A Report
by
THE ADVISORY COMMITTEE
to the
NATIONAL PARK SERVICE ON RESEARCH

National Academy of Sciences—
National Research Council

Washington, D. C.
November 13, 1963

To: All Recipients of A Report by the Advisory Committee to the National Park Service on Research

The National Academy of Sciences Advisory Committee to the National Park Service on Research calls attention to the following correction which should be made to Recommendation 11, page xiv, of its report of August 1, 1963:

11. Research on aquatic life, as well as on that existing on and above the land, should be pursued to assist in determining general policies for the maintenance of natural conditions for their scientific, educational, and cultural values.

The Committee would appreciate it if these changes were made in all copies which have been thus far distributed.

A Report

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The Advisory Committee to the National Park Service on Research

of the

National Academy of Sciences - National Research Council

NATIONAL ACADEMY OF SCIENCES

OFFICE OF THE PRESIDENT
2101 CONSTITUTION AVENUE
WASHINGTON 25, D. C.

August 1, 1963

The Honorable Stewart L. Udall
The Secretary of the Interior
Washington, D. C. 20240

Dear Secretary Udall:

Your letter of April 25, 1962 asked the advice and assistance of the National Academy of Sciences in the planning and organizing of an expanded program of natural history research by the National Park Service. I am pleased to transmit herewith the report of the committee that was appointed by the Academy to respond to that request. Supplemental material is being gathered together in an appendix which will be forwarded to you as soon as it is completed.

We have felt a special responsibility in undertaking this task. The challenge of preserving both the beauty and the substance of a significant portion of our environmental heritage, in the interests of this and future generations, is one that calls for the best that those with appropriate knowledge and competence can give. Our committee, under the chairmanship of William J. Robbins, has devoted sustained and careful thought to the several aspects of the problem.

Dr. Robbins assures me that the committee members will be glad to discuss with you any parts of their report if you would find that helpful.

Sincerely yours,

F. Seitz

Frederick Seitz
President

A Committee of the National Academy of Sciences, appointed at the request of the Secretary of the Interior, was instructed to report on the natural history research needs and opportunities in the National Park Service, in particular on those of the national parks. The Committee included:

Edward A. Ackerman	Tom Gill
Marston Bates	Joseph M. Gillson
Stanley A. Cain	E. Raymond Hall
F. Fraser Darling	Carl L. Hubbs
John M. Fogg, Jr.	William J. Robbins, Chairman

C.J.S. Durham, Executive Secretary

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ABSTRACT

The report submitted to the Secretary describes how the Committee conducted its study and surveys the development of the national parks idea, which originated in the United States and has reached its fullest expression there. It calls attention to the responsibilities and obligations which stem from the worldwide recognition and appreciation of the leadership of the United States in this area.

It discusses some of the historical aspects of the establishment of national parks, the first of which was Yellowstone National Park in 1872, and highlights the characteristics of some of the 31 parks now in existence. The report asserts that the national parks of the United States are among the most valuable heritages of this country; that in setting these lands aside the people and the government of the United States demonstrated particular wisdom; and that the role of national parks in the lives of our citizens is dramatically enlarging.

The objectives or purposes of the National Park Service are discussed in the light of the origin of the national parks and the various Acts of Congress which deal with them. The conclusion is reached that the Service should strive first to preserve and conserve the national parks with due consideration for the enjoyment by their owners, the people of the United States, of the aesthetic, spiritual, inspirational, educational, and scientific values which are inherent in natural wonders and nature's creatures. The Service should be concerned with the preservation of nature in the national parks, the maintenance of natural conditions, and the avoidance of artificiality, with such provisions for the accommodation of visitors as

will neither destroy nor deteriorate the natural features, which should be preserved for the enjoyment of future visitors who may come to the parks.

Each park should be regarded as a system of interrelated plants, animals, and habitat (an ecosystem) in which evolutionary processes will occur under such control and guidance as seems necessary to preserve its unique features. Naturalness, the avoidance of artificiality, should be the rule.

Each park should be dealt with individually, and the National Park Service in consultation with appropriate advisers should define their objectives and purposes for each park. These will vary from park to park and in general should be those for which the park was originally established, with special consideration for the specific natural phenomena (biological, geological, archeological) which instigated its establishment.

The report points out that the National Park Service has the responsibility of administering the national parks in accordance with the purposes for which they are or may be set aside by specific Acts of Congress and emphasizes that knowledge about the parks and their problems is needed to discharge this responsibility. Such knowledge comes from research, especially research in natural history.

An examination of natural history research in the National Park Service shows that it has been only incipient, consisting of many reports, numerous recommendations, vacillations in policy, and little action.

Research by the National Park Service has lacked continuity, coordination, and depth. It has been marked by expediency rather than by long-term considerations. It has in general lacked direction, has been fragmented

between divisions and branches, has been applied piecemeal, has suffered because of a failure to recognize the distinctions between research and administrative decision-making, and has failed to insure the implementation of the results of research in operational management.

In fact, the Committee is not convinced that the policies of the National Park Service have been such that the potential contribution of research and a research staff to the solution of the problems of the national parks is recognized and appreciated. Reports and recommendations on this subject will remain futile unless and until the National Park Service itself becomes research-minded and is prepared to support research and to apply its findings.

It is inconceivable that property so unique and valuable as the national parks, used by such a large number of people, and regarded internationally as one of the finest examples of our national spirit should not be provided adequately with competent research scientists in natural history as elementary insurance for the preservation and best use of the parks.

It is pointed out, however, that the results of research can neither be predicted or prejudged. The results may not always be pleasant. They may indicate that a facility should not have been built, that a road should have been routed another way, that visitors into a particular region should not be encouraged in large numbers and without control. It may even indicate that a particular park has deteriorated so far that it can never be returned to its former state. It is the very integrity of these conclusions, however, that make it essential that they be brought to bear upon the management problems of the national parks.

The report presents the pressing need for research in the national parks by citing specific examples in which degradation or deterioration has occurred because research on which proper management operations should have been based was not carried out in time; because the results of research known to operational management were not implemented; or because the research staff was not consulted before action was taken. In still other situations problems are recognized for the solution of which research is needed, but where none has been undertaken or planned or, if planned, has not been financed.

Attention is called to the meager dollar support given to research and development in the natural sciences in the national parks. In the National Park Service as a whole less than one per cent of the appropriation in 1960, 1961, and 1962 was devoted to research and development while the proportion for comparable government agencies was in the neighborhood of 10 per cent. In fact, unless drastic steps are immediately taken there is a good possibility that within this generation several, if not all, the national parks will be degraded to a state totally different from that for which they were preserved and in which they were to be enjoyed.

Particular attention is called to the precarious condition of the Everglades National Park and the big trees in California.

As a result of the study made by the Committee a series of twenty recommendations are made.

Recommendations

1. The objectives or purposes of each national park should be defined.
2. The natural history resources of each park should be inventoried and mapped.
3. A distinction should be made between administration, operational management, and research management.
4. A permanent, independent, and identifiable research unit should be established within the National Park Service to conduct and supervise research in natural history in the national parks and to serve as consultant on natural history problems for the entire National Park System.
5. The research unit in natural history in the National Park Service should be organized as a line arrangement, with an "Assistant Director for Research in the Natural Sciences" reporting to the Director of the National Park Service.
6. Most of the research by the National Park Service should be mission-oriented.
7. The National Park Service should itself plan and administer its own mission-oriented research program directed toward the preservation, restoration, and interpretation of the national parks.
8. Research should be designed to anticipate and prevent problems in operational management as well as to meet those which have already developed.
9. A research program should be prepared for each park.

10. Consultation with the research unit in natural history of the National Park Service should precede all decisions on management operations involving preservation, restoration, development, protection and interpretation and the public use of a park.

11. Research on aquatic life, on and above the land, should be pursued to assist in determining general policies or the maintenance of natural conditions for their scientific, educational,aand cultural values.

12. Research should include specific attention to significant changes in land use, in other natural resource use, or in economic activities on areas adjacent to national parks likely to affect the parks.

13. Research laboratories or centers should be established for a national park when justified by the nature of the park and the importance of the research.

14. The results of research undertaken by the National Park Service should be publishable and should be published.

15. Additional substantial financial support should be furnished the National Park Service for research in the national parks.

16. Cooperative planning as a result of research should be fostered with other agencies which administer public and private lands devoted to conservation and to recreation.

17. Universities, private research institutions, and qualified independent investigators should be encouraged to use the national parks in teaching and research.

18. Consideration should be given to including in the budget of the National Park Service an item for aid to advanced students who wish to conduct research in the national parks.

19. A Scientific Advisory Committee for the National Park Service should be established, and Scientific Advisory Committees for individual parks are desirable.

20. Action in implementing the recommendations of the present Committee's report should be taken promptly.

INTRODUCTION

At the request of the Secretary of the Interior, the President of the National Academy of Sciences appointed an Advisory Committee to the National Park Service on Research and instructed it to submit to the Secretary of the Interior a report on the natural history research needs and opportunities in the National Park System.

The agreement between the National Park Service and the National Academy of Sciences, dated June 29, 1962, states that advice and assistance on a research program are needed because the national parks are complex natural systems which, for their care, management, development, use, protection and interpretation, require a broad ecological understanding and continuous flow of knowledge about the characteristics of the national parks and monuments, the nature of normal and man-imposed forces at work within them and of the relation of man to these natural environments and because they constitute a scientific resource of increasing value to scientists in this country and abroad.

The Committee was specifically instructed to:

"A. Conduct a study of national park research accomplishments, needs, resources, values, and opportunities in the natural sciences and in such related fields as may be deemed appropriate by the Academy; and

"B. To submit to the Secretary of the Interior a report which shall:

1. Describe in reasonable detail the methods used in performance of the study described in "A" above; and

2. Set forth in reasonable detail any relevant and material data gathered or disclosed as part of said study, or in connection with it; and

3. Set forth the Academy's findings and recommendations for a research program designed to provide the data required for effective management, development, protection, and interpretation of the national parks; and to encourage the greater use of the national parks by scientists for basic research."

In making its study and recommendations the Committee has devoted its attention mainly to those 31 areas specifically designated as national parks, though the Committee recognizes that some areas otherwise labeled (especially a number of the national monuments) should be included with the national parks because of their area and/or character.[1]

The Committee has given most consideration to the role of natural history in the national parks. At the same time, it has not forgotten that important factors affecting the proper maintenance of the natural features of the national parks include visitor use, access by road, land use in surrounding areas and the location and architecture of man-made facilities; and that archeology and human history as well as natural history are related to the

[1]Reference to national parks hereafter will apply only to those 31 areas; reference to the National Park System will include the 31 national parks and other areas administered by the National Park Service.

overall consideration of the Committee's directive. The Committee has not endeavored to propose research programs for solving the problems of any specific park, though it calls attention to some existing problems in particular parks.[1]

In its study the Committee has recognized numerous problems which deserve investigation because of their importance for the national parks. Not all of them were believed to be pertinent to the major directives of this Committee and not all could be considered adequately in the time at its disposal. Some are mentioned and briefly discussed below; others are considered at more length later.

For example, what are the objectives or purposes of the national parks? There is some confusion and uncertainty, even within the National Park Service itself, about the proper purposes and objectives for which the national parks should be administered. Yet it is obvious that a definition of objectives is of prime importance, and the Committee considered this question at some length.

What is the effect of the rapidly increasing number of visitors on the national parks? The magnitude of this problem impressed the Committee when figures on attendance were examined. In 1933 nearly 3,500,000 visits were made to the areas administered by the National Park Service. By 1962, this number had increased to 88,500,000; and it is estimated that in 1972 the total number of visits will have reached the fantastic figure of 126,000,000. A considerable proportion of visitors go to the national parks.

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[1]See Appendix.

In 1962, for example, 32,000,000 visits were made to the national parks, which include 0.6 per cent of the total area of the United States. It is estimated that in 1972 there will be nearly 41,000,000 visits to the national parks.

Figures for individual parks are equally impressive. In 1951 about 500,000 visits were made to Grand Teton National Park; in 1962 the number was nearly 1,800,000, and the estimate for 1972 is 2,600,000. Graphs of numbers of visitors annually to a number of national parks during the past 20 or 30 years are presented.[1] They reveal that with the exception of Crater Lake and Carlsbad Caverns attendance has been rapidly increasing for those parks which had 500,000 visitors or more in 1962. These are, in general, the larger parks and readily accessible to centers of population. With one exception (the Virgin Islands National Park) attendance for those with fewer than 500,000 visitors in 1962, has reached a constant level or has decreased. This emphasizes that parks must be considered individually, generalizations are not necessarily correct, except for the aggregate.

It is obvious that the large numbers concentrated in the summer months in many of the national parks present a group of serious problems which range from simple logistics to human relations and the impact of people on the plants, animals and habitat of the park itself. Why do visitors come to the national parks? What proportion simply pass through the park without planning a stopover? How many leave the roads and penetrate the wilderness areas? How far should provision for camp, cabin, or lodge accommodations meet the demands

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[1] See Appendix.

for such facilities? Should the number of visitors to a park be limited? What is the effect of a park on visitors and what is their effect on a park? Since the results of a special investigation under the aegis of the Conservation Foundation on the effects of people on the parks will be reported separately to the Secretary, this Committee did not pursue the visitor problem extensively.

What is the proper place of the national parks in the totality of Federal land management? How are proper uses of the national parks coordinated with those of other public lands? What harm or benefit results from management practices or the lack thereof on lands adjacent to the national parks and vice versa? To what extent do the national parks suffer from uses which do not conform to the legally expressed purposes? What are the attitudes of local and state authorities toward a national park? Is its national and international importance fully appreciated locally; is its economic contribution correctly judged; is it considered to be something in which to take pride or an area to be exploited without regard to effects on the park? What are the interrelations in research between natural history and archeology, history, landscape design and architecture in the National Park Service? How is research of the United States Geological Survey, Bureau of Sport Fisheries and Wildlife, the Forest Service and the National Park Service correlated?

These questions and many others came before the Committee and were discussed; on many the Committee is not prepared to express a judgment; on others recommendations will be found at the end of this report.

HOW THE COMMITTEE CONDUCTED ITS STUDY

The Committee held five meetings.

The first was held in Washington, D.C., December 7-8, 1962, where it was addressed by Park Service officials, including Director Conrad Wirth, Assistant Director Jackson Price, and Howard Eckles, Assistant to the Secretary's Science Advisor.

The second meeting, combined with a field trip, was held in Everglades National Park, January 10-12, 1963.

On the evening of January 10, the Committee was briefed on research problems of the Everglades, and on the following day it made an extensive tour of the park, including an airplane inspection as well as on-the-ground visits to some of the park's more critical spots, such as water diversion projects, deteriorating bird refuges, experimental controlled-fire burns, various areas which show vegetation changes and effects of fire, hurricanes, and flooding.

The third meeting was held in Washington, D.C., March 8-9, 1963, where the Committee discussed organization and staffing of the Park Service Research unit.

The fourth meeting was held in Grand Teton and Yellowstone National Parks, June 14, 15, and 16. An executive session of the Committee was held at Jackson Lake Lodge, Sunday, June 16. During the preceding two days, the Committee made a tour of approximately 200 miles in the two parks. At various inspection points in the Yellowstone Park, the Committee was briefed on such topics as the fisheries studies in Yellowstone Lake, grizzly bear ecology and

elk migration studies, the biology of the Northern Yellowstone elk herd, northern winter range studies, black bear distribution, the hydrobiology of Madison River and headwater streams and hydrothermal problems.

In Grand Teton National Park the Committee discussed with officials such problems as the impact of visitors on the Park (visits increased from 144,000 in 1946 to 1,800,000 in 1962); the ski and snowplane, and other mass recreational areas; the geology of the Teton Range; forest pest control; the national elk refuge, and the Jackson Hole Biological Research Station which has about 20 researchers in alpine ecological problems, range-type studies and other problems. The Committee was briefed also on places for proposed location of roads and facilities in accordance with preservation of park features. The fifth and concluding meeting was held in Washington, July 19, when the Committee considered a final report.

During the course of its investigation the Committee, individually and collectively, consulted with upwards of 100 persons with special competence in its field of inquiry, including Park Service officials and employees, representatives of other Federal agencies, scientists with State and local institutions and agencies, and private investigators. The resources of the National Academy of Sciences - National Research Council were made available to the Committee, as well as those of the National Science Foundation. The Committee consulted books, papers, reports and memoranda on the parks. Individual members visited many parks, other than the three mentioned, and one member visited all of them.

DEVELOPMENT OF THE NATIONAL PARKS

As background for its study the Committee was concerned with learning something of the development of national parks in the United States.

In his history of the United States, Henry Adams pointed out that in 1800, the Nation as it then existed held 5,300,000 persons. Nearly one-fifth of the people were Negro slaves; the true political population consisted of four and one-half million free whites, or fewer than one million able-bodied males. The land was still untamed; forest covered every portion, except here and there a strip of cultivated soil; the minerals lay "undisturbed in their rocky beds; and more than two-thirds of the people clung to the seaboard within 50 miles of tidewater, where alone the wants of civilized life could be supplied. The center of population rested within 18 miles of Baltimore and the interior of the country was little more civilized than when La Salle and Hennepin found their way to the Mississippi more than a century before."

Adams added that with the exception that half a million people had crossed the Alleghenies and were struggling with difficulties of their own "in an isolation like that of the Jutes or Angles in the Fifth Century," America had changed little in more than half a century. The old landmarks stood nearly where they had before. The same bad roads and difficult rivers, connecting the same small villages "stretched into the same forests as when the armies of Braddock and Amherst pierced the northern and western wilderness; nature was rather man's master than his servant, and the five million Americans struggling with the untamed continent seemed hardly more competent than the beavers and buffalo which for countless generations made bridges and roads of their own."

How do we find our country today? We have a population of more than 180,000,000. We have and are building an almost incomprehensible network of highways, turnpikes and speedways. We can cross the wide continent in less time than it took to send a letter from Baltimore to Washington in 1800.

Domestically, we are faced with the challenge of growth. Our postwar industrial expansion, although not as great as some would like, is changing the face of the land and the habits of millions. In the early days Americans with few exceptions, were too interested in the exploitation of a continent to be concerned about conservation of natural resources. Thomas Jefferson practiced contour farming on his Virginia plantation, Patrick Henry is reported to have said that "he is the best patriot who fills the most gullies," and Washington himself stated that the proper management of land was the thing least understood in Virginia. But general interest in conservation is of fairly recent origin.

It is somehow fitting that one of the earliest of the prophetic voices raised on behalf of the creation of national parks was that of an artist. In 1833, George Catlin, the great painter of Indians and the West, published in the Daily Commercial Advertiser the hope that the western regions "might in the future (by some great protecting policy of government) be preserved in their pristine beauty and wildness, in a magnificent park, where the world could see for ages to come" the primitive environment and its native inhabitants.

The next important voice raised in behalf of Catlin's park conservation plan, Huth, in Nature and the American,[1] reports, was that of Emerson, who in

[1]University of California Press.

1844, in a speech entitled "The Young American," stated that the "interminable forests should become graceful parks for use and delight." And in 1847, a similar idea was suggested by the painter Thomas Cole, who felt that it was necessary to save and perpetuate the disappearing wilderness.

National parks, as we know them today, first came into being when the Congress by the Act of March 1, 1872, created Yellowstone National Park. That park was "dedicated and set apart as a public park or pleasuring ground for the benefit and enjoyment of the people." Establishment of Yellowstone National Park pointed the way to a new type of land use which has served to guide this country and other nations of the world.

During the first three-quarters of the nineteenth century, the geysers and hot springs of the Yellowstone region had been seen by a few trappers and hunters. Their stories of the wonders of that wilderness area filtered to the outside world. At first disbelieved, their persistence finally led to the explorations of the Washburn-Langford-Doane Expedition in 1870. The members of that party confirmed the rumors of the outstanding natural features of the Yellowstone region.

Cornelius Hedges, a member of the Washburn-Langford-Doane Expedition, propagated the new idea regarding the disposition of public lands. He proposed that the Yellowstone area should not be privately exploited, but should be preserved as a national park for the benefit of all of the people for all time.

No other national parks were created until 1890, when the Yosemite, Sequoia, and General Grant National Parks in California were established, followed in 1899 by Mount Rainier National Park in Washington. Others have

been created since 1900, bringing the present total to 31. The latest is Petrified Forest National Park, established December 9, 1962.

The most important legislation affecting national parks, and perhaps the most far-reaching in its effects since the approval of the Act establishing Yellowstone National Park, is the Act of June 8, 1906. That Act gave the President of the United States authority "to declare by public proclamation historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest that are situated upon the lands owned or controlled by the Government of the United States to be national monuments."

The national parks and national monuments that came into being between 1900 and 1915 were administered by three different departments. There was no unified or systematic federal plan or policy for the protection, administration, and development of the areas whose characteristics and uses were closely related.

In 1915, Secretary of the Interior Franklin K. Lane, realizing the important and distinctive type of conservation represented by these areas and the advantages of unifying the parks and monuments into an integrated system, appointed Stephen T. Mather as his assistant to devote his energies entirely to park matters. Under Secretary Lane's guidance, Mr. Mather and his assistant, Horace M. Albright, drafted the bill which became the Act of August 25, 1916, establishing the National Park Service as a bureau of the Department of the Interior.

In connection with the Federal Government's reorganization in 1933, many additional areas were transferred to the National Park System. Section 2 of

Executive Order 6166 of June 10, 1933, issued pursuant to the Act of March 3, 1933 (47 Stat. 1517), relating to reorganization of the Executive Department, transferred the monuments, military parks and allied areas, and the National Capital Parks, administered by other federal agencies, to the National Park Service on August 10, 1933. Executive Order 6228 of July 28, 1933, clarified Executive Order of June 10, 1933, in that it limited the national cemeteries transferred from the War Department to National Park Service jurisdiction to those contiguous to, or connected with, national military parks and monuments.

It cannot be emphasized too strongly or too often that the massive growth of population throughout the world -- in the United States from four million in 1700 to more than 200 million predicted by the close of the century -- is a direct threat to survival unless we learn the lesson of conservation and wise use of our natural resources, and the term "wise use" includes conservation of spiritual and intellectual values as well as material ones. National parks and the national park idea, which originated in the United States, are powerful influences contributing to this wise use of natural resources.

RESOURCES OF THE NATIONAL PARKS

The National Park System includes 187 units comprising 22,967,763.55 acres of which 22,560,437.64 acres are federally owned. Of the 187 acres, 31 are known as national parks and cover 13,561,082.46 acres of which all but 228,165.78 acres are federally owned.[1] The 31 national parks are located in 24 of the 50 States and in the Virgin Islands.

The national parks, together with some of the national monuments, comprise a bewildering array of notable examples of scenic beauty, desert solitudes, unique geology, archeology and paleontology, and an unequaled range of plant and animal life. There are rugged coastal areas (Acadia, Maine; Olympic, Washington); spectacular mountain and desert scenery (Big Bend, Texas); colorful and unique caverns with magnificent and curious formations (Carlsbad Caverns, New Mexico; Mammoth Cave, Kentucky; Wind Cave, South Dakota); a lake of deepest blue in the heart of an inactive volcano (Crater Lake, Oregon); the largest remaining subtropical wilderness in the United States (Everglades, Florida); superb mountain scenery with glaciers and lakes (Glacier, Montana; Mount McKinley, Alaska; Mount Rainier, Washington); spectacular river canyons (Grand Canyon, Arizona; Kings Canyon, California); active and inactive volcanoes (Lassen Volcano, California; Hawaii Volcanoes, Hawaii); cliff dwellings of ancient man (Mesa Verde, Colorado); geysers and hot springs (Yellowstone, Wyoming, Montana and Idaho; Hot Springs, Arkansas); island and mountain wilderness areas (Isle Royale, Michigan; Olympic,

[1]The National Park Service is eliminating private inholdings as rapidly as appropriations permit because their usage does not conform to the purpose for which the parks were established.

Washington); the Grand Tetons in Wyoming; Great Smoky Mountains of North Carolina and Tennessee; Blue Ridge Mountains in Virginia; groves of giant sequoias (California); the mountains and waterfalls of Yosemite; tropical plant and animal life (Virgin Islands). Some features of each park represent the best and perhaps only examples of their kind in the United States. In some instances, these features are unique or nearly unique in the world: the geysers of the Yellowstone National Park, the giant sequoias, the redwoods, the temperate rain forest of the Olympic Peninsula, the Grand Canyon.

Even a casual examination of the natural resources of the National Park System of the United States inspires admiration for those who conceived the idea, pride in the possession of such natural treasures, and sympathy for those who have the responsibility for their management.

It emphasizes also that in the preservation of these natural resources, the United States has an obligation to the world community. At the First World Conference on National Parks held in Seattle, Washington, 1962, the leadership of the United States in the field of park preservation was universally recognized. The Secretary of the Interior pledged the efforts of this country to continue this leadership by maintaining the quality of our parks and by sharing our experience with other interested countries. That we may be worthy of our reputation, that the people of the United States may continue to enjoy their national parks and that we may wisely advise other countries upon request, this Committee has given its attention and consideration to the role of research in natural history in the national parks and has made its recommendations.

It is our conclusion that the national parks of the United States represent one of the most valuable heritages of this country; that in setting aside these lands the people and government of the United States have demonstrated particular wisdom; and that the role of national parks in the lives of our citizens is dramatically enlarging. The Committee is likewise convinced that unless drastic steps are immediately taken there is a strong possibility that within this generation we will see reduction of several if not all of our parks to a state totally different from that for which they were preserved and for which they were to be enjoyed.

PURPOSES OF THE NATIONAL PARKS AND RESPONSIBILITIES OF THE NATIONAL PARK SERVICE

Before an activity can be administered or managed, before its problems can be defined, investigated or solved, one must be completely clear about the objectives and one must have a fairly good idea of what, in a given set of circumstances, the changes in those circumstances are likely to be in order that they may be anticipated. Unless the purposes and objectives of the national parks are determined and clearly and generally understood, the management of the plants, the animals, the habitat in which they live and of man in his impact upon them is likely to be ineffective, and may even be harmful and destructive.

What are the objectives or purposes of the national parks? Who has the responsibility for seeing to it that the objectives are attained?

Purposes originally understood for each park are contained in the legislative act establishing it. The National Park Service has the responsibility for administering the national parks, and receives its overall authority from the Act of Congress, approved August 25, 1916, by which the National Park Service was established in the Department of Interior. The latter Act states:

> "The Service thus established [the National Park Service] shall <u>promote and regulate the use</u> of the Federal areas known as national parks, monuments and reservations hereinafter specified by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, <u>which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the</u>

same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."[1]

By the legislation referred to above the National Park Service is confronted with the responsibility of administering, in accordance with the provisions of the various acts, areas which vary widely in size, in states of preservation, in geology, biology, and climate and in actual or potential impact of man and his activities within and without the park.

