #5, Mt. Moriah 12,050') and eight in the south (including peaks #2, 3 and 4, namely Wheeler Peak 13,063', Jefferson Davis 12,800', and Baker Peak 12,294').

The Southern Snake Range is the site of the proposed Great Basin National Park. It is itself divided in two parts, the northern being largely composed of quartzite and granites, while the southern part consists largely of limestone and other sedimentary and metamorphic rock. The dividing line between these two regions is approximately the saddle between Mt. Washington 11,676' (Nevada peak #14) on the south and unnamed peak 11,804' (Nevada peak #12) on the north. This regional dividing line runs more or less ESE and WNW and forms approximately the southern boundary of the park area proposed in H.R. 6122 (Baring). The region south of this line contains about 95% of the probable mineralization of commercial interest and the famous beryllium deposit.

The range has seen extensive glacial action in the Quaternary period, the South Snake Range having a dozen or more glacial cirques of varying magnitudes, including one large cirque which contains a threshold glacier (the so-called Matthes Glacier) and a rock glacier, both evidences of periglacial conditions. This large cirque is the one northwest of Wheeler Peak located between it and Jefferson Davis.

The Southern Snake Range contains a number of fine stands of bristlecone pines. Two will receive special attention in this report—the stand immediately adjacent to the Matthes Glacier in the Lehman Creek drainage and an extensive stand on Mt. Washington, a large part of which is on mining claims.

Around the flanks of the range on the east side, in particular, there are many limestone caves, some incorporated in the Lehman Caves National Monument. In Lexington Canyon there is a substantial natural bridge of some interest.

The range contains the largest known mountain mahogany (in Lehman Creek) and several of the largest aspen trees known are found in canyons along the eastern slopes of the range. There are at least four species or subspecies of endemic fishes present, dating from the Pleistocene epoch.

Biologically the Snake Range appears to be somewhat of a melting pot, with influences present from the Sierran and Wasatchian regimes and others from north and south. This very mixture may eventually prove one of the most interesting features of the range and be of substantial scientific significance.

The recent development of interest in interdisciplinary research of great practical and theoretical importance has not yet been reviewed publicly, and not much is known about its prospects. It is interesting to note that the original field investigations of the Park Service study team stressed the scientific aspects of the proposed park. Other relevant matters entered the public record in the December, 1959, hearings. These were but precursors of the recent realization that great importance must be attached to the scientific problems which should be studied in the area, particularly in the back country which is now in more or less wild condition. This subject is treated in more detail in another part of this report.

A suggestion is made that if a Great Basin National Park is established and if it is to be a valuable member of the Park System certain features should be emphasized:

(1) Unparalleled opportunity exists for dramatic and meaningful interpretive programs, nature trails, exhibits, etc. Heavy and proper emphasis on this phase can make this one of the most visited and respected national parks. Intimate contact with the back-country basic research can keep the program developing and growing in attractiveness and stature. This is the strongest single feature this small park possesses in addition to representative and, in its own way, excellent but not spectacular scenery.

(2) An unparalleled opportunity exists for essential basic research into problems of Pleistocene glaciation and climatology, plant and animal dispersal during the past, and understanding of the present state of the Great Basin. While there are many other areas in Nevada and in the Basin and Range Province that have important research possibilities and challenges, only in the Southern Snake Range is there a threshold glacier. In addition the bristlecone pines closely adjacent to this important indicator of climatic conditions and variations com-

bine into unduplicated opportunities for research of major importance for itself and to help research elsewhere. Rock glaciers are not well understood but are believed themselves to have significance as being in periglacial condition. If this rock glacier can be studied thoroughly, it may permit use of other rock glaciers that exist elsewhere in the Great Basin to extend knowledge still further. It is for this reason that attention has been focused on the proposed Great Basin National Park area in spite of its inherent complex social, economic, and political problems.

Intensive instrumentation is needed to study the climatological and ecological problems and this is discussed later in this report in more detail. In general, however, telemetered data would permit running displays of temperature, moisture content, precipitation, wind velocity, and their profiles in the glacier cirque, bristlecone pine stands, Bald Mountain, Wheeler Peak, Stella Lake, etc. in the interpretive centers.

(3) A basic scientific laboratory should be set up near Lehman Caves as soon after the establishment of the National Park as possible, and its Director should be a broad and competent scientist carrying the permanent title and rank of Assistant Superintendent of the National Park. A national advisory board should advise and assist him. The interdisciplinary nature of the research must be preserved, and eventually the research center should have a permanent staff on a half dozen scientists, and as many technicians including some first-rate specialists in modern electronic physical instrumentation and telemetry.

(4) Road development in the back country should be minimized until the research center is well established and its personnel know what its reference base is and can plan a suitable and long-range scientific program.

(5) Recreational opportunities are adequate, especially if supplemented with the proposed adjacent National Recreation Area.

One substantial administrative problem is that of wildlife management in this and any research natural area.

Ranchers have traditionally favored heavy predator control efforts to protect their livestock. However, as a result, they have not infrequently been invaded by deer and rodents. As a consequence wildlife management has proven difficult. Hunters expect a reasonable chance of making a kill and, as a result, decry the deer taken by the mountain lions. They too usually seek virtual eradication of large predators. The effect is to place the burden of predation on man, whose selectivity is not at all the same as is that of the mountain lion, who frequently if not usually achieves his kill among the slow, weak, or even diseased animals. Long-range consequences of this alteration of selection probably can be predicted, but remedial action is not at all clear unless enough mountain lion and other predation is permitted so that the deer species does not deteriorate entirely. Man's chivalrous distaste for shooting does is doubtless having a selective effect on the temperament of the bucks that survive to breed, with totally unknown effects. It is desirable for additional basic and long-range research to be done on these subjects, and while not absolutely essential here, could be done in connection with the intensive research effort envisaged with good likelihood of achieving results of significance. Of course the best information available from wildlife management research going on elsewhere should be used in this area. This feature, serving to strengthen knowledge of proper game management might help the sportsmen to accept the suggested compromise in spite of the apparent withdrawal of 53,000 acres from public hunting (most of which does not contribute much hunting opportunity.)

Detailed review of scientific research and interpretive opportunities in the Snake Range

Introduction

One of the most dramatic episodes in recent geological history has been the successive appearance, advance, and retreat of continental and mountain glaciers in the Quaternary Period. Four times the ice sheets have spread over the high lands and northern parts of the continents and four times have retreated. The most recent glaciation, in the Pleistocene Epoch, reached its farthest advance about 35,000 years ago, and retreat began at that time. The changes in glacial extent with time have not always been smooth. For example, it has been reported that many current mountain glaciers date from the Little Ice Age (as Francois Matthes termed it) of a few thousand years ago. They may have disappeared entirely in a warmer period which shortly preceded it. (About 10,000

years ago most of Ontario Province was still under ice for a chronological reference point.) Whether we have fully emerged from the latest and fourth glacial stage is a moot question. It is true that the successive interglacial stages have apparently become successively shorter in duration, but so have the glacial stages. It is only 35,000 years from the last maximum extent of the fourth glacial stage, and about half of the last ice sheet remains. It seems possible we may have not fully emerged from this latest period of glaciation and may in fact only be experiencing a momentary lull before the ice fields grow or are formed again.

Major scientific problems exist relevant to the Quaternary glacial epochs. The Quaternary is of particular interest to man, not only because of its glimpse of great forces at work and its drama but also because man appeared and evolved into homo sapiens in this same period. Only in the late Paleozoic and in the late pre-Cambrian eras is there evidence of similar massive continental glaciation. The intervening Mesozoic and the Cenozoic (until the last million years or so) had warm marine climates. No adequate theory that could account for these glaciers was available until the theory of Ewing and Donn of the Lamont Geophysical Laboratory, which suggests that the Arctic Ocean when isolated from the Pacific and Atlantic Oceans (as is the case when much water is stored as ice on the continents) freezes over and provides little moisture to the northern hemisphere atmospheric burden. As a result the glaciers melt and the ocean level rises until communication is reestablished to the Arctic Ocean which then becomes relatively ice-free. In this condition it provides large amounts of moisture to the storms which deposit water as snow on the colder and higher centers permitting glaciers to develop once more. A vast oscillatory system is thus established which accounts in general for the facts that are known.

Testing this theory is not only of great interest but also have some long-range practical significance. If some way were available to modify the weather adequately, man might find himself triggering a return to the glacial period or possibly the reverse trend might be initiated. Once well under way, it might not be possible to stop the global machinery. While the time scale is probably in the order of thousands of years and therefore of little immediate significance for man, yet, if one looks on a smaller scale, he finds he ought not so quickly dismiss concern. It seems obvious that much greater knowledge of such processes is in order since there is some reason to believe that the Basin and Range Province may be particularly susceptible to varying moisture inputs (see the attached preprint of a paper in preparation by the author which is identified as Section V.) and some evidence exists that relatively minor increases in moisture and/or lowering of the mean temperature might start the Basin and Range Province climate toward a more pluvial period. Professor Vincent Gianella has indicated that his studies of Nevada geology and present conditions suggest an increase in rainfall of perhaps only 50% might start the reestablishment of the old lakes. Such an increase in average precipitation is not unthinkable for the not distant future as a result of weather modification studies currently in process and efforts that will inevitably be mounted.

Scientific research

Among many research topics that could profitably be investigated in the area there are several that are uniquely desirable. These include the following:

- (1) As noted earlier unique opportunities exist in this area. Modern remote indicating instrumentation should be placed in the Matthes Glacier cirque and in the bristlecone pine stands which closely adjoin it. Such instrumentation should also be placed at other sites as needed to guarantee the needed supporting information about microclimate in the Lehman Creek drainage. With the instrumentation techniques developed in connection with the exploration of space, these instrument packages can be made small and with minimum power drain. They can either store information and play it back on demand or can be read instantaneously on a challenge-transmit basis by a challenge-receiver situated on the east ridge of Buck Mountain at about the present (April 1966) terminus of the Lehman Creek road. From here land lines can relay the signals and hence data to the research centers at Lehman Caves, or even more remotely, and make available detailed information no matter what the season or time of day, of temperature, moisture, wind velocity, etc., and profiles of these and other quantities. It is possible that new measurement techniques such as the Mössbauer effect (of nuclear physics) can be used to make continuous measurements

of motion of the ice of the glacier. (Velocities as little as millimeters per month are thus accessible for measurement.) All of these data available remotely and continuously can provide the most sensitive determination possible of just what is happening to the glacier and can permit evaluating the significance of the rings on the bristlecone pines on a year to year basis.

(2) Intensive studies should be made of the plant and animal communities that exist in the Park, including meticulous collections and population evaluations coupled with detailed microclimate data and bioenergetic studies of selected plots and ecosystems so that it may be known what is in the region, what the "preferred" conditions are, and whether these are stable or in some dynamic adjustment. In addition one can suggest pollen analysis, soil genesis in relation to plant succession studies. These data should be supplemented as soon as possible with similar (but necessarily less detailed) evaluations of plants and animal occurrences in nearby ranges and eventually over the whole Basin and Range Province. Together a picture of conditions and occurrences will permit an evaluation of how and where biological bridges existed in the past and might be hoped to provide a chronology for these conditions in addition (an ordered chronology if not a numerically precise one.)

(3) Correlated geological studies can help provide information about related geological matters and therefore round out the over-all picture.

(4) Ground water studies, again using the most modern available techniques and theories together with the old fashioned gauging stations and weirs, will supplement all of the above. Also overland flow in relation to erosion and natural ecosystems in the Great Basin region.

(5) Archaeological studies should prove of further correlative significance.

(Problems of maintaining the National Parks in accordance with their purposes and in presenting knowledge to the public involve research of basic nature in most of the biological and some of the physical and earth sciences. The National Park Service has not been particularly successful in past times in conducting or applying the results of this research. Its importance is thoroughly discussed and specific recommendations made to rectify these failures and/or omissions in "A Report by the Advisory Committee to the National Park Service on Research" by the National Academy of Sciences, National Research Council, William J. Robbins, Chairman, and submitted to Secretary Udall by Frederick Seitz, President of the National Academy of Sciences on August 1, 1963. The recommendations should be compared with those contained in the present Report on Proposed Great Basin National Park. In this connection reference should also be made to two other reports, "Study of Wildlife Problems in National Parks," dated March 4, 1963 and "Predator and Rodent Control in the United States," dated March 9, 1964, being reports of Advisory Boards to Secretary Udall. A. Starker Leopold was Chairman of both Advisory Boards.)

The Question of Roads

While there can be little doubt that access roads would facilitate the placing of instrument packages and would permit rapid movement of personnel, they would also guide the visiting public to the instrumented regions with hazards to the instruments and what they are measuring. Special conditions prevail at the edges of roads, and they form ecological bridges themselves. In addition, vehicles can introduce seeds of exotic species, some of which are not present only because they have not otherwise been able to get to the Snake Range. Steam cleaning of cars would help but would not be feasible. Generally instrument packages can now be made small enough so that placement from horseback or backpack or, in extreme cases, by helicopter are practical. A hiker or horseback rider will generally have more respect for the effort to which someone else went to place such instrumentation and will be more likely to leave it alone than some of those who drive in. Closing the roads to the visiting public would be politically impractical and would require intensive policing. This is to be a National Park and a research facility together, and neither should make impossible demands on the other. The practical answer is to have an absolute minimum of roads in the back, research country and those that do exist must be open to the public.

Lip service was given to scientific features and almost no recognition of the interpretive possibilities in the Ely hearings of December, 1959. (In fairness the writer should note that at those hearings Dr. Fritz Kramer of the University of Nevada said:

"The ice field, first mentioned in the Fifth Annual Report, 1883-84, U.S. Geological Survey, is of general interest because of its occurrence in the semi-arid Great Basin. It should also lend itself readily to the study of climatic fluctuations since it seems to respond rapidly to annual variations in snowfall and may be expected to be sensitive to long-term cyclic changes in precipitation. These rapid responses should make this small body of ice a more suitable subject of scientific investigation for that purpose than a larger glacier would be."

