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## Research Natural Areas: Contributors to Environmental Quality Programs<sup>1</sup>

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### ABSTRACT

Research programs on environmental quality will require studies of conditions in natural environments. Numerous protected natural ecosystems, known as Research Natural Areas, are available for such studies. The Research Natural Area concept and history and scope of present programs are outlined. These tracts are particularly valuable sites for baseline and monitoring programs, for ecosystem studies, as in situ preserves of gene pools, and for selected educational purposes.

Additional Index Words: ecosystem studies.

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The Nation's attention and energies are increasingly focused on the development and maintenance of a high quality environment. This concern with environmental quality is reflected in the creation of an Environmental Protection Agency and the President's Council on Environmental Quality, and passage of an Environmental Policy Act. The heightened interest and expanded environmental programs will require far more ecological data than are now available; consequently, rapid expansion of research in areas relating to the quality of man's environment is needed and planned in the next few years.

Much of the environmental research will involve identification and solution of problems in urban and agricultural environments. But baseline information on levels of pollutants and resource qualities in natural environments

must also be collected, and long-term changes in background levels of pollutants must be monitored. Collection of baseline information and much of the monitoring is best carried out on permanently protected sites, tracts which are not subject to the day-to-day, direct influences of man.

Over a period of years, a Federal system of protected natural ecosystems, known as Research Natural Areas, has been created in the United States. Although far from complete, this series of preserves encompasses many of the important terrestrial and aquatic ecosystems and is undergoing rapid expansion. It is our purpose to make these areas, as well as similar areas being protected by States, universities, and private institutions, known to scientists and administrators concerned with environmental quality. We will discuss the Research Natural Area concept, its historical development, and the scope of present programs, and suggest ways in which these areas can contribute to environmental quality programs.

## RESEARCH NATURAL AREAS

### Definition and Criteria for Selection and Management<sup>4</sup>

Land management terminology is far from standardized, and the term "natural area" has been variously applied to everything from rigorously protected, pristine research areas to parks and open space devoted to mass recreation. For this reason, the Federal Committee on Research Natural Areas has chosen a more restrictive name, Research Natural Areas, to focus attention on a specific type of area which it defines as follows: "A Research Natural Area consists of a naturally occurring physical or biological unit where natural conditions are maintained insofar as possible." Although regulations differ among Federal agencies, all have a common purpose and similar criteria for selection, protection, and management.

The purpose of Research Natural Areas is to preserve some natural feature(s), physical or biological or both, in as nearly an undisturbed state as possible for research and educational purposes. These can be important or unique terrestrial or aquatic ecosystems, geological formations, paleontological sites, or habitats of rare or endangered organisms.

Most tracts selected as Research Natural Areas are those where the features of interest are in as nearly an undisturbed or natural conditions as can be found. Research Natural Areas do not necessarily have to be pristine, however. Examples of many ecosystems which are essentially free of human influences are no longer available. Other kinds of ecosystems are dependent on recurrent disturbances, such as fire or flood, for their maintenance. Insofar as size is concerned, Research Natural Areas are, ideally, sufficiently large to protect the features of interest from significant unnatural influences. Accessibility and past history of research are also considered (7).

The overriding guideline for management is that natural

<sup>4</sup>In this section, we will rely very heavily upon the concepts and criteria underlying Research Natural Areas in the Federal program, the largest such natural area program. This program is coordinated through the interagency Federal Committee on Research Natural Areas, which will be discussed later.

processes are allowed to dominate, to the degree consistent with preservation of the natural features of interest. On many Research Natural Areas, protection from outside disturbances, such as logging, grazing, and fire, is the only management required. However, deliberate manipulation is allowed and may be necessary in order to maintain desired communities or organisms. Prescribed burning or grazing of some grassland types is an example. Use of Research Natural Areas for research or education must also be consistent with maintenance of natural processes and features. For this reason, only research which is non-destructive in character is generally allowed. Often research of this type can be complemented with manipulative research on adjacent experimental tracts.

The goal of the Federal Research Natural Area system can be described as preservation of the maximum diversity of natural systems. It can be likened to an information storage system, or library, of enormous complexity and incomparable significance. The information stored provides research and educational opportunities for the study of natural ecosystems or any of their parts. Like a library, Research Natural Areas are intended for use, but the user must not consume or damage the materials.

The standardization of terminology and regulation achieved among the Federal landholding agencies has not yet spread to other groups involved in preserving Research Natural Areas. As a result, such tracts may be labeled as natural area, nature center, research station, preserve, sanctuary, living museum, etc. This should not obscure the commonality of intent.

### Historical Perspective

In the United States, scientists working in the fields of natural resources and natural sciences have been the leaders in recognizing the need for natural areas for scientific purposes. In 1917, Victor E. Shelford, working through the Ecological Society of America, stated the need for inventorying the remnants of wild, natural America. His activities culminated in a listing of preserved and preservable areas in a *Naturalist's Guide to the Americas* (17), a major collaboration among 75 scientists which was supported by three scientific societies, the National Research Council, and the Forest Service. In 1922, W. W. Ashe (3) pointed out the utility of natural areas in developing silvicultural methods, and E. N. Munns played a key role in establishment of the first Research Natural Area on the Coronado National Forest in Arizona in 1927.

In ensuing years, interest in Research Natural Areas has continued and intensified, with the involvement of innumerable scientists, institutions, professional societies, and Government agencies. The preliminary inventory of nature sanctuaries in the United States and Canada, prepared by Kendeigh (10) in 1950 to succeed Shelford's guide, listed 691 sanctuaries, with 634 of these found in the United States. The most comprehensive study of natural areas undertaken in the United States was conducted and published by the American Association for the Advancement of Science in 1963 (1). This report called for an enlarged and better coordinated natural area program and listed 2,400 scientific papers based on research within natural areas.

The importance of Research Natural Areas has been recognized outside of the scientific community as well. The Public Land Law Review Commission recommended that Congress provide for creation and preservation of a natural area system for science and education (23). The National Environmental Policy Act of 1969 specifically mentions the need to "...preserve important historic, cultural, and natural aspects of our national heritage..." (20).

#### **Present and Proposed Programs**

Today the major resource managing agencies of the Federal government, more than 20 states, uncounted schools and universities, half a dozen professional societies, and several private foundations have programs for natural area preservation (9, 11, 24). The International Biological Program, through its Conservation of Ecosystems Section, is giving additional impetus to national and worldwide efforts to preserve examples of natural terrestrial and aquatic