In some instances, by specific legislation, administrative orders or agreements, uses are authorized which may be considered as not conforming to the purpose of the National Park System as defined in the Act of 1916.[2]

There are differences of public opinion on the major purposes of the national parks. One extreme wishes the national parks to be developed as neon-lighted vacation resorts; another wishes them left as nearly primeval as possible. Should a major aim of the national parks be the attraction of more and more visitors, by adding more paved roads, more resort buildings, larger and more numerous trailer camps, greater mass recreational facilities,[3] golf courses, ski lifts, motorboat marinas, tennis courts, and amusement concessions?

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[1]The underlining is that of the Committee.

[2]Such nonconforming uses include: Borax mining in Death Valley; prospecting and mining in McKinley Park; hunting in McKinley Park in connection with prospecting; copper mining in Organ Pipe Cactus; grazing rights in various parks; TV relay stations in Shenandoah National Park and Death Valley; use of part of White Sands, New Mexico, National Monument as an Air Force impact area for missile testing.

[3]The Committee means by mass recreational facilities those which are primarily for amusement or which require elaborate construction or extensive and/or artificial modification of the natural features of a park.

The unique character of the national parks, the existence and extensive development of other areas specifically designed and administered for mass recreation and the injunction that the national parks are to be "conserved unimpaired for the enjoyment of future generations" dictate that the pre-eminent objectives and purposes of the national parks are and should be their preservation and conservation with due consideration for the enjoyment by their owners, the people of the United States, of the aesthetic, spiritual, inspirational, educational, and scientific values which are inherent in natural wonders and nature's creatures. The Committee believes that the purpose of the national parks should be the preservation of nature, the maintenance of natural conditions, the avoidance of artificiality, with such provisions for the accommodation of visitors as will neither destroy nor deteriorate the natural features which should be preserved for the enjoyment of future visitors who may come to the parks.

Differences of opinion exist on the place of management in the administration of the national parks. On the one hand it is said that management or artificial control of the native biological resources of a park is contrary to the concept of preservation and conservation; that the plants and animals in a national park should be left undisturbed to multiply, survive or disappear as natural forces might dictate. On the other hand, it is said that no national park is large enough or adequately isolated to be, in fact, a self-regulatory ecological unit, but is subject to direct and indirect modification by activities (visitors, for example) within the park, and by the effect of changes in the area surrounding a park. According to this point

of view, limitation of herds of elk, supervision of visitors to a park, control of water levels, proper location of roads and other facilities, controlled burning, even the decision to leave untouched some areas in a park, are necessary functions of management if a park is to survive in anything like the condition which meets the purpose for which it was established. This Committee believes that management[1] of national parks is unavoidable.

The statement in Management of National Parks and Equivalent Areas formulated by a committee of the First World Conference on National Parks that was convened in Seattle in July 1962, serves to illustrate the concept:

> "Management is defined as any activity directed toward achieving or maintaining a given condition in plant and/or animal populations and/or habitats in accordance with the conservation plan for the area. A prior definition of the purposes and objectives of each park is assumed. Management may involve active manipulation of the plant and animal communities, or protection from modification or external influences."

It is not enough, however, to urge that the purposes of the national parks should be the preservation of nature, the maintenance of natural conditions. Any administrator honestly attempting to satisfy this recommendation is immediately faced with the questions -- What state of nature? What natural conditions? The biological nature, the condition of a national park when first established, with rare exceptions, has not persisted; factors

[1]Management as applied to the national parks in the United States is understood to be primarily for the purpose of or to lead in the direction of preservation or restoration of natural conditions.

within and without the limits of a park have modified it, sometimes profoundly. Should the management of a national park endeavor to restore a park to its primitive condition, maintain it as now, or aim for some state in between?

In a report on Wildlife Management in the National Parks, prepared by a committee appointed by the Secretary, it is recommended that the goal of park management in the United States should be to maintain, or where necessary, restore the biotic associations as nearly as possible to the condition that prevailed when the area was first visited by white man. This wildlife management report recognizes that the implications of this "seemingly simple aspiration are stupendous," and that most, if not all, national parks as they now exist have a complex biological history ranging from indiscriminate exploitation by logging, burning, livestock grazing, and hunting, through artificial protection from fires, insect pests, predators, and changes in normal fluctuation of water levels. Exotic vertebrates, insects and plants, as well as plant diseases and pests have been inadvertently introduced; and some endemic species of living things are even now extinct. The activities of people within and in the vicinity of a national park have profoundly modified some of them.

The present Committee views with sympathy the ideal of making a national park "a vignette of primitive America," so eloquently presented in the wildlife report mentioned, and appreciates as keenly as the authors of the report the difficulties in even approaching such an ideal. In some instances because of the paucity of historical records it would be impossible to determine what the condition of a particular park was when white man first saw it. Changes, some irreversible, and current activities, in some instances impossible to

control, in areas surrounding a park, as well as the impact of increasing numbers of visitors suggest that the ideal, though admirable, may not be fully attainable; yet it is desirable to move in that direction.

The Committee recognizes that national parks are not pictures on the wall; they are not museum exhibits in glass cases; they are dynamic biological complexes with self-generating changes. To attempt to maintain them in any fixed condition, past, present, or future, would not only be futile but contrary to nature. Each park should be regarded as a system of interrelated plants, animals and habitat (an ecosystem) in which evolutionary processes will occur under such human control and guidance as seems necessary to preserve its unique features. Naturalness, the avoidance of artificiality, should be the rule.

This Committee suggests that each park be dealt with individually and that the National Park Service, in consultation with appropriate advisors, define the objectives and purposes for each park. These will vary from park to park and, in general, should be those for which the park was originally established, giving special consideration to the specific natural phenomena (biological, geological, archeological) which instigated its establishment.

In some instances the original particular objective of a national park is specific, and comparatively simple to define, though it may be difficult to accomplish. For example, the preservation of the organ pipe cactus, of ancient cliff dwellings, of a limited but unique group of living organisms, of colorful and spectacular erosion forms. For other parks the objectives are numerous and complex. They involve not only several special natural

phenomena but the totality of the habitat and its biology, the ecosystem. McKinley, as a great mountain, cannot be separated from the tundra which surrounds it. The giant sequoia is unique, but it would lose part of its value if divorced from the natural setting in which it exists.

Objectives, insofar as possible, should be clear and definite, not diffuse; e.g., the best possible spectacle of wildlife in a natural setting, the restoration of a natural meadow, the introduction of bighorn sheep into an area from which they have disappeared, the protection (restoration) of the water table, control of surplus destructive elk, deer, or other hoofed animals. In setting up such specific objectives, it must be recognized, however, that each is a part of a whole and cannot be considered as an isolated phenomenon.

Some parks, because of their size, their remoteness or isolation contain areas which approach primitive conditions. Every effort should be made to preserve these areas, not only because they may be "vignettes of primitive America," but because of their scientific value as outdoor natural laboratories in which the working of natural laws can be observed to greater advantage than anywhere else and because each such area is a refuge or plant and animal species -- a nature's biological bank in which a biological reserve can exist and from which species may spread to adjacent areas. It should be recognized, however, that with time these areas, too, change.

Such natural undisturbed areas could be preserved for research and park interpretation by developing and applying the concept of zoning[1] which would

[1]The term "zoning" as applied here to existing national parks in the United States refers to areas rather than belts.

also dictate the type of use permitted in each zone. Parks and/or areas within a park might be zoned as follows:

1. Natural undisturbed areas. These are undisturbed ecological areas into which a visitor would be conducted or permitted by special permission. They would serve as examples and standards of natural conditions characteristic of the particular area as well as refuges for wild plants and animals.
2. Naturalistic areas. These are regions which are wild (natural) in appearance but affected to some degree by use or by outside influences. They would be maintained to give, so far as possible, "a reasonable illusion of primitive America."
3. Public use areas.
4. Park Service facility areas.

NATURAL HISTORY RESEARCH IN THE NATIONAL PARKS

The National Park Service bears the responsibility of administering the national parks of the United States for the purpose for which they are or may be set aside by specific Acts of Congress. The Service is also charged with the responsibility of preserving these lands for the use and enjoyment of the public and for interpreting meaningfully the natural features. Finally, it must administer these lands as part of a complex public land system. National parks are units of the public domain and have a definable role within the totality of federal lands.

Carrying out these responsibilities requires knowledge about the parks and their problems and this can only come from research. Too frequently operational management acts even when the necessary information for action is fragmentary, or is lacking. Scientific research furnishes the knowledge and understanding of the complex natural elements of the national parks and their interaction with one another on which effective management can be based.

What is the past and present status of research in natural history in the national parks? Its status has been and is one of many reports, numerous recommendations, vacillations in policy and little action, insofar as actual financial support is concerned.

In 1929, the Secretary of the Interior appointed a Committee on Educational Problems in the National Parks to devise an educational or interpretive program for park visitors. Confronted with vast gaps in the scientific knowledge essential for this activity, the Committee recommended a research program to gather scientific information for the museum, education, and wildlife administrative programs.

Research as an activity of the National Park Service was made official with the creation, July 1, 1930, of a Branch of Research and Education to coordinate the new educational program.

Also in 1930, a comprehensive ecological management survey of the fauna of the national parks was launched and privately financed by the late George M. Wright. Beginning in 1931, this survey was gradually integrated into and financed by the Branch of Research and Education as an official National Park Service function. In the first publication resulting from this research program, Fauna Series No. 1 (1932) of the National Park Service, the wildlife research and management policies of the Service were officially formulated. Fauna No. 1 analyzed the major ecological situations prevailing in each park in the early thirties and recommended numerous management solutions as well as more research. It analyzed the Yellowstone elk situation, which had been a cause for concern since 1911, warned of further range destruction, urged elk control and further research.

In 1935, a second publication on wildlife research and management, Fauna No. 2, was produced. By that time, seven current biological research projects were described and the practice was established of designating and protecting as "research reserves" unique, unusually fragile scientific areas within the parks.

Between 1932 and 1940, 28 research reserves were listed in Ecology as established in 10 national parks and other areas under the National Park Service. There were approximately 25 biologists in the National Park Service at that time, mostly in field positions, financed from Civilian Conservation

Corps funds. About half of the time of this staff of field biologists was spent in ecological reviews of proposed development projects; the other half was divided between wildlife management and research, which at that time were considered for practical purposes to be indistinguishable components of the total program. Fauna No. 4, Ecology of the Coyote in the Yellowstone, by Adolph Murie (1940), exemplifies the best of the biological research carried out by the Service during this period. In this publication, Murie repeated the warnings of severe range destruction by elk in the Yellowstone and indicated that a two-thirds reduction was necessary.

Moral support to research was given during this period by the Advisory Board on National Parks, Historic Sites, Buildings and Monuments, which has consistently urged greater support for research in natural history.

In November, 1939, in accordance with a reorganization program of the Department, the National Park Service biologists were transferred to the Fish and Wildlife Service, now called the Bureau of Sport Fisheries and Wildlife, but their stations and duties unchanged. The word "research" was dropped from the Branch of Research and Education of the National Park Service. With the outbreak of World War II, nearly all of these biology positions lapsed, owing to the abolition of the CCC from which funds for most of the positions had been derived. A comparable staff and program in geology, established during the 30's, was eliminated preceding World War II and has not been restored.

Fauna Series No. 5, The Wolves of Mount McKinley, by Adolph Murie (1944) marked the last of the Fauna Series for the next 17 years.

The resident Park Naturalists contributed much, particularly in the earlier years, to the knowledge of the parks through observation, collections and inventories of park resources, and through some basic research. The geological research of Edwin McKee at Grand Canyon is a most notable example, but the observations of Arthur Stupka at Great Smoky Mountains, Frank Brockman at Mount Rainier, and the early work of Milton Skinner at Yellowstone, also illustrate the research opportunities and accomplishments of that period.

World War II reduced the naturalist staffs to a minimum. After the war the National Park Service reestablished eight biologist positions under the Division of Interpretation, which was the lineal descendant of the old Branch of Research and Education. The number of biologists was not restored to prewar strength despite the increasing pressures on park resources; a situation experienced by no other professional group within the National Park Service except the geologists.

On February 10, 1945, the National Park Service issued a statement on Research in the National Park System, and its Relation to Private Research and the Work of Research Foundations. Its recommendations covered natural history as well as history and archaeology and advocated a research program to provide a constant flow of knowledge on the interrelations of life forms (ecology) essential for interpretation and management and an adequate staff of biologists. A list of 77 needed biological research programs was included, with priorities. The years passed -- but little happened.

During the period 1948-1957, research biologist Walter Kittams was stationed in Yellowstone to study the chronically serious elk situation and

recommend corrective measures. He produced voluminous illustrated reports showing the spread of ecological destruction and urging an adequate elk-reduction program.

In 1953, the National Park Conference advocated research as a basic tool for interpretation and management. This led to inclusion in the Administrative Manual of a policy statement in support of research.

In 1956, the first (and last) meeting of National Park Service biologists since 1939 was held in Washington. A list of suggestions for strengthening and implementing the Service's biological program was submitted by the conferees, but was not implemented.

In 1957, a position of aquatic biologist was reestablished to handle research, interpretation, and management of fisheries and related aquatic resources. A previous fishery position had existed between 1934 and 1940.

In 1957, members of the first Everglades National Park Research Conference met to consider the urgent need for a research program to provide answers as soon as possible to various threats to the park's ecological existence. Special funds from the Service's Water Resources Branch were allocated annually for several years (until the first regular research funds finally were secured) for a study by the University of Miami of the park's freshwater needs -- which study was recognized as being by far the most acute and immediate need. However, even with special funds derived from other sources, financing of this study never approached the $20,000 annually which the University has shown would be the minimum required for ecological field research covering the subject. A research project on the ecologically essential role of fire in the park received no research financing.

In 1958, the first research funds became available for natural history (ecology and geology). The total allocated in the National Park Service for this purpose was $28,000, in subsequent years reduced to $26,880 by a four per cent administrative overhead deduction. The annual amount allotted for natural history research has remained at this low level to the present. However, miscellaneous year-end moneys, and, at the local level, occasional contributions from park budgets, and donations, may have equalled or exceeded the formal allotments. The pump-priming effect of even so small a research budget as $28,000 (supplemented by year-end and other miscellaneous small funds, as mentioned) stimulated research institutions and scientific collaborators to produce for the Service, by 1962, several dozen manuscript reports on critical ecological problems. The majority of these reports have indicated the most immediately needed corrective management measures.

On February 10, 1958, the National Park Service reorganized the Divisions of Interpretation (Natural History) and Ranger Activities "to strengthen both the research and protection phases of biological resource conservation." This reorganization made a "clear-cut division of responsibilities between interpretation and conservation functions in the field areas with respect to biological research and management." It transferred one of the eight Service biologists to the Division of Ranger Activities, with responsibilities for all operational functions, and gave the Division of Interpretation (Natural History) the responsibility "for developing and carrying out a program of research on biological resources." In that year also, biologist Coleman Newman completed his four-year research on the ecology of The Roosevelt Elk of Olympic National Park.

In 1961, the Advisory Board on National Parks, Historic Sites, Buildings and Monuments recommended an expanded research program, stating that history and archaeology have proved the value of research, but that research in natural history has remained inadequate. The National Park Service revived the long-dormant Fauna Series with No. 6, The Bighorn of Death Valley by Welles and Welles, summarizing an ecological research project that had been partially financed out of the Service's annual allotment.

In January 1962, the National Park Service issued a prospectus on a proposed Comprehensive Natural History Research Program.

In 1963, the Secretary's Committee on Wildlife Management in the National Parks issued a report on Wildlife Management in the National Parks which included recommendations on the control of elk herd in Yellowstone National Park. This report dealt with a problem of concern since 1911 on which recommendations were made in Fauna Series No. 1 (1932) published by the National Park Service, again in Fauna Series No. 4 (1940), and again in a series of reports during the period 1948-1957.

The Department of Interior is well aware of the unsatisfactory status of natural history research in our national parks. Secretary Udall in a letter of April 25, 1962, addressed to Dr. D.W. Bronk, then President of the National Academy of Sciences, said:

"The National Park Service has long recognized that broad ecological knowledge is indispensable to the integrity and general welfare of the national parks. During recent decades, however, research undertaken by the Service has of necessity, consisted largely of projects stimulated by crises in park management, planning, protection, and interpretation.

Some more broadly based and fundamental studies in the national parks have been made by scientists from universities, other federal agencies, and research organizations such as the Carnegie and Smithsonian Institutions, but no coordinated or long range plan of investigations has been developed. As a result, the needs of some areas have been fairly adequately met; in others, the accomplishments bear a haphazard relationship to actual needs; while for the remainder, comprising far too many areas, little has been done." The Committee agrees with Secretary Udall.

Research by the National Park Service has lacked continuity, coordination, and depth. It has been marked by expediency rather than by long-term considerations. It has in general lacked direction, has been fragmented between divisions and branches, has been applied piecemeal and has suffered because of a failure to recognize the distinctions between research and administrative decision-making, and has failed to insure the implementation of the results of research in operational management. Too few funds have been requested; too few appropriated. In fact, the Committee is not convinced that the policies of the National Park Service have been such that the potential contribution of research and a research staff to the solution of the problems of the national parks is recognized and appreciated. Reports and recommendations on this subject will remain futile unless and until the National Park Service itself becomes research-minded and is prepared to support research and to apply its findings.

These harsh comments are not to be interpreted as a criticism of much of the personnel of the Park Service. The Committee has been most favorably

impressed by the quality of the men, their dedication to their profession and the morale which exists in the Service. There are simply too few research people and these few are inadequately supported. The Committee was shocked to learn that for the year 1962 the research staff (including the Chief Naturalist and field men in natural history) was limited to 10 people[1] and that the Service budget for natural history research was $28,000 -- about the cost of one campground comfort station.

The Committee recognizes also that a limited amount of excellent research in natural history has been carried on by the Park Service and that much has been accomplished by independent investigators with the encouragement and cooperation of the Park Service. In fact, the accomplishment of research in natural history in the national parks should be a matter of pride to the Service in view of the limited funds and personnel available for that purpose. A list of publications and reports (far too many of these have not been published) is appended to this report.[2]

It is inconceivable to this Committee that property so unique and valuable as the national parks, used by such a large number of people and regarded internationally as one of the finest examples of our national spirit, should not be provided with sufficient competent research scientists in natural history as elementary insurance for the preservation and best use of parks.

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[1]Total number NPS employees 5359; in Washington 386; in regional offices 1126; in National Parks 1638; in other Field areas 2209.

[2]See Appendix 5.

The national parks idea originated in the United States, and, in spite of all deficiencies, the parks are far beyond anything similar elsewhere in the world. The need for sound knowledge on which to make decisions was expressed to the Committee in strong terms by several of those responsible for the operational management of some of the more important parks. Such knowledge results from research. An examination of research in natural history accomplished by the National Park Service, projects now under way and the conditions in various national parks forcefully demonstrate the need for an expanded research staff adequately supported and emphasizes the urgency of immediate action.

One of the first needs is a complete inventory of each of the national parks including information on such items as topography, geology, climate, water regime, soil, flora and fauna, land use and archeology, with distribution maps where appropriate. Insofar as historical records permit, the inventory should include past as well as present conditions. An inventory furnishes a base from which changes in biology and habitat can be judged and by which management practices can be planned.[1] It supplies also a major part of the information by which a park and its significance can be presented (interpreted) to the public.

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[1]The Committee has been impressed by the management plans developed by the Nature Conservancy of Britain. Of the eighty-five National Nature Reserves in Britain, more than half are now under approved management plans, each of which is a document of from twenty to one hundred pages prepared according to a standard *pro forma* pattern. The Committee recognizes that plans devised for the nature reserves in Britain are not applicable *in toto* to the national parks of the United States but believes that they contain suggestions of value, and has submitted to the Secretary of the Interior with this report examples of the management plans prepared by the Nature Conservancy of Britain.

The Committee found that a great deal of inventory information has been accumulated for some parks and that much of it is effectively presented in attractive form for the pleasure and instruction of the public. There are, however, obvious deficiencies, the correction of which demands research. Most significant is a lack of detailed information on geology, aerial photography, adequate maps of topography, soil types and the distribution of plants and animals.

The place of natural history research in the national parks is demonstrated by the clear and present danger to some parks because research on which proper management operations should have been based was not carried out in time; because the results of research known to operational management were not implemented; or because the research staff was not consulted before action was taken. In still other situations problems are recognized for the solution of which research is needed but none has been undertaken or planned, or if planned, has not been financed.

> The condition of the Everglades National Park in its entirety is perhaps the most precarious. This park is the third largest in the National Park System and is the largest semi-tropical wilderness in the United States, a vast primitive area of prairie, swamp, and bay with unusual birds, fish, animals and plants in extraordinary and intimate ecological relationships. Its existence depends upon water, not only the annual quantity but the seasonal distribution which determines alternate periods of flooding and of drought.

The development of canals and the diversion north of the park of water for agricultural and domestic uses has interfered so seriously with the normal supply of water that the future of the Everglades as a park is threatened and adjacent areas seriously affected. Insufficient fresh water in the Everglades influences the salinity of Florida Bay with potential deleterious effects on fisheries in the Bay and on its role as a main nursery ground for the Tortugas pink shrimp. A canal into Coot Bay has destroyed that area as a bird feeding center and additional canals contemplated for the convenience of motor boats will have further harmful effects on the ecology of the area. The importance of water for this park is clearly recognized and is a matter of serious concern to the management. However, much more information is needed on the ecology of the Everglades, on the effects of seasonal variations in the water supply and on the best and most intelligent way to provide water. Far too little research on these and related problems is under way. The adverse effect of the canal into Coot Bay should be corrected and further development of canals undertaken, if at all, only after thorough investigation. The Committee considers the future of the Everglades National Park a problem of pressing national concern.

The dangerous condition of the giant sequoias of the Mariposa grove in Yosemite National Park is another situation

which disturbed the Committee. These trees, some of them 2,000 years or more in age and the largest living things on earth, are unique; they occur in limited areas in California and nowhere else in the world. However, roots of older trees have been damaged by artificially induced high water tables, by roadways, motor traffic and visitor paths close to the trees. Because of the loss of a substantial portion of the root system some trees have fallen and others leaned so badly that it was necessary to fell them. Vandalism by visitors who have removed bark, injured the cambium or otherwise harmed the trees is also a factor. Of greatest importance is that young sequoias are choked out by competing plants and natural reproduction is not occurring. The Committee is pleased to note that research is under way looking toward the preservation of these extraordinary trees. It is hoped that the investigation is not too late and that suitable management practices can be introduced to save the groves.

Other situations which demonstrate the need for research and/or adequate research staff in natural history in the National Park Service were noted by members of the Committee in their visits to the national parks or were called to their attention. Some of these were the following:

Recommendations have been made in the past to curtail development of public accommodations in the Great Basin of

Big Bend National Park. The Great Basin of the Chisos mountains is a remarkable physiographic feature of great beauty, now being defaced and the habitat of rare animals thus degraded. The ecology of such an unusual area should have been investigated before development in order at least that knowledge of its characteristics could have been preserved, if the basin itself cannot be.

In Yellowstone National Park problems of maintenance and the necessity of relocating some roads because of unstable roadbeds near hydrothermal features, as well as interference with these features, could have been reduced or eliminated had a prior geological study of underground features been made. For example, a road between Bonita Pool, Daisy Geyser and a parking area caused compaction of the center cap of Bonita and contributed to the dormancy of the Daisy Geyser. Plans are now in preparation to relocate the road. The importance of prior research is illustrated by experience at Beryl Spring. Investigations by a hydrothermal geologist employed during the construction of a bridge and new road prevented destruction as well as expensive construction.

In the mid-1930's, crested wheat grass, not indigenous to the area, was sown on some previously cultivated lands to furnish forage for grazing animals. Most of this grass disappeared during a series of unfavorable growing seasons

between 1944 and 1953, but some native grasses survived. This experience emphasizes the need for investigation of the ecology of vegetation as a basis for operational management. A study of the development of vegetation in limited areas protected from overgrazing by fencing would reveal those plants best adapted to the region and furnish the information needed for intelligent management.

Slippage brought on by construction operations greatly delayed the construction of Sections 15A6 and 15A7 of the Foothills Parkway in the Great Smoky Mountains National Park. Adequate geological investigations would have shown that the tilting of rock strata with layers of clay between the rocks would allow slippage and preventive steps could have been taken. Construction along 8G-1 and 8G-2 on the Foothills Parkway (U.S. 73 to Butterfly Gap) caused a flow of freshets of sand into the stream and silting of waters on adjacent lands. This resulted in claims against the United States Government. Geological research before construction would probably have detected the weak condition of the sandstone and suggested measures to prevent the silting.

A water system project in Mount McKinley National Park, for which a swatch of vegetation fifty feet or more in width was clear-cut and bench-graded around the hillside for upwards of a mile, proved to be useless and is known

locally as the "$90,000 icicle." This scar on the virgin wilderness and failure to accomplish the purpose could have been avoided if an investigation had been made prior to full-scale action.

Road construction in areas of permafrost in Mount McKinley National Park have resulted in serious and continued problems in road maintenance. Had research guidance been obtained from scientists experienced with permafrost in different locations, the magnitude and type of construction would have been suggested for critical areas, and the problems now existing would not have developed or would have been much reduced. Road construction on tundra slopes has produced bleeding scars which will heal slowly even with man's help. The extreme gullying and "raveling out" of slopes resulting from cuts and fills have dismayed some who made the plans. Botanists and geologists have long known the disastrous erosion which follows disturbance of the delicate equilibrium of soil and plants of tundra slopes. Research on a small-scale pilot project should have preceded the road construction to determine how to hold physical and aesthetic damage to a minimum.

Big Meadow Swamp was a unique park feature in Shenandoah National Park containing many plant species of unusual distribution and interest. The flora of this area has been under study for nearly 25 years. In

> 1962, the Park Service decided to extend the neighboring camp grounds into the swamp area with the result that the water level has been reduced by drainage, the flora has been seriously damaged in the construction and use of the camp site, and the ecology has been permanently altered.

In each of these examples, and there are others, operational management decisions were made by the National Park Service without benefit of adequate information such as comes from research, and the parks suffered serious damage.