And in those hearings Mr. Virilis Fischer noted: "The Park Service . . . assures me they can make of (the proposed park) a very interesting ecological exhibit. Knowing the fine work of this organization as I do, and the excellence of its interpretive service, I have no doubt this is true." Later in his testimony, speaking of retention of the area under the Forest Service, he comments, ". . . there is a wide open field for development here, one which might even find the Forest Service busying itself with a much-belated interpretive program."

Interpretive program, a discussion

In general, visitors to the Park will have come from any direction across several hundred miles of desert without significant knowledge of its meaning. They will view this as a great wasteland and hurry to be through it. If the Park has been in existence long enough, they will stop as they might at an oasis but also because they will have heard of its interest. It is the burden of the Park Service and Recreation Area staffs in their interpretive programs to explain and demonstrate what it is that the visitor has seen and to help him to understand it. If adequate attention is given to his program, the visitor will leave with his eyes opened. He will view the dark dusting of vegetation on the peaks as embattled pines pushed into the sky to survive, and in his mind's eye he will see the dry lakes filled to shorelines whose vestigial evidence he will be looking for. The trees in that not so distant past will be on the banks standing in close array interspersed with meadows and behind them will be the snow-covered mountains. Over all will be frequent, heavy, cloud cover. He will see the clouds depart, the lakeshore recede (followed for awhile by the trees), the forest will grow thin and burn and then retreat. He will see the country evolve into what it is now, and, if he is of the right turn of mind (as it seems most Americans are) he will become fascinated with country he despised a day or two before. In the heady days of great lakes and snowy peaks and a boreal forest, he will see glaciers which, in some places, reached from the peaks into the lakes themselves, and he cannot help but wonder what could have happened so to drain off a country's lifeblood. He will have a picture of the unity of life and the mystery of how a bigger or smaller gap between Siberia and Alaska could result in glacial advance or retreat thousands of miles away in Nevada. He will pause to explore or promise himself to return just to explore.

The Park Service will have given him a brochure noting the significant landmarks to look for (which tells of these olden times) on the main highways and perhaps pictures of reconstructions of how a given (locatable and identifiable) modern viewpoint would have appeared 35,000 years ago and 10,000 years ago. He will wish to stop there and compare the view in detail. A book can be prepared and sold at the Lehman Caves visitor center with more such views off the main roads, with carefully written explanations and descriptions, and with references for further study. All the current aids to understanding should be employed including books, pamphlets, maps, closed tapes, movies, closed circuit television, diorama's slides, models, examples, trailside exhibits, guided walks, tours, displays, etc.

The current research going on can be discussed by the Ranger naturalists to add depth to the picture. Attempts to pre-construct the future would be interesting, and displays of current meteorological conditions in the back country would keep the visitor in touch with the excitement of the quest for further knowledge. Examples of specific situations or problems can be discussed in talks by Park naturalists or even by the scientific staff, as in the following examples—stage directions are implied in parentheses:

(1) In the most recent glacial epoch the waters rose in the basins of Utah and Nevada and finally joined to form ancient Lakes Lahontan and Bonneville (maps, reconstructions.) The water in Lake Bonneville reached a depth of a thousand feet where it stayed for many years and finally found a way out to the sea (picture of Red Rock Pass in Utah.) The water from the peaks and glaciers thus returned to the sea by the Snake River. But the rock was relatively easily eroded and what began as a creek and then became a river turned into a deluge.

The water tore at the restraining rock and in weeks or months or years (?) the present gorge was cut. The water level of Lake Bonneville quickly dropped about 350 feet. The shores of the lake retreated rapidly, leaving stranded fish and driftwood. Some of the smaller basins once more became isolated. Others maintained contact with the main lake and cut their own connecting river beds (pictures and maps of some that can still be traced). Then the drying began, and the water level dropped too low, the lake, with no outlet, started to turn to salt, and the forests began to die and retreat upward into the sky islands such as this one behind us.

(2) In the days of water, as now, plants could spread by seed and by root. Some could make long jumps, such as those whose seed is carried in the fur of animals (a list with illustrations), and others are wind-borne (a list with illustrations.) Still others have seeds that resist digestive juices and are dropped at great distances from their point of ingestion by birds or animals to take up a new domain (a list with illustrations.) Still others spread by root stock, and of these the aspen is numbered. Let us see where aspen grows today and try to see what the conditions had to be to let it reach its present sites, and how long these conditions had to exist for it to have done so. Does aspen now spread most readily after fire has opened the way for it? Does it encircle lake shores and follow up streams and thus bridge gaps? Are there places it now lives that cannot be explained? If so, does this suggest that not so long ago it still had the capacity to spread by seed—a capacity now lost?

(3) Starting with a current distribution of a given type of animal, one can discuss the conditions it prefers or must have now and assume it was so in the past, or in some cases show they have changed, show that it started its spread too late (perhaps) to reach all of the Great Basin mountains or perhaps that its failure to reach some parts must suggest something specific about conditions which did not exist in some areas at the time the species was emerging.

(4) Animal and plants will have certainly been in places where they no longer are. One can show why we know they must recently have been eradicated from certain specific areas. The telling can be impressive and informative.

(5) The Indians lived here—in fact they came from Asia across the land bridge provided by the lowered ocean level associated with the height of the glacial period. How did they migrate? What do we know of their culture? What did they find on their path and in particular in Nevada and Utah? Indian legends may give a vague, partly unfocussed eyewitness account of their emigration but can be fascinating. How did the Hohokum's develop their nearly unique irrigation system and when? Can the conditions that prevailed then help tell us? When must the central and South American Indians have passed through the United States? What were conditions like then?

(6) Report on the growing body of information from the research center on how the Matthes Glacier has been responding to the known atmospheric conditions and show how the line on the graph started to depart its previous course as the result of weather modification work done elsewhere (if and when this occurs.) Discuss the plant and animal communities and show how they adjust to external factors. Use the bristlecone pine data to present rough ("mean") weather, precipitation, temperature maps of the Great Basin for the past 10,000 years or more. Emphasize the "we don't know yet" point of view where it is informative and exciting.

(7) Discuss the endemic Lahontan or Bonneville fishes. What can they tell?

(8) Do species that were isolated from each other during the pluvial heights or minima show biological evidence of long separation? Can one tell about the rapidity of such divergence? How do some plant species get into various parts of the world? (One very dramatic case is that of some of the Arctic-Alpine grasses which live in the high mountains over much of the earth with thousands of miles including major oceans between successive colonies and yet all are still of the same species with little if any biological divergency.)

(9) The growth of continents and mountains and other geological subjects, well displayed in this naked landscape, would provide still other existing exhibits and talks.

These are but sketchy samples, and there are many more. This is a compelling story which needs being told, and here right in the hub of this great basin and range country, with the research going on, is the place to tell it. The public will respond, and no one will ever regret having the Great Basin National Park established if attention is paid to how it is established and the kind of National Park it is to be.

THE NEED FOR NATURAL AREAS AND WILDLAND RESEARCH AREAS IN NEVADA
AND IN PARTICULAR A SCIENTIFIC WILDERNESS RESERVE IN THE SNAKE RANGE
IN EASTERN NEVADA

Richard C. Sill

Basin and Range Physiographic Province

The Basin and Range Physiographic Province, which occupies most of Nevada and Utah, is unique in the world. It is a hydrologically closed system, consisting of a large number of isolated smaller basins separated by many north-south trending fault-block mountain ranges and valleys. The intermountain valleys are filled with alluvium to depths up to thousands of feet because of long continued water erosion of the steep, relatively new mountains.

The area is the locale of innumerable seismic faults of all ages, with displacements and patterns that indicate right-lateral displacement along the north-south trending systems. The coast of California appears to be drifting northward along the San Andreas fault displacement, and related shear fractures in the lithosphere occur inland until they disappear in the Uinta and Wasatch Ranges of the Cordilleran system. The reasons for this structure are not known, and nowhere else on earth is such an enormous area dominated by the fault-block basin and range system and subject to the same sort of shear system, which resembles ice floes in an ice field breaking up under heavy shear.

Currently the Basin and Range Province is characterized by climatic conditions which vary in the lower elevations from very arid through semiarid to the higher mountains where rainfall in excess of 20 to 30 inches yearly is recorded. The basins are the sites of playas which are often without surface water and are usually too salty for halophytic vegetation, even though the water table is often not far below the ground surface. The climatic zones of the central and southern areas in Nevada are dominated by the so-called rain shadow of the Sierra Nevada. Much of the rain here falls in the summer in the form of thunder showers from moist air masses which originate in the Gulf of California and sometimes in the Gulf of Mexico. The parts of the northern areas that are generally of higher elevation receive their major precipitation in the winter and spring from cyclonic storms that develop over the state east of the main mountain mass of the Sierra Nevada. During the summer, thunderstorms contribute moisture to the higher ranges in north and south. Almost all of the useful water in the state falls in the form of winter, spring, and fall snow or in summer thunderstorms, and watershed conditions are of paramount importance to agriculture and to life itself in the province.

In prehistoric times most of the intermountain basins were partially filled with water. Some were interconnected to form ancient Lake Lahontan and ancient Lake Bonneville in northern Nevada and Utah, respectively. Many of the higher ranges were sites of moderately large to large active mountain glaciers, and in some cases the glaciation was so great that textbook valley glaciers existed, pushing out at least to the edges of the ranges themselves, if not into the lakes. Ancient lake shores can still be seen showing that water depths of the order of 500 to 1000 feet were reached in some cases and maintained for long enough periods for definite lakeshore terracing, rock polishing, and other evidences that are unequivocally characteristic of a pluvial epoch.

During this time the flora and fauna probably were adapted to the conditions. Dense forests of boreal type trees existed. Fresh water fish lived in the lakes or inland seas. Winter snowfall was probably the predominant form of precipitation, but ablation in summer was minimized by the frequent and heavy cloud cover. The area probably represented a semi-permanent meteorological low pressure area. During long intervals of time, continuous land travel, even by foot, across the area that is now Nevada would have been exceedingly difficult. Geological evidence exists for a number of different stationary levels of water in the province, and it is certain that man existed in the area in all or most of these more recent periods. It is said that some of the Indians living in New Mexico and Arizona have legends involving their emigrating to their present domain via canoe down from the north through interminable damp caves, a picture which can be interpreted as a dim racial memory of a long hegira down these inland seas by canoe under massive and nearly continuous cloud cover. These legends should be collected and studied for relevance, if they do in fact exist.

The cause of the warming and drying are probably related to the postglacial conditions that are almost ubiquitous in the northern hemisphere, and it is common to regard the current situation as the result of this general climatic trend. The causes of onset and ultimate failure of the successive glacial epochs are, however, only subject to hypothesis at this time. The most attractive hypothesis at present is one by Ewing and Donn based on a relaxation oscillator model with the input to hemispheric atmospheric water content from the Arctic Ocean varying inversely with the degree to which that ocean is frozen over. There is much to be learned regarding the most recent Pleistocene glaciation in the Basin and Range Province, and questions which will be posed in the following paragraphs should demonstrate that this knowledge would be of more than academic interest to people currently living in the basin and range country.

POSITIVE FEEDBACK IN A CLOSED BASIN OF GREAT SIZE

It has been suggested that the local pluvial period was as much the cause as an effect of the climatic cooling, since positive "feedback" exists in the sense that, once the area was cooled to a threshold level and a required minimum of water was present, the correlated low pressure area encouraged further precipitation and further cooling. Very wet and cool periods (as well, perhaps to a lesser degree, as very dry and warm periods) are probably more readily regeneratively maintained in a large closed basin than in basins whose excess surface moisture could drain off to the oceans. That is, the former have a greater positive feedback than the latter. This would be analogous to asymmetric bistable multivibrators in general, which drive themselves by positive feedback so far in one or the other direction of the experimental parameter that they enter a nonlinear region and saturate or suffer an infinite catastrophe. Only the former is possible here because of the real limits on water. Normal fluctuations in weather could conceivably, in long enough intervals of time, acquire large enough excursions to trigger the system to swing toward the other extreme in a way that seems a totally disproportionate response to a minor cause. It has been said that perhaps an average temperature difference of only five degrees and/or a change in precipitation of 50% separates Nevada now from a new pluvial glacial epoch. The warm dry saturation limit may not be the stable state preferred by the asymmetric bistable multivibrator proposed as a model for the Basin and Range Province climate.

A question is, then, how much variation in precipitation would trigger off a regenerative drying trend from a saturated pluvial period, and, conversely, and to us more important, how much variation in moisture could trigger off a regenerative hydrating trend? The latter would probably not carry to completion under the current conditions of lack of moisture resources associated with the hemispheric post-glacial conditions and a frozen Arctic Ocean, but it could conceivably carry far enough to make drastic changes in the Basin and Range Province.

The possibility of extensive changes associated with weather modification is one of such great potential that the evaluation of the long-term effects is essential. Certainly, if the humidity increased enough, greater mountain precipitation would occur which would support more vegetation and encourage further cooling. If this progressed far enough, a semi-permanent atmospheric low pressure area might be maintained which could "attract" additional moisture-bearing storms or extract moisture from them more efficiently to reinforce the cooling and pluviation. While a return to full pluvial and glacial conditions seems extremely unlikely, in the absence of real knowledge it would seem wise to undertake massive alteration of climatic conditions circumspectly and with the maximum possible a prior knowledge.

NEED FOR NATURAL AREAS IN NEVADA

In order that scientists might achieve the requisite knowledge, the areas in Nevada that can provide information must be preserved. Unfortunately, in Nevada as elsewhere in the world, man has altered conditions so drastically that over much of the state natural conditions cannot be disentangled from man's imposed conditions. However, if care is taken, the needed study areas can still be saved. What is needed, in part, is a thorough study of geological conditions, and, by and large, these are not yet seriously endangered by man's activities except in isolated cases such as under Lake Mead or Ryepatch Reservoir.

The biological conditions, however, are seriously endangered, even in the most protected or isolated areas within the state, and are altered beyond recognition in the least protected areas. Therefore, the regions whose biological conditions are, as yet, relatively unaffected by man must be identified and protected with dispatch. The University of Nevada is attempting a preliminary identification of Nevada's natural areas at this time. This program is headed by Dr. Frits Went of the Desert Research Institute. A list of suggested scientific areas for inclusion in the Nevada State Recreational Master Plan was prepared and submitted by a group of University of Nevada scientists in 1965.

NEED FOR INTENSIVELY INSTRUMENTED WILDLAND RESEARCH AREAS IN NEVADA

In addition, an area in or adjacent to the Great Basin should be secured from any further alteration by man for use in research studies covering micrometeorology, microclimatology, plant and animal ecology, ground water and watershed dynamics, soil chemistry and physics, snowfall and ablation, plant and animal succession, and the relationships between atmospheric moisture, precipitation, forest evapo-transpiration, and production of nuclei of condensation. The George Whittell Forest and Wildlife Area of the University of Nevada in the Carson Range is one such area, and the research and instrumentation program is in its initial stages there. It cannot serve the basic need for the province, but yet must exist as a biological and hydrological standard reference as well as a center of active and integrated research on this broad range of disciplines.

THE SCIENTIFIC CHALLENGES NEED FOR A SCIENTIFIC WILDERNESS RESERVE IN THE SNAKE RANGE

The major biological and meteorological requirements may be met in the Snake Range, which lies southeast of Ely, Nevada. This is a mountain range which is so large and high and remote that a great enough variation in microclimatic conditions exists that many living examples of the geologically recent biota are preserved. Only because the range is remote is it possible for these ecosystems yet to remain to be studied and interpreted. Conditions of natural predation probably no longer exist in the area, although these may be susceptible of rapid recovery if it is so desired. The range also contains the last remnant of active mountain glacier which can serve as an indicator for climatic and meteorological conditions and also as a moisture level reference for the biological communities in its neighborhood. The glacier" is so close to its threshold that critical studies can be made which may be extended elsewhere over the Great Basin with reasonable significance. The rock glacier is another feature of periglacial conditions and is therefore scientifically important. There are also fine stands of bristlecone pine in the range which probably provide continuous tree rings for the past 10,000 years or more. These include well-preserved dead trees, as well as living trees that, in the case of one tree recently cut, include specimens as old as 4900 years. Dendrochronological and paleoclimatological studies of these trees, together with other data, can be compared with measurements in other stands of bristlecone pine and hence permit extension of precipitation records over the entire state for the last 10,000 years and thus into the Pleistocene itself. These results may profitably be compared with those of Douglas in Ariona, for example, for the time interval his data cover.

In addition, the presence of species of plants such as the Douglas fir in the range, species which have become rare over the Great Basin in general, except for isolated pockets in the mountain "sky islands," provide evidence that climatic bridges have existed in the past whose limiting conditions can be ascertained by study of the stands of these extant species. Other species in the Great Basin such as the ponderosa pine and Jeffrey pine, mountain mahogany, and Englemann spruce provide similar information which can be correlated with other stands elsewhere. There are other living species of plants in the Snake Range (including the common aspen) which are identical to those in the Sierra Nevada, the Wasatch Mountains, and other ranges both north and south, which show under careful study biological and perhaps chronological features of past climatic variations. There also conspicuous absences and also limits of species' ranges that must be studied and understood. The possibility must be carefully studied that the Snake Range has served and serves as a dispersal route for plants and animals.

The variety of animal species is also interesting. The reported absence of the pika in the Snake Range may be significant. Careful animal inventories must be made there and elsewhere in the province. The presence of four endemic fish species from the Bonneville system in the rivers of the eastern slope of the range tells of a continuous thread of fish life over the post-glacial period of dessication and confirms that enough water flowed in the streams in which the fishes are found so that this genetic thread has remained unbroken. The fact that the fish do not occur in all of the streams of the range may show that some of these streams dried up too much to sustain life. Properly interpreted, this may suggest limits to climatic fluctuations or a prior period substantially drier than the present, or yet other factors may appear upon careful study.

MANAGEMENT OF THE PROPOSED SCIENTIFIC WILDERNESS RESERVE

In order for maximum knowledge of natural conditions to be obtained, natural predation must be established in the range as quickly as possible so that the more fragile areas will be protected from destructive overuse by deer or from the subtle changes engendered by man's introduction of exotic species. They should also be protected from domestic livestock. This does not preclude recreational use, but it does require that trails, roads, and camps be planned so that the recreational use will not exceed tolerance or will be concentrated in areas which will be predetermined and hence allowed for, once enough knowledge is available. As much as possible of the area should be left in or encouraged to revert to wild condition. Fishing requires thoughtful management. Hunting should be confined to the outskirts of the area, and no hunting of predators allowed until the mountain lions, coyotes, hawks and eagles, foxes, and bobcats can re-establish a proper balance. The re-introduction of wolves should be considered carefully, however, since they alone of major predators have been extirpated from the area because of their reported belligerent pack activities.

The very substantial task of cataloguing and evaluation plant and animal species, of evaluation current conditions with which the present ecosystems are in dynamic balance, meticulous review of meteorological conditions from the bristlecone pines and other trees correlated with detailed instrumental analysis of the moisture and microclimatological conditions of the periglacial indicators adjacent to some of the stands of bristlecone pine—these tasks and others must be thoroughly and intensively done in the area of the proposed Great Basin National Park, since nowhere else in the province are enough factors preserved and so well juxtaposed as here. Furthermore, this area is geographically central to the whole Basin and Range Province and hence provides an excellent hub for extended study of the whole province by analytic continuation.

All this requires as little tampering or alteration by man as possible, and therefore the 25,000 core acres of de facto wilderness should be preserved as such. An additional 25,000 acres can revert quickly to wild condition if managed for it. This entire 25,000 acre block should be surrounded by a buffer zone which can have careful road and drive-in campground development with no harm to the scientific integrity of the core and can also simultaneously serve the economic interests of Nevada as well as the mass recreational and educational needs of visitors to the area. A large enough area with predator hunting excluded should exist to provide adequate range for such far-roaming predators as the mountain lion. For such reasons, an area of 100,000 acres or more should be under compatible management. Mining and other such commercial enterprises are inconsistent with the scientific reserve features of at least the core area. Even so, the broad meaning of multiple use will be satisfied, provided scientific research is given its proper recognition as a proper use for public lands. In this case the scientific use for the 25,000 acre core lands is probably the most important individual use the land can have, and it should be administered in an appropriate manner for maximum benefit to science and perhaps to the general area.

Dr. SILL. I merely want to implement a suggestion that was made that we request copies of the testimony. If possible I would like one for myself and one for the Wilderness Society.

Senator METCALF. I am glad I had an opportunity to hear the last witness.

Dr. SILL. Thank you, Senator Metcalf.

Senator METCALF. The record will be kept open for 10 days for any further or additional material that anyone wishes to submit, at which time the record will be closed.

Unless there is anything else to come before the committee, this committee will stand adjourned.

(Whereupon, at 4:05 p.m., the committee adjourned, subject to call of the Chair.)

APPENDIX

(Under authority previously granted the following statements and communications were ordered printed:)

STATEMENT OF THE ECOLOGICAL SOCIETY OF AMERICA

An Ecological Context for the Use and Conservation of Natural Resources

(Prepared by the Committee on Applied Ecology of the Ecological Society of America)

It is necessary to place in perspective an ecological context for the use and conservation of natural resources. This is not the only possible context. Others include, at least, economic, technological, political, social, humanitarian, cultural or esthetic, and religious contexts.

The preservation of *Gingko biloba* in Chinese temple grounds and bits of North African forests about shrines are frequently cited as examples of religious interference with exploitative use of natural resources which have led to preservation. The Christian religions have not included such considerations. They have coincided in time and place with an overriding interest in economics.

Esthetic considerations are little defended. Some people feel a sense of shame or loss when a landscape and its animals and plants are desecrated, but assuredly most people do not, since the desecration is man-made and continues to be permitted. Perhaps the feeling of kinship between man and nature is more profound in some artists; however, they seem ineffective in giving the dominant groups of mankind the same feelings. And if the artist reflects his economically determined social milieu, there is no reason to expect a unique contribution from esthetics to our problem of use and conservation of natural resources. The completely natural scene is often suggested as an escape from the boredom induced by urban existence. For ecologists it obviously has other values as well. Diffusion of ecological understanding can conceivably lead to support for conservation if understanding is construed as an esthetic value.

Humanitarian reasons for conservation can easily be derived. However, the trend today is for fuller and more rapid exploitation of their resources by primitive societies. Clearly "improvement" of the lot of primitive peoples has invariably meant more exploitation of their resources. This arises because we equate economic well-being with improvement of man's lot. The equation may be true, but it seems incapable of proof since our society builds into its anthropologists a certain economic bias. In our dominant society there is some humanitarian movement to provide recreational opportunities for people in conserved bits of our country as a psychological or even physiological escape from the ecological conditions we have created in our urban areas. The history of the Wilderness Bill in Congress indicates these humanitarian motives are less strong than others.

Social considerations are weak. Instead "local interests" or the needs and desires of individuals predominate in resource use. Whole industries may promote socially useless or harmful resource management practices such as planned obsolescence, titillated consumption, incitements to highway slaughter, obesity, carcinoma, poor medical care, perversion of a public property such as TV channels, not to mention pollution of waters and air. Society seems helpless. The long-term needs of our society, at least, have simply not been the concern of anyone who could or did have an effect on events. Galbraith (1958) has asked the question, "How much should a country consume?" This is perhaps a beginning.

Political effects on resource use and conservation can be overwhelming. The prosecution of a war sacrifices not only human resources but squanders mate-

rial resources as well. On a less gigantic scale pressures for colonialism or political self-sufficiency or other strictly political considerations are often unrelated to other criteria of resource management.

Technologically *almost* anything in the way of resource substitution, upgrading, reutilization, avoidance of waste, multiple use, preservation, or even restoration of resources is possible. We may not have the knowledge now to perform some of these tasks, but we do not believe the knowledge is impossible to obtain or the task technologically impossible to perform. We may be fooling ourselves on both counts, of course.

The problems in resource management are always economic. Ours is an economic society. Economics overrides every other consideration in use and conservation of resources. This is not a logical situation.

There is one necessary brake on an exclusively economic view of natural resources management, and that is, of course, ecological considerations (Costello 1957:52). *The relationships of resources and men to their environments provide absolute limitations to what can be done with resources* (Cain 1961). The ecological considerations are therefore fundamental, however minor they may paradoxically actually be in application.

Natural resources are of physical or biological nature. They form part of the ecosystems of which man himself is a component. The science which is dedicated to the study of ecosystems is ecology. It relies, of course, on data and ideas from other sciences, but somewhere along the line the results of these other sciences must be interpreted in ecological terms. Not necessarily in ecological terminology.

The above is a description. It is intended to suggest just what is the ecological context for the use and conservation of natural resources. The position of ecology is fundamental. When ecological considerations are ignored, resources are destroyed.

In applying our analysis, the *various* contexts governing natural resource use and conservation will have to be judged as to relative value. It seems obvious that value judgments can be made best in any society by those who know values best. This immediately qualifies the ecologist, presumably. There are no inherent reasons why esthetics should have little value and economics much. We hardly live in a subsistence economy. There is very good reason for beginning with an evaluation of the ecological considerations since they limit application of the others in an absolute sense. Since most people are aware of their own interests, or others can tell them, based on how they have acted in the past, it should not be too difficult to select panels to arrive at a decent and balanced evaluation of proposals for resource management. If engineers, foresters, agronomists, graziers, land planners, miners, politicians, businessmen, etc. had an elementary education in ecology, they might be trusted to do the job. Results indicate they need help. Some desire to make a balanced evaluation is, of course, necessary.

There is always the trouble that it may be nobody's business how a resource is handled. Since natural resources are the public's resources, there are political means to obviate this difficulty, once the necessity of government is accepted. There is some present tendency to confuse the necessity of government with the power to issue a hunting license valid for all species, including other men.

Ecology can offer information for value judgments on a wide variety of resource use and conservation problems. Use of nonrenewable resources has an impact on renewable resources such as plants, animals, and men; the results of various rates and methods of use are all ecological problems. Uses of land for forestry, grazing, cropping are applied ecology. The ability of men and women to survive not only physically but psychologically in the environments planned or projected for them is not only a matter of clinical test but also depends some on ecological understanding. Periodical lapses in our civilization, both on the part of whole societies and of individuals, make it evident that even the forbidding and unsolved questions of rational use and conservation of natural, physical and biotic, resources may be of less importance in the long run than the health of the human species. Our health obviously depends on a favorable environment.

Projecting present trends, we can predict a future for mankind, at least in the more highly developed countries, where unlimited supplies of energy will have enabled an almost unlimited population explosion, with the results living on algae. The picture is projected from modern egg factories.

The question is whether or not we want to, or even whether we can, live like these hens. Perhaps if the human mind is developed to a limit of its capacity a person will be able to occupy his scientifically allotted amount of space and spend his time in meditation, contemplation, and other purely intellectual activities. For those who cannot achieve this, there will be television. Modern airplane travel is an approximation.

Clearly this is not what we want. We do not want it for ourselves, and we do not want it for great-grandchildren. We do not even want to be conditioned to think that this is what we want. Most of us, if we had to face this problem, would insist that what we want is to be able to move around freely, to have a certain amount of physical exercise, to enjoy the outdoors, to plant a garden, to create something, to have privacy when we want it and company when we want it, to eat recognizable food—beefsteak, not algae—and above all, to have a variety of experience. Monotony is a dreaded punishment.

Perhaps this is the proper context in which to look at natural resources—to *preserve and maintain an environment, in which a full and rewarding life is possible, not only in a material sense, but in a psychological, emotional and spiritual sense.* The human being, as we know him, is a product of evolution controlled by natural selection exerted by the environment. Man's requirements are, as a result, the features of this environment. This is not only true of his physical requirements, but of those of his other levels of being. Perhaps in the long run beauty and inspiration are fully as important aspects of this environment, as a habitat for man, as are food and energy. Perhaps this is what is meant by total environment as a resource, and all other resources are merely parts of it.