A review of the areas included within the National Park System has also brought to light current need for specific research:

> The causes of limited reproduction of the saguaro cactus in Saguaro National Monument are imperfectly known. Since the older cacti in the monument, when it was acquired in 1933, are dying out, some means to insure reproduction are essential to the continuance of this park for the purpose for which it was established.
>
> Organ pipe and sinita cacti are not reproducing in Organ Pipe Cactus National Monument. The effects of a herd of approximately 800 cattle on the desert plant life are imperfectly known.
>
> Numbers of surface streams and permanent springs in Big Bend National Park are not as large as they once

were. The causes of this reduced water supply and its effects upon the animal life are not known. The reasons for the disappearance of bear from this park are not known.

The failure of Ponderosa Pine, Douglas Fir and Arizona Cypress to reproduce in this park has not been investigated. Modification of park features due to influences outside of the park require study to assess their effects upon the park and to provide guidance in restoration and further protection.

The only water supply in Carlsbad Caverns National Park is from Rattlesnake Spring -- an out-holding on which the park has some first rights to part of the flow. The present total flow from the spring is reported to be far less than when the park was first established, and a nearby stream which once ran year round is now dry most of the time. Causes for the reduced flow from Rattlesnake Spring are suspected but not confirmed. The deer population in this park may be too large. The mountain mahogany is overbrowsed to the point that it may not be able to reproduce. The deer population has not been investigated.

A dam on the Green River downstream from Mammoth Cave National Park prevents the water level in the cave

from falling as far as it once did. The effects on the biology of the cave, on cave formations and on the solution rates are not known.

The finest wild flower display in Acadia National Park is that of Rhodora (Rhodendron Canadense) in Great Meadow, near Sieur de Merits Spring, in late May or early June. Since 1956, this display has been modest as compared to earlier years. The cause for this deterioration may be associated with changes in the water table caused by dams built by beavers. Adequate research on the ecological relations between the activities of the beaver and the mass display of Rhodora flowers is needed.

In calling attention to these specific examples for which research in natural history should have been done before action was taken, and in emphasizing the great need for research on existing problems, the Committee is fully aware of the excellent but limited researches that the Park Service has been able to accomplish. The demonstration that it is necessary to maintain a ratio of at least 70 per cent grass cover to 30 per cent bare soil if the elk ranges of the Grand Tetons and Yellowstone are protected from destructive soil erosion, and that areas damaged by over grazing have a ratio of 30 per cent grass to 70 per cent bare soil, is one fundamental finding for the proper management of elk herds in these parks.

The discovery by Welles and Welles that it is not disease, predators or competition with wild burros that threatens the desert bighorn sheep in the southwest but competition with man for ancestral watering places, offers a solution for the preservation of that species.

The discovery of the differences in the causes for large-scale invasion of mountain meadows above 7,500 feet by lodgepole pine in the national parks of the High Sierra, and for the excessive invasion by forest on the floor of Yosemite Valley at 4,000 feet should suggest reasonable methods of management for preserving these meadows.

Other examples of research accomplished could be cited but the Committee considers that the amount is too little, the problems solved are too few and the need is too great for the status of research in natural history in the national parks to remain in its present anemic condition.

ORGANIZATION OF A RESEARCH PROGRAM

It is of the utmost importance that a research program in the natural sciences be inaugurated in the National Park Service and integrated smoothly into the continuing functions and activities of the Service in such a way as to insure that the results of such a program will be utilized in the decision-making process of operational management. A research program will provide the parameters and guidelines for operation. Its role in the National Park Service should not be simply an advisory function. It should be a line responsibility in the National Park Service organization.

The research organization within the National Park Service should be distinct from administration and the operational management organization. Management criteria for a research program are not identical with those for operational functions; they differ at headquarters as well as in the field. Research contract review and negotiation are not the same as with construction contracts. Research field personnel cannot fulfill their assignments effectively under the same personnel management policies as are most satisfactory for maintenance personnel.

In the final analysis the success of a research program in the National Park Service will depend upon the capabilities of the individuals who have the responsibility for planning, managing and executing this activity. In order to bring the necessary scientific knowledge and judgment to bear upon the research problems confronting the Park Service, and in order that the research program may achieve rapport with the scientific community at large, the scientific personnel must be of the highest professional quality.

As a line responsibility in the administration of the National Park Service, the research program in natural science will involve a heavy administrative burden. Not only will the development, review, and management of a research program require considerable imaginative and administrative effort but, in order to focus research conclusions upon general park management problems, considerable time and effort will be required on administrative procedures and coordination.

Following the principle that scientific personnel directly involved in research responsibilities should not be distracted with administrative and operational matters, it is suggested that the research program be established under an Assistant Director for Research in the Natural Sciences who will be responsible for the administration of the research programs and for other activities directly related to the research program functions. It is further recommended that a Chief Scientist be appointed to direct the natural history research activities and the natural history research staff. The Chief Scientist would report immediately to the Assistant Director.

The Assistant Director to whom the responsibility for the research program is assigned, should be a scientist, thoroughly conversant with the general concepts of the problems to be encountered. He should have experience in working with other scientists and with research programs, and be knowledgeable in administrative techniques involved in reviewing, developing, and managing scientific programs. He must, particularly, recognize and be sympathetic with the importance of freedom of action which scientific investigation requires.

The Committee recommends that a nucleus of highly competent scientists be assembled in the headquarters of the National Park Service primarily to develop a research program in natural history, and to determine the exact extent and nature of the research problems confronting the parks with an assessment of priorities to be pursued. This nucleus should comprise at least 10 individuals including the present staff. Increases in staff, together with field personnel, should be based on the conclusions of this central group, and be determined by it.

Since the research problems of the National Park Service will involve complex biological and physical situations, emphasis should be placed on selecting scientists for the directing staff who have broad competence in their fields rather than merely specialists in particular areas or problems. Specialists, where necessary, may be sought when the problems of the parks are further defined.

Since the research program will directly relate to operational management policies of the national parks, the research program in natural history in the National Park Service should be mission-oriented; that is, it should be concerned with the problems involved in the preservation of the natural features of a park, their restoration, where necessary and possible; and the development of sound information for the interpretation of the parks to the interested public. The scientific investigators must, however, be free to pursue experiments which are in their judgment the most promising within the defined areas of the mission.

The National Park Service should not attempt to include on its natural history staff competence for every type of problem requiring mission-oriented

research. Problems, specialized in nature, the solution for which may be anticipated within a limited period of time (one to five years), lend themselves to contractual arrangements for the needed research.

The permanent research staff in natural history of the National Park Service should be set up with the following criteria in mind:

It should include personnel of high scientific and administrative ability qualified to plan and direct a natural history inventory of the national parks; to assess the nature of the research problems encountered in each park and assign priority to the study and solution of these problems; to develop and direct a Service capability to conduct research on problems of long-term duration, common to multiple areas and involving interdisciplinary study; to review, approve, and coordinate proposed research in national parks by independent investigators; and to negotiate and manage research contracts for mission-oriented projects of specific problems of finite duration in which the best competence available is outside the Service.

It should be clearly realized by the Department of the Interior and by the Park Service that the results of research cannot be predicted nor prejudged. The results may not always be pleasant. They may indicate that a facility should not have been built, that a road should have been routed another way, that visitors into a particular region should not be encouraged in large numbers and without control. It may even indicate that a particular park has deteriorated so far that it can never be returned to its former state. It is the very integrity of these conclusions, however, that this Committee feels must be brought to bear upon the management problems of our national parks.

An important element of research activity is the line of communication between those directing and managing the program in Washington and those executing the research. During the course of the Committee's investigations, two occasions were discovered in which research reports submitted by field naturalists were either held in the regional office and not forwarded to Washington or were misdirected upon arrival in the Washington office. Examples were noted of research activities conducted by independent researchers in national parks about which the Washington Office was uninformed. Regional offices have negotiated research contracts without authorization by or previous knowledge of the Washington office. In some instances, duplication of research efforts resulted or low-priority projects were supported. In order to prevent such occurrences, communication between research personnel should be direct from field to the Office of the Chief Scientist. Regional offices serve as useful supporting services to field research activities, but the direction of the professional scientific research program should center on the Office of the Chief Scientist.

The National Park Service should immediately seek authority to hire the Chief Scientist and his top scientific staff at the highest possible salary levels (GS15). The Service should also seek authority to hire research personnel under excepted positions where necessary. This authority would greatly reduce the problem of securing adequate research staff and would permit utilization of personnel for relatively short periods of time (one to three years) from universities and other non-governmental organizations.

Policies of rotation of field research personnel should be developed in such a way as to allow the individual sufficient time in a location to accomplish effective research and yet not be excluded from appropriate professional opportunities and advancement. These policies should take into account also the importance that must be placed upon continuing familiarity with developments in the fields of science. Field research personnel should have the important benefit of association and regular contact with those planning and administering the program in Washington and should be encouraged also to participate in scientific gatherings and meetings within their respective disciplines and to exchange their results within the scientific community. Finally, research personnel should be encouraged to improve their capabilities by further study, and should be permitted to take advantage of government assignments or scholarships for such purposes.

Research in natural history conducted by the National Park Service should be of such quality that the results are worthy of publication and provision should be made for prompt publication either in established journals or publications sponsored by the National Park Service. It is in the public interest that the results of research be published. The policy of publication will be an element in attracting to the research staff qualified scientists who will find through this means one method of participating in the scientific community; and the research publications will play an important part in developing the interpretation program of the Service. It should be understood, however, that not all research results will be of a publishable nature, particularly studies conducted on specific operational problems through which a problem is solved but little new knowledge is gained.

Facilities to support research may be required in connection with some of the national parks. Although much field work can be conducted satisfactorily without a nearby laboratory some research projects are made more productive by or actually require a readily accessible field laboratory with supporting living accommodations for the research personnel.

The Committee suggests that in the establishment of a research facility the following criteria are pertinent:

It should be established and controlled by the National Park Service; it should not duplicate facilities conveniently available to independent investigators or the National Park Service personnel elsewhere; it should be located in park areas already zoned for facilities and not in a natural area; it should be as simple and inconspicuous as its purposes permit. Wherever possible, consideration should be given to the desirability of constructing research centers outside the limits of a park. Some of these might be supported, administered and used jointly with other agencies or organizations.

Interpretation of the National Parks is closely associated with the research program in natural history as well as with the operational management. Through its interpretation program the National Park Service presents the natural features of the parks in their historic setting. To do this adequately requires the information developed by the research program and requires also methods and facilities for presenting the data to the public and a staff qualified to serve as interpreters of the information and its significance. During the summer months members of the interpretive staff

are fully occupied in that activity; at other times of the year they could assume other duties which might well include, for those individuals interested and qualified, assignment to research duties or participation in field research. The Committee believes that interpretive personnel should be organized separately from the research personnel in natural history but well integrated with it. Although depending on the natural history research staff for information within its competency, the interpretive staff should be well grounded in science and skilled in modern techniques and media of dissemination of information to the public.

Greater use of the parks will involve deeper penetration into the areas adjacent to facilities and access roads. The Committee notes that today only about five per cent of park users penetrate farther than one-half a mile from the facilities and access routes. Heavier use of the national parks indicates a larger and deeper penetration and, if this occurs without impairing the parks, it will have to be done, in large part though not exclusively, on a guided basis. Such guiding should be included with interpretive activities. Therefore, the size of the interpretive staff in some of the parks areas will have to be greatly increased.

The Committee believes that the overall role and importance of research in natural history in the proper preservation, restoration and interpretation of the national parks is a subject which could profitably receive continued attention by the Advisory Board of National Parks, Historic Sites, Buildings

and Monuments.[1] The Committee believes also that a Scientific Advisory Committee should be established to advise the Assistant Director of Research in the Natural Sciences and the Chief Scientist on such overall policy matters in natural history as may require attention.

In addition, ad hoc scientific advisory committees for individual parks are useful. Such committees would consist of individuals familiar with the particular region and with special competence in the area in which the particular research problems might fall.

Financial support is a limiting factor in determining the extent of any program. The Committee has considered the problem of how much money could

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[1]The Advisory Board of National Parks Historic Sites, Buildings and Monuments was established under the Historic Sites Act in 1935 (Section 3). Briefly the Act states that an Advisory Board will be established to advise and recommend to the Secretary of the Interior on matters concerning National Parks and the preservation, conservation, and restoration of Historic Sites, Buildings, and Monuments. The Advisory Board consists of 11 persons representing competence in the fields of history, archeology, architecture and human geography. The term of appointment is at the pleasure of the Secretary of the Interior and by administrative decision has been set so that several positions rotate each year. As of June 1963, the Board was composed of the following individuals:

Harold P. Fabian, Chairman, (Former Director of Utah State Parks)
Stanley A. Cain, Vice Chairman, (Chairman, Department of Conservation, University of Michigan)
E.B. Danson, Jr., Secretary, (Director, Museum of Northern Arizona)
Mrs. N.S. Dryfoos, (Wife of the late Publisher of New York Times)
Dr. Melville B. Grosvenor, (President, National Geographic Society)
Dr. John A. Krout, (Director of History, Arizona State University)
Mr. Sigurd F. Olson, (Author)
Mr. Earl H. Reed, (Architect, The American Institute of Architects)
Dr. R.G. Sproul, (President Emeritus, University of California)
Dr. W.E. Stegner, (Director of Creative Writing Institute, Stanford University)
Dr. R.L. Stearns, (Citizens Committee on Modern Courts, Inc.)

justifiably be devoted to supporting research in the national parks. To determine the cost of meeting the research needs of each park and arriving in this way at a sum total was not considered by the Committee to be feasible at this time. An examination, however, of the annual appropriations for comparable bureaus disclosed the following:

The dollars devoted to research and development and scientific informamation in the Department of the Interior as a whole ranged from 10 to 12 per cent of the total appropriation in the years 1960, 1961 and 1962, for the Department of Agriculture about 3 per cent and for the Department of Commerce from 9.8 to 24 per cent (Table I). The figures for comparable Services or Bureaus within these Departments show the National Park Service was next to the lowest, with less than one per cent of its annual appropriations devoted to research and development. In fact, the percentage for the National Park Service is substantially behind the percentage (2.8%) of the gross national product devoted to research and development and behind that (1.8%) of net sales in private industry. An overall consideration of the figures in Table I suggests that 10% of the annual appropriation should be a reasonable basis for estimating the cost of research and development. This would have meant for the year 1962 an allotment for research and development in the National Park Service of approximately $10,000,000 instead of the $930,000 actually available.

The budget of the 31 national parks in 1962 was $42,754,866. Applying the 10 per cent yardstick the amount of money available for research and development in the 31 national parks alone should have been not less than $4,275,000.

TABLE I

From Federal Organization for Scientific Activities
1962, NSF 62-37

All Figures in thousands of dollars

		1960	1961	1962
Department of Interior	Total Appro.	$750,000	$837,000	$888,000
	R&D Sci. Info.	75,000	89,000	106,000
	Per Cent	10%	10.5%	12%
Fish & Wildlife Service	Total Appro.	65,000	73,000	83,000
	R&D Sci. Info.	21,000	26,000	32,000
	Per Cent	32%	35%	39%
Bureau of Mines	Total Appro.	29,000	46,000	48,000
	R&D Sci. Info.	25,000	30,000	30,000
	Per Cent	86%	65%	62.5%
U.S. Geological Survey	Total Appro.	42,000	46,000	50,000
	R&D Sci. Info.	23,000	26,000	29,000
	Per Cent	55%	56%	58%
Bureau of Land Management	Total Appro.	86,000	94,000	100,000
	R&D Sci. Info.	88	94	94
	Per Cent	0.1%	0.1%	0.1%
National Park Service	Total Appro.	86,000	94,000	105,000
	R&D Sci. Info.	726	878	930
	Per Cent	0.85%	0.93%	0.89%

TABLE I (Continued)

		1960	1961	1962
Bureau of Reclamation	Total Appro.	$ 260,000	$ 286,000	$ 290,000
	R&D Sci. Info.	1,500	1,900	6,400
	Per Cent	0.58%	0.67%	2.2%
Department of Agriculture	Total Appro.	5,684,000	5,361,000	5,509,000
	R&D Sci. Info.	133,000	178,000	168,000
	Per Cent	2.3%	3.3%	3.1%
Forest Service	Total Appro.	210,000	324,000	230,000
	R&D Sci. Info.	16,000	20,000	25,000
	Per Cent	7.6%	6.2%	11.0%
Department of Commerce	Total Appro.	571,000	549,000	612,000
	R&D Sci. Info.	56,000	80,000	146,000
	Per Cent	9.8%	14.7%	24.0%
National Bureau of Standards	Total Appro.	19,300	445,000	77,000
	R&D Sci. Info.	17,000	34,000	50,000
	Per Cent	89.0%	75.0%	65.0%
Coast & Geodetic Survey	Total Appro.	14,000	23,000	26,000
	R&D Sci. Info.	100	410	932
	Per Cent	.71%	1.78%	3.6%
Weather Bureau	Total Appro.	51,000	60,000	70,000
	R&D Sci. Info.	5,000	7,000	10,000
	Per Cent	9.8%	11.6%	14.5%

It is essential in future research appropriations and allocations within the National Park Service, which includes archeology, history, interpretation, landscape design and architecture, that natural history research be given support commensurate with the extent of the land in the national parks, the use of these lands, the preservation of national parks in the overall system and the key position of natural history in the preservation, restoration and interpretation of the parks.

The money spent on research and development by the National Park Service in 1962 amounted to one cent per visitor, or 0.6 cent per acre.

USE OF THE NATIONAL PARKS BY SCIENTISTS FOR BASIC RESEARCH

Although the word "research" does not appear in the National Park Service Act of 1916, when new parks were created their use by scientists was soon advocated. In 1902, an invitation to so use them was specifically included in the Act establishing Crater Lake National Park.

Outside institutions, recognizing the value of these areas for research, accepted the Service's invitation. In 1914, the University of California began in Yosemite the first of its series of scientific monographs and shorter publications on the ecology of western national parks and monuments.

In 1917, the annual report of the Director of the National Park Service stated:

"It is our hope to encourage the general use of all parks as fields for scientific study."

The list of publications and reports appended to this report demonstrates the research which has resulted from this encouragement.

The mission of the National Park Service is to preserve and conserve the national parks for the proper enjoyment of them by their owners, the people of the United States, and by future generations. Research carried on by the National Park Service should be governed primarily by this mission.

National Parks are, however, more than areas of importance for the aesthetic, spiritual, inspirational and educational values inherent in their physiographic and biological features. They are irreplaceable natural laboratories in which scientific studies can be carried out which would not

be possible in even the most elaborate and conventional man-made laboratory. In the national parks it is possible to study the structure, interrelations and behavior of biological communities, discover how they are adapted to their environment and compare them with the artificial communities elsewhere created by the clearings, drainage, and contamination, and by the introduction of exotic animals and plants by man. They offer the opportunity to pursue long-term ecological studies difficult if not impossible to conduct elsewhere. Such studies by university scientists and independent investigators should be systematically encouraged by the National Park Service. For example, Isle Royale National Park is an area with a nearly undisturbed balance of plants and animals including moose, wolves, and beaver; it is an unrivaled laboratory in which to learn the role played by each species in an ecological system and by comparison with other areas to learn the effect of man on the land and the living things which inhabit it.

The National Parks contain unique or nearly unique plants and animals which may be of great scientific importance.

The thermophilic algae and other organisms in hot springs offer challenging questions of a fundamental character. What accounts for their ability to survive at temperatures considerably above those which are lethal for most organisms? The blind fish and other organisms in Mammoth Cave and other blind organisms in Carlsbad Caverns raise another series of questions which are basic to the problem of evolution and the loss of organs through disuse. Can natural selection account for the origin of these creatures or are principles at work with which we are ill acquainted?

The genus Tripsacum has become important in maize (Zea Mays) breeding, and the discovery that T. floridanum hybridizes readily with maize and produces highly fertile hybrids has aroused a great deal of interest in Tripsacum as a source of breeding material. The University of Illinois has three men devoting virtually all their time to research on hybrids of maize and Tripsacum, much of it on hybrids between maize and T. floridanum. T. floridanum occurs in the Everglades National Park; and Dr. Paul Mangelsdorf, "dean" of students of the genetics of maize, has this to say:

"T. floridanum is confined to southern Florida and its natural habitats are constantly being encroached upon by the construction of residential areas, highways, and airports. I first collected this species beside a shell road just south of Homestead. When I looked for it there again last September the road had been paved and the Tripsacum had disappeared. It is still to be found in empty lots in Homestead and indeed as far north as Coral Gables but these empty lots will eventually be built on and the Tripsacum will be destroyed. All of these facts point to the importance of maintaining the Everglades National Park, if for no other reason than to preserve this grass which is related to maize, and which is an endemic to the southern part of Florida. I suspect that the Everglades National Park has other endemics which are of botanical interest but probably none is so closely related to America's principal food plant, corn."

Glaciers in the Cascade Mountains are advancing in contrast to the steady retreat of those almost everywhere else in the world, including glaciers in Olympic National Park. A comparative study of the glaciers of the Cascade

Mountains and those of nearby Olympic National Park might contribute to our understanding of the mechanics of glaciation and the Pleistocene era.

The Grand Canyon of the Colorado still serves as a classic laboratory for the study of geologic history of the formation of this continent. The Grand Tetons and Jackson Hole form one of the finest examples in the world of blockfault mountain building, exposing a very fine geologic sequence from Precambrian to Mesozoic. Glacier National Park presents an equally fine example of overthrust faulting.

The temperate rain forest of Olympic Park, the subtropical Everglades, the desert flora of Big Bend National Park provide nearly unique situations for ecological studies.

For those interested in the vulcanology of the Pacific Basin, Lassen Volcanic Park and Hawaii Volcanoes contain some of the most active volcanic regions in the northern western hemisphere.

Climatological investigations involving the geysers of Yellowstone National Park are being conducted by the Atmospheric Service Research Center of the State University of New York; ecological and geological studies are being conducted at Mammoth Cave; and glaciological studies in McKinley National Park.

The narrow, deep, well-watered gorge of McKittrick Canyon, a part of Carlsbad Caverns National Park in the Guadalupe Mountains, offers a striking contrast to the desert conditions of the surrounding terrain. In this narrow canyon, scientists have found an association of plants and animals which represent a relict from the Pleistocene era. More than 20 species

of insects new to science have been discovered; four of them belong to new genera and it is likely that more new species, both plant and animal, exist there. An abundance of small and uncommon reptiles has been discovered. McKittrick Canyon offers to the biologist an opportunity to study an unusual example of evolution, and the ecological relations of organisms carried over from ancient times.

The isolated, high-altitude valley of Paradise Park in Rocky Mountain National Park has been virtually unmolested ecologically since the last glacial epoch. Many situations like McKittrick Canyon and the valley of Paradise Park exist in the national parks and offer the biologist an opportunity to study the interrelations of plants, animals and their habitat unmodified and undisturbed by man. They are rapidly disappearing elsewhere. This is not the place to list all the opportunities for research in the national parks. They are numerous and fundamental and range widely in the physical and biological sciences.

The Committee urges that the Park Service encourage research activities by independent investigators in these and other fields in the national parks. There are opportunities available that will increase general scientific knowledge and provide insight into basic scientific questions. The Committee does not believe that the Park Service itself should engage extensively in such research activities, however. There are sufficient research problems directly related to park management questions to absorb most of the efforts which can appropriately be directly supported by the Park Service. The Committee feels that independent research conducted in the national parks

should be carried out with the full knowledge and permission of the Service and that cooperation between Park Service research personnel and independent research personnel should be encouraged. Independent researchers should realize that the Park Service, with its responsibilities to preserve the parks and to make them available to the public, must exercise its responsibility to insure that no research activity is harmful to the parks nor interferes with the preservation of natural conditions and public enjoyment. On the other hand, the Park Service must honor the basic freedom of the independent investigator to pursue his objectives, within the limits of these responsibilities, without interference.

Furthermore, the Park Service should avoid interference with independent research which has been authorized within the parks. Recently, in Mammoth Cave National Park, a beetle study plot in the cave was severely damaged when workmen, improving the visitor access in another area of the cave, dumped rubble and boulders down a shaft directly above the study plot. Similarly, in Shenandoah National Park a mammal study plot, without warning, was bulldozed into a new campsite area.

The Park Service should make every effort to support and accommodate independent research effort, and should recognize that basic research of this kind will enhance the importance of the national parks and will contribute to the interpretational functions of the Service and to our national scientific effort.

Closely related to the use of the national parks for basic research is their use for teaching and for research by advanced students. The Committee

believes that there is considerable opportunity for advanced students to engage in research problems in the national parks. The National Park Service has engaged in a program part of which was directed towards this purpose: the Student Conservation Program. These efforts have demonstrated that such advanced student training can be beneficial to the park and to the individual. The concept of cost-sharing by the Park Service and interested private capital in the Student Conservation Program might offer an arrangement which would well serve the Park Service needs in research staff at the field assistant level and might reduce the necessity of maintaining the number of individuals required throughout the entire year on the permanent staff of the Park Service.

RECOMMENDATIONS

This Committee has stated that in its opinion the National Park Service must manage to some degree the lands which fall within the National Park System. The Committee has stated further that the management of any enterprise cannot be effective unless the objectives of the enterprise are clearly defined and well understood, and plans are devised to accomplish the objectives.

Plans must be based on information of the resources (inventory) of the activity, on its problems, and on its relation with other similar activities; and they must be implemented by adequate and competent personnel, properly organized, motivated, and supported financially.

Research is an essential part of the program outlined above and its use a necessity in each of the steps. These elementary principles apply to the national parks as well as to a business or any other organized activity.

The Committee has based its recommendations on these considerations, as well as on its acquaintance with the parks and their problems and begs leave to submit the following:

1. The objectives or purposes of each national park should be defined.

   COMMENT: Each national park was established because of the potential esthetic, educational, scientific and cultural values of its natural history and/or its human history. The features of a park which make the values possible of attainment should be carefully defined to serve as the basis for operational management. They should be preserved and restored, where necessary, and provisions made for their proper enjoyment and use by the people. The objectives

should exclude the use of the national parks for amusement or such mass recreation as requires elaborate facilities or extensive and/or artificial modification of the natural features of a park. The Committee endorses, in this respect, the conclusion of the report: "Wildlife Management in the National Parks." Zoning of a national park into, for example, natural undisturbed areas, naturalistic areas, public use areas and Park Service facility areas is suggested.

2. Inventory and mapping of the natural history resources of each park should be made.

COMMENT: Such an inventory should cover the past as well as the present, and include information on topography, geology, climate, water regime, soil types, flora and fauna and natural communities. Mapping, including aerial maps, should cover species distributions, natural communities, land use, archeology and such other mappable features as may be of importance in the park.

An inventory serves as a basis for judging changes, good or bad, in the condition of a park, supplies the information necessary for interpreting the area to the public, and is essential for proper operational management, as well as for further research.