If such is the case, our approach to every aspect of natural resources should be that they all are essential to continuing life as we know it. Therefore, their renewal, preservation, and maintenance are of overriding importance, and waste is the greatest of all sins. The search for substitutes should, of course, go on, but it should not be regarded as the solution to all resource problems and its success should not be used to justify extravagance and waste. In the long run, the substitute may be found wanting in some vital respect. Perhaps if we sacrifice even such a small thing as a species of bird, or such a large thing as the Greenland ice cap we may find that subsequently the world will not so well satisfy our needs. Perhaps the knowledge that such a thing as a giraffe exists, even though we never get to see one, is of importance to our well-being. These are not economic questions.

In all probability, as the population grows, these considerations will become more, rather than less, important. What we take for granted now will acquire an undreamed-of value. This is already happening with fresh air and water. It can happen with the more intangible of our resources, too, even those which defy the efforts of the economists to measure.

It is not enough to say that ecology occupies a basic informational place in resource management. What information does it have to offer? Two kinds: (1) Specific facts for specific ecosystems, (2) principles to apply to any ecosystem. Obviously, information of the first kind is or has been lacking for most controversial resource management problems in the U.S. Disasters, such as the collapse of the logging industry in the Lake States, present West Virginia coal mining, dry-farm wheat enterprises of the 30's, salinized soils of western irrigation districts, smog in southern California, the collapse of the western range cattle industry in 1886, the "development" of the Lake Tahoe area in California and Nevada would all surely not be allowed in a society which had some control of its own destiny and at the same time had some information on what its destiny was to be under a given course of action. The difficulties with nonrenewable resource use in terms of human communities are particularly great, but even renewable resources do not spring back within the usable lifetime of one man.

There is no assurance that present programs of basic ecological research are providing the factual material with which future disastrous mistakes can be avoided. They certainly have not provided them.

Ecology is such a broad field that many excellent students are repelled by its lack of rigor. It can become at the same time so narrow by specialization that its practitioners are useless outside their specialty. Perhaps the necessary reliance of ecology on such primitive, poorly developed, and incomplete sciences as taxonomy, physiology, thermodynamics of open systems, geography, pedology,

geochemistry, animal behavior, genetics, etc. precludes the emergency among ecologists of scientifically acceptable personages who at the same time are worth attention for their ecological knowledge. This is a real dilemma.

The bases for ecological work are inadequate. Systematic work on the biota is a prerequisite for syntheses useful in resource management. However, there are only a few monographs on specific animals. These are mostly on big game or large predatory species. There are a few state faunal accounts, almost exclusively on mammals or birds. A few states have adequate floras. No states and no regions have adequate monographs of the distinctive kinds of regions or animal and plant communities occurring within their border except, perhaps, Wisconsin. Many of the federal agencies have relapsed into a coma of applied work, which turns out to be work without broad applicability.

Nor are the principles of ecology so well-defined that applications can be made safely to unmonographed ecosystems. It is impractical to expect that ecological information could be accumulated in the ordinary course of uncoordinated research management. It is practicable to expect that ecological principles can be developed which can be applied. However, principles need to be tested by applications in monographic work. Instead of work on the principles of ecology many university departments concerned with biology and many research agencies associated with land management bureaus have retired into biochemistry or physiology. This work is inapplicable to ecology because it is not related to any known environment. Such work is necessary but insufficient.

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F. R. FOSBERG,
CLARENCE COTTAM,
A. M. STEBLER,
JACK MAJOR, *Chairman*.

STATEMENT OF STANLEY I. AUERBACH,¹ ECOLOGIST AND SECRETARY OF THE
ECOLOGICAL SOCIETY OF AMERICA

The need for developing and establishing some orderly, sound, and systematic basis for evaluating the impact of our burgeoning society on our resources is not a new concept or idea. Thirty-five years ago a distinguished ecologist, Aldo Leopold, wrote: "Every countryside proclaims the fact that we have, today, less control in the field of conservation than in any other contact with surrounding nature. We patrol the air and the ether, but we do not keep filth out of our creeks and rivers. We stand guard over works of art, but species representing the works of aeons are stolen from under our noses. We stamp out the diseases of crops and livestock, but we do not know what ails the grouse, or the ducks, or the antelope. In a certain sense we are learning more about the fires that burn in the spiral nebulae than those that burn in our forests. We aspire to build a mechanical cow before we know how to build a fishway, or control a flood, or handle a woodlot so it will produce a covey of grouse."

Professor Leopold's concerns of 1932 were not new to ecologists at that time. The need for developing some organized effort to preserve examples of our natural environment in their original condition or to establish means for restoring them to as near an original ecological condition was recognized by the Ecological Society of America within two years of its founding in 1915. In 1917 the Ecological Society formed a committee on the Preservation of Natural Conditions for Ecological Research of which the chairman was the distinguished ecologist, Professor Victor E. Shelford. What was foreseen by ecologists when our nation had approximately 107,000,000 people is now becoming more evident to a large portion of our people as our population nears the 200,000,000 mark.

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The reasons and need for establishing a national ecological program are many. I will enumerate only a few.

The growth of our population, the increased time for recreation, and the ever-increasing network of roads and industries make it mandatory that use of our natural resources be planned for on a regional basis. The time is almost past for independent, non-related judgements on the use of land or water resources for recreational, industrial, or other types of uses. Continuation of this essentially random approach to the utilization of resources, aside from promoting basic conflicts of purpose, can only lead to further deterioration of some resources and the inadequate use of others. What is needed is planning for multiple resource use and management on an extremely large scale.

Inputs of ecological information such as would become available if S2282 were enacted into law would aid in putting such multiple resource planning on a sound scientific basis. Two kinds of ecological information would be forthcoming under this proposed program. The first would be specific facts for specific ecosystems. The second would be principles to apply to any ecosystem. Obviously, information of the first kind is or has been lacking for most controversial resource management problems in the United States. Disasters, such as the collapse of the logging industry in the Lake states, the present West Virginia coal mining problem, the dry-farm wheat enterprises of the 1930's, the salinized soils of the western irrigation districts, the destruction of the fisheries industry of the Great Lakes, and the industrialization and habitation in river flood plains, would all not have been allowed in a society which had some control of its own destiny and at the same time had some information on what its destiny was to be under a given course of action. There is no assurance that present programs of basic ecological research are at all adequate for providing the factual material with which future disastrous mistakes can be avoided.

Four major problems of national concern illustrate why it is essential that a systematic ecological program be established with objectives which would include the obtaining of baseline information in environments which have had little or no disturbance by man and also studies in areas which have received varying degrees of disturbance. These problems are radioactive, pesticide, and chemical pollution of the environment; large scale weather modification; and the possible environmental origins of cancer and other diseases.

Work on radioactive pollution begun by the U.S. Atomic Energy Commission clearly demonstrated how ecological processes such as food chain transfers can serve to move residual radiocontaminants within and between different kinds of ecosystems. This web of feeding and food relationships is the matrix which interlocks all organisms and is the prime biological means whereby materials, both organic and inorganic, are manipulated so that they may be used and reused for the maintenance of life.

The current concern over pesticides and other chemical pollutants stems from the evidence that many of these residual toxicants are being moved and otherwise manipulated in our ecosystems in unpredictable ways. It has become increasingly clear that we know little of the mechanisms of food chains in our ecosystems; nor do we understand much of how they tie in with man's economics.

More recently we have become interested in the possibility of modifying the weather over large areas of our land. Assuming that the technology for inducing climatic change (whether it be simply one of increasing precipitation consistently or the more difficult one of altering temperature regimes) becomes feasible, how would such changes alter the manifold ecological mechanisms in the ecosystems that would be manipulated? Would the changes in the food webs, the population cycles, the flowering times, and the reproductive behavior of organisms, among other factors, be consistent and remain in synchrony with each other? Or would we, for example, have flowering plants maturing without bees to pollinate them because the life histories would be out of phase? It would be absolutely vital to establish a national ecology program such as proposed under this bill if this country begins large-scale climate control. Without a program that would systematically document the changes as well as provide the facts on what are the normal patterns of ecological balance in our environment, we might have no way of indicating that our climate control methods are leading into serious and perhaps nonrectifiable problems.

Another recent development is the possible environmental origins of cancer. Data are being developed by a number of investigators which indicate a relation between the incidence of stomach cancer and soil. There is some speculation

that carcinogens exist in soils either in organic form as may result from the interaction between soil organisms, trace elements, and organic substances that are present or find entry into the soil. Or, these carcinogens can be present as organics that have been introduced into the soil through various means of pollution. If such carcinogens do exist or are being created, they must find pathways to the human gastric mucosa. There are several possible mechanisms which involve directly or indirectly food chain processes or physical and related biological processes that could account for such a movement.

These four major problem areas in themselves are reasons why programs of ecological research on a broad scale should be established. To do this research the ecologist needs to have areas which have been little disturbed and in which the life processes of food chain behavior, population cycles and the other aspects of ecological change and balance are being carried on as they evolved over millions of years. By getting this information over a period of time sufficient to factor in time-related changes, the ecologist will have a baseline or standard of measurement against which deliberate changes induced elsewhere but in similar types of environments can be assessed. Likewise, by establishing ecological research programs in environments that will receive change or other use, we will begin to document in a consistent, factual manner the impact of these manipulations so that our children, grandchildren, and their successors will have the means at hand for making wiser decisions about the use of the renewable and non-renewable resources that we bequeath to them.

The history of mankind is essentially one of the rise and fall of great civilizations and cultures. An examination of the historical reasons for the downfall of great civilizations shows us that failure to conserve their resources, especially their not-easily renewable resources, ultimately led to their destruction. This self-destructive process occurred gradually. But without the interposition of planning or utilizing the lessons from others, it occurred inevitably.

With our tremendous knowledge, wealth, and capability as a nation it would seem essential that we draw on the lessons of history and undertake more and more of the knowledge-gaining steps which can serve to preserve our kind of civilization. The enactment of S2282 into law would be a positive step in this direction.

STATEMENT OF EUGENE H. NICKERSON, NASSAU COUNTY EXECUTIVE

I am most grateful to this Committee and Senator Nelson for the opportunity to submit this statement concerning the "Ecological Research and Surveys Bill," Senate bill 2282.

One time conservationist and author of the Sand County Almanac, Aldo Leopold, once commented upon man and resources in the following manner:

"We know that engines and governments are organisms; that tampering with a part may affect the whole. We do not yet know that this is true of soils and water. Thus men too wise to tolerate hasty tinkering with our political constitution accept without qualm the most radical amendment to our biotic constitution."

This quotation epitomizes the lack of knowledge and awareness by man and his agent, government, concerning the impact of man's industriousness and growth and progress on nature's resources—land, water, game, fish and air. In certain areas and for certain species, we know the number of and composition of our resources; where this information is lacking, a substantial void exists. What we do not know are the ramifications of our industrial, residential, and commercial expansion into previously rural or natural areas and the consequences in terms of (1) the effect upon the existence of those resources and (2) the effect upon the biological, economic, and social patterns of a community.

For example, by the year 2000, it is estimated that 320,000,000 people will be living in the United States, four-fifths of whom will reside in urban concentrations. These urban complexes will include ten huge super-metropolitan regions ranging from 5,000,000 to 15,000,000 in population, and 285 smaller metropolitan areas ranging from 100,000 to 5,000,000 in population.

By the end of the century, New York City's population will increase from the present 8,000,000 to more than 10,000,000, and it is estimated that the outlying regions, including our own Nassau County, will use up more additional land in the next 25 years for urban purposes than all the land now occupied. Stated differently, the rate of urbanization will increase at two thousand acres per week

in the New York region. Stated still differently, for every increase of a million in population, something like 160,000 new acres will pass into urban or metropolitan use, and an additional 35,000,000 gallons of fresh water per year will have to be made available for municipal supply.

For New York State as a whole the population projections are 23,000,000 people by 1976 and by the end of the century nearly 30,000,000 people. During this same period, we can expect technological and industrial innovations capable of transforming the character and nature of our land and water resources in multiple and heretofore inconceivable fashions. Furthermore, it has been estimated that transportation and economic developments will increase the contact of man and nature and, hence, the demand for expanded recreational opportunities. The increase in recreational and resource use will be spurred by shorter work weeks, increase in personal income, and lengthier vacation periods.

Human industrial and residential growth and use is going to expand by unimaginable degrees. What we must be concerned with now is what sort of land do we want to inhabit at the turn of the century? If, for example, 95% of the remaining open land in the New York Metropolitan region is zoned single family at an average density of one-half acre per house, what will be the impact upon the area's natural resources of game, fish, water, air, and land? What ethic should prevail during the next twenty-five years to guide interaction of men and resources?

Do we want all of our New York State's 70,000 miles of streams, 4,000,000 acres of lakes, 1,000 miles of marine shores, 31,000,000 acres of land area, and our 14,500,000 acres of forest land to become a conglomeration of land, water and air pollution problems? Do we want New York State's wetlands, which have declined from their previous 1,000,000 acres to the present 150,000 acres to all but disappear? Do we want continual repetitions of Lake Erie, the Buffalo River, and the Hudson River disasters which have reduced the total commercial catch in New York State of fresh water and anadromous fish from 1,467,000 pounds in 1958 to 884,000 pounds in 1963?

In 1939, in a book entitled "State Conservation of Resources," the National Resources Committee of the United States eulogized New York State's management of resources stating that its history is one of an "epic in public administration." Such a statement could not be made today.

The fact is that statistics do not exist which can demonstrate the relationship of man-made intrusions upon environment and resources. Inventories exist for a certain species throughout the State and certain species in certain areas of the State. They are prepared only as considered necessary and, for example, the only fish or marine inventory existing for Long Island was prepared by the New York State Department of Conservation in 1938 and since that time has not been up-dated?

Such data are not merely useful for historical and publication purposes. They should be assuming a major role in the future of New York State and should be considered a primary factor to be evaluated by government executives and legislators in determining zoning patterns, projecting their service requirements over the next fifteen to twenty-five years, and projecting the impact of urban sprawl upon interior and surrounding resources and its impact upon each particular community.

A primary example of this void is the Hudson River. The Governor recently established a Hudson River Valley Commission to determine the impact of the Storm King project upon the river's resources and conservation considerations. If an inventory had existed, these answers, instead of taking years to evaluate could have been immediately available so that the interested parties could have made a responsible decision at that time. The 1965 report of the New York State Joint Legislature Committee on Natural Resources clearly verified this point, stating "The State Conservation Department admitted that it could not project the effect of the Storm King project on fish life."

Furthermore, the State Government should be intensely concerned with scientific advances and their effects upon natural resources. For example, atomic plants are a threat to water resources in the form of thermal pollution. This hot water discharge into cooler bays and other water areas is highly detrimental to the fishery and marine resources of that particular water area. Instead of continuing the State's lax attitude towards water pollution and the polluters, the State should be cracking down on violators and researching new forms of water pollution by industrial concerns.

The essential point is that while our economic standard of living has continually increased, our environmental standard of living has decreased, and at a much more rapid rate. What is needed, therefore, is an ecological inventory. Senator Nelson's Bill is a great step forward in a new direction. New York State and all States need and must be concerned with this vital area. Facts on the impact of future development, as measured by historical trends, must be available to government, the legislatures, and the public. We must be aware of the alternative costs to our resources of future developments in urban growths, of future housing and industrial zoning patterns, and of the direction of our scientific and engineering advances as they relate to the resource existence. For example, when a local government decides to develop a certain area to build ten thousand new homes, what is the impact upon its resources of our fish, game, water, forests, soils, minerals and land, and how are they related to the economic and social patterns of existing groups? How will the need for new facilities such as roads, sewers, and water affect resources? How will the inevitable intrusions of business and industry affect the area? What will be the affect upon the recreation resources of that community? Quite simply, a tool in the form of an ecological inventory is an essential to government and should be a vital consideration in answering the question: What should be the future of land and water use and of man's overall development?

One specific proposal that I might make regarding the Bill is that in developing systems of analysis and collection of data, coordinating, regional, governmental and private groups be encouraged. The intent here is to balance and correlate resource impact with jurisdictional responsibility. For instance, a program to combat air pollution will take on greater scope than a water pollution program aimed at a more restricted area. These types of problems should be correlated to multiple or regional jurisdictions capable of realizing solutions.

To conclude, the objective is to inter-relate man and nature so that we can be in a position to measure, project and judge the impact of human intrusions upon natural resources. Such intrusions are occurring daily in the form of metropolitan sprawl, urban expansion and rural attenuation primarily as a result of the population boom and technological innovations. These are the facts that must be considered and related in any wise conservation development.

In the words of John F. Kennedy—

“ . . . the race between education and erosion, between wisdom and waste, has not run its course. . . . Each generation must deal anew with the raiders, with the scramble to use public resources for private profit, and with the tendency to prefer short-run profits to long-run necessities. The Nation's battle to preserve the common estate is far from won. . . . The crisis may be quiet, but it is urgent. We must do in our own day what Theodore Roosevelt did sixty years ago, and Franklin Roosevelt thirty years ago; we must expand the concept of conservation to meet the imperious problems of the new age. . . . We must develop new instruments of foresight and protection and nurture in order to recover the relationship between man and nature and to make sure that the national estate we pass on to our multiplying descendants is green and flourishing.”

Hence, we must develop this inventory to measure (1) shifts in resource use and (2) the impact of human expansion, using data gathered from every public and private source, from questionnaires and aerial surveys, to be interpolated and processed by the most sophisticated, capable research techniques, including use of statewide electronic data processing systems to store and calculate and project resource measurements.

I strongly urge support of Senator Nelson's Bill as a new tool in a new age.

STATEMENT OF PROF. ROGER REVELLE, CHAIRMAN, U.S. NATIONAL ACADEMY OF SCIENCES COMMITTEE FOR THE INTERNATIONAL BIOLOGICAL PROGRAM

Man is using his dominance of the earth to produce the most far reaching, sudden and drastic upset of natural conditions the world has ever seen. During his time on earth, man has changed nearly all the world's biotic communities in one way or another. He has altered beyond recognition much of the land surface in temperate regions and in the drier part of the tropics. His modification of his environment is continuing at an accelerating rate.

Man has shown that he can guide the evolution of communities of organisms in ways which satisfy his esthetic sense and at the same time provide him with

a stable source of natural resources, or alternatively he can destroy that which is irreplaceable.

Reconstruction of biological resources, the development on a world-wide scale of biotic communities which will have a maximum stability and usefulness to mankind is a task that has been barely begun. It will require for its successful completion all the knowledge of living organisms we can acquire.

The role of biologists is clear. We must supply the basic information needed by the architects and planners of these new and more productive, man-directed communities of organisms. Ecologists, conservationists, foresters, agriculturists, and other specialists will require a great quantity of facts, now unknown, both about the individual species that can form these communities and their actual or potential relationships to each other.

The task is to explore the diversity of life. We must learn about the population structure of individual species, the ways in which species interact with each other in communities, and how both species and communities evolve. Such knowledge is essential to make the world a better home for mankind.

To help obtain this essential knowledge, the International Biological Program was initiated several years ago by the top international scientific body, the International Council of Scientific Unions (ICSU). At the moment, about 48 countries are participating in the planning phase of the International Biological Program. International cooperative research activities will begin in mid-1967 and will last for at least five years.

The International Biological Program is focused on the parts of ecology that deal with the productivity of living systems, and with human adaptability to changing conditions. Its objectives were stated by the ICSU Planning Committee as follows:

"As a consequence of the rapid rate of increase in the numbers and needs of human populations of the world, and their impact on natural environments, there is an urgent need for increased biological and related research on problems of maintenance and change in natural and managed ecosystems, and in man's relations to these systems.

"It is therefore proposed that there be an international biological program in environmental biology, on the biological basis of productivity and human welfare. The general objectives of this IBP will be to stimulate and coordinate comparative studies, in contrasting environments, of:

"1. Organic production, nutrient cycles, and system regulation on the land, in fresh waters, and in the seas, so that adequate estimates may be made of the potential yield and the stability of new as well as existing resources, and,

"2. The adaptability of man as a component and manager of these ecosystems."

Senate Bill #2282, the Ecological Research Bill, introduced by Senator Nelson, provides for strengthening just those activities of the federal Government that will be needed to carry out the objectives of the International Biological Program. It will also initiate new activities, specifically designed to increase our understanding of man's relationship to his environment and to the world of other living creatures. These new activities would enable us to cooperate more effectively with scientists of other countries, particularly the developing countries, in a world-wide scientific effort to understand, protect, and conserve the living resources of the earth. This is, of course, what the International Biological Program is all about. I, therefore, wish to endorse S. 2282 wholeheartedly and to express the hope that it will be given favorable consideration by this Committee and by the Congress.

STATEMENT OF THE DEFENDERS OF WILDLIFE, WASHINGTON, D.C.

The Defenders of Wildlife, a national non-profit educational organization with headquarters in Washington, D.C. wholeheartedly supports the intent and the provisions of S. 2282. In the course of this organization's efforts to represent the wild animal in the affairs and debates of twentieth-century man, it has become all too evident that the only way to preserve many species either from sudden extinction or slow decline and disappearance is to protect the habitat in which these species have developed and in which they live, or spend important parts of their time. Some species which remain alive today have been spared only because governments, foundations, institutions, businesses, conservation groups,

and private citizens have set aside wilderness areas, wildlife refuges, parks, forests and other types of land and water where a semblance of naturalness is retained, and where the course of change is predictable.

Much of this preservation has been from the typically human point of view—for the use, enjoyment, or advantage of man. More often than not the objective of these efforts has been to save favorite game species such as antelope or waterfowl, or to assure continuance to a particularly awe-inspiring species such as bison, moose, whooping cranes, redwoods or organ-pipe cactus. While limited in scope, these projects have been beneficial, and have often extended protection to many species other than those of primary concern. However, there has been nothing systematic about this approach, and undoubtedly the habitats of many species have been destroyed and species exterminated through lack of knowledge of their needs or even of their existence.

Today, we have reached the mid-point in the transition of our nation from complete wilderness to the man-dominated landscape of more ancient nations. At this point, if ever, action must be taken to provide for the orderly preservation of our native plants and animals in so far as possible in legitimate natural communities. This must be done not only because each species and each habitat is unique by itself, being the product of time and chance and deserving of continued existence, but also for the selfish reason that each species and each environment contributes to man's knowledge and understanding of the earth which is his own environment.

Perhaps it is not possible to prove that the way of the world, or the life of man will be changed substantially if a rare bog orchid or an unusual fish in the Colorado River are brought to extinction, but both man and nature will be the poorer for this loss. Nevertheless, it should be apparent to anyone that if the ancestor of corn had been exterminated by an aggressive pre-columbian race bent on modifying the environment to suit itself, the entire earth would be modified. Imagine the loss if the ancestor of the domestic cow had been hunted to death. Imagine the consequences if the last honey bee were laid to rest among the fossil remains of a race of insect-hating humans.

S. 2282 is one of the most advanced efforts of mankind. It is reassuring in its purpose, foresight and its broad intentions. It may well be unique among the civilizations of the world, both past and present. In an article, "Dying in the Smog" which appeared in the summer issue of the *Land* magazine, 1950, Dr. Alfred Etter, now a field representative for Defenders of Wildlife, commented on the desolate conditions existing in the vicinity of Donora, Pennsylvania as the result of man's misuse of the environment and destruction of the natural scene. "It is a problem", he said, "which should precipitate the formation of a wholly new organization in the research branch of government, an organization whose function should be the study of ecologic principles and their application to man and society for the encouragement of a full, natural, and productive existence. Ultimately, such a service should achieve Departmental rank with representation on the President's cabinet."

S. 2282 does not, of course, suggest the creation of a new department, nor does that appear necessary at this time in view of the beginning strides being taken within the Department of the Interior to apply ecological thought to the management of Interior affairs. It is our belief, however, that this inclination needs to be strongly encouraged, and propagated in all aspects of the Department of Interior's work, as well as in other departments. We feel that there is no better way to do this at the present time than through the provisions of S. 2282. The Department of Interior should not be merely a repository for pieces of property which the nation administers. It should be a vital organization curious about the nature of these lands, the life upon them, and the effects of government programs on them. Nature is the stage upon which the play of "Interior Affairs" takes place. We need to know all we can about it, and the only way to do this is to preserve critical portions of it in an undisturbed state, to study and inventory it, to describe it, and to tell the rest of the nation of its discoveries. The public education aspects of the bill should not be neglected, and information developed as part of this program should not be affected or altered in any way by the special interests of any of the Bureaus of the Department. It will be of no benefit to develop a program of study if there is not complete freedom of choice of subject matter and of publication.

In conclusion, it is appropriate to quote from "The Importance of Natural Places," an article by Dr. Etter: "When people grow ignorant of what is natural,

then there is no obstacle to their growing unnatural themselves. Nature is the basis of common sense, an important item in the future of a nation. I envision the time when the natural areas being set aside now will become veritable shrines to which people and science alike will appeal for truth and inspiration. Once entrusted to protection these preserves will stand as visible evidence of Man's conquest of himself, of his admission of his identity with all life, of his respect for the creations of time, and of his ultimate dependence on nature."

STATEMENT OF GEORGE ALDERSON, WASHINGTON, D.C.

Mr. Chairman, my name is George Alderson, and my address is 105 Galveston Place, SW., Washington, D.C. 20032. I appreciate the opportunity to testify on the Ecological Research and Surveys bill, S. 2282.

The enactment of legislation providing for an expanded and coordinated program of ecological research will be an excellent step toward maximal adaptation of American civilization to its environment. With the aid of modern technology, manipulation of the natural environment can result in a thoroughly efficient and livable landscape, but without an adequate understanding of the biological relationships in the environment, an otherwise elegant plan can prove to be sheer folly.

In range management, the field of my graduate training, the results of ecological research have been the keystone of modern management techniques. To cite a simple-minded example: the concept of "carrying capacity" which figured in early range management has fortunately been outmoded. In the early days, carrying capacity was regarded as the fixed number of animal-unit-months which a given land unit would support. More recently the development of techniques such as the rest-rotation and deferred-rotation grazing systems, taking advantage of natural ecological characteristics of the forage plants, has shown that the productivity of a given land area is highly variable. Now range managers think more in terms of a variable "stocking rate."

Important gains have been made, but we have far to go before range management is entirely based on ecology; much of the modern range technician's work is based on his own guessing. L. A. Stoddart, who has long been a leader in the profession, argues that range management is still "more of an art than a science."

The major problem is that most range research has been directed at current needs, rather than at long-range goals. We have been looking for ways to avoid cutting back on allotments, we have been trying to cope with cheatgrass and sagebrush, because these, and concerns like these, were the pressing needs. In the rush to solve these contemporary problems, the opportunities in basic research which will lead to new and more efficient range management have gone unexploited. Opportunities to fit grazing into satisfactory management plans with other important land uses, such as recreation, water and wildlife production, have not been realized.

Modern pressures, Mr. Chairman, have made land management a matter of national concern in a way it never was before. In this context, efficient use of natural resources should be sought with new vigor. The results of ecological research as contemplated in the legislation which is before you will contribute to the development of sound concepts of land management which will more adequately provide for the diverse needs of the American people.

NORTHWEST PUBLIC POWER ASSOCIATION,
Vancouver, Wash., April 18, 1966.

Re Ecological Studies S. 2282 (H.R. 9955).

HON. HENRY M. JACKSON,
Chairman, Interior and Insular Affairs Committee, Senate Office Building,
Washington, D.C.

DEAR SENATOR JACKSON: Although the Northwest Public Power Association has no specific resolution on S. 2282 to authorize ecological studies, we find it necessary to testify in opposition to this bill unless it is substantially amended.

TITLE MISLEADING

Although the title refers to this as authorizing studies and research, section 2(9) and section 3 authorize on a blank check basis, the withdrawal by the Secretary of Interior of any federal lands and acquisition of private lands and the prohibition of nonconforming uses.

Since we will discuss the Rampart Dam Case later in our testimony, we submit that this bill authorizes the Secretary of Interior to reserve or withdraw some federal land or all the federal land in the Rampart Dam reservoir and by this bill prohibit construction of a water resources project.

BLANK CHECK LEGISLATION

Where a power reservation exists under the Federal Power Act, S. 2282 raises the question and places a cloud over all such power reservations. Presumably an ecological reservation would be a paramount purpose which overrides and precludes all other uses. It is a blank check not subject to study, review or approval by Congress.