3. A distinction should be made between administration, operational management, and research management.

COMMENT: Research is essential to solve problems of operational management whether the latter concerns preservation, restoration, interpretation or the use of the parks by the public. Administration, the management of research and the management of operations

require somewhat different though well recognized administrative procedures. In most situations, the following steps are involved:

1) Identification and definition of the problem or situation;
2) Research, or fact finding, based on observation and/or experimentation;
3) Administrative action which involves decision on a course of action, grounded on the findings and recommendations of research and such other considerations as may be involved; and
4) Operational management, which means the implementation of the decisions by the appropriate operational division.

4. A permanent, independent, and identifiable research unit should be established within the National Park Service to conduct and supervise research in natural history in the national parks, and to serve as consultant on natural history problems for the entire National Park System.

COMMENT: In order to maintain objectivity, the principal research organization should be independent of operational management. It should provide knowledge which would allow predictions of the consequences of alternate lines of action or inaction. Close liaison should be maintained between the research unit and the administrative and operating divisions in order that the results of research may be adequately applied. All branches of the service should participate fully in identifying problems and in preparing programs and budgets for research. The research staff should have complete freedom in

the execution of an approved research program, in evaluating the results, in reporting the findings and in making recommendations based on the findings. There should be free communication on research ideas and research accomplishment from anywhere in the National Park Service to and from the top research staff. Provision should be made to enable the research staff to maintain close association with other scientists.

5. The research unit in natural history in the National Park Service should be organized as a line arrangement with an "Assistant Director for Research in the Natural Sciences" reporting to the Director of the National Park Service.

COMMENT: A nucleus of highly competent scientists headed by a Chief Scientist should be assembled in the headquarters of the National Park Service. This nucleus should comprise at least 10 individuals -- including the present staff. The scientific group in Washington should be supported by an appropriate staff of natural history specialists available for field assignments and other research. The committee emphasizes that quality is more important than numbers and that a selective and flexible approach to research problems is likely to be most profitable in the long term. Field research personnel should report directly to the Washington staff, and should be administered by personnel management policies compatible with their responsibilities.

6. Most of the research by the National Park Service should be mission-oriented.

COMMENT: The National Park Service should direct its in-service research mainly toward the problems involved in the preservation and/or restoration of the national parks for the esthetic, educational and scientific values and toward the adequate interpretation of these values. The solution of some of the problems may extend beyond the conventional bounds of natural history and involve, at least temporarily, contributions by, for example, economists, social scientists, and engineers. The problem should be emphasized and assistance for its solution sought wherever competence may be found. When appropriate, mission-oriented research should be carried out on a contract basis with universities or private research organizations.

7. The National Park Service should itself plan and administer its own mission-oriented research program directed toward the preservation, restoration, and interpretation of the national parks.

COMMENT: The mission of the Service in the preservation of the total environment is a unique responsibility. The research program necessary to support this objective is of a scope and character different from that of any other institution or land management agency. The Service must therefore accept the responsibility for the planning, administration and conduct of its own research program. While it may, and is encouraged to utilize the specialized

services of other agencies and institutions, it cannot abrogate its responsibilities for the direction and execution of its own mission-oriented research program.

8. Research should be designed to anticipate and prevent problems in operational management as well as to meet those which have already developed.

COMMENT: A limited staff which has inadequate support can deal only with immediate "brush fire" problems; that is to say, it can deal only with situations which have already become critical and perhaps irreparable. A research staff adequate in competence and numbers can conduct research from long-term considerations, detect problems before they become critical and offer alternate choices of action for their solution.

9. A research program should be prepared for each park.

COMMENT: A basic goal of management should be to perpetuate and where necessary restore the values which justified the parks' creation and maintenance. A program of research studies needed to provide management with the information required to reach this goal should be established and implemented with the requisite funds and personnel.

10. Consultation with the research unit in natural history of the National Park Service should precede all decisions on management operations involving preservation, restoration, development, protection and interpretation, and the public use of a park.

COMMENT: The Committee discovered or had its attention called to numerous instances in which consultation with qualified scientists

would have prevented or modified a development or operation which had harmful effects on a park or required expensive changes to prevent or correct such effects. Operational management is sensible of this need, as judged by frequent unsolicited comments to the Committee, but is handicapped by limited research staff available for consultation or by failures in communication.

11. Research on aquatic life, as well as on that existing on and above the land, should be pursued to assist in determining general policies for the maintenance of natural conditions for their scientific, educational, and cultural values.

COMMENT: The Committee recognizes that serious management problems for the preservation and restoration of aquatic life in the parks exist and that research is needed to arrive at rational decisions on these problems. They arise in part from the use of rotenone or other poisons as a fish management tool, the effects on aquatic life of motorboat traffic, sport fishing, the introduction of exotic forms and their effects on native aquatic life. The so-called "barren" lakes and streams are devoid of game fish but are of considerable scientific interest because of that fact. Each of these raise questions which can be properly settled only through the results of research.

12. Research should include specific attention to significant changes in land use, in other natural resource use, or in other economic activities on areas adjacent to national parks, and likely to affect the parks.

COMMENT: The problems of operating a park to meet objectives given the National Park Service by legislation are closely related to events in areas surrounding each of the parks. Effective, economical administration of each park could be materially aided by timely research of a modest extent on resource use in such surrounding areas. This research could be carried on jointly with the other agencies directly concerned.

13. Research laboratories or centers should be established for a national park when justified by the nature of the park and the importance of the research.

COMMENT: Such research laboratories or centers should not only serve the staff of the National Park Service but also scientists from universities and independent research organizations. Control of such centers should remain with the National Park Service. The location of such centers, and access to them, should be such as will not destroy other values of a park nor interfere with the proper use and enjoyment of a park by the public. Consideration should be given to establishing research centers, whenever possible, outside the limits of a park in some instances supported, administered and used jointly with other agencies or organizations.

14. The results of research undertaken by the National Park Service should be publishable and should be published.

COMMENT: Research in natural history carried out by the National Park Service should be of such quality that the results are worthy of publication and should be published. Although the research

conducted by the National Park Service should be directed primarily toward park problems, it is in the public interest that the results be made available through publication, either in established journals or in a series sponsored by the National Park Service. It is recognized that on occasion research may be undertaken the results of which are not of general interest and do not require publication. Such investigations should be exceptions and not the rule.

15. Additional substantial financial support should be furnished the National Park Service for research in the national parks.

COMMENT: The Committee could not in the time available and from the data at hand, estimate the total cost of research, based upon the needs of each park. The Committee noted, however, that on the average, approximately 10 per cent of the annual budget was devoted in 1962 to research and development by those government agencies comparable to the National Park Service. The Committee considers this to be a reasonable basis for establishing a research budget and recommends that research in the National Park Service be supported at a level consistent with that of comparable agencies.

The Committee strongly urges that in future research appropriations and allotments within the National Park Service natural history research be given support commensurate with the key position of natural history in the preservation, restoration and interpretation of the parks. The number, variety and extent of the national parks, their unique character and international significance, as well as

the complexity of their problems suggest that the allotment of money to research be of the order recommended above.

16. Cooperative planning as a result of research should be fostered with other agencies which administer public and private lands devoted to conservation and to recreation.

COMMENT: Various agencies in the federal government, the states, municipalities, universities, and other private or public organizations administer lands devoted to conservation and to recreation of one type or another. The National Park Service should be fully cognizant of the resources, objectives, and activities of these areas, and cooperate fully with those responsible for their administration, especially as related to natural history research.

17. Universities, private research institutions, and qualified independent investigators should be encouraged to use the national parks in teaching and research.

COMMENT: The national parks are a national and international scientific resource. In some respects, their natural history is unique or nearly so. They are outdoor laboratories of great scientific value and should be made available to independent investigators when the research work does not threaten deterioration of the park or interfere with its appropriate use by the public and when it can be effectively facilitated by the staff of the National Park Service.

18. Consideration should be given to including in the budget of the National Park Service an item for aid to advanced students who wish to conduct research in the national parks.

COMMENT: A program of this character should be considered in part a training program and a practical source of future personnel. Support for field work by advanced students is frequently inadequate, especially in natural history. It is recognized that the supervision of students places responsibilities on park personnel, and that provision for adequate supervision should be a part of any plan of the nature recommended. An expansion of those aspects of the Student Conservation Program concerned with the support of advanced students as Assistant Ranger Naturalists should be considered.

19. A Scientific Advisory Committee for the National Park Service should be established, and Scientific Advisory Committees for individual parks are desirable.

COMMENT: Such Advisory Committees should be working committees concerned with park problems. It should be clearly understood, however, that advisory committees are advisory, not decision-making bodies. The practice of engaging the assistance of *ad hoc* committees for special park problems should be continued.

20. Action in implementing the recommendations of this Committee's report should be taken promptly.

COMMENT: Time is an essential factor in dealing with forces that threaten the existence of certain indigenous animal and plant species and threaten or otherwise degrade park values, in some instances beyond

the possibility of restoration. Among these factors are excessive human use, overgrazing, the invasion of park areas by aggressive exotic flora and fauna and interference with water supply. Studies are urgently needed to provide the basis for prompt action.

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APPENDIXES

TO

REPORT OF ADVISORY COMMITTEE TO THE NATIONAL PARK SERVICE
ON RESEARCH
NATIONAL ACADEMY OF SCIENCES--NATIONAL RESEARCH COUNCIL

1. Excerpts from the Committee's minutes at the Everglades Park on January 10-12, 1963

2. Excerpts from the Committee's minutes at Grand Teton and Yellowstone Parks on June 14-16, 1963

3. The Water Supply Problem of the Everglades by Dr. Joseph L. Gillson

4. Charts of Park visits

5. Lists of Natural Sciences Publications

APPENDIX 1

THE EVERGLADES NATIONAL PARK

(Excerpts from the Minutes of the Committee's Meeting at Everglades National Park, January 10-12, 1963)

Although the Committee realizes that it cannot deal with all the problems of all the national parks individually, but must concentrate on guiding principles of research, comments on some of the parks visited, especially the Everglades National Park, will illustrate its thinking.

Everglades is the third largest national park in the United States, being exceeded only by Yellowstone and Mount McKinley. Its preservation as a vast primitive area of prairie, swamp, and bay, teeming with many forms of wildlife, constitutes a national problem.

Located at the southern tip of the Florida Peninsula, Everglades is bounded on the north by a rich agricultural area supplying winter fruits and vegetables to snowbound northern states, and on the northeast by Miami -- one of the fastest-growing cities in the country. Around its shores, on east, south, and west, and in its bays and harbors, are some of the nation's finest fishing grounds.

The Committee noted the lack of sufficient scientific data on which to base claims to a proper supply of water for the Park. During its meeting at Everglades, the Committee adopted the following resolutions and recommendations relating to water[1] and other problems.

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[1]See Appendix 3 for a more extended discussion of the Everglades Park water problem by Dr. Gillson, Geologist member of the Committee.

1. An example of the need for more research in national parks is seen in Everglades National Park. A crisis there has resulted in part from the diversion of natural water flow essential to preservation of the ecosystem and in part from insufficient information, attributable to inadequate provision of funds and to the lack in the past of full awareness at higher administrative levels of the need for such research.

2. Pursuant to its examination of National Park research problems in the United States, the National Academy of Sciences Advisory Committee on Research in the National Parks has visited and studied the Everglades National Park. As a result of this study and discussion thereof, the Committee unanimously agreed that:

a) The present water deficit in the Park between the months of November and March is not natural, and is caused by diversion to areas beyond the Park boundaries of water which flowed into the Park under natural conditions.

b) This water deficit is causing detrimental changes in the vegetation and wildlife of the Park, for which the Park was created. It is of such extent that if the conditions are not reversed the numbers of fish, birds, and other wildlife will be reduced to disastrously low levels.

3. In its agreement with the National Park Service the National Academy of Sciences will, among other things, "set forth the Academy's findings and recommendations for a research program designed to provide the data required for effective management and protection of the national parks."

Because of the natural dynamics of ecological systems, the protection of the significant natural features of many, if not all, national parks requires action.

For example, vegetation seems to proceed by a process of natural succession toward a climax of approximate stability, long-term and dynamic. The National Park Service needs to decide whether to allow natural succession to proceed of itself everywhere or whether to interfere, if it would result in the loss of species and communities that were an integral part of the complex of the parks at the time the parks were formed and for which, in part, they were created.

The necessity for such a decision can be illustrated in the Everglades National Park by the existence of communities dominated by pine (*Pinus elliotti* var. densa), which are natural in south Florida because of the periodic lightning-caused fires and, probably, prehistoric Indian-set fires. Complete fire protection would result in the eventual elimination of the pine-dominated community and its animal associates, because the progressively developing hardwood undergrowth stops the reproduction of pine.

The Service has to decide, in such cases, which of the alternative results its policy is directed toward, and beyond that it must decide which policy agrees best with park purposes in preservation, what it is that is to be preserved.

The Service should conduct adequate research on (1) the effects of fire, past and present; and (2) the conditions under which fire can be used as a management tool to preserve the natural conditions of a park.

The problem referred to here is not unique; it is true also for Sequoia and for many other species. This is not a general approval of indiscriminate burning or an attack on fire control.

4. Research is needed to clarify the role of annual flooding and desiccation in the ecology of the lower Everglades.

5. Research is needed to permit more precise definition of the relation between fresh-water supply and the biological productivity of Everglades communities.

6. Research is needed on vegetation changes in the Everglades resulting from diminished fresh-water supply.

7. Research is needed (synthesizing 4, 5, and 6 above) leading to prediction of the optimum fresh-water supply and the likely effects, in terms of ecological changes, upon the Everglades of volumes at various levels below optimal flow.

8. Research is needed through such techniques as vegetation mapping, aerial photography (or photogrammetry), and pollen analysis, and through studies of the history of the plant cover and its rejuvenation from the effects of such factors as fire, hurricane, and flooding. The Committee believes that the Everglades National Park offers a unique opportunity for these and related studies.

9. Research is needed on population trends and ecological requirements of rare and threatened species like the American crocodile, the reddish egret, and the roseate spoonbill.

10. Research on the following is needed at Fort Jefferson National Monument, which is administered by the Park Service:

a) Sea turtle nesting

b) Terrestrial arthropod of the Dry Tortugas Keys

c) Land flora of the Dry Tortugas Keys

d) Marine resources of the Dry Tortugas Keys

e) Tern colony studies; life history and behavior of terns

f) Tortugas bird migration studies

The Committee also wishes to call attention to the August 10, 1962, Robertson Report, which presented a comprehensive research program in natural history for the Everglades National Park. The 37-page report is a competent one, covering in great detail the fields of botany, zoology, and archeology. Dr. Robertson states:

"The nationally significant features of Everglades National Park are almost entirely biological, and many aspects of the natural history of the area are still little known. The area is not closely comparable with any other, and research findings in a given field obtained elsewhere are seldom directly applicable. Much of the biology of the area appears to depend upon minute variations in environmental factors and delicate fluctuating balances, between flooding and desiccation and between salt and fresh water. Though vast, the area is not large enough to be in control of its own ecological destiny. Various alien forms of land use around its periphery threaten serious ecological deterioration. Dozens of species of animals and plants are

restricted to the area, and, being represented by small populations that occupy limited ranges, are continually under threat from adverse ecological change, natural disaster, and disturbance.

"The above facts combine to make the need for an active program of natural history research particularly acute in Everglades. No phase of Park operations can afford to proceed without careful evaluation of possible effects upon natural history values. Construction programs and plans for channeling visitor use have continual need for such information. Interpretation activities require research findings not only to do a proper job of forcefully illustrating difficult concepts by exhibits and other forms of presentation but also in order to broaden and refresh the program continually.

"The present report undertakes to review the natural history fields of greatest importance in Everglades, showing research in progress and presenting project outlines for research that appears to be needed in the next several years. The range of possible worthwhile natural history research in Everglades is so nearly unlimited that it would be futile even to attempt a complete listing. Obviously, our present interest must be concentrated upon the most critical needs, leaving much interesting and valuable biological research of more limited significance for a later day."

This report was "lost" for several months and was only accidentally discovered during the Committee's visit to the Everglades.

APPENDIX 2

SOME ECOLOGICAL RESEARCH NEEDS OF YELLOWSTONE AND GRAND TETON NATIONAL PARKS

(Excerpts from the Minutes of the Committee's Meeting at Grand Teton - Yellowstone Park, June 14-16, 1963)

The Committee found that a comprehensive research program for both the Yellowstone and the Grand Teton National Parks, stressing the ecological approach, had been outlined in the general direction of the Committee's report. The Committee also found, however, that neither the scientific staff nor funds for the research necessary -- if the parks' management is to comply with the laws and regulations governing the areas -- are available.

The following outlines of research needs in these two parks were presented by local Parks officials to the Committee:

Yellowstone National Park

I. Ecology of the Northern Yellowstone Winter Range

A. Justification. In many parts of the Park the activities of modern man, in altering ecosystems and causing a severe loss of soil, have created an imbalance between the ungulate populations and their habitat. The areas most seriously affected are the northern Yellowstone and Gallatin ranges where these animals congregate in the winter. Although the management is energetically attempting to improve unsatisfactory conditions on the northern Yellowstone range, its program is rather crude and is based on inadequate information.

Moreover, not enough is known about what management is doing, what changes and refinements are needed, or for that matter, what the purposes are.

B. Objectives

1. To describe ecological condition on the northern Yellowstone winter range before the advent of modern man. The description, to provide a basis for evaluating current conditions, should include:

   a) Climate, geology, and soils;

   b) The mosaic of plant and animal communities;

   c) The interrelationships of plants and animals, particularly in relation to dominant species like ungulates.

2. To describe current ecological conditions in detail, including:

   a) Current climate and climatic trends;

   b) Soil;

   c) The vegetation mosaic and the factors creating it;

   d) Successional patterns in the various biotic communities and their dynamic ecology;

   e) Interrelationships of dominant animals like elk, deer, bighorn sheep, moose, buffalo, antelope, and beaver with their habitat;

   f) Interspecies and intraspecies relationships of dominant animals (competition for food, space, etc.).

3. To describe and evaluate:

   a) How and to what degree current ecological conditions vary from the original;

   b) The factors that have caused deviations from original conditions, and how they have operated;

   c) The extent to which it is practicable or possible to re-create original ecological conditions where ecological damage or deterioration (like soil loss) has occurred.

4. To formulate a management program designed to restore original ecological conditions as nearly as practicable.

The proposed ecological study of the northern Yellowstone winter range would provide much information directly applicable to other critical winter range areas in the Park (such as the Upper Gallatin winter range and Hayden Valley). Moreover, the approach and the techniques developed would be a guide for research in other areas of the Park where ecological problems are somewhat different, and so would lead to continuing coordination and integration of research effort throughout the National Park Service. A study of the ecology of ungulate summer range, though of lower priority than winter range studies, is needed also; a comparable research approach would certainly be required for it.

II. The Ecology of the Black Bear in Yellowstone National Park

A. Justification. Although bears are in general tolerant of human beings and their activities, so that most Park visitors have an opportunity

to see and photograph them, they do, every year, cause a significant number of injuries to visitors and a considerable amount of damage to property. Therefore, management and control of the bear population are essential. The current black bear management program is not based on adequate knowledge of its effect on the bear population.

B. Objectives

1. To understand over-all black bear ecology in the Park, with emphasis on determining bear numbers and distribution and on describing population dynamics.
2. To describe and analyze the behavior of bears toward visitors.
3. To devise methods for evaluating the effects of management and control measures on the bear population.
4. To develop an effective management program designed to maintain the black bear population in its "natural" ecological role, while providing visitors with opportunities to view black bears and still keeping injuries and property damages at an acceptable minimum level.

III. An Evaluation of the Park's Aquatic Resources with Emphasis on Fishing

A. Justification. National Park Service objectives concerning fisheries resources require the maintaining of native fish populations in as natural a condition as possible while providing recreational fishing at a level compatible with the natural ability of the fisheries to support themselves. On many Park waters the pressure of demands for fishing facilities is heavy and

growing heavier. Little information is available about natural conditions in most Park waters or the effect that fishing is having on them. The factual basis for sound management of most Park waters is lacking.

B. Objectives

An adequate problem analysis is needed. This, with subsequent delineation of specific projects and objectives, should be made by capable aquatic ecologists and fishery biologists if over-all program coordination and maximum results are to be attained. Objectives should include sufficient study of aquatic ecology, fish population dynamics, and associated fishing demands to permit evaluation of the effects of fishing and recognition of undesirable ecological conditions. The most heavily used or otherwise ecologically sensitive Park waters should be studied first. Efforts should be made to determine the "fishing load" that specific Park waters can support without deterioration of aquatic ecosystems. The findings of the studies should be synthesized into sound management programs for specific Park waters with emphasis on methods of collecting information needed for routine management and innovations for regulating and distributing the fishing load.

IV. Research Needs of Lower Priority include:

A. The ecology of forest vegetation. Here the objectives should be:

1. A description and evaluation of the pattern of forest vegetation that should be sought in relation to the pattern now existing.

2. Description of successional patterns in forest vegetation especially in relation to the effect of:

   a) Control of forest fires

   b) Insect and disease control programs

   c) Climatic factors

3. Formulation and testing of management techniques designed to accomplish defined goals.

B. An evaluation of the direct effect of visitors on important natural features.

Consideration of Park problems by the proposed ecological research "planning team" would result in changes in and additions to this list of needed research projects. It is proposed that these and other projects relating to specific Park needs be well planned, well coordinated, and well directed, but that additional research by individuals or groups into problems of specific interest to them, even though it may not seem to pertain to Park problems, continue to be encouraged. In the long run, the results of such studies will add to our understanding of the Park's ecology.

Grand Teton National Park

The most pressing research needs in Grand Teton National Park may be classed as biological, geological, archeological, and human history. Basic research is needed in all these fields to provide a background of information for application in management and interpretation operations. Considerable applied research in the biological field is also needed to identify management problems, test solutions to problems, and develop criteria and standard methods for management operations.

Practically all research on Park biota and physical features would be of value for increasing the effectiveness of interpretive and management operations, but the research jobs that should have the highest priority involve situations where problems are either apparent or suspected. A listing of such high-priority jobs follows.

A. Biological Research

1. An ecological classification of the vegetation of Grand Teton National Park.

   Scope: A quantative classification of natural vegetative units.

   Purpose: To provide an organized description of all natural vegetative units that will serve as a foundation for detailed autecological and synecological research on both plants and animals and will permit more effective communication in interpretive and management operations.

2. Plant ecology.

   Scope: Autecological and synecological research on the vegetation within Grand Teton National Park.

   Purpose: To provide basic reference data on plant ecology to serve as a foundation for animal-habitat interrelationship research, management operations, and interpretive work.

3. Moose ecology.

   Scope: Integrated quantitative studies of the life habits of moose, their population dynamics, their habitat interrelationships, and their relationships to other animals.

Purpose: To provide basic reference data on the moose, to identify factors regulating population numbers, and to suggest practices needed for the management of moose populations and their habitat.

4. Ecology of the Snake River Cutthroat Trout within Grand Teton National Park.

   Scope: Life history, population dynamics, ecology, and management of the native cutthroat.

   Purpose: To provide basic reference data on the cutthroat, to identify factors regulating populations, and to suggest needed management practices.

5. Bighorn sheep ecology.

   Scope: Integrated quantitative studies of life habits of bighorn sheep, their population dynamics, their habitat interrelationships, and their relationships to other animals.

   Purpose: To provide basic reference data on the bighorn sheep, to identify factors limiting population increases, and to suggest practices needed for management of bighorn populations and their habitat.

B. Geological Research

1. Pliocene paleontology.

   Pliocene mollusks, ostracods, diatoms, pollen, and vertebrate fossils range from common to prolific. They have been studied in only a few places, and no extensive collections have been made. Collection and

identification of these assemblages should properly be a long-range study involving specialists in each field. Material is well preserved. The data would be useful not only in interpreting climate and environment during Pliocene time but also in charting the evolution of plant and animal life in this area during the last 10 million years and in determining how it was affected by the rise of the Teton Range and the foundering of Jackson Hole.

2. Late Tertiary volcanism.

   Geochemical and petrographic studies should be made of Miocene, Pliocene, and Pleistocene pyroclastic and igneous rocks in the Teton Park area. The Miocene rocks comprise the thickest (7,000 feet) nonmarine sequence of that age anywhere in North America. They are mafic and derived from local vents in and adjacent to Grand Teton National Park. The Pliocene rocks are felsic in composition, are about 7,000 feet thick, but represent a completely different volcanic cycle. This study should be integrated with a similar one in Yellowstone National Park. The combination of data from the two areas would be of great value in determining the why and when of both volcanic and tectonic events in the region.

3. Carboniferous paleontology.

   The Mississippian and Pennsylvanian faunas of the Berry Creek area, in the northern part of Teton Park, are exceptionally well preserved and abundant. They consist chiefly of marine brachiopods and corals. Their study is of regional significance, for they will supplement data on the distribution of faunas in other national parks and adjacent areas in the Rocky Mountain region.

4. Rock age determinations.

The Precambrian, Cambrian, Jurassic, Cretaceous, and Cenozoic rocks contain biotite, glauconite, potash feldspars, and other minerals suitable for either rubidium-strontium, potassium-argon, or lead-alpha age determinations. About a dozen are now available on Precambrian rocks of the Teton Range and one on the middle Pliocene. Many more are needed. This would be an expensive undertaking, but it is important because Teton Park and adjacent areas have the most complete sedimentary record known in North America and it seems likely that a remarkably precise time scale could eventually be compiled.

5. Determination of continuing crustal movement.

Tiltmeters should be installed along several lines extending across the floor of Jackson Hole and into the Teton Range, both in and adjacent to Teton Park. They would given quantitative data on the rapidity of the sinking of Jackson Hole and the rising of the Teton Range and also disclose whether all or some of the movement is along the Teton fault. Army Engineers have spent many millions of dollars during the last 10 years in trying to keep the Snake River from moving westward, adjacent to Teton Park. The tiltmeter program would help to determine whether this expenditure is economically justified and also whether the movements of the valley floor could affect proposed adjacent reclamation projects that could be detrimental to the natural values of the Park.

6. Gravity survey.

A gravity survey of this seismically active area should be made and correlated with the surface geological data.

7. Effects of glaciers on flora.

Ancient stumps, now far above timberline, are known in this area. The types of trees that grew, and their carbon 14 age, should be determined so that the postglacial, but pre-recent, altithermal time can be bracketed. This information, in turn, can be used in plotting climatic variations and the rate of return of floras after the last ice age.