This would apply under section 2(9) to federal lands but under section 3 a private owner of land in a proposed reservoir area could sell or donate some land as an ecological reservation, and if the Secretary approves, then the private owner would have succeeded in stopping the building of a road or dam or other public works improvement.

RECOMMENDATION

We respectfully urge that section 2(9) and section 3 be removed from the bill. We oppose a blank check in the hands of any Secretary of the Interior to reserve or withdraw federal lands or acquire nonfederal lands so as to preclude improvements, dams and roads.

We do not oppose studies which might result in recommendations to Congress that a specific area be established as an ecological reservation, and we would not oppose a blank check authorization of such an ecological reservation within a National Park.

BIAS OF "UNDISTURBED"

When Senator Gaylor Nelson introduced S. 2282 on July 13, 1965, he quoted Paul B. Sears to show that the purpose of the bill was to reserve areas as "undisturbed natural communities."

The literature of the Conservation Foundation also emphasizes the goal of "undisturbed."

We do not object to an undisturbed natural community within existing National Parks. We oppose any blank check for creating any other ecological reservations except upon a specific report to Congress and authorization of the ecological reservation by Congress.

WEAK ON ENHANCEMENT

Only once and in an off-hand manner does the bill suggest that the ecology might be enhanced.

Section 1 mentions enhancement once, and apparently in passing.

We know from experience that irrigation disrupts the desert life, what life there is, and makes the desert bloom. We know that ducks flourish in the Columbia Basin Project. We know that dozens and hundreds of reservoir projects create new ecological systems and values.

This bill has too much of a negative, "don't-disturb-nature" attitude. We think the bill should positively and strongly seek and authorize research to create such new values and encourage necessary disruption of an old ecological system for the purpose of creating a better ecological system.

DOUBLE CONSERVATION

We are conservationists in the double sense of both preservation and use. Wherever possible we favor optimum development for the greatest good of the largest number of people forever.

We cannot favor preserving a minor ecological system as an argument for preventing the creation of a better ecosystem for man.

MAN NEGLECTED

The world is an ecosystem for man. We think man comes first and certainly man wishes fauna and flora, recreation, scenery, fish and wildlife, high quality air and water. Our fear in this bill is that the muskrat will become an end in itself.

THE RAMPART STUDY

A portent and ill omen of things to come if this bill is approved is the November 1, 1965 document of 27 pages, typewritten double-spaced, entitled, "A Report to the Secretary of the Interior by the Rampart Canyon Dam and Reservoir Project Committee," issued by the Division of Biology and Agriculture, National Academy of Sciences—National Research Council.

I regard this report as prejudiced, incompetent, undocumented, unsubstantiated, irresponsible, inappropriate, unauthorized and uncalled for.

The report in turn purports to evaluate a report prepared by the U.S. Fish and Wildlife Service which is equally untested and subject to challenge.

It is possible, let us suppose, that on balance, the Rampart Dam should not be built. Our quarrel with the Secretary of the Interior is his determined effort to prevent the Corps of Engineers from submitting a project report.

If Congress decides not to approve Rampart, we will at least know that the evidence has been weighed. We object to an a priori veto by the Secretary of the Interior via the U.S. Fish and Wildlife Service.

Our problem with the U.S. Fish and Wildlife Service report is that the Service is opposed in advance and they insist on using federal appropriations for issuing vast quantities of propaganda for the purpose of preventing a balanced, systematic, logical presentation of the facts.

ECOLOGICAL VETO

Every proposed public works disturbs something. The pros and cons need to be analyzed and weighed.

We merely object to being hung before we know what accusation is being made.

NO OBJECTION TO STUDIES

Every kindergarten library is saturated with books about our feathered friends and Bobby Muskrat. The American public is friendly and we are friendly toward improving our environment.

We like to hear the singbird and enjoy the mountain silence.

We also appreciate a difference in relative needs between the populated East and the vast open spaces of the West and Alaska.

We in the West want to avoid the mistakes of the East but it takes different ground rules for achieving a proper balance between the conservation of use and the conservation of preservation.

For these reasons in part we oppose S. 2282 as written.

We would wish to endorse S. 2282 in principle for broad studies which include improving or replacing the existing ecology. We favor amendment of the bill by striking, or limiting to National Parks, the provisions of section 2(9) and section 3.

We also urge that the legislative history make clear that Congress will reserve to itself the authority to establish any ecological reservations.

Sincerely,

GUS NORWOOD,
Executive Secretary.

NATIONAL WILDLIFE FEDERATION,
Washington, D.C., April 22, 1966.

HON. HENRY M. JACKSON,
Chairman, Senate Committee on Interior and Insular Affairs, New Senate Office Building, Washington, D.C.

DEAR MR. CHAIRMAN: The National Wildlife Federation appreciates the invitation and opportunity of commenting upon S. 2282, authorizing the Secretary of the Interior "to conduct a program of research, study and surveys, documentation, and description of the natural environmental systems of the United States

for the purpose of understanding and evaluating the condition of these systems and to provide information to those concerned with natural resources management, and for other purposes." I should be pleased if this letter can be made a part of the record of the current hearings.

By way of identification, the National Wildlife Federation is a private organization which seeks to attain conservation goals through educational means.

Affiliates of the National Wildlife Federation are located in 49 states. These affiliates are made up of local groups and individuals who, when combined with associate members and other supporters of the National Wildlife Federation, number an estimated 2,000,000 persons.

The National Wildlife Federation supports the principles expressed in S. 2282, believing the added research it would authorize is both desirable and necessary.

Our organization long has been concerned with the interrelationships between man and his environment, which is one definition of the relatively new science of ecology. Wildlife, including fish and shellfish and amphibians, are dependent upon their respective habitats. Man, to successfully manage wildlife in the public interest, has to be concerned with many and varied problems. Contamination of the environment, by water and air pollution and chemical pesticides, has a profound effect upon wildlife. The construction of roads, airports, and residential and industrial areas competes with habitat for wildlife. The draining and filling of marshes and wetlands, the application of soil and water management techniques, and even modification of the weather are other factors which influence wildlife and are of high interest to us and other wide segments of the American public. While there has been much research along lines of specific interests, relatively little has been directed toward the interrelationships.

In summary, Mr. Chairman, we believe the program authorized by S. 2282 is needed and we hope the Committee sees fit to act favorably upon it.

Sincerely,

THOMAS L. KIMBALL,
Executive Director.

SPORT FISHING INSTITUTE,
Washington, D.C., July 15, 1966.

HON. HENRY M. JACKSON,
*Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.*

DEAR SENATOR JACKSON: I understand that your committee heard S. 2282, a bill "To authorize the Secretary of Interior to conduct a program of research, study and surveys, documentation, and description of the natural environmental systems of the United States" on April 27, 1966. Unfortunately, we did not learn of this until several months subsequent to this, and are therefore a bit tardy in presenting the views of Sport Fishing Institute on this bill. I have checked with your Interior Committee and they tell me that the record is just now being printed, but that if I get this letter in within the next day or so there is a good chance that it still can be included in the testimony on S. 2282.

As you know, we in fisheries are vitally concerned with the aquatic resources of America and feel very strongly that there should be a broad authority to include ecological studies of such resources even though there is no defined project involving such resources. In other words, we would favor the authorization granted by this legislation to give us basic research data on subjects that might not be covered by mission-oriented studies. This would enlarge our "library" of knowledge so that there is an improved capability for furnishing public and private agencies, upon request, an "educated guess" as to the consequences of a proposed large-scale construction project, resource management activity, or other environment alterations that are of sufficient magnitude to affect this particular living organism by causing a change in its ecology. If this knowledge is available to the altering agency at the outset of a proposed program there will be less danger through interference of the ecological system which might completely destroy a particular natural resource.

"A program of ecological research would be of material assistance in advancing our Nation's efforts in the challenging task of reversing the trend of deterioration of our environment, and in elucidating scientifically the conditions on which successful and satisfying human existence on this earth must be predicated." These are the stated feelings of the Department of Interior and Sport Fishing Institute agrees. We would like to be included as favoring this

type of research now, while there is still some time available before the resource might become an item on our endangered species list.

We would appreciate inclusion of these brief remarks in your record of hearings as favoring passage of S. 2282.

Thank you.

Sincerely,

PHILIP A. DOUGLAS,
Executive Secretary.

THE IZAAK WALTON LEAGUE OF AMERICA, INC.,
Washington, D.C., April 28, 1966.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: The Izaak Walton League of America supports enactment of S. 2282, to authorize a program of ecological surveys and research.

We feel the justification for such a program is obvious—no matter how great or how many our technological achievements, the simple fact is that the people of this Nation are part of a complex ecological system. We are changing that system, have the power to change it further, and ought to know the potential results of such change. At present, however, our knowledge of ecological matters is alarmingly limited.

To document the need for accelerated ecological study, we simply refer to the November 1965 report of the Environmental Pollution Panel of the President's Science Advisory Committee. Indeed, that report—compiled by authorities whose credentials are impeccable—suggests that S. 2282 might not go far enough. We refer, for example, to categories "C" and "F" of the Environmental Pollution Panel recommendations which indicate that the many environmental programs of various Federal agencies ought to be far better coordinated than at present. This suggests to us an "operations center" at Cabinet level. The Secretary of the Interior would seem the obvious choice—yet, Section 6 of S. 2282 would strictly limit his authority.

Mr. Chairman, the Izaak Walton League hopes the 89th Congress will enact an ecological research law.

Respectfully,

ROBERT T. DENNIS,
Assistant Conservation Director, IWLA.

THE IZAAK WALTON LEAGUE OF AMERICA, INC.,
INDIANA DIVISION,
April 2, 1966.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
Senate Office Building, Washington, D.C.

DEAR SENATOR JACKSON: It is our understanding that hearings have been scheduled on or about April 21, for the Ecological Research and Surveys Bill, S. 2282, by Senator Nelson.

Attached to this letter is a copy of a resolution adopted unanimously by the Board of Directors of the Indiana Division of the Izaak Walton League March 13, and we request that both the resolution and this letter be printed in the Record of that hearing.

S. 2282 is a landmark bill in our opinion, giving definitive articulation to a principle not fully identified in any existing statutes. It is true that many of our Administrative bodies are interested in ecological surveys, and are turning increasing attention toward the cataloguing of highly significant natural areas. Some of these principles are intended in the Wilderness Act, certainly the National Parks Act, and by many recent indications from the Bureau of Land Management.

But there is no comprehensive policy that we know of which creates so important a base for scientific and educational evaluation of undisturbed areas as the present Nelson bill. We are encouraged in this bill that recognition is given to private groups and competent individuals as potential participants in the conduct of ecological studies. We believe that such a measure as this will also have far-reaching secondary impact, and will do much to call attention to basic

ethical principles, and will broaden interest beyond sophisticated specialists right into the fabric of the lay society itself. That concept is very strongly supported by the League and specifically by its Indiana Division.

We greatly hope that this measure may be reported and move through Congress at the best pace possible. Thank you.

Sincerely yours,

THOMAS E. DUSTIN, *President.*

RESOLUTION OF THE INDIANA DIVISION—THE IZAAK WALTON LEAGUE OF AMERICA, INC.

ECOLOGICAL RESEARCH AND SURVEYS

Whereas, it is in the public interest that maximum knowledge of the communities of nature be developed, assembled and understood for all possible areas; and,

Whereas, this knowledge is necessary if the highest uses and dedication for various areas of the outdoor domain are to be recognized and achieved;

Whereas, many areas of the nation and throughout the world are rapidly being diverted to other purposes and are being lost before their highest values can be understood based upon competent scientific investigation; and,

Whereas, measures now before the Congress of the United States would establish as public policy the need for and implementation of detailed studies of all possible areas, and would provide for not only Federal studies but also cooperative programs with states, local governments, private groups and competent individuals, assuring the widest and most rapid accumulation of vital data on natural communities; now, therefore,

Be it resolved, by the Board of Directors of the Indiana Division, Izaak Walton League of America, Inc., assembled at Michigan City, Indiana, this 13th day of March, 1966, that the principles of the Ecological Research and Surveys Bill, S. 2282, are hereby endorsed, and passage of the measure by the Congress is urged at the earliest date possible.

(Adopted unanimously.)

THE NATIONAL CONFERENCE ON STATE PARKS,
Washington, D.C., April 26, 1966.

Senator HENRY M. JACKSON,
Chairman, Interior and Insular Affairs Committee, Old Senate Office Building, Washington, D.C.

DEAR SENATOR JACKSON: At its Board of Directors meeting in Washington, D.C. on March 18, 1966 the National Conference on State Parks expressed its interest in the passage of S. 2282 introduced by Senator Gaylord Nelson which would provide for ecological research and surveys of natural resources.

It appears to us that the purposes of this bill are highly meritorious and the results of such surveys would provide a considerable expanded body of knowledge most useful in identifying and planning for the protection and conservation of park and recreation areas in the United States.

Sincerely yours,

DONALD B. ALEXANDER,
Executive Secretary.

THE AMERICAN NATURE STUDY SOCIETY,
Harborside, Maine.

CHAIRMAN,
Committee on Interior and Insular Affairs, U.S. Senate, Washington, D.C.

DEAR SIR: In a remote part of Maine, I find it difficult to keep track of national legislation but wish to express great interest in S. 2282, a bill to authorize a program of research of natural environmental systems, introduced by Mr. Nelson *et al.* on July 12 and referred to your committee.

I urge you to give strong support to this bill.

Our well-intentioned nation has so often been ecologically insensitive in both its domestic land and water policies and in its foreign policy also that it is high time that our Secretary of The Interior be given the powers of fact-finding called for in this enlightened bill.

Our federal agencies dealing with natural resources have of necessity in the earlier days of our nation been so involved with the rather short-term economics

of use that they have not done the job which should have been done in assessing the subtle natural systems by which our continent and all the activity thereon hang together.

As a trained ecologist for more than 25 years and as an educator whose daily job confronts the resource ignorance of a vast population, I am encouraged by the astuteness of the legislators who have proposed this bill, S. 2282, and hope that your Committee can soon take positive action thereon.

Sincerely yours,

DR. JOHN W. BRAINERD,
Department of Biology, Springfield College.

SPRINGFIELD, MASS.

SIERRA CLUB,
San Francisco, December 29, 1965.

Senator HENRY M. JACKSON,
*Chairman, Committee on Interior and Insular Affairs, Senate Office Building,
Washington, D.C.*

DEAR SENATOR JACKSON: I am pleased to be able to report that the Board of Directors of the Sierra Club adopted the statement of policy that follows at their most recent meeting in Los Angeles on December 11, 1965.

The Sierra Club endorses the principles embodied in the Ecological Research and Surveys Bill (S. 2282—Nelson).

As you may know, the Sierra Club is a national conservation organization of 35,000 members with chapters now in much of the country.

I hope that you will be able to take appropriate action in accordance with this statement of policy.

Sincerely,

MICHAEL McCLOSKEY,
Conservation Director.

THE GARDEN CLUB OF AMERICA,
New York, N.Y., April 20, 1966.

Mr. Chairman and Members of the Committee:

The Conservation Committee of the Garden Club of America herewith records its approval of S. 2282, the Ecological Research and Surveys Bill. The Garden Club of America is a national organization with member clubs from coast to coast and in Hawaii.

It is reassuring to us that a long last national legislation has been introduced in Congress to conduct a program of research, study, documentation and description of the natural environmental systems of the United States.

The growing technological age necessitates a thorough evaluation of our environment, and man's influence on it. The pollution of the three elements of our total environment, namely, air, water and soil is of serious concern to us as individuals, and members of an organization dedicated to the preservation of our natural resources. The population explosion will increase our demands on these natural resources. A better understanding of ecology is vital for the future of our great country.

I appreciate the opportunity to state the approval of this constructive legislation on behalf of the Conservation Committee of The Garden Club of America.

Respectfully submitted.

LOUISE H. McKEON,
Mrs. Daniel M. McKeon,
Chairman, Conservation Committee.

COMMUNITY RESEARCH AND DEVELOPMENT, INC.,
Baltimore, Md., April 26, 1966.

Hon. GAYLORD NELSON,
*Old Senate Office Building,
Washington, D.C.*

DEAR SENATOR NELSON: After reading the Ecological Research and Surveys bill proposed by you, I am pleased to say that I am in complete support of the bill and its purposes.

We are building a new city midway between Washington and Baltimore. In order to do this, we acquired 15,000 acres of Maryland farmland. It has been one of our goals to respect and dignify the land in the course of planning and develop-

ment and thus to enhance the enrichment of the new city. In order to reach our goals, one of the first consultants to whom we turned was Dr. Paul Sears, quoted in the introduction to the the bill. We have provided for the preservation of the stream valleys; the building of five lakes; the proper forestation of natural wooded areas, and the building of parks and bridle paths.

All of this has been done at great expense and often, unfortunately, with insufficient information regarding the ecological conditions which would be affected. It would be wonderful, for example, to have really substantial knowledge as to the role of water in the environment. The process of building the many lakes which we propose in Columbia is a difficult and tedious one. We are confident that the creation of lakes is a worthwhile effort; but because of the lack of general knowledge as to their broader values to the environment, we seem to have few allies in the process. The same general problem pervades the entire city-building process. It is hard to quantify or evaluate specifically the worth of the various elements of natural amenity we seek to preserve.

I regret that my schedule will not permit me to testify on behalf of the bill. My testimony could only elaborate on these general remarks. We have no real expertise on this subject within our staff. No doubt you know about Ian McHarg, Professor at the University of Pennsylvania, School of Landscape Architecture. I would recommend him as a witness since he has long pioneered the need for ecological concern and research in our changing environment.

Thank you for considering us in relation to this bill. We hope that we can be more helpful in the future.

Sincerely,

JAMES W. ROUSE.

MATANUSKA ELECTRIC ASSOCIATION INC.,
Palmer, Alaska, May 2, 1966.

HON. ERNEST GRUENING,
U.S. Senate, Washington, D.C.

DEAR SENATOR GRUENING: I have been instructed by the Board of Directors to indicate to you the concern of the Association regarding Senate Bill 2282, relating to ecological studies in Federal reserve areas. The particular objection raised by Mr. Gus Norwood, Executive Secretary, Northwest Public Power Association, is that section 2(9) of the bill provides for an ecological reservation within other reservations, as for instance power reserves. In addition, section 3 would apparently allow a private individual who might own land within such a reserve through prior right, or in a reservoir area, might dedicate or sell some land as an ecological reservation, and thus effectively stop other development such as roads or dams or other public works improvement.

Mr. Norwood makes the very cogent point, which you have often voiced, that it is necessary and desirable in many cases to preserve existing ecological systems favoring the growth and perpetuation of wildlife. However, it is hardly logical to preserve a minor ecological system which aids in preventing development of a better system for man.

The Board fears, as does Mr. Norwood, that the bill, as written, might provide the vehicle by which a narrowly conservation minded Secretary of the Interior could easily preclude development of such projects as the Rampart Dam. We have already in Alaska felt the full weight of the conservationists about the country who would reserve Alaska to the moose and the muskrat, largely without ever having visited our state and observed the thousands of square miles of virgin area, and the relatively minute inroads made upon this great mass by man and his works. I have felt that the most vehement of these prophets of doom for the wildlife should be deposited in the middle of the Yukon Flats, or in the great swamps between the Kuskokwim and the Yukon, preferably in the height of the mosquito season.

Your efforts to modify this bill, to retain the good and root out the evil, will be appreciated. Copies of this letter will be sent to the other members of our fine delegation, for their information. We were apprised of the bill through a copy of a letter from Mr. Norwood to Senator Henry M. Jackson. I am certain that Mr. Norwood would be happy to send you a copy of his letter, which is, as always, well thought out and complete.

Sincerely yours,

MASON LAZELLE, *General Manager.*

BURNS CLINIC,
DEPARTMENT OF OPHTHALMOLOGY,
Petoskey, Mich., March 28, 1966.

HON. PHILIP A. HART,
U.S. Senate, Washington, D.C.

DEAR SENATOR HART: This note is in support of S. 2282 introduced by Senator Nelson, and cosponsored by yourself. The opening statement of the bill is an eloquent appraisal of the need for such legislation. It is gratifying to see population pressures recognized as one of the factors contributing to the loss of natural areas. Indeed, the population problem is at the root of many of the dilemmas we face today.

On page 5, line 1, it is good to see the *scientific* purposes of a natural area system spelled out, to distinguish it from recreational purposes. On line 11, page 5, I assume the "interests" could include an easement for conservation purposes. This device has certainly worked well in isolated instances on the local and state level. On line 16, page 5, it is good to see that manipulation is necessary to some natural areas.

I hope for speedy consideration of this excellent bill by the Interior and Insular Affairs Committee.

Sincerely yours,

JOHN H. TANTON, M.D.

UNIVERSITY OF WASHINGTON,
Seattle, Wash., April 7, 1966.

Senator HENRY M. JACKSON,
Chairman, Interior and Insular Affairs, U.S. Senate, Washington, D.C.

DEAR SENATOR JACKSON: I appreciate your calling to my attention the forthcoming hearing on Senate Bill 2282, the Ecological Study proposal. Unfortunately, I am unable to attend in person but would like to present in writing my views on this commendable piece of legislation.

First of all, I would offer my whole-hearted support of the Bill as it, to my mind, represents a meritorious example of the concern by Congress for scientific approaches to preservation of ecological systems.

My interests in the proposed legislation (S-2282) are both personal and professional. I am a field botanist on the staff of the Department of Botany, University of Washington, and am doing work in ecology of the coniferous forest ecosystems in the Pacific Northwest. As a professional ecologist I have become interested in a number of efforts in our region to preserve bits of specific biota under the aegis of several organizations. Therefore, I have become affiliated with North Cascades Conservation Council (Board member) and the Washington Chapter of Nature Conservancy (a Trustee).

Senate Bill 2282 is commendable for a number of reasons. First, it concentrates its impact on the preservation of individual species of the biota as well as the preservation of samples of entire ecosystems. Secondly, it encourages—in fact, stipulates—that research be conducted on proper management of natural areas. It is in this province of activity that much is needed for even our existing wilderness and other natural areas. How to preserve the status quo in a changing ecosystem introduces a whole complex of problems that need the help of ecologists. Support through Federal Legislation would be very welcome here. The Bill's acknowledgment that some natural areas should be set aside for scientific study is also meritorious. I am sure that within the community of biological scientists interested in the realm of ecology it would be possible to find considerable aid from those who would utilize financial support for research specified under this Bill. Various biological societies, especially the Ecological Society, certainly offer a reservoir of personnel for such work. Lastly, the wise suggestion that there be free inter-agency cooperation in conducting ecological studies is noteworthy and commendable.

Thus, I whole-heartedly and unreservedly support Senate Bill 2282.

Sincerely yours,

ARTHUR R. KRUCKEBERG,
Professor, Department of Botany.

INDIANA UNIVERSITY,
DEPARTMENT OF GOVERNMENT,
Bloomington, Ind., April 23, 1966.

Senator HENRY M. JACKSON,
Chairman, Senate Interior Committee, New Senate Office Building, The Capitol,
Washington, D.C.

MY DEAR SENATOR: I regret that it has proved impossible for me to testify in person in Washington on behalf of Senate Bill 2282 (the Ecological Survey and Research Bill) submitted for consideration by Senator Gaylord Nelson. However, I do wish to submit this written statement and accompanying documents in support of the bill, and to urge that it receive prompt and favorable action by your committee.

I am Professor of Government at Indiana University and have directed the major part of my professional work to study of the impact of science and technology on contemporary society. It is my considered judgment that S2282 is possibly the most significant legislative proposal to come before a Congressional Committee in this Congress. Certainly it is among the most important. This bill provides for the better organization and reinforcement of research on conditions of our natural environment. The knowledge derived from this research is essential to wise policy decisions by the Congress and the Executive branch. The life-sustaining capacity of our natural environment is the foundation upon which the health, security and prosperity of the American people ultimately must rest. To argue that we cannot or should not afford to make this investment in our national future would be comparable to arguing that a man could not afford to have physical examinations or to carry insurance. Our neglect of research into the environmental basis of our national welfare has already cost us dearly in the heavy accrued liabilities for air and water pollution, abuse of pesticides, misuse of land and destruction of irreplaceable assets of climate, scenery and wildlife.

It would be a reproach to the good sense and foresight of the American people if, in our concern for national security and world peace, we defeat our own efforts toward these goals by neglecting the physical and biological basis of our national strength. The forces which science and technology have placed in our hands now require us to take necessary measures to make their use as wise as possible. S2282 provides a means toward realization of this objective. It facilitates the mobilization and enlargement of the informational resources of this nation without which we cannot hope to achieve effective control over our future.

I therefore respectfully request that this statement and the two accompanying documents:

Environment—"A New Focus for Public Policy" *Public Administration Review XXIII* (September, 1963) and

"Public Policies in Environmental Values—Toward a Sounder Basis for Decisions" *Bulletin of the International Union for the Protection of Nature and Natural Resources*. (April-June, 1964)

be entered into the record of committee hearings on S2282.

Very sincerely,

LYNTON K. CALDWELL,
Professor of Government.

(The two documents mentioned are incorporated in the record by reference.)

OBERLIN COLLEGE,
DEPARTMENT OF BIOLOGY,
Oberlin, Ohio, September 8, 1965.

HON. HENRY M. JACKSON,
U.S. Senate, Washington, D.C.

DEAR MR. JACKSON: I wish to express support for the ecological research and surveys bill (S. 2282) which is before the Committee on Interior and Insular Affairs.

The provisions of this bill, as I read them in the Congressional Record, July 13, 1965, No. 126, are ample and sound. They should provide the means and access to basic ecological information which is requisite to an intelligent application to man's ecological problems.

As an ecologist, educator, and human being, I perceive many of man's immediate and long-range living problems to be basically ecological in nature. The types of studies suggested in the bill can not be initiated too soon.

I respectfully request this letter be made part of the record of the Committee.

Very truly yours,

EDWARD J. KORMONDY,
Associate Professor of Biology.

UNIVERSITY OF HAWAII,
Honolulu, Hawaii, May 4, 1966.

Senator HENRY M. JACKSON,
Chairman, U.S. Senate Interior Committee, New Senate Office Building, Washington, D.C.

DEAR SENATOR JACKSON: It is with great joy and appreciation for the insight of your committee that I heard of the proposed Bill 2282 aimed at establishing an Office of Ecological Research and Surveys.

In a time when the pressures and demands on the use of our natural resources are increasing in geometrical proportions, it becomes a real necessity that we do learn as much as we can about the potential of the land. This is so necessary as we must find the management methods and uses for the land that ensures the highest sustained yield, for agricultural purposes, forestry, or multiple use and research. For the latter, we need to preserve representative natural areas that can be used as "controls" against the effects of management (good or bad in the long run) and pollution.

In order to understand how to manipulate the land for its best use, we must survey our resources from an ecological viewpoint and derive at scientifically and practically useful regional classifications of our major ecosystems.

The scope of such an Office of Ecological Research and Surveys should go beyond the national level. It is particularly in this area of deriving a knowledge and appreciation of the land resources that we can make a lasting contribution on the international level.

It has by now become apparent that the best form of help we can extend to developing nations is in the area of education. The message of the role and responsibility of man in relation to his ecosystems is a vital part of education.

With this, I wish to lend my whole-hearted support for your intellectually sound and morally responsible step in introducing this bill.

Cordially,

DIETER MUELLER-DOMBOIS,
Assistant Professor of Botany.

MISSOURI BOTANICAL GARDEN,
St. Louis, Mo., April 25, 1966.

Senator HENRY M. JACKSON,
*Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.*

DEAR SENATOR JACKSON: I wish to recommend immediate favorable action by your committee concerning Senator Nelson's Ecological Research and Surveys Bill. This nation is faced with an ecological crisis which will become worse very soon. It is in the best interest of this nation to have a strong ecological research program in order to further our understanding of the complex environment in which we live.

Ecological research is urgently needed by this nation. I urge favorable action on Senator Nelson's bill.