C. Archeological Research

1. Jackson Lake artifacts.

A study of artifacts along the shore of Jackson Lake and adjacent areas, supplemented by Lawrence, Nelson, Stewart, and other collections from Jackson Hole (including also material in possession of the Park Service), would contribute to an understanding of the Indian cultures of the Park. Nothing along this line has ever been attempted.

2. Travel routes of the Indians.

A study of the artifacts along travois trails and migration routes, with special reference to the Conant Pass route around the north end of the Teton Range, should be made before the artifacts are picked up by amateur collectors or the trails obliterated by time.

D. Historical Research

1. Post fur trade history.

A study and documentation as complete as possible should be made of the period from about 1840 to the present time. The purpose of this job would be to provide information for background interpretive material and to document the information before it is completely lost.

The committee took no formal vote on these two Park research programs but considered that they were valid and should be carried out.

APPENDIX 3

THE WATER SUPPLY PROBLEM OF THE EVERGLADES NATIONAL PARK*

Introductory Statement

Southern Florida is a low-lying peninsula of prairie and swamp. Only a small portion of the area stands at an elevation above 25 feet, and the extreme southern part lies almost at sea level. Prior to 1900 it was almost uninhabited except by the Seminole Indians. That part known as the Everglades is the eastern half of the peninsula south of Lake Okeechobee. The Everglades Park, which was not established until 1947, lies south of latitude 25 45' (which is about the latitude of Miami) and does not include the coastal strip about 25 miles wide, extending from Miami south to Key Largo. (see Plate I)

Prior to the drainage of the northern Everglades, the whole area was a vast solitude of saw grass and water with "hammocks" of trees, various slough areas and higher ridges of pine land. Along the south and west coasts were extensive forests of mangroves. The rainfall is heavy, averaging about 57 inches per year, but the rains come almost entirely in the summer months, leaving the winter and spring very dry. There is a great variation in the amount of annual precipitation.

Prior to the digging of drainage ditches, the area now occupied by the Park, received a large amount of water flowing slowly down from the north, and during the summer most of the area was covered with water. The Kissimmee

*Prepared by Joseph L. Gillson, Geologist member of the Committee.

River which flows southward from Central Florida, drains a large area south of Orlando, and discharges into Lake Okeechobee. In its natural state, the lake had no well-defined outlet. Before the digging of the canals, the lake would fill to overflowing in the summer months and the water would flow over its banks, and spill slowly through the swampy areas and sloughs, moving generally outward to the tip of the Peninsula.

Hurricanes caused heavy flooding. The hurricane of 1928 during which there was a wind velocity of 150 miles per hour, caused a "tidal wave" on the lake 13 feet high, which flowed over the land to the south and drowned hundreds of people. Following this catastrophe, the Federal Government unde: took an extensive flood control project to drain away the flood waters from the rich agricultural land south of the lake.

However beneficial the drainage was to the agricultural community, there were many side effects. Gerald Parker of the U.S. Geological Survey wrote:[1]

"It is doubtful that the drainage enthusiasts ever envisioned that, among other results of their operations, they would induce or cause:

1. Shrinkage, compaction, oxidation, burning and general subsidence of the organic soils ... as much as 5 feet over extensive cultivated areas.
2. Development of wide shallow "subsidence valleys" along each drainage canal.
3. Increase frost damage, which formerly had been held in check in the muck and peat soils by the ever present

[1]Soil and Crop Science of Florida, Proc. vol. 20, 1960, pp 213-4.

water which gave off heat as it froze. (Parker wrote this before the winter of 1962-3 when the loss by freezing of vegetable crops was enormous. Note by author of this paper.)

4. Reduce the original capacity of the canals, thus contributing to flooding.
5. Cessation of the processes that had built up the muck and peat in the first place.
6. Changed ecologic conditions seriously affecting wildlife of the drained areas, resulting in species migration or near extinction.

Water problems have become of prime importance. Whereas we in this area were first concerned only with getting rid of water, or practicing flood control, we now are greatly concerned (with effects caused by inadequacy of water)."

It is not possible to state accurately how much water formerly flowed into and through the area now occupied by the Park. A publication dated May 22, 1950, by the Flood Control District, as quoted by Lamar Johnson of Lake Worth in a report which he wrote in July, 1958, entitled, "A Survey of the Water Resources of Everglades National Park," page 7, is as follows:

"The estimated discharge along the 40-mile front at the present location of Tamiami Trail during the pre-drainage period, was:

"Average rainfall year	-	2,315,000 acre feet
Dry rainfall year	-	Negligible
Wet rainfall year	-	10,744,000 acre feet"

An acre foot is approximately 325,800 gallons.

These figures indicate not only the tremendous amount of water which flowed through that area in wet years, but also testify to the great fluctuation in quantities from wet to dry years.

A program of stream flow measurement was begun in 1940 by the U.S. Geological Survey. The average flow through the 43 mile reach of the Tamiami Trail for the 17 years, 1941-1957, was 473,200 acre feet, with a minimum discharge of 80,120 acre feet and a maximum of 1,437,000 acre feet. Thus the average flow was only 20% of the "pre-drainage period" and the maximum was only 15% of the original maximum. Further, in not one year of the seventeen years, did the maximum flow <u>even approach the average</u> of the pre-drainage period. It is that fact that is most discouraging in the study of the water situation of south Florida.

The resulting lowering of the water table within the area of the Park, is indicated most convincingly by the fact that the vista of the vast sea of saw grass is now broken by the presence of abundant willows which have sprung up here and there. More serious is the diminishing number of colorful sea birds, which come into rookeries in the sloughs within the Park area during the spring months, feeding on young fish which had been spawned during the previous period of high water. Whereas these birds used to come into the Park area to raise their young by the hundreds of thousands, now the numbers are in the thousands, since there is not enough food available for the larger number.

If the Everglades had a principal reason for having been made a National Park it was to protect these birds which thousands of tourists and bird watchers were coming to see and admire every year.

Can the supply of water for the Everglades Park be increased to anything like the quantity that formerly flowed into the area? This is the burden of this discussion. It must be remembered that the Park was not established until 1947, by which time the damage done by the drainage of the northern Everglades was well under way.

Greater Miami and Its Water Supply

East and northeast of the Everglades Park is a huge municipal complex within Dade County, called "Greater Miami", which includes the city of Miami itself, Miami Beach, Hialeah, Coral Gables, and numerous smaller communities. Fort Lauderdale is north in Broward County, and Palm Beach still further north in Palm Beach County. The present population of Dade County is estimated at about 1¼ million, but the area is one of the fastest growing in the country. The population has been doubled every 10 years, and if this rate continues, the population will reach 2 million by 1970, and 4 million by 1980. One shudders at the thought that 1980 is only 16 years away, less than the time since the end of World War II, which to those who were active in it, seems a very short time ago. Four million people take up a lot of room. One thinks of Los Angeles or Chicago each with 500 square miles of fairly densely built-up city. When that many people have come to live in Greater Miami, there will hardly be an open field or wood lot in the eastern half of Dade County. Most of the residential area of Greater Miami is built on the "Atlantic Ridge", (see Plate II) a coastal sand strip of Pleistocene deposition. Outside of "downtown" Miami most of the people live in individual homes surrounded by lawns and the present planners seem to believe that this condition will

continue. It must be remembered, however, that even in "suburbia", streets, driveways, and sidewalks take up one third of the available area, and community service facilities such as shopping centers with their huge parking areas bring the paved-over surface to about half of the total.

Greater Miami is blessed by having available to it one of the largest sources of fresh water of any city in the United States, except those cities located along the shores of the Great Lakes. All of this water comes from wells driven into a formation immediately underlying the Atlantic Ridge called the Biscayne aquifer. This aquifer is kept supplied now by water from rains so that there is now no conflict of interest between the water needs of the great municipal area, and the needs of the Everglades Park. Whether this happy situation can continue will be analyzed on subsequent pages.

The Biscayne aquifer, named after Biscayne Bay (Plate III) extends along the Eastern coast from southern Dade County north into coastal Palm Beach County, as a wedge-shaped underground reservoir having the thin edge to the west. It underlies the Everglades as far north as northern Broward County, but is thin under the Park itself.

Gerald Parker has described the Biscayne aquifer as follows:[2]

> "The Biscayne aquifer is a hydrologic unit of water-bearing rocks ranging in age from upper Miocene through Pleistocene. The important members are the Miami oolite and the Fort Thompson formation, both of which are very porous, and permit very free movement of water."

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[2]Parker, G.G. et al., "Water Resources of Southeastern Florida," U.S. Geological Survey, Water Supply Paper 1255, 1955, pp 198-221.

"The aquifer is at once one of the area's greatest natural resources and one of its most difficult assets to protect. It rests on a gently sloping impermeable floor of clay, silt and dense marl. No saline intrusion can work its way upward through these materials, but the Biscayne aquifer is leaky above and on all sides. Rain finds ready access to the aquifer, and with Miami's 60 inches of rainfall per year, the aquifer is kept nearly full much of the time. The aquifer is open to the ocean on its seaward side, and the fresh water of the aquifer discharges into salty bay and ocean water."

The drainage canals have cut through the upper part of the aquifer, thus bleeding off some of its reserves, and these canals connecting with the sea, have permitted salt water to come inland during high tide, and much damage from this salt water intrusion has occurred, so that many wells have had to be abandoned. The danger has been recognized, and tidal traps have been installed in the canals near their points of discharge into the Bay or ocean. These traps let fresh water flow out at low tide, but close automatically against the rising tide, like a trap door.

Tremendous quantities of water are stored in the Biscayne aquifer, but most of this is "dead storage", that is, so much of it lies below sea level, that the water table cannot be drawn down by heavy pumping without inviting salt water to flow in from the sea.

Parker has estimated that there is an annual net gain of new water from recharge by rain of .15 to .45 billion gallons per year in each square mile of surface. Using a median figure of .3 billion gallons per year per square

mile of area, one may make an approximation of the "safe yield" that can be pumped from the aquifer, without depleting the reserve.

The area in Dade County within which wells can be drilled for water to supply existing or future populated areas is a zone roughly 20 miles east-west by 40 miles north-south, giving an area of 800 square miles for recharge. Thus there may be a potential supply of water from the Biscayne aquifer of 240 billion gallons per year which may be pumped, without depleting the reserves, or causing excessive draw down which will invite salt water invasion.

When the population reaches four million, and a large part of that area is taken up by "suburbia" about half of that suburban area will be paved. This will reduce the recharge, since water that falls on streets, sidewalks and the enormous parking lots around shopping centers flows down sewers. It can be hoped that by that time storm sewers will have been built in the suburban area, and the discharge collected and returned to the ground through recharge wells, Ranney-type collectors, or ponds established in areas not yet then completely built-up.

It is pertinent and important at this point to introduce the reader to the Conservation Areas which have been established (Plate I). These have been a most wise development. There are three of these, No. 1, No. 2 and No. 3, graded at elevations so that water from No. 1 will flow into No. 2 and from 2 into 3. The Conservation Areas are bounded by levees, the construction of which is presently almost complete. The purpose of the Conservation areas is to intercept flood water running out of the canals before it is lost out to sea, and to store it so that the Biscayne aquifer will be kept recharged.

If the recharge into the aquifer used by the present well fields is reduced, some wells may be drilled further west in order to have the benefit of the recharge from the water in the Conservation Areas. A western location for these wells, further away from the danger of salt water infiltration is advantageous. There the water level can be lowered by more intensive pumping, and more water will run into the ground from the conservation areas. That was the purpose of these conservation areas, and the recharge into these western wells will supply the water for the urban area.

At the present location of the wells, little or no recharge could result from these conservation areas, since the distance is too far to give any effective gradient. Hence any water standing on the Conservation area 3 will seep gradually south into the Park. When the wells are moved west into area 3-B, or area 3 itself, the recharge will tend to exhaust the standing water in Conservation area 3, (except in flood years) and there will be less water to move down into the Park. That is when the flow into the Park will indeed by greatly reduced.

If there are any alternatives, now is the time to consider them as advance planning.

At the present time the average community in the United States uses about 150 gallons of water per day per person. This quantity includes industrial requirements, if any; water to sprinkle lawns and gardens, to fill swimming pools, to cool the compressors used for air conditioning, sanitary water to flush toilets, and, finally, for such domestic use as bathing, cooking, and for thirst quenching. Biscayne aquifer is adequate for the requirements of over 4 million people (based on present requirements). Hence, so far as the

inhabitants of Greater Miami are concerned, they will not have to turn elsewhere for water until well into the 1980's. They are thus much better off than most other communities in the United States.

Generally, the wells in the Biscayne aquifer are easily developed. They are either of open-hole, rock wall construction, or they are finished with a sand point. Most of the wells are of the former type and are from 1¼ to 18 inches in diameter. A common well in the area is 6 inches in diameter and from 50 to 65 feet deep, with 3 to 10 feet of open hole in highly permeable sandy limestone below the bottom of the casing. The yield ranges from 1,000 to 1,500 gpm, with a draw down during pumping of less than 4 feet; recovery occurs almost immediately after pumping stops. Most municipalities in the Greater Miami area are now served by the supply of the city of Miami, most of which is pumped from a well field in the Miami Springs-Hialeah area. Currently, about 60 million gallons per day are pumped. Some of the adjacent municipalities, such as Opa Locka, North Miami and North Miami Beach, have their own public water supplies.

The Miami area makes considerable use of wells for fire-fighting purposes. In order to obtain large quantities of water for this purpose, wells have been drilled at strategic locations over most of the settled area. Each well will supply a fire-fighting "pumper" with at least 1,000 gpm. Probably no other large city in the country has such facilities.

The possibility of developing well water to supplement the natural flow into the Everglades Park is good. Parker and Associates state in Water Supply paper 1255, p 178:

"In the Everglades National Park area, the Biscayne aquifer is composed of rocks of the Miami oolite and Fort Thompson formation. These rocks are riddled with solution holes and are highly permeable ... the aquifer is not thick however; at the Tamiami Trail it is only about 20 feet thick ... the quality of the water several miles inland from the Bay of Florida or the Gulf of Mexico is good, being a typical calcium bicarbonate type water ... excellent wells for potable water could be developed and would be capable of yielding as much as several thousand gallons per minute ... it would be essential to stay as far away from salt water sources as possible to prevent contamination by encroachment of sea water."

The flooding of Conservation Area No. 3 to supply recharge to the Biscayne aquifer for the benefit of the Greater Miami area will also benefit wells that might be drilled on the Park side of the Tamiami Trail. The modest thickness of the aquifer limits the draw down that can be operated in each well, but the cone of influence around each will therefore not be too great, and a number of wells can be drilled. Greater Miami will obviously put its wells either in the 3-B area, or lined up along Levee 67, in order to keep as short a pipe line distance to its mains as is possible. The Park can tap the aquifer all along the Tamiami Trail, a distance of 12 miles and along the west side, south of Tamiami Trail. It is not unreasonable to expect that 25 to 40 wells might be put into operation along these lines. These wells might yield as much as 250 acre feet per day. They could be operated during the dry season of the spring months, contributing 25,000 acre feet into the Rookeries at the very time it is needed most.

During wet years, when ample water is flowing down from the heavily flooded area of Conservation Area No. 3, and water is standing all over the north part of the Park, these wells should not be needed, but in dry years, they would be a "Godsend".

Salt Water Infiltration

It has been mentioned that salt water encroachment into the Biscayne aquifer is a constant threat and has occurred and caused some wells to be abandoned. Fortunately the danger has been appreciated, and remedial measures have been taken. The subject is discussed at length in Florida Information Circular No. 9, by Howard Klein, Tallahassee, 1957. Figure I of that report shows six maps delineating the progressive salt water encroachment for the period 1904 - 1953.

The only serious threat in the Miami area now is from careless over pumping. The water supplies in the Biscayne aquifer are like money in the bank. In times of need, it is a natural impulse to overdraw. If the ground water level is lowered below sea level near the ocean shore, or near the salt marshes, salt water will come in, and once in an aquifer, the salt is difficult to flush out. During times of high water levels, salty wells can be pumped to waste, with the hope that additional infiltration of fresh water can be induced.

In the Park area, salt water encroachment has taken place. In a well 13 miles southwest of Royal Palm State Park, the chloride content is high. Since most of the extreme southern part of the Park is at or below sea level, the surface water is salty, and is inhabited by marine species.

Florida Bay is an anomaly, since the water in it is saltier than in the open ocean, due to inadequate circulation through the narrow connections at its opposite ends. A serious effect was noted at Flamingo during the visit of the Committee in Jaunary. There a canal had been dug to give motor boats access to Coot Bay and on through to Whitewater Bay. This canal is allowing the super-salty water of Florida Bay to pass into the under-salty water of Coot Bay. The harm in that situation is that baby shrimp are hatched in the brackish waters of Coot Bay, and are killed if the water becomes super-salty. The canal is so big that simple tidal traps will not serve. It will require regular locks which will have to be opened and closed for the benefit of the motor boats.

Sewage Disposal

Incredible as it may seem, a large part of Greater Miami is not served by sewers, but rather each home or group has septic tanks which have been emplaced in the top of the very permeable Biscayne aquifer. That such a practice has not led to repeated epidemics is surprising, and must be a proof of the efficacy of chlorine. The built-up parts of the cities of Miami and Miami Beach are served by a sewage system, with a treatment plant on Virginia Key, which is the next island south of the one on which Miami Beach is located. The effluent is pumped out to sea. Whether any of it gets back on the beach is not reported in the travel brochures.

Obviously septic tanks will not be adequate for very long, considering the steep rate of growth of the population. Collection and treatment of all sewage except in the most outlying communities must be installed.

Dade County has taken a very wise decision and has passed a law stating that by early 1965, no "hard" detergents can be used or sold in the county. This vote resulted from difficulties with foaming in sewerage lines and in septic tanks. This elimination of hard detergents makes possible the use here proposed for piping the effluents from primary sewage settling tanks which eliminate solids, both organic and inorganic, out to oxidation ponds or lagoons and from them decant the purified water into the sloughs in the Park. Hard detergents are poisonous to fish, even in very minor concentrations. The new soft detergents are not.

Several chemical companies are known to have the soft alkylate detergents ready. These companies include Monsanto Chemical Company, Allied Chemical and Dye Corp., Union Carbide Corp., California Chemical Company (Standard Oil of Calif.), Continental Oil Company, and Ejay Chemical Company (Standard Oil of N.J.). The rapid degradation of the soft detergents, which are called linear alkylate sulfonates, by bacterial action has been described in a recent article in "Chemical and Engineering News" for June 24th, 1963, p. 37.

On the assumption that within a very few years, Greater Miami will have to collect and treat all of its sewage, it is pertinent to estimate how much effluent would be obtained as water which can subsequently be purified by oxidation in ponds or lagoons. Ignoring the run-off from storm sewers, which run-off should be essentially clean water and which as above suggested should be collected separately and put back into the Biscayne aquifer through recharge wells, Ranney collectors or ponds in new city parks, the amount of sanitary sewage effluent can be estimated.

It has been stated that the water use per person per day in the typical American community is 150 gallons. How much of this will come out as the fluid effluent from the primary stage in a sewage treatment plant involving essentially only sedimentation or settling out of the solids?

It is fortunate that Miami does not now have, and probably never will have large chemical plants which have chemical wastes to discharge which can neither be neutralized nor sufficiently diluted and which would kill the bacteria which cause purification in oxidation ponds, and which chemicals could later kill fish which might be planted in these ponds. Hence the effluent will be reasonably free from chemical wastes.

In a climate such as that of southern Florida, where a substantial amount of water used is for lawn sprinkling, and for cooling the compressors in air conditioning, it can be assumed arbitrarily that of the 150 gallons of water used per day per person, 25 gallons of this will never reach a sewer, but rather will be evaporated or will soak into the ground. According to Fair, Geyer and Norris[3] the volume of wet sludge from the primary sedimentation of raw sewage has a volume of 37.8 cu. ft. per 1,000 persons in the community, and the sludge contains 95% water. This is only .0378 cu. ft. per person, and hence the water loss with the sludge is insignificant, most of it is separated as almost clear effluent. However, to be conservative, and for easy calculations, it is assumed that the effluent will amount to 100 gallons per day, per person.

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[3]Water Supply and Waste Water Disposal, John Wiley, 1954, p. 771.

Oxidation ponds or lagoons are now an accepted method of treatment of effluent water. The oxidation pond is an artificial lake into which this effluent flows. The pond is shallow and absorbs air at the surface so that aerobic bacteria thrive and reduce the B.O.D. (biological oxygen demand). According to Steel[4] there are 188 communities in Texas served by oxidation ponds, and many others in other southwestern States. Although these ponds are used in the north, they are not effective during the winter when the ponds are frozen over.

Steel estimates that a pond should have an area of one acre per 500 persons contributing to the sewage. The retention period is about 25 days, or, for convenience in calculations, a month. Assuming a population of 1,000,000 persons, contributing 100 million gallons per day of effluent, or 3 billion gallons per month, this is equivalent to 9,200 acre feet. If the pond has an effective depth of 3 feet, the pond to give a month's retention time for the effluent from the treatment of the sewage produced by 1,000,000 persons will have an area of a little over 3,000 acres, or 4½ square miles. This is an insignificant requirement in the Southwest Dade Area, for example, which contains about 235 sq. miles.

Steel says that depths in practice vary from 2.5 to 4 feet. Lesser depths encourage emergent aquatic vegetation which fosters mosquito breeding, and interferes with convection currents and movements in the water, thus reducing oxygen intake. The soil in the bottom should be relatively impervious to avoid

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[4]Steel, E.W., Water Supply and Sewerage, McGraw-Hill Book Co., 1960, p. 478.

rapid seepage. He states further that a number of studies indicate the feasibility of returning treated sewages to the ground water for any industrial purpose or for irrigation with no restrictions as to crops. Studies made in California indicate that after filtration through four feet of sandy loam, a primary effluent or a completely treated sewage will comply bacteriologically with the U.S. Public Health Standards. Steel says that there appears to be no reason except aesthetic, why treated sewage should not be used, where conditions are favorable, to replenish dwindling ground waters by seepage from open basins or recharge wells and to use such ground waters for public use as well as industrial and agricultural uses. No objections to the ponds have been reported by residents living one-quarter of a mile from oxidation ponds.

Babbit and Bauman[5] say that the cultivation of fish in dilute sewage plant effluents can be done successfully. These authors also report on the replenishment of ground water by seepage from such ponds, citing a reference by G.T. Orlob and R.G. Butler.[6]

An outstanding advantage of the use of sewage effluent to supplement water supplies in the Everglades Park is that the quantity is approximately uniform throughout the year, and as the population of the urban area increases, the quantity of effluent will rise in direct proportion. Looking forward to the year 1970, when there will probably be 2 million people living in Dade

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[5] Sewerage and Sewage Treatment, John Wiley & Sons Book Co., New York, 1958, p. 392.

[6] Journal Sanitary Engineering Section American Society Civil Engineers, Paper 1002, June 1956.

County, there could be available 200 million gallons per day as effluent from the primary sedimentation stage in the sewage treatment plant. This is 613 acre feet per day, or 215,000 acre feet per year. With 4 million people in 1980, the quantity could be 430,000 acre feet per year, wet year or dry. As the thirsty population of the municipal area has pushed its well fields out into the Conservation Area No. 3, and greatly reduced the seepage south into the Park during dry years, this may be about all the water that will seep into the Park since that flowing south from the Tamiami Trail may have been previously intercepted by the recharge into the ground in the underlying aquifer. This quantity will at least be as much as the Park has received from along the Tamiami Trail on the average for the last 17 years, and a great deal more than has been available during dry years.

The Dade County Water Conservation District

This district was organized in 1945 and has power to carry out any measures to conserve water resources, construct necessary works and to establish the levels to be maintained in all fresh waters of the County. It has power to levy taxes to pay for its operations. Canals were enlarged to reduce flood heights, and gated control structures in the canals were built to hold up levels in dry weather. The work of the Conservation district has been most effective in controlling salt water infiltration, and the body is to be commended most highly for its continued devotion to duty.

The Federal Water Control Project

The Conservation Areas which have been repeatedly mentioned and which are shown on Plate I have been built by a Federal Project. The destructive

floods of 1947 resulted in the passage of a federal law, (House Document 643, 80th Congress, 2nd Session), which appropriated money for the control of the level of Lake Okeechobee and for control of floods in the St. Johns and Kissimmee Rivers. The State of Florida created the Central and Southern Flood Control District. In Dade County, the Federal project is practically the same as the project for the County Conservation District. Federal funds have been appropriated at the rate of several million dollars annually. This money has been spent principally for the construction of levees. Numbers L-30, L-31, L-33 and L-67A have been completed, and L-28 is well advanced. These levees are designed to enclose large areas, called Conservation Pools. These extend south from a point west of West Palm Beach down to the Tamiami Trail. The area of each, the storage capacity, and the amount of water which it is estimated will be stored in them is as follows:

Pool No.	Area Sq. Miles	Storage Capacity Acre Feet	Amount of Water To Be Stored, Acre Feet
1	216	206,000	1,265,000
2	204	547,300	479,000
3	926	3,350,500	1,696,000

The reason that Pool No. 1 will store much more water than its capacity is that the water will pass continually down into the other pools. Pool No. 1 has been designated as a Wildlife Refuge. Presumably all land within these Conservation Areas is federally owned, and none can be sold or leased for private occupancy without an Act of Congress.

It must be repeated for emphasis that the creation of these Conservation Pools or Areas is a most constructive step forward in improving the water supply situation in the whole area. The essential reason for the creation of them was to provide a place for the storage of flood water without seeing it all drained out to sea, and lost forever; and hence to provide water for recharge of the Biscayne aquifer. It has been pointed out that so long as the wells serving Greater Miami are all several miles to the east of Conservation Area No. 3, no recharge of the aquifer will come from the water on the Conservation Area. There is not head enough to move water that far. Hence the 1,696,000 acre feet of water in Conservation Area No. 3, standing an average of three feet deep over the 926 square miles will partly evaporate, but some will seep down through the Tamiami Trail into the Park. The engineer, Lamar Johnson whose report has been quoted several times, estimates that the amount will be 588,000 acre feet, as compared with the present seepage of 473,200 acre feet along the same frontage. This is a substantial increase.

Another important area where much additional water can get into the Park is along the north-south boundary between the Park and the Southwest Dade Area. Mr. A. Van V. Dunn, Formerly Chief, Branch of Water Resources, National Park Service, made an estimate that an average of 160,000 acre feet of water could be pumped into the head of Shark River Slough by two pumps of large capacity installed at points respectively 7 miles and 10 miles south of the Tamiami Trail along that common boundary of Park and the Southwest Dade Area. Neither these pumps, nor even the levee called "67 Ext" to be built along that boundary are yet in place, nor even assured. These pumps will not raise water from wells, but rather standing water in the head of Shark River Slough within the

Southwest Dade Area. Presumably this water would be available only during the wet season, and perhaps not then if heavy pumping by future wells which may be drilled in the Southwest Dade Area induces infiltration for recharge.