Sincerely yours,

DAVID M. GATES, *Director.*

BERNICE P. BISHOP MUSEUM,
Honolulu, Hawaii, April 25, 1966.

Senator HENRY M. JACKSON,
*Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.*

MY DEAR SENATOR JACKSON: It is my understanding that a hearing is to be held on Wednesday, April 27, in connection with Senator Nelson's Ecological Research and Surveys Bill. This Bill was discussed at the Tenth Conference of

Directors of Systematic Collections which met at Bishop Museum on March 28 through 30, at which the heads of the major natural history museums and botanical gardens in the United States and Canada were present. I have had an opportunity to read the Congressional Record, Senate, July 13, 1965, and urge the passage of this Bill. The study of ecology, while not new, has burgeoned in recent time. There is a great deal of work which needs to be done and time is of the essence. Museums can play a vital role in the development of this program should the Bill be passed. For these and many other reasons, I offer my wholehearted support of this legislation.

Sincerely yours,

ROLAND W. FORCE, *Director.*

WASHINGTON, D.C., July 1, 1966.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate,
Washington, D.C.

DEAR MR. CHAIRMAN: At the request of Mr. Richard Falknor of your Committee staff, I am enclosing a copy of my February 1966 article entitled "Needed Research for Population Policy" for inclusion in your Committee's Record of Hearing on S. 2282, the Ecological Research and Surveys Bill.

The topics discussed in my article relate to the policy concerns underlying S. 2282.

My own experience on the professional staff of the Congress leads me to believe that the issues I discussed will be of particular interest to your Committee in its continuing study of the implications of current and anticipated environmental changes.

Yours faithfully,

DR. ROBERT W. LAMSON.

NEEDED RESEARCH FOR POPULATION POLICY

The author is a Sociologist and Research Analyst in the Postattack Research Division of the Office of Civil Defense. This article represents his views, and not those of the Office of Civil Defense or the Department of the Army.

By Robert Lamson

In his State of the Union Message before Congress on January 4, 1965, President Johnson said:

"I will seek new ways to use our knowledge to help deal with the explosion in world population and the growing scarcity in world resources";¹ and in his State of the Union Message on January 12, 1966, he proposed: "to help countries trying to control population growth by increasing our research."²

The President's statements contain implications which are new for United States government officials who are attempting to solve problems, define goals, and pursue programs in such areas as national security, resources, and welfare.

In the past, the United States Government has used knowledge to solve problems within the conditions set by such factors as population size and growth rates, geography, and climate. And although government officials have attempted to modify some of these conditions through programs such as flood control and research in cloud seeding, they have tended to treat population size and growth rates as fundamental conditions or facts of nature which they must take into account in their planning, but which, in themselves, are not subject to conscious choice, change and control.

What is new in the President's 1965 statement is that, for the first time in United States' history, a President, in a State of the Union message, has referred to the "explosion in world population" as an object for the application of human knowledge rather than as merely a condition to which government planning and action must adjust in order to achieve national goals. Both statements indicate that population size and growth rates now tend to be viewed,

¹ Message from the President of the United States Transmitting the State of the Union Message (House of Representatives, Document No. 1, 89th Congress, 1st Session, 1965), p. 4.

² Message from the President of the United States Transmitting the State of the Union Message (House of Representatives, Document No. 321, 89th Congress, 2d Session, 1966), p. 7.

at the highest levels of government, as objects which can and should be altered through the application of human knowledge.

This new fact raises a series of questions:

1. What is the relation of the "population explosion," that is, of rapid population growth rates, to such problems as national security, resources, and welfare?

2. If, as the President's Messages indicate, we are to use our knowledge to help deal with the explosion in world population, what is the range of possible and desirable goals, means and programs for using our knowledge to deal with this problem, domestically and internationally?

3. What is the relation of these goals to current national problems in such fields as national security, resources and welfare?

The asking of these questions reveals our lack of knowledge as well as our need for systematic study and analysis of the goals, means and problems involved in using "our knowledge to help deal with the explosion in world population and the growing scarcity in world resources" and in acting "to help countries trying to control population growth by increasing our research."

However, some tentative answers and suggestions may be offered with respect to: 1. the relation of explosive population growth to problems of national security, resources and welfare; 2. the range of goals and means for using our knowledge to help deal with the explosion in world population; 3. types of research needed to help answer these questions and to implement the President's statements of purpose.

1. Population Growth and Problems of National Security, Resources and Welfare

National Security: In the area of strategic defense, planning and programs for the protection of the population are based on assumptions about population size, growth rates, composition and distribution—basic elements involved in planning nationwide requirements for protection against nuclear attack. Planning for military manpower is based on similar assumptions.

Insofar as population size, composition and growth are factors in national power and military capacity, these elements also enter into the calculus of United States' power and capability with respect to other nations. Population growth rates are also crucial factors which affect the success of our programs to promote economic growth and political autonomy and stability in underdeveloped areas. Rapid population growth rates have made economic growth and political stability increasingly difficult to maintain in some parts of the world, thereby adding to the need for programs and forces to help maintain internal order and to defend against guerrilla warfare.

Resources: With respect to problems of domestic and world resources, population size, and growth rates affect the ability of any society to conserve, to use efficiently or to expand such resources as land, pure air and water, fuel and power, timber, wildlife, wilderness, outdoor recreation areas, open spaces, natural beauty and silence. Population growth rates also affect a nation's ability to provide adequately such functions as transportation, communications, housing, sanitation and education.

Welfare: Population size, composition and growth rates are crucial elements in such problems as poverty, standards of living, health, employment and automation, not only as part of the conditions within which these problems are solved, but also as causes of these welfare problems themselves—in the United States as well as in the rest of the world.

In addition to these problems of security, resources and welfare, of great importance is the fact that such values as freedom, autonomy of personality, the nature of our democratic political system and the extent of intrusion of government into the lives of citizens depend, to a certain extent, on the relation between population (size, composition, density, distribution) and availability of resources. These values may be jeopardized by rapid population growth before limits are reached in the availability of such economic resources as land, water, food, power and fuel, or in our ability to provide such services as housing, schools and transport.

Interaction: The various parts of these problems of security, resources, welfare and political value interact, on the domestic as well as international levels, and the solution of one part of a problem may depend eventually upon the solution of other parts. For instance, the eventual reduction of population growth rates in underdeveloped countries to the point which would allow for economic growth and political stability may possibly depend upon our success in reducing popu-

lation growth within the United States. For other countries which we attempt to help and motivate to control their population growth may be less willing to do so if the United States does not provide an example, or if they are urged to limit their population growth and consumption of world resources while, at the same time, the United States doubles in size and increases its percentage and rate of consumption of world resources.

In the long run, our ability to solve our welfare problems of poverty, unemployment, automation and health, to increase our domestic standards of living and to provide adequate housing, schools and transportation may depend on whether and what level a balance is struck between population and resources within the United States, even granting the fact that technology can help us to expand and to make more efficient use of our resources.

In the long run also, solutions to our domestic welfare and resource problems may depend upon our success in encouraging other countries to reduce their rates of population growth, if it is granted that the domestic balance between population and resources is ultimately affected by the world population-resource balance.

2. *The Range of Goals and Means*

In order to implement the President's statement of purpose to use our knowledge to deal with the explosion in world population, various alternative goals (domestic and international) may be explored by assuming, for the sake of analysis, that it is within the power of the United States to attain any population policy goal which it sets for itself.

Many curves describing the hypothetical future population size of the United States and of the world can be drawn. The range of alternative goals include: A. Population growth increasing more rapidly than the predicted doubling of the current United States and world population by the year 2000; B. The predicted doubling of current United States and world population by the year 2000; C. A somewhat reduced rate of growth so that the doubling of the United States and world population takes longer, for instance, 60, 75 or 100 years, instead of the predicted 35 years; D. The stabilization of the United States and world population size at less than its present size, or double its present size, or greater by a factor of 2.5, 3, or 4. Here, the question arises: At what level and when should this stabilization occur, in 60, 75, 100, 200 years?

Given a range of population policy goals, which one(s) should the United States choose to pursue, domestically and internationally, and for what reasons? Which particular curve(s) should the United States take as its goal for domestic and international policy? And, what is the relation of these curves to problems of national security, resources and welfare, and to our political values?

To achieve whatever goal is chosen for dealing with the explosion in world population, there is a range of alternative means which differ with respect to effectiveness, religious, moral and political acceptability, degree of individual choice, practicality and cost. They include: 1. methods for controlling birth rates, for instance, infanticide, abortion, sterilization, pills, chemicals, various types of contraceptives, rhythm, abstinence and delayed marriage; 2. methods for motivating people to limit family size, for instance, clinics, information and propaganda, and removal of incentives for having additional children beyond a given number; and 3. alternative government policies for combining elements of these two methods into a program for achieving a particular population policy goal.

Given such a range of possible alternatives for dealing with the explosion in world population, which one's should be used to pursue the goal chosen for population policy?

3. *Needed Research*

Various types of research are needed to help implement the President's statements of purpose and to answer the questions raised above. For if, as the President's statements suggest, we are moving toward acquiring the national capability as well as the intent to use human knowledge to alter population growth rates and to treat United States and world population growth as objects for government planning and action, then there is a great need for research on: 1. the relation between population size, composition and growth and our problems and goals in fields such as national security, resources and welfare; 2. the range of alternative domestic and international goals for United States' application of human knowledge to the population explosion; 3. the relation of these alterna-

tive goals to such problems as national security, resources and welfare; 4. the combination of means (medical, motivational and policy) which would be required to achieve the goals; and 5, the costs and benefits—economic, political, social and moral—of each alternative and combination.

Paramount in such research should be a concern with the effects on domestic political systems and on the values of freedom and autonomy of personality which are created, first, by rapid population growth and, second, by the goals and means which are chosen for applying human knowledge to the population explosion.

The following is an outline of the goals of various types of needed research.

1. *Medical-Biological*: To provide medical techniques for population control.
2. *Social-Psychological*: To provide the information and techniques for understanding and influencing individual decisions to limit births.
3. *Demographic*: To provide basic information about the nature of the population problems as well as analytical techniques for evaluation of alternative population policies.
4. *Policy-Systems Analysis-Economic-Legal*: To outline and analyze the benefits, costs, risks and requirements of various alternative population policy goals and programs.
5. *Theological-Philosophical*: To reconcile effectiveness, moral acceptability and desirability of alternative population control techniques and programs.

BETHESDA, MD., April 22, 1966.

HON. HENRY M. JACKSON,
Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

MY DEAR MR. JACKSON: I want to express my favorable opinion of "The Ecological Research and Surveys Bill", S. 2282, on which I understand hearings by your Committee are planned for the near future.

I am convinced that the stated objectives of the Bill are worthy and that their realization is essential for our future well-being. I believe that the proposed means of accomplishment are sound. I feel that the time arrived long ago when we should have started replacing opinions and guesses about management of our natural resources with basic knowledge derived from scientific research. While it is not too late, I feel that we should not delay longer.

I am a research scientist in biology. My special area is the study of feeding behavior of bloodsucking insects, ticks, and mites, including the interrelationships that biting and bloodsucking involve.

Thank you for your time and attention.

Sincerely,

PAUL A. WOKE.

DUKE UNIVERSITY,
Durham, N.C., April 25, 1966.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

DEAR SENATOR JACKSON: I understand that hearings on the Ecological Survey and Research bill, S. 2282, are being held this week. I regret that I am unable to testify in person, but would like to express my enthusiasm for this proposed legislation.

There is mounting concern over the levels of pollution and contamination by toxic substances placed in the environment by ever-increasing human beings. Each individual's life is being dependent or demanding of greater consumption, greater waste, and greater complexity. Water tables fall, recreation space becomes crowded, and our earthly nest is becoming fouled in general. These and other symptoms require action—immediate symptomatic relief.

But beneath the symptoms, there is a chronic ignorance of ecological fundamentals. We live in disharmony with the world upon which we depend for our survival. Our patent medicines of beautification campaigns, flood control dams, insecticides, and herbicides may avert intolerable pain, but we need more knowledge and appreciation of what Aldo Leopold called "the physiology of the land" if we would achieve permanent problem-solving capacities.

S. 2282 may be objected to because of expense and red tape. However, our most successful practices are based upon fundamental knowledge. Knowing how the body functions is economically desirable for human medicine. Likewise, knowing how our ecosystems function is needed for wise management.

Thank you.

WILLIAM A. CALDER,
NSF Graduate Fellow, Department of Zoology.

ACRES, INC.,
Fort Wayne, Ind., April 26, 1966.

Senator HENRY JACKSON,
*Senate Office Building,
Washington, D.C.*

DEAR SENATOR JACKSON: The Board of Directors of ACRES, Inc., in regular meeting April 26, 1966 went on record as endorsing the principles of Senate Bill 2282, the Ecological Research and Surveys Bill. We are convinced that this measure is an important one. Detailed studies must be made of all types of natural areas by ecologists and competent biologists. Little scientific research has been carried out thus far in the area of balanced ecological studies. We need to know more of the complicated natural balances if we are to meet the challenges imposed by growing populations not only in the United States but also throughout the world.

We hope that this bill or a similar one will soon pass both houses of congress.

Sincerely yours,

JOHN W. KLOTZ, *President.*

TACOMA, WASH.,
April 27, 1966.

Senator HENRY M. JACKSON,
*Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.:*

We wish to add our voices in favor of S. 2282 in order to preserve a small Federal area in Pierce County for educational purposes.

THE PLANTERS.

MEGATECH INC.,
Raleigh, N.C., June 10, 1966.

Senator HENRY M. JACKSON,
*Chairman of the Senate Interior Committee,
New Senate Office Building,
Washington, D.C.*

DEAR SENATOR JACKSON: It was with great interest that I read The Ecological Research and Surveys Bill S. 2282, which was introduced by Senator Gaylord A. Nelson.

I strongly believe that the increased ecological research and a more precise understanding of ecology are urgently needed especially with the rapid rate of increase in population and pressure on the natural environment.

Therefore, I fully express my support for the bill.

Yours truly,

HERBERT R. SCHAAL,
Landscape Architect.