Of the two pumps shown on Mr. Dunn's map (not reproduced here) the one planned seven miles from the Tamiami Trail will be installed instead just south of the Tamiami Trail. The other pump at 10 miles south of the Trail is still under consideration for future installation.

During wet years, when the storage capacity of Conservation Area No. 3 is filled, then there will be a large amount of excess water, much of which will flow freely south into the Park along the Tamiami Trail. The problem then will be to retain enough of this water north of the Shark River Slough, so that it will not run off too rapidly into the Gulf of Mexico and be dissipated. To retain this flood water, it is recommended that consideration be given to the construction of a levee, 18 miles long and running in a southeasterly direction. The center point of this proposed levee will be in the middle of the Shark River Slough, some 15 miles due south of the Tamiami Trail. To be specific, that center point will be in Section 22, T.56 S, R. 35 E. The location of the suggested levee is shown on Plate I.

The purpose of the levee is not to retain all of the water until it evaporates, but rather to retard its southwestward flow, so that the rookeries will have plenty of water during the nesting season. During dry years there will be no water to retain behind this proposed levee. In such years, if the rookeries receive any water it will have to come from the discharge of the Park wells, and from the sewage effluent.

Conclusions and Recommendations

It is concluded that there is no possibility of ever restoring to the Everglades Park the amount of water that that area received in "predrainage canal" times. However, the establishment of the Conservation Areas by the construction of levees by the Federal Water Control Project has been a most constructive development, and will add some water to the Park area from seepage during dry and normal years, and during wet years, there will be a great deal of water available to the Park, running down from the Conservation Areas.

At the present time, there is no conflict of interest for available water for the needs of the people of Greater Miami, and for the Park, and so long as the needs of the people can be met from wells in or near their present positions, there will be no conflict. Up until 1980, when the population of Greater Miami may reach 4 million, the needs of the people should be satisfied from wells drilled well east of the Park Area, and east of Conservation Area No. 3. 1980 is only sixteen years away; hence it is very pertinent to look beyond that time when a conflict of interest can develop between people and Park.

Additonal water for the Park can be made available through wells drilled in the Park along its northern boundary, and its western boundary south of 40-mile Bend. Recharge of the aquifer will be promoted by the water seeping down from Conservation Area No. 3.

Another source, and one which could grow in quantity as the population of Greater Miami grows, is the effluent water from oxidation lagoons, treating

the liquid effluent from Sewage Treatment Plants. Such water is not odor-iferous, and within the tolerance of Public Health rules for infiltration to ground water for human consumption. Fish thrive in such waters. This effluent water could be a regular and continual supply, available in equal quantities in dry as well as wet years, and available in regular increments throughout the year. It could be a most helpful supplement during dry years.

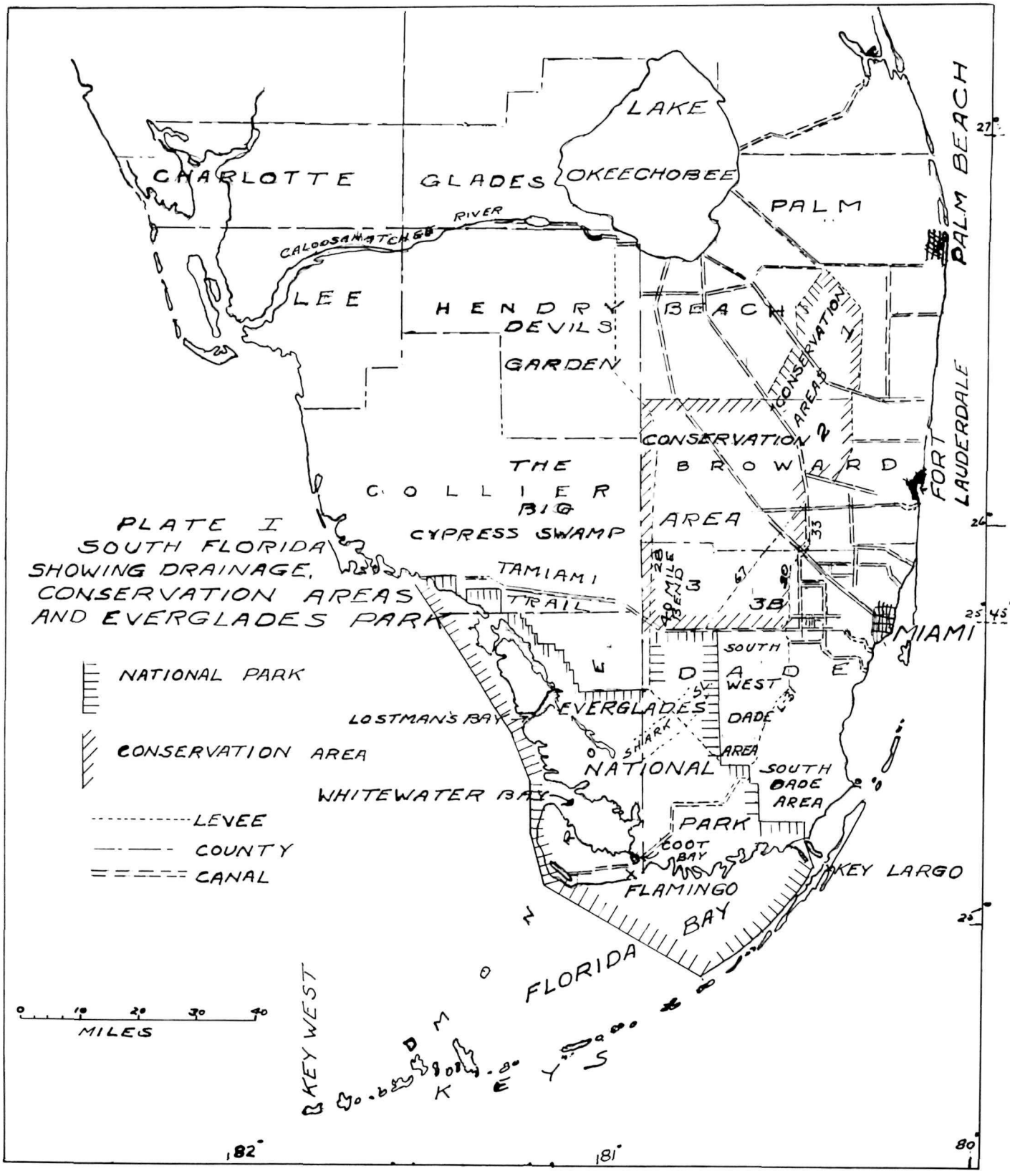
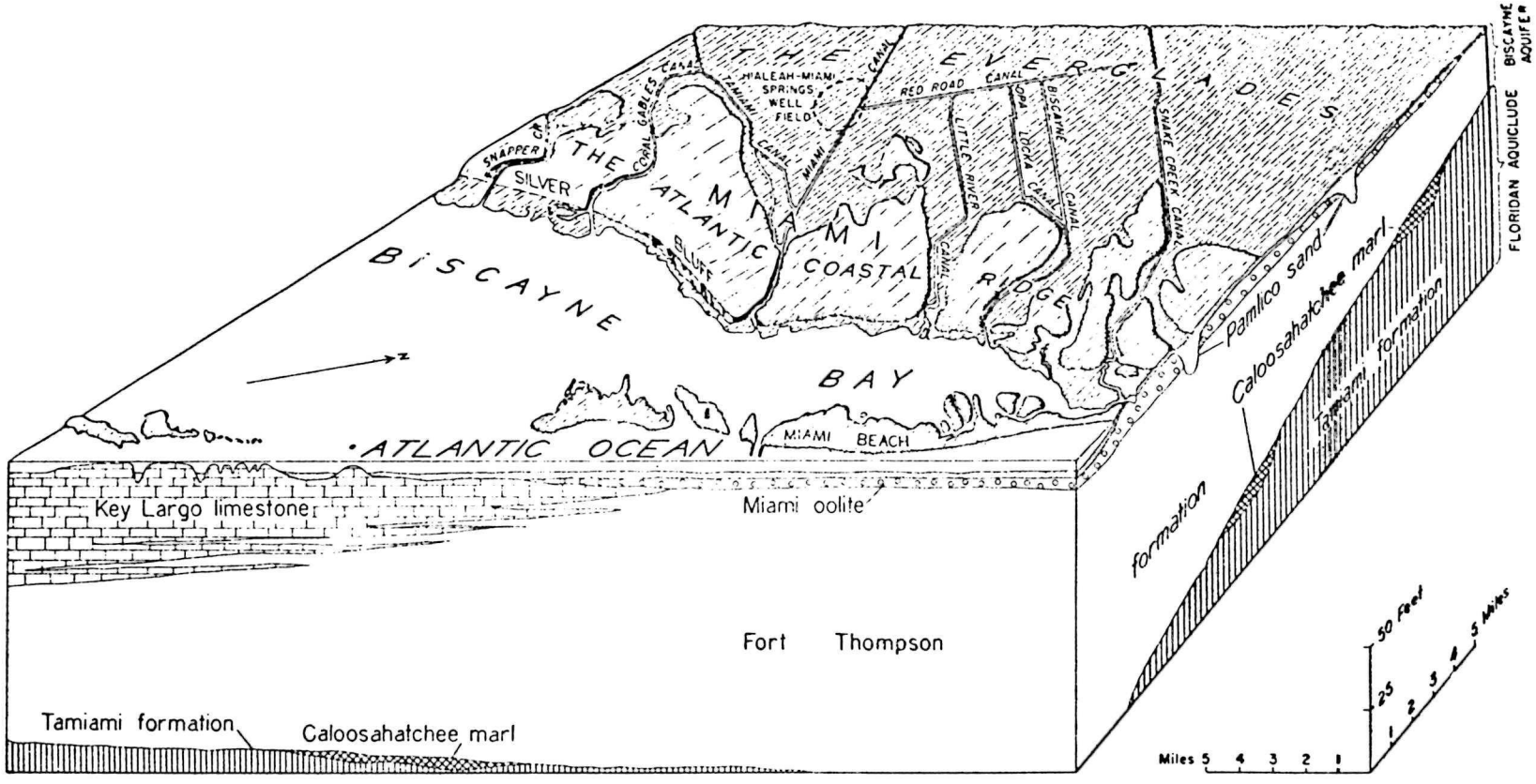


PLATE I
SOUTH FLORIDA
SHOWING DRAINAGE,
CONSERVATION AREAS
AND EVERGLADES PARK
NATIONAL PARK
CONSERVATION AREA
LEVEE
COUNTY
CANAL
MILES
CHARLOTTE
GLADES
LAKE OKEECHOBEE
PALM BEACH
PALM
CALOOSAHATCHEE RIVER
LEE
HENDRY
BEACH
DEVILS GARDEN
CONSERVATION AREAS
CONSERVATION 2
THE COLLIER BIG CYPRESS SWAMP
BROWARD
FORT LAUDERDALE
AREA
TAMIAMI TRAIL
3
3B
MIAMI
SOUTH DADE
WEST DADE AREA
EVERGLADES NATIONAL PARK
LOSTMAN'S BAY
SHARK
WHITEWATER BAY
SOUTH DADE AREA
COOT BAY
FLAMINGO
KEY LARGO
BAY
FLORIDA
KEY WEST
DRY TORTUGAS
0 10 20 30 40
82°
81°
80°
27°
26°
25°45'
25°

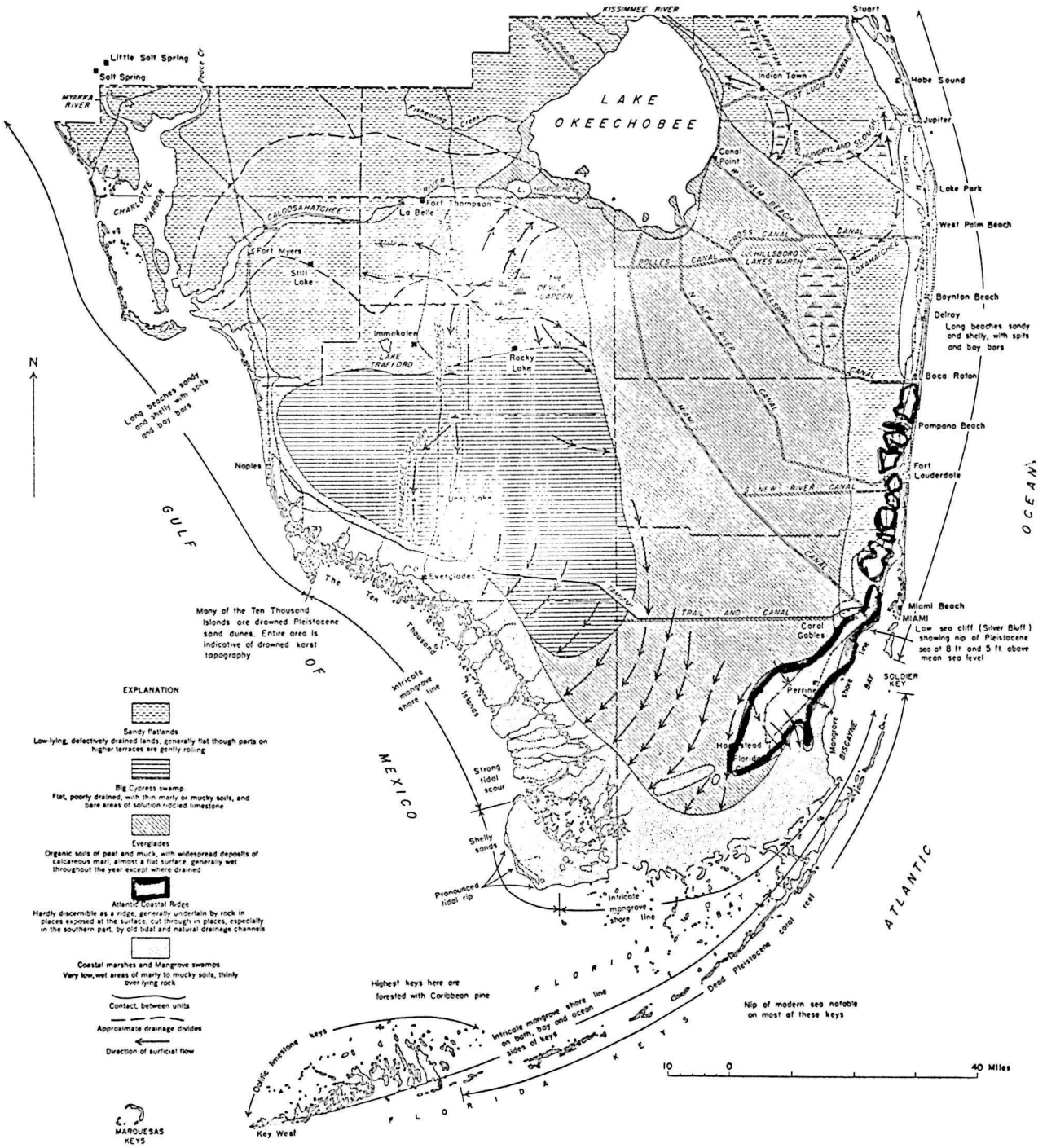
PLATE I



From U.S Geological Survey Water Supply Paper 1255, Page 93.

PLATE II

Block Diagram of the Miami Area

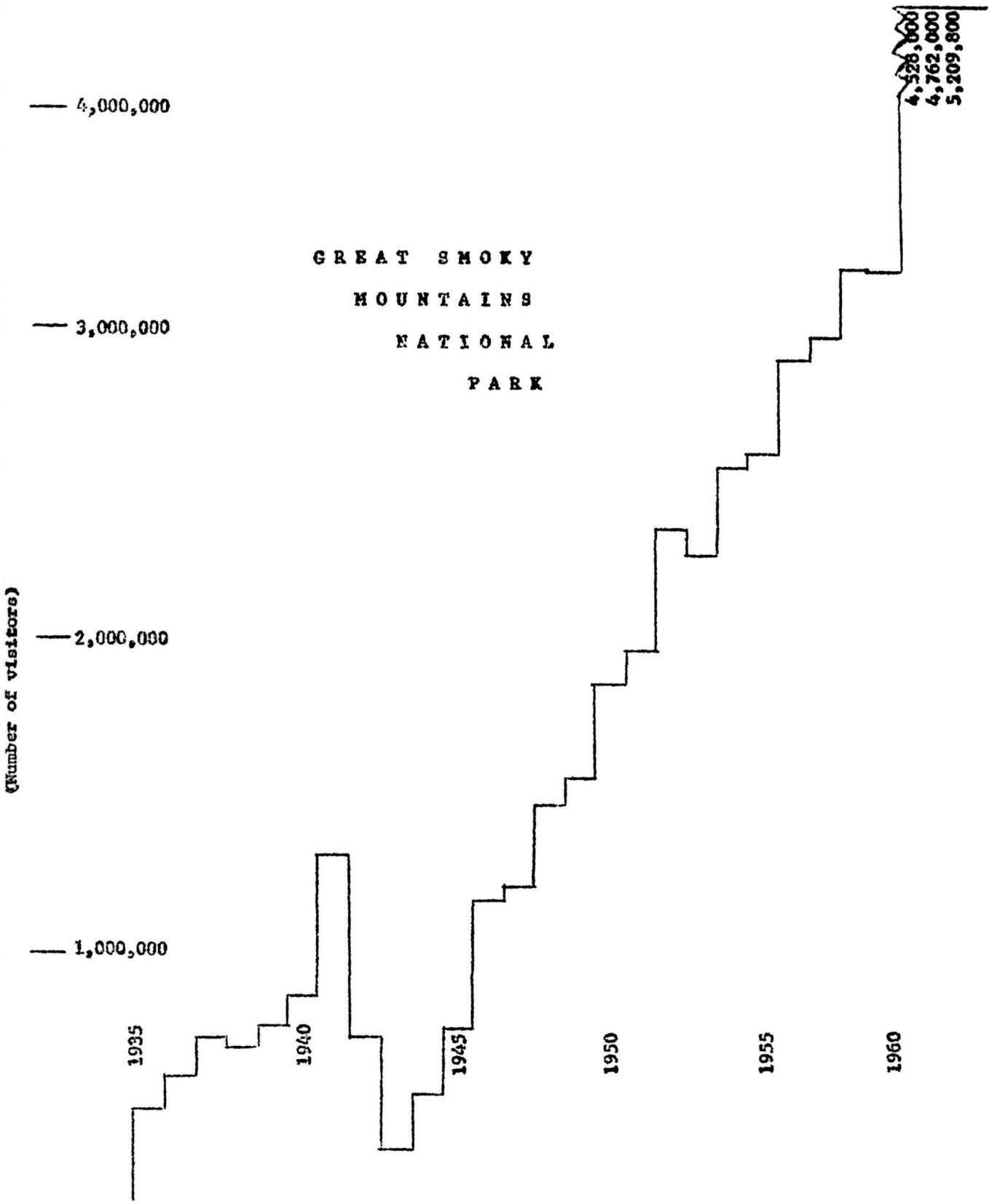


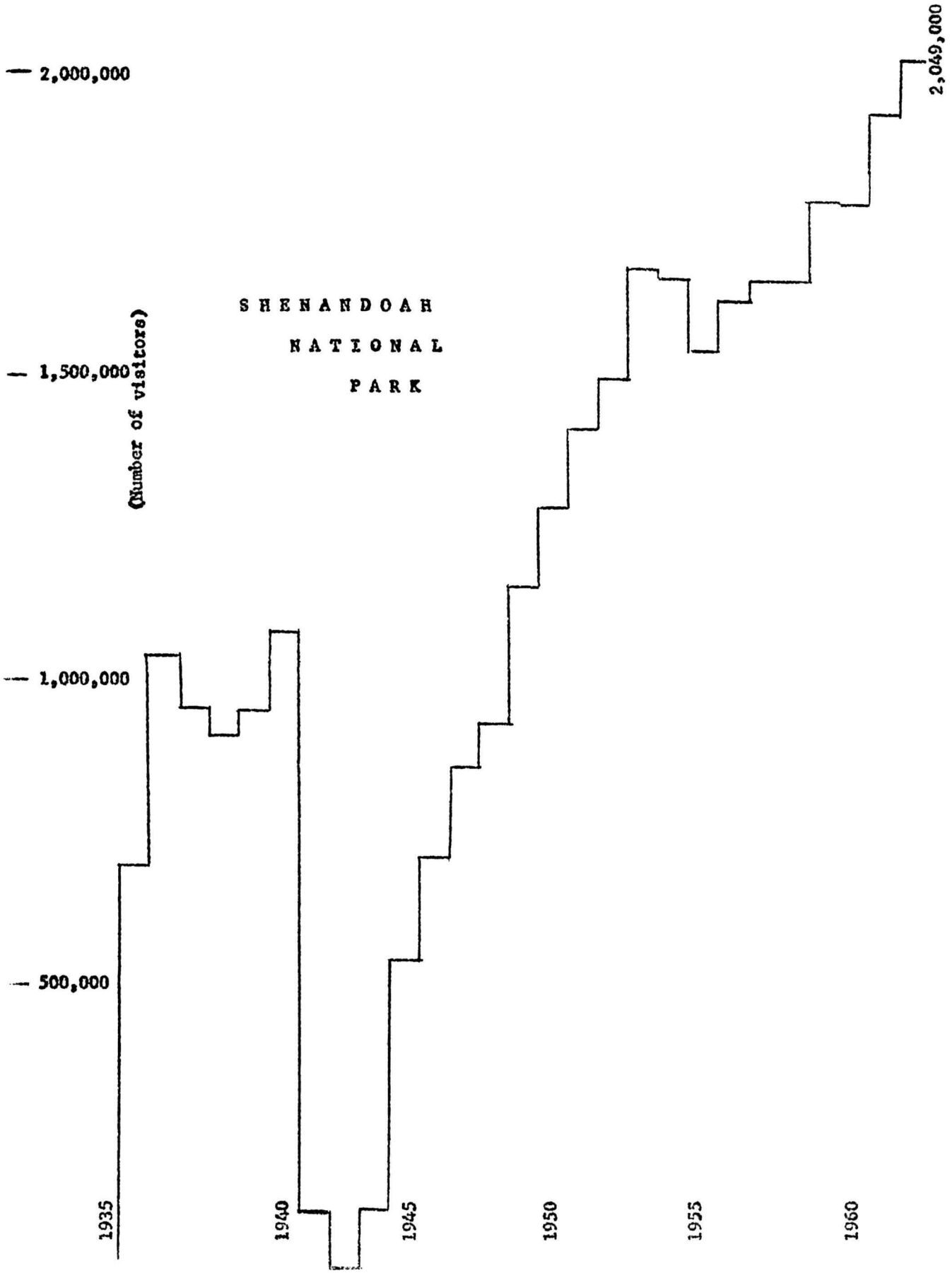
From U.S. Geological Survey Water Supply Paper 1255.

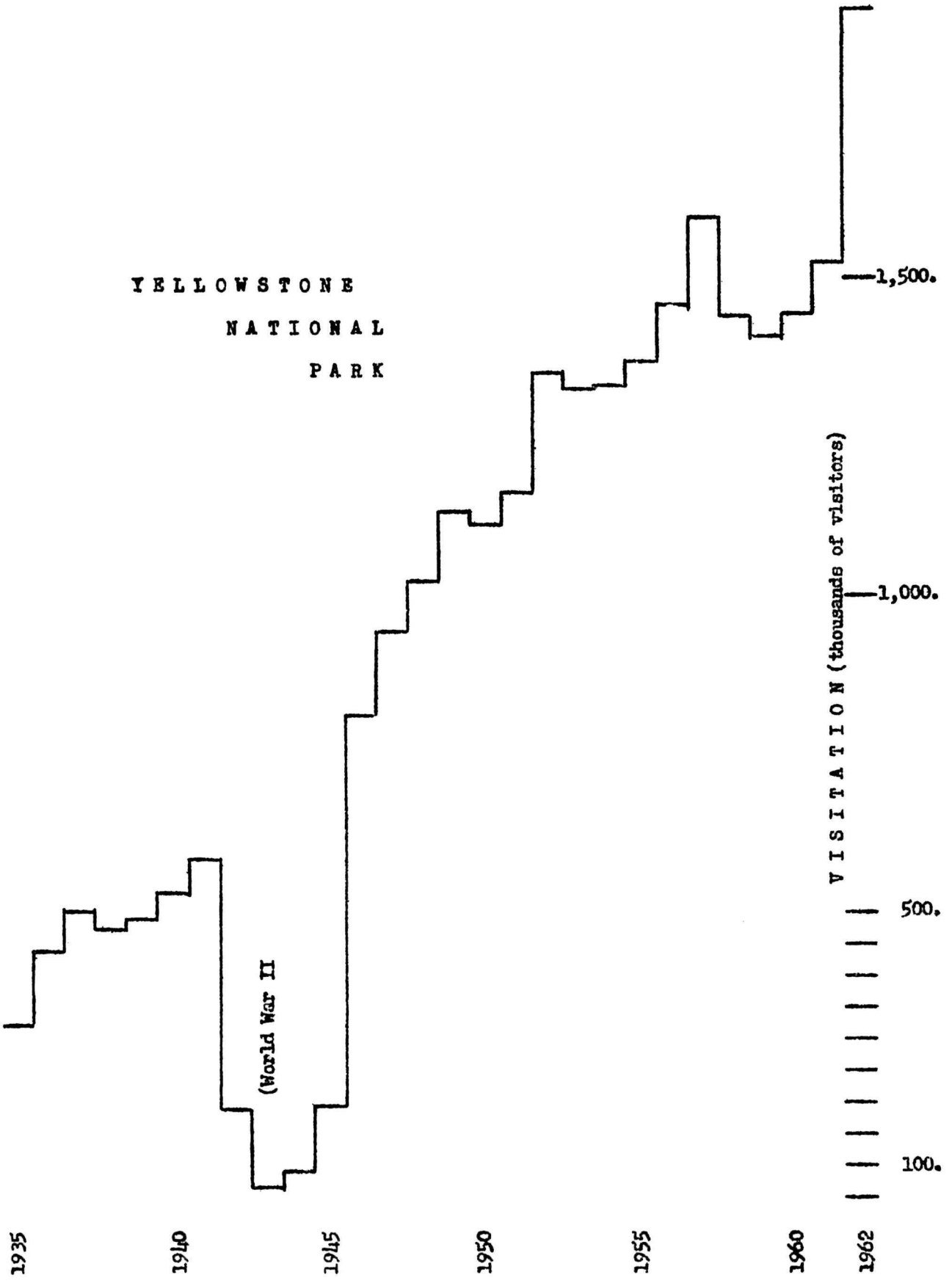
PLATE III

Topographic-Ecologic Map of Southern Florida

APPENDIX 4


GREAT SMOKY
MOUNTAINS
NATIONAL
PARK
(Number of visitors)
4,000,000
3,000,000
2,000,000
1,000,000
1935
1940
1945
1950
1955
1960
4,528,000
4,762,000
5,209,800


SHENANDOAH
NATIONAL
PARK
(Number of visitors)
2,000,000
1,500,000
1,000,000
500,000
2,049,000
1935
1940
1945
1950
1955
1960


YELLOWSTONE
NATIONAL
PARK
(World War II
VISITATION (thousands of visitors)
1,500.
1,000.
500.
100.
1935
1940
1945
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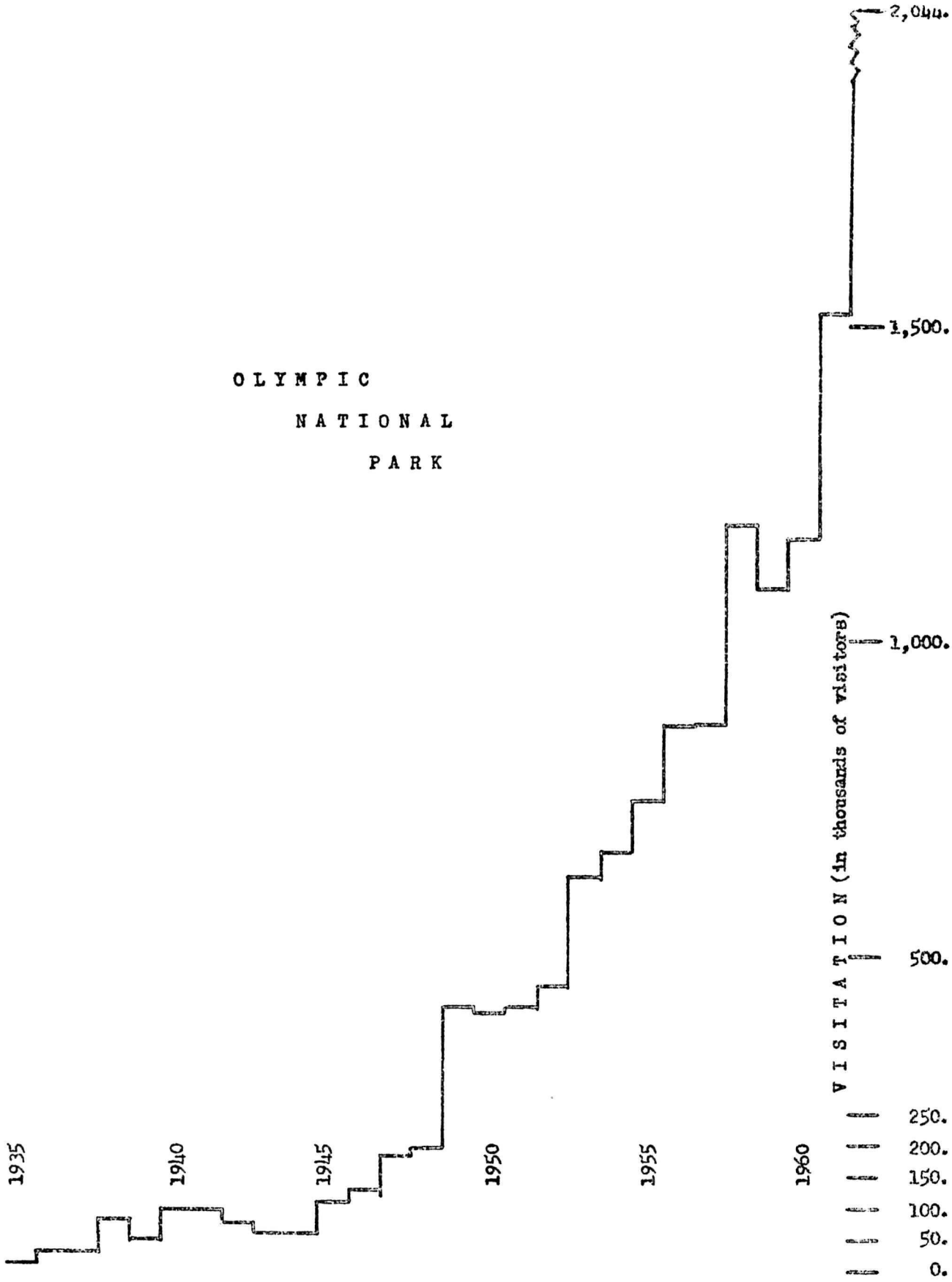
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NATIONAL
PARK
VISITATION (in thousands of visitors)
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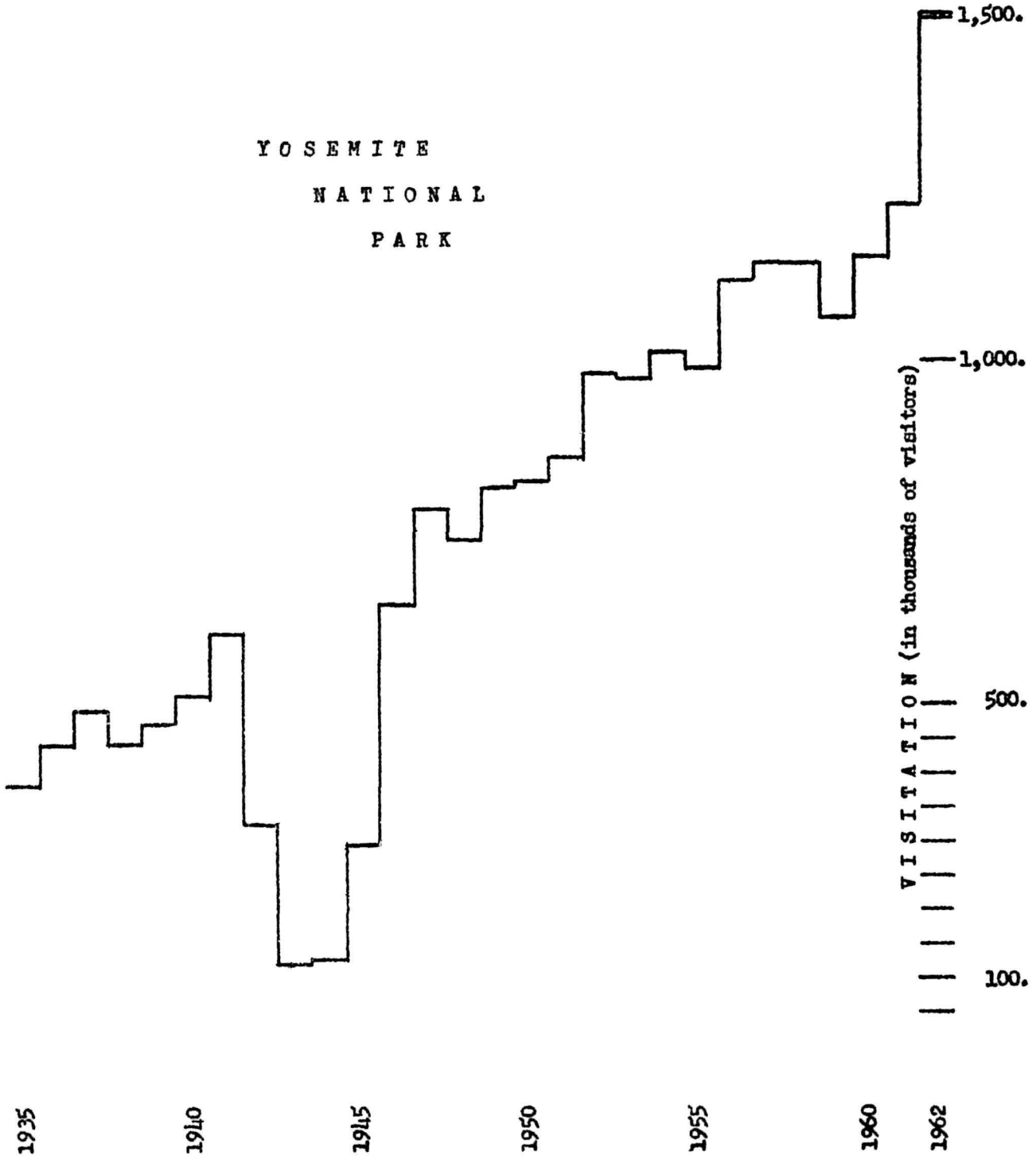
YOSEMITE
NATIONAL
PARK
VISITATION (in thousands of visitors)
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1,000.
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1935
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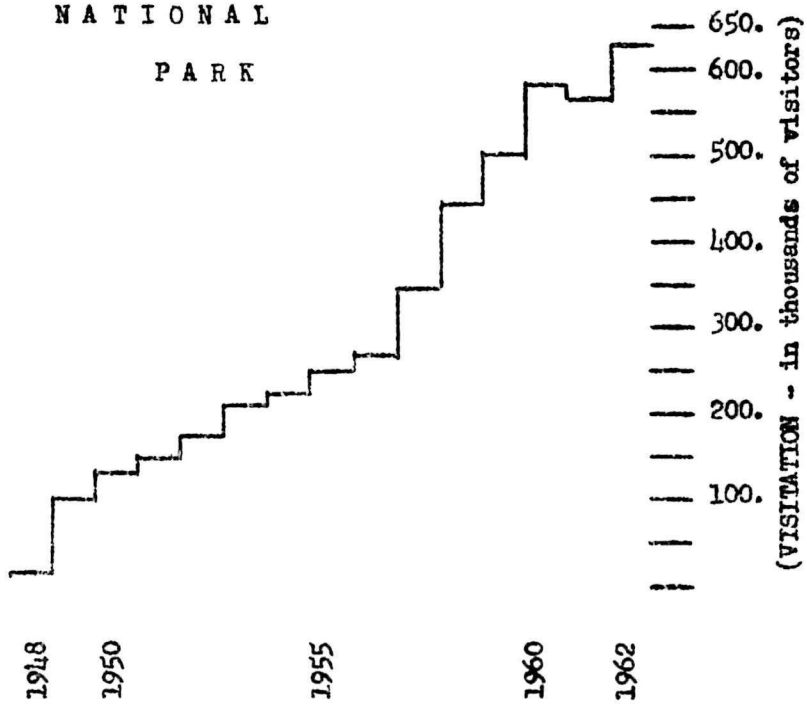
1960
1962

EVERGLADES

NATIONAL

PARK



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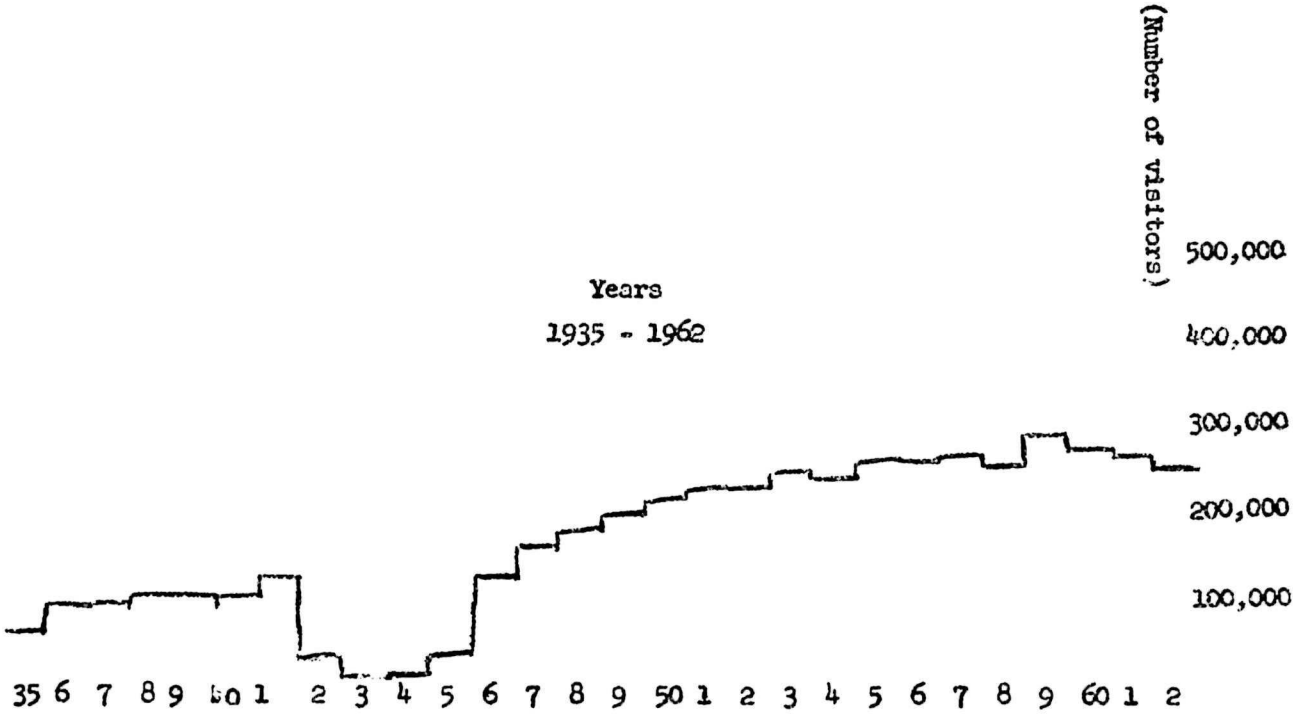

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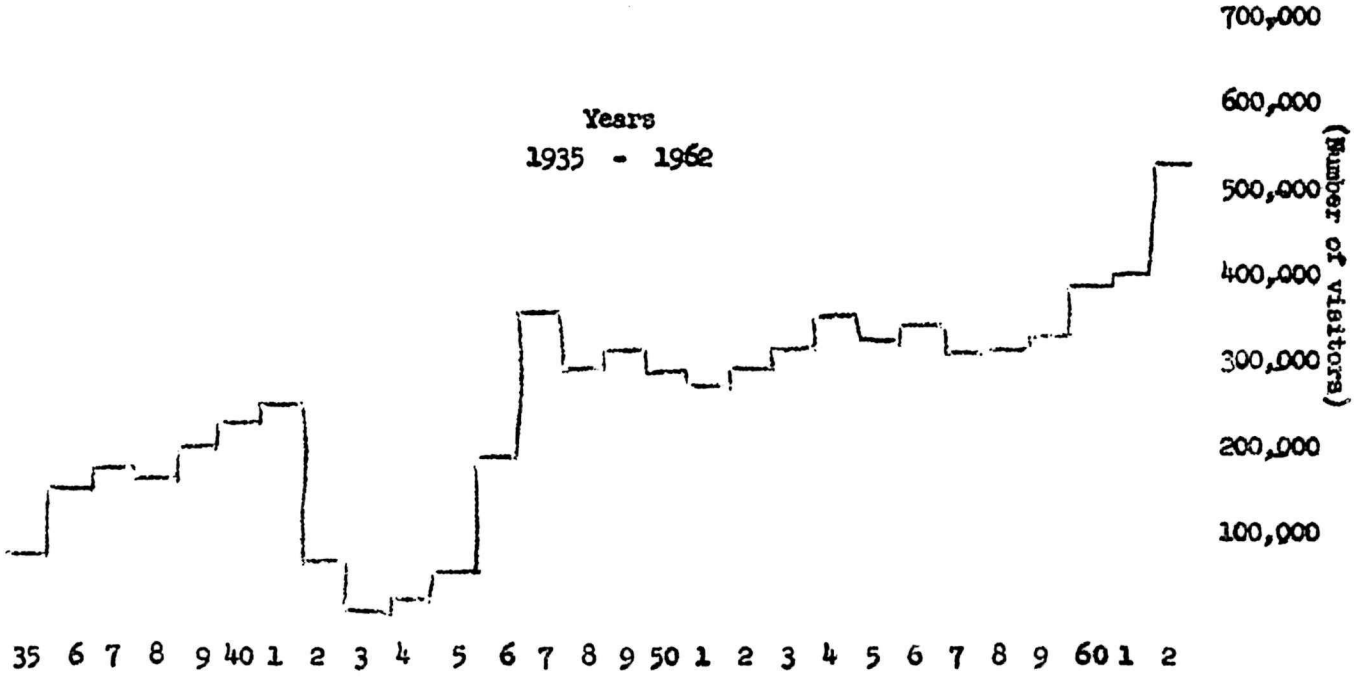
Years
1935 - 1962
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600,000
500,000
400,000
300,000
200,000
100,000
(Number of visitors)
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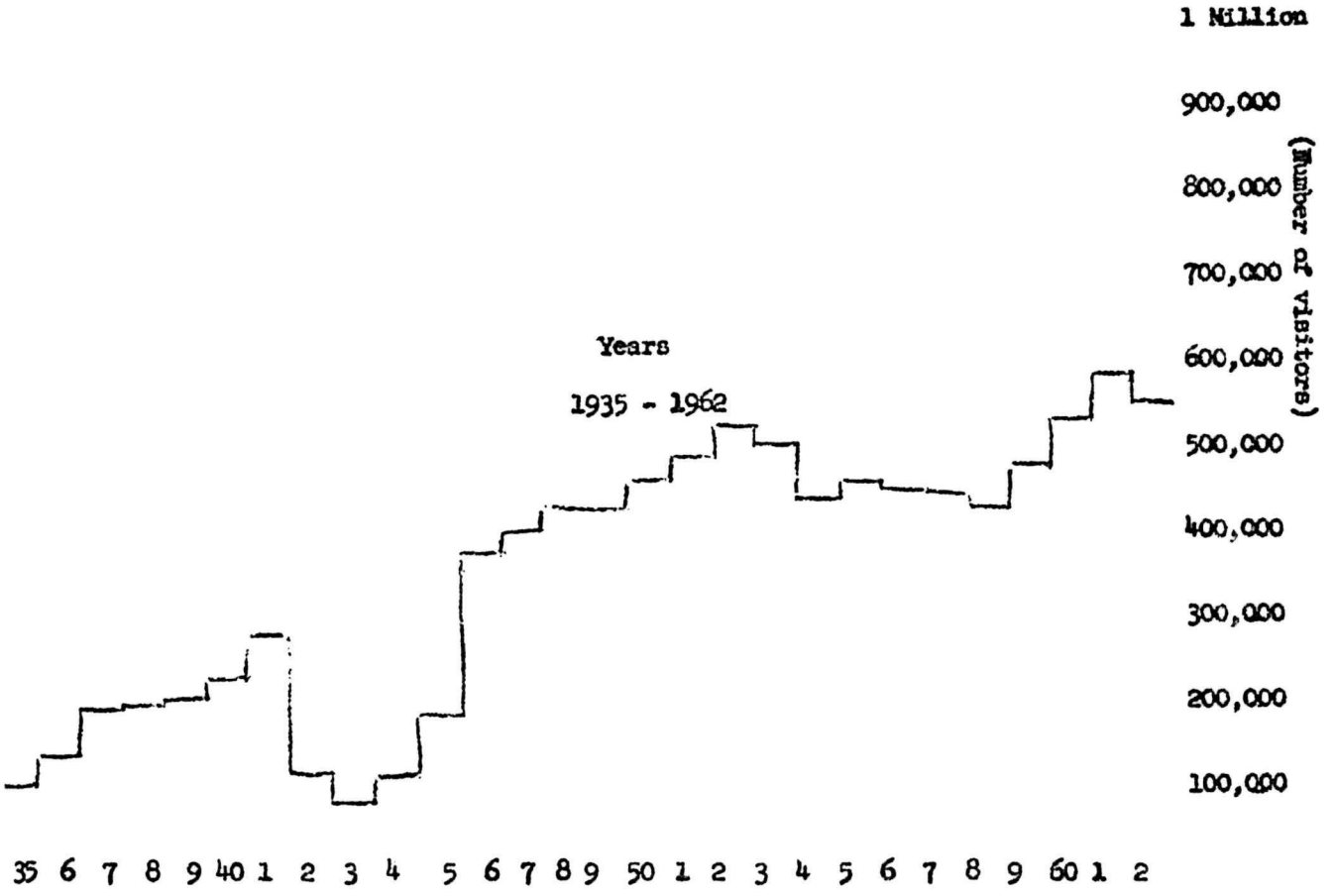
CARLSBAD


1 Million
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
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(Number of visitors)
Years
1935 - 1962
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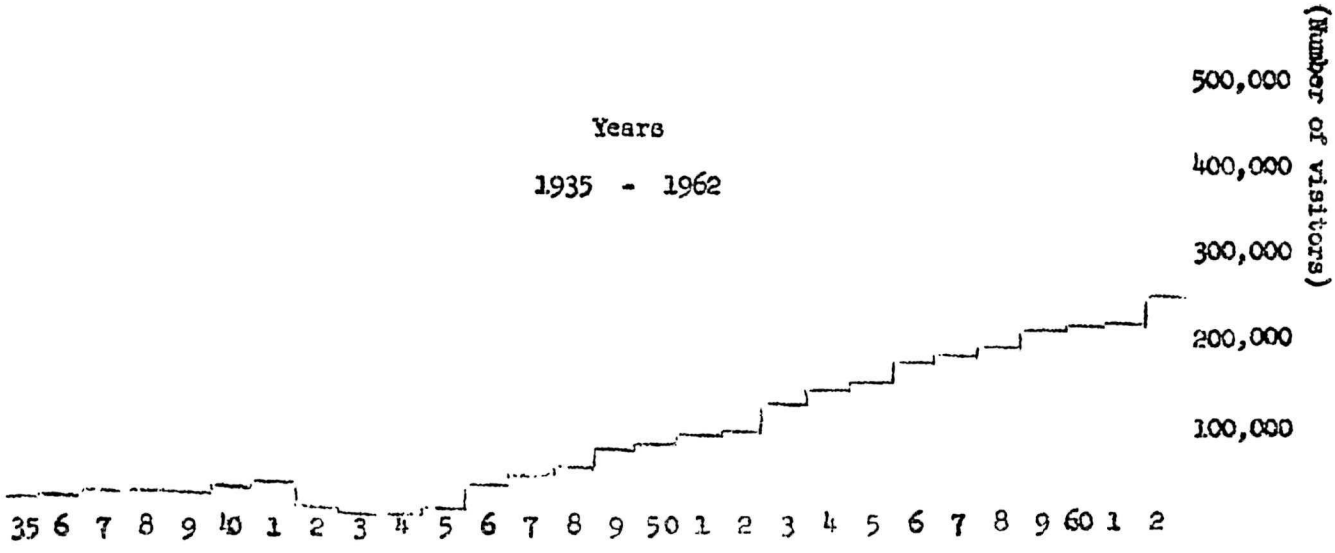
MESA VERDE


Years
1935 - 1962
500,000
400,000
300,000
200,000
100,000
(Number of visitors)
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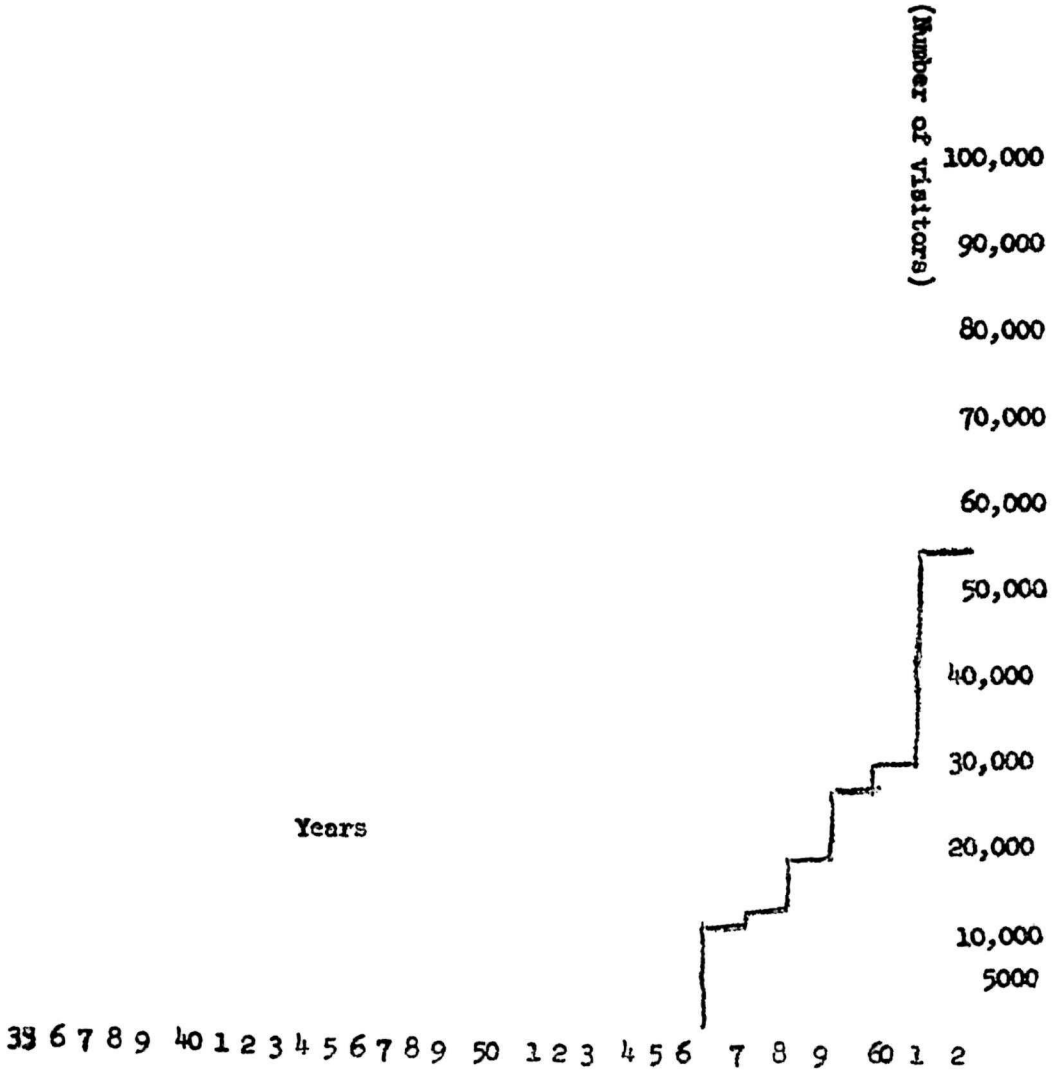
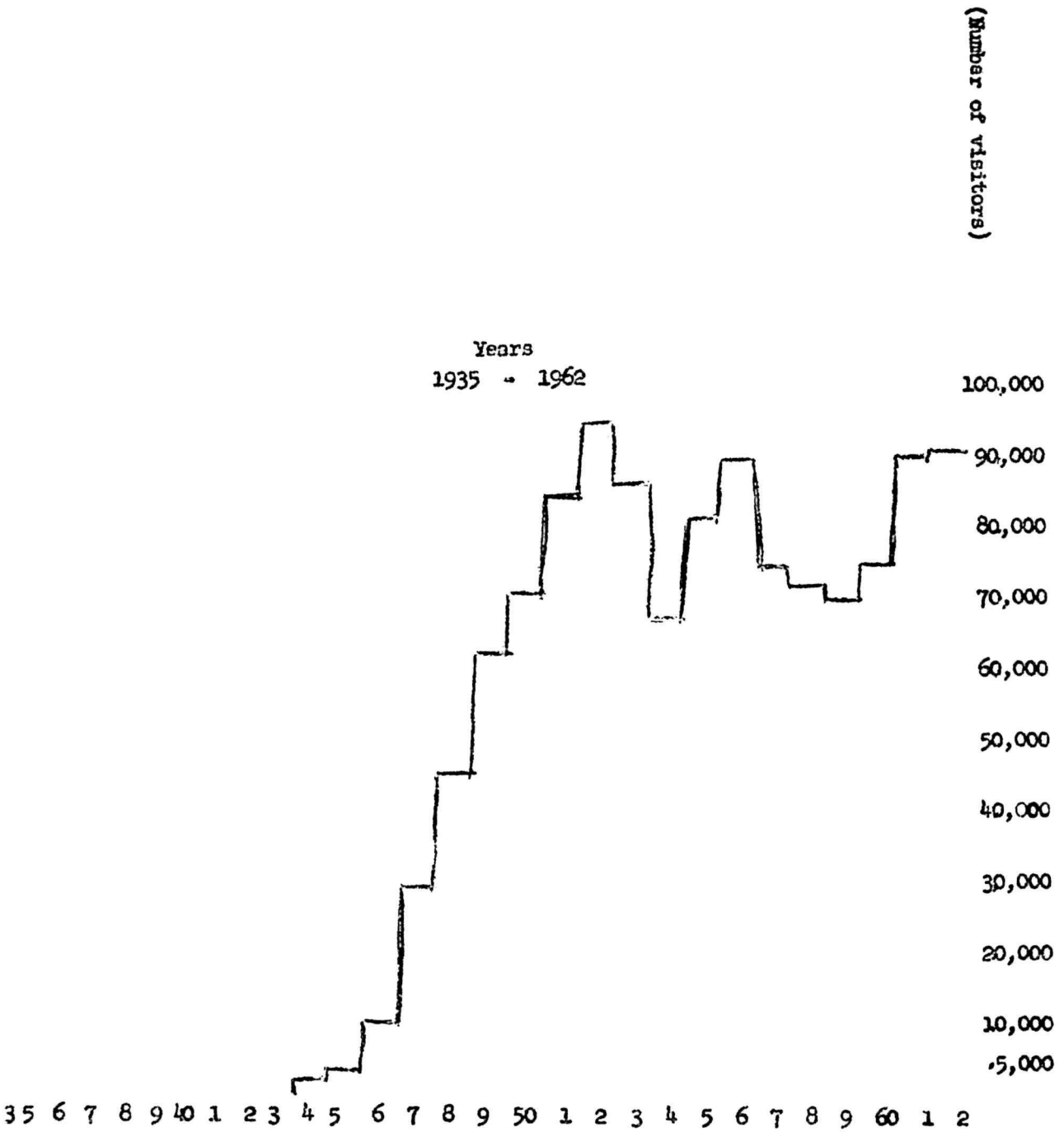
VIRGIN ISLANDS
V.I.



BIG BEND
TEXAS



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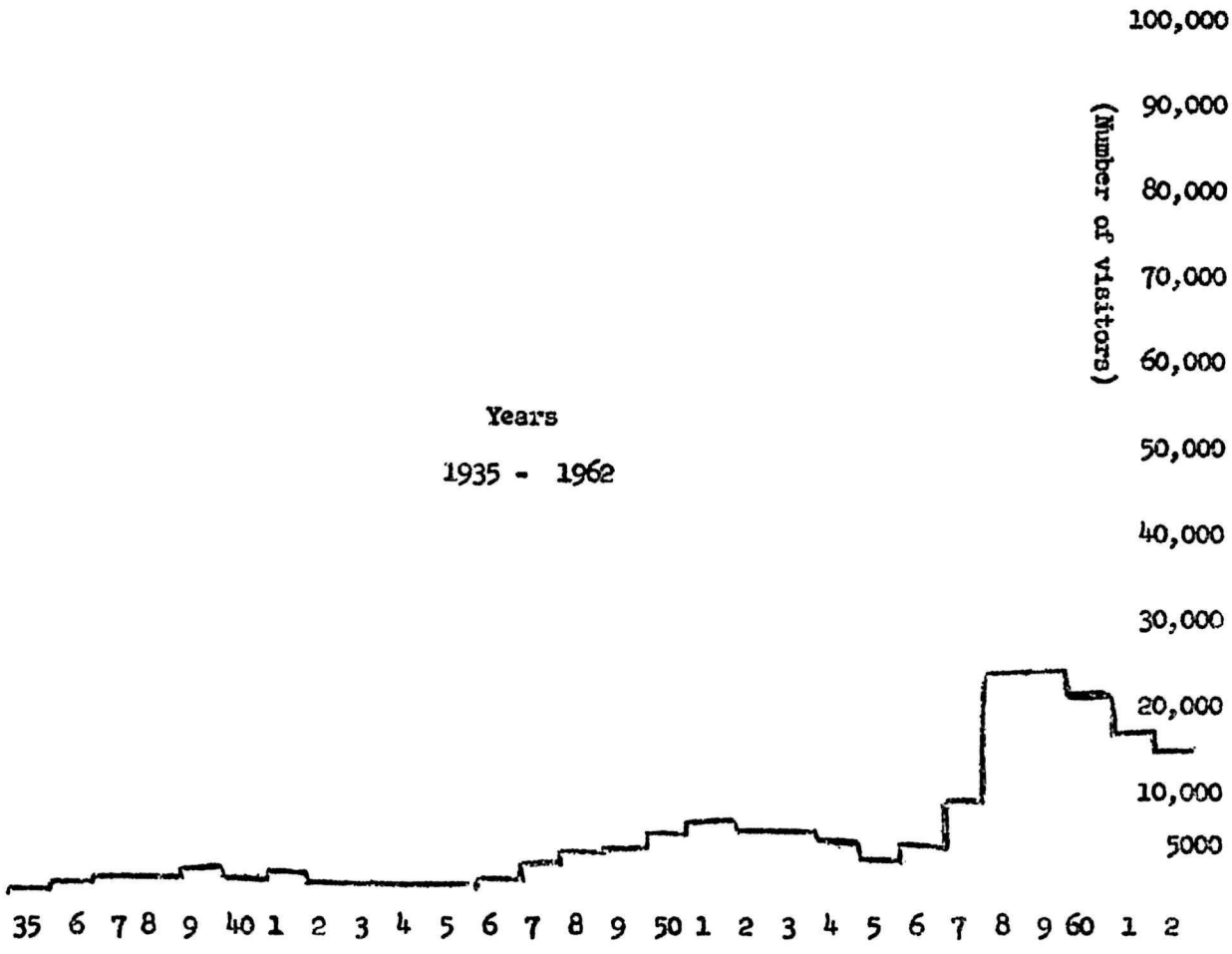
ALASKA



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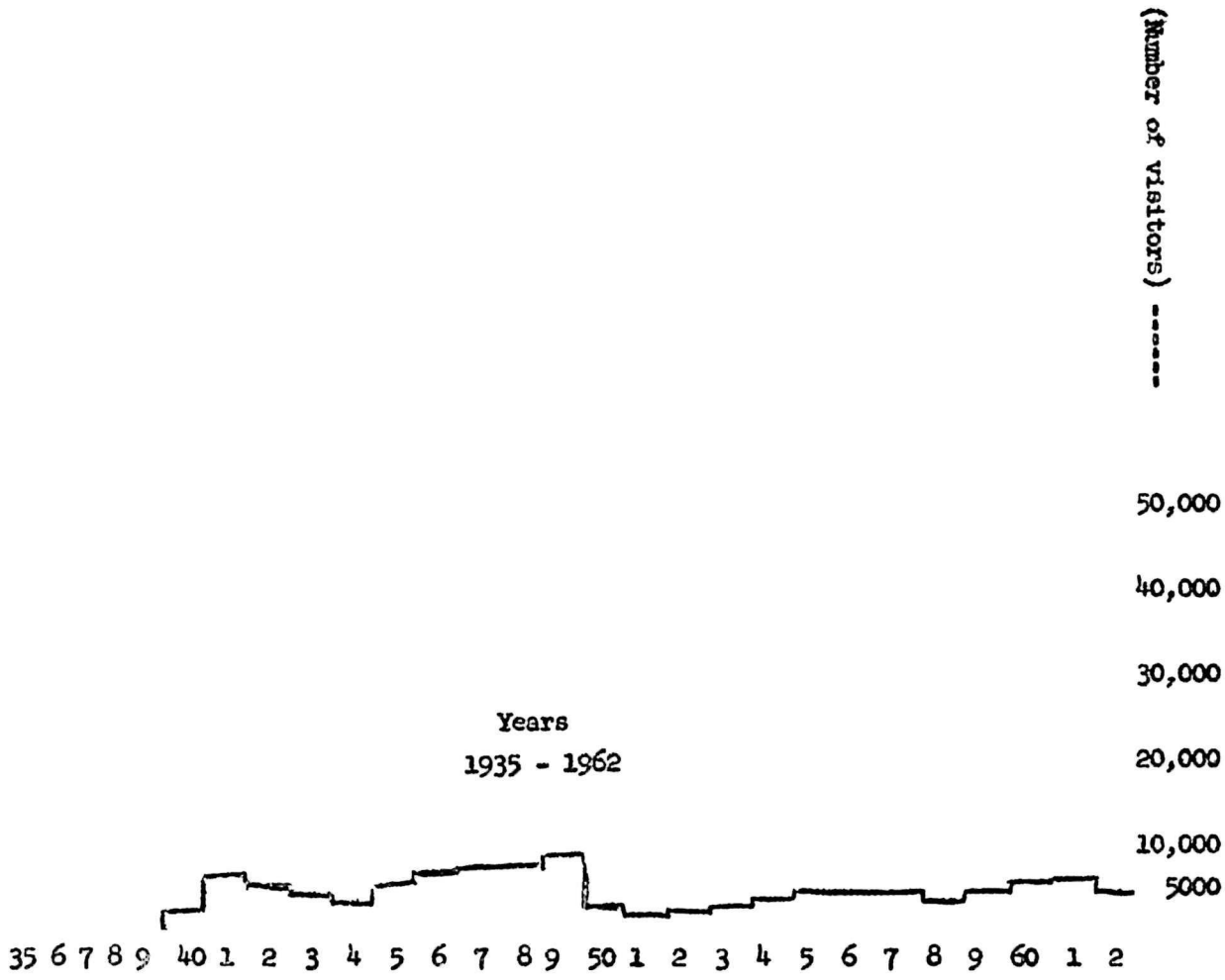

APPENDIX 5

LIST OF NATURAL SCIENCES PUBLICATIONS

A - List of National Park Service Natural History publications as they pertain to National Parks, published by Government or Natural History Associations, etc.

B - List of publications by National Park Service personnel (as individuals) in Professional Journals.

C - List of publications by Non-National Park Service personnel of Natural History investigations in National Parks.

PUBLISHED RESEARCH PERTAINING TO NATIONAL PARKS

C - Wheeler, George C. The Amphibians and Reptiles of the North Dakota Badlands. University of North Dakota; Theodore Roosevelt Nature and History Association, 1954.

C - Griggs, Robert F., George Washington University. The Vegetation of the Katmai District. Ecology, Vol. 17, No. 3, July 1936.

A - Potts, Merlin K. and Russell K. Grater. Mammals of Mount Rainier National Park. Mount Rainier Natural History Association, 1949.

C - White, John R. and Samuel J. Pusateri. Sequoia and Kings Canyon National Parks. Stanford University Press, 1949.

A - Evans, Willis A. and Orthello L. Wallis. Fishes of Yosemite National Park. Yosemite Nature Notes, Vol. XXIII, No. 1, January 1944.

A - Dixon, Joseph S. Birds and Mammals of Mount McKinley National Park Alaska. Fauna Series No. 3, 1938; GPO, Washington.

A - Murie, Adolph. Ecology of the Coyote in the Yellowstone. Fauna Series No. 4, 1940, Conservation Bulletin No. 4; GPO, Washington.

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C - Anderson, Sydney. Mammals of Mesa Verde National Park, Colorado. University of Kansas Publications, Vol. 14, No. 3, July 24, 1961. 67 pp.

A - Taylor, Walter P. and William T. Shaw. Mammals and Birds of Mount Rainier National Park. GPO, Washington, 1927.

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C - Hastings, James Rodney, University of Arizona and Stanley M. Alcorn, U.S. Department of Agriculture, Tucson. Physical Determinations of Growth and Age in the Giant Cactus. Journal of the Arizona Academy of Science, Vol. 2, No. 1, August 1961.

C - Alcorn, Stanley M. Natural History of the Saguaro. U.S. Dept. of Agriculture; 1959-1960 Colloquia Papers; The University of Arizona, Arid Lands Colloquia.

C - Hastings, James Rodney Precipitation and Saguaro Growth. University of Arizona; 1959-1960 Colloquia Papers; The University of Arizona, Arid Lands Colloquia.

A - Robertson, William B., Jr., and Joseph Curtis Moore. Checklist of Everglades National Park Birds.

C - Donnelly, Thomas Wallace, Princeton University. Geology of St. Thomas and St. John, Virgin Islands. (179 pp. multilithed; supported by a $3,000 grant from Jackson Hole Preserve, Inc., and the work was carried out under agreement with the NPS); 1959.

C - Ross, Clyde P. and Richard Rezak. The Rocks and Fossils of Glacier National Park: The Story of Their Origin and History. (GPO, Washington; Geological Survey Professional Paper 294-K.); 1959.

C - Rossman, Darwin L. Geology and Ore Deposits in the Reid Inlet Area, Glacier Bay, Alaska. (Geological Survey Bulletin 1058-B - U.S. G.P.O., 1958. iii, 33-59); 1959.

C - Geology of Geikie Inlet Area, Glacier Bay, Alaska. James F. Seitz. (Geological Survey Bulletin 1058-C - U.S.G.P.O., 1958. IV, 61-120 pp); 1959.

C - Benson, Norman G., Oliver B. Cope and Ross V. Bulkley. Fishery Management Studies on the Madison River System in Yellowstone National Park. (Fish and Wildlife Service, Special Scientific Report--Fisheries No. 307); 1959.

C - Kruse, Thomas E. Grayling of Grebe Lake, Yellowstone National Park, Wyoming. U.S. Fish and Wildlife Service (Fishery Bulletin 149); 1959.

C - Lennon, Robert E. and Phillip S. Parker. Applications of Salt in Electrofishing. (Fish and Wildlife Service, Special Scientific Report--Fisheries No. 280. From research in Shenandoah and Great Smoky Mountains National Parks); 1959.

C - Lennon, Robert E. The Electrical Resistivity Meter in Fishing Investigations. (Fish and Wildlife Service - Special Scientific Report--Fisheries No. 287. Product of cooperative research in Shenandoah and Great Smoky Mountains National Parks); 1959.

C - Altmann, Margaret. Group Dynamics in Wyoming Moose During the Rutting Season. Journal of Mammalogy, Vol. 40, No. 3, August 1959); 1959.

B - Cahalane, Victor H. A Biological Survey of Katmai National Monument. (Smithsonian Miscellaneous Collections, Vol. 138, No. 5); 1959.

C - Koford, Carl B. Prairie Dogs, Whitefaces, and Blue Grama. (The Wildlife Society: Wildlife Monographs No. 3, December 1958. Mr. Koford's studies included work at Wind Cave, Theodore Roosevelt and Devils Tower National Monument); 1959.

C - Woodbury, Angus M., et al. Ecological Studies of the Flora and Fauna in Glen Canyon. University of Utah Press: (Anthropological Papers No. 40); 1959.

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C - Ross, C.P. Geology of Western Slope, Glacier National Park. (U.S. Geological Survey Pro. Paper 296, "Geology of Glacier National Park and the Flathead Region. . ."); 1960.

C - Aller, A.L., Montana State University. Ecology of Cedar-Hemlock Forest. (Paper in Ecology 41:1, Jan 1960, "Composition of the Lake McDonald Forest, Glacier National Park"); 1960.

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C - Bailey, Vernon. Animal Life of the Carlsbad Cavern. U.S. Biological Survey, Monographs of the American Society of Mammalogists, No. 3; The Williams and Wilkins Company, Baltimore, 1928.

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C - Applegate, Elmer I. Plants of Crater Lake National Park. The American Midland Naturalist, Vol. 22, No. 2, September 1939.

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A - McDougall, W.B. and Herma A. Baggley. Plants of Yellowstone National Park. Second Edition, thoroughly revised and rewritten; Yellowstone Interpretive Series No. 8; Yellowstone Library and Museum Association, 1956.

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C - Gehlbach, Frederick R. and Robert Rush Miller. Fishes From Archaeological Sites in Northern New Mexico. The Southwestern Naturalist 6(1): pp. 2-8, June 10, 1961.

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A - Wright, George M. and Ben H. Thompson. Fauna of the National Parks of the United States - Wildlife Management in the National Parks. Fauna No. 2; July 1934. viii + 142 pp. Government Printing Office, Washington, D.C.

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C - White, William B., Penna. State Univ. Investigation of Sulfate and Clay Minerals. (Mammouth Cave) (Report to be presented at Denver AAAS meetings in June 1962.)

A - Craighead, F.C. and W.B. Robertson. Effects Hurricane "Donna." (Everglades)

C - Alcorn. Some Hosts of Erwinia Carnegieana. Plant Disease Reporter, August 15, 1961, Vol. 45, No. 8.

C - Hastings and Alcorn. Physical Determinations of Growth and Age in the Giant Cactus. Journal of the Arizona Academy of Science, August 1961, Vol. 2, No. 1.

C - Alcorn. Natural History of the Saguaro. Arid Lands Colloquia, University of Arizona, 1960-1961.

C - Wauer, Roland H. A Survey of the Birds of Death Valley. The Condor 64(3): pp. 220-233, May-June 1962.

C - Drs. Miller and Stebbins. Distribution of the Vertebrate Animals of Joshua Tree National Monument. (Continuing long-term project)

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C - Chapman, Carleton A. and Robert L. Rioux. Statistical Study of Topography, Sheeting, and Jointing in Granite, Acadia National Park, Maine. American Journal of Science, Vol. 256, February 1958.

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C - Tyson, Carroll and James Bond. Birds of Mt. Desert Island Acadia National Park, Maine. The Academy of Natural Sciences of Philadelphia, 1941.

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A - McDougall, W.B. and Omer E. Sperry. Plants of Big Bend National Park. U.S. Government Printing Office, Washington, 1951.

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CARLSBAD CAVERNS NATIONAL PARK

C - Horberg, Leland. Geomorphic History of the Carlsbad Caverns Area, New Mexico. The Journal of Geology, Vol. 57, No. 5, Sept. 1949.

C - Wetmore, Alexander. Bones of the Great Horned Owl from the Carlsbad Caverns. The Condor, Vol. XXXIII, Nov. 1931.

C - Baker, James K. The Manner and Efficiency of Raptor Depredations on Bats. Journal of the Cooper Ornithological Society, Vol. 64, No. 6, Nov.-Dec. 1962, pp. 500-503.

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C - Applegate, Elmer I. Plants of Crater Lake National Park. The American Midland Naturalist, Vol. 22, No. 2, Sept. 1939.

C - Diller, J.S. Geological History of Crater Lake. Government Printing Office, 1912.

C - Moore, Bernard N. Deposits of Possible Nuce Ardente Origin in the Crater Lake Region. The Journal of Geology, Vol. XLII, No. 4, May-June 1934.

B - Smith, Warren D. and Carl R. Swartzlow. Mount Mazama: Explosion Versus Collapse. Bulletin of the Geological Society of America, Vol. 47, 1936.

C - Williams, Howel. The Geology of Crater Lake National Park, Oregon. Book; Carnegie Institution of Washington Publication 540; 1942.

C - Farner, Donald S. The Birds of Crater Lake National Park. Book; University of Kansas Press, 1952.

C - Hasler, Arthur D. Fish Biology and Limnology of Crater Lake, Oregon. The Journal of Wildlife Management, Vol. 2, No. 3, July 1938.

C - Farner, Donald S. and James Kezer. Notes on the Amphibians and Reptiles of Crater Lake National Park. The American Midland Naturalist, Vol. 20, No. 2, October 1953.

C - Farner, Donald S. Notes on the Food Habits of the Salamanders of Crater Lake, Oregon. Copeia, No. 4, 1947.

C - Sternes, G.L. Climate of Crater Lake National Park. Published by Crater Lake Natural History Association; 1963. 14 pp.

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A - Dilley, Willard E. Preliminary Checklist of Trees of Everglades National Park. 1953 - Revised January 1957.

C - Schroeder, Melvin C. and Howard Klein. Geology of the Western Everglades Area, Southern Florida. Geological Survey, Circular 314, 1954.

C - Small, John K. Vegetation and Erosion on the Everglade Keys. The Scientific Monthly, Vol. XXX, January 1930.

C - Moore, Joseph Curtis. The Status of the Manatee in the Everglades National Park, with Notes on its Natural History. Journal of Mammalogy, Vol. 32, No. 1, February 1951.

C - Iversen, E.S. and D.C. Tabb. Subpopulations Based on Growth and Tagging Studies of Spotted Seatrout, Cynoscion nebulosus, in Florida. Copeia, No. 3, Sep. 28, 1962, pp. 544-548.

C - Tabb, Durbin C. and Albert C. Jones. Effect of Hurricane Donna on the Aquatic Fauna of North Florida Bay. Transactions of the American Fisheries Society, Vol. 91, No. 4, Oct. 1962, pp. 375-378.

C - Tabb, Durbin C., David L. Dubrow, Raymond B. Manning. The Ecology of Northern Florida Bay and Adjacent Estuaries. Florida State Board of Conservation Technical Series No. 39, November 1962. 81 pp.

B - Robertson, William B., Jr. Fire and Vegetation in the Everglades. Proceedings First Annual Tall Timbers Fire Ecology Conference, Mar. 1-2, 1962. Published by Tall Timbers Research Station, Tallahassee, Florida, pp. 67-80.

C - Tabb, Durbin C., David L. Dubrow and Andrew E. Jones. Studies on the Biology of the Pink Shrimp, Penaeus duorarum Burkenroad, in Everglades National Park, Florida. Florida State Board of Conservation, Technical Series No. 37, 32 pp. 1962.

C - Thomas, Lowell P. Distribution and Salinity Tolerance in the Amphiurid Brittlestar, Ophiophragmus Filograneus (Lyman, 1875). Bulletin of Marine Science of the Gulf and Caribbean, Vol. 11, No. 1, pp. 158-160, March 1961.

C - Manning, Raymond B. Some Growth Changes in the Stone Crab, Menippe Mercenaria (Say). Quart. Journ. Fla. Acad. Sci. 23(4): pp. 273-277, 1961.

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B - Robertson, William B., Jr. Birds 1962 Florida Region. Audubon Field Notes, Vol. 16, No. 5, pp. 468-473, October 1962.

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C - Schenk, Edward T. and Harry E. Wheeler. Cambrian Sequence in Western Grand Canyon, Arizona. The Journal of Geology, Vol. L, No. 7, October-November 1942.

B - McKee, Edwin D. Three Types of Cross-Lamination in Paleozoic Rocks of Northern Arizona. American Journal of Science, Vol. 238, November 1940.

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C - Bassler, R.S. A Supposed Jellyfish from the Pre-Cambrian of the Grand Canyon. Proceedings of the United States National Museum, 1941.

B - McKee, Edwin D. Grand Canyon Climates During the Age of Mammals. Museum Notes, Museum of Northern Arizona, Vol. 4, No. 10, April 1932.

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C - Luss, Richard Swann. Fossil Footprints from the Grand Canyon of the Colorado. American Journal of Science, Art. XXI, May 1918.

B - McKee, Edwin D. and Charles M. Bogert. The Amphibians and Reptiles of Grand Canyon National Park. Copeia, No. 4, December 1934.

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C - Fryxell, Fritiof M. The Geology of Jackson Hole. National Parks Magazine, January-March 1944.

C - Horberg, Leland, R.W. Edmund, and F.M. Fryxell. Geomorphic and Structural Relations of Tertiary Volcanics in the Northern Teton Range and Jackson Hole, Wyoming. The Journal of Geology, Vol. 63, No. 6, November 1955.

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C - Horberg, Leland and Fritiof Fryxell. Pre-Cambrian Metasediments in Grand Teton National Park, Wyoming. American Journal of Science, Vol. 240, June 1942.

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C - Fryxell, F.M. and Leland Horberg. Alpine Mudflows in Grand Teton National Park, Wyoming. Bulletin of the Geological Society of America, Vol. 54, 1943.

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C - Levi, Lorna R. and Herbert W. Levi. A Report on Land Snails of the Jackson Hole Region, Wyoming. The Nautilus, Vol. 65, No. 2, October 1951.

C - John, Kenneth R. Comparative Rates of Survival of Normal and Deformed Chub, Gila Atraria Girard, in Two Ocean Lake, Teton County, Wyoming. Proceedings of the Pennsylvania Academy of Science, Vol. XXXI, 1957.

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C - Lennon, Robert E. The Electrical Resistivity Meter in Fishery Investigations. January 1959.

C - Cain, Stanley A. Ecological Studies of Vegetation of the Great Smoky Mountains of North Carolina and Tennessee. The Botanical Gazette, Vol. XCI, No. 1, March 1931.

C - Healer, L.R. A Preliminary List of the Fungi of the Great Smoky Mountains National Park. Castanea, Jour. So. App. Bot. Club, Vol. II, 1937.

C - Cain, Stanley A. An Ecological Study of the Heath Balds of the Great Smoky Mountains. Butler University Botanical Studies, Vol. I, Paper No. 13, Dec. 1930.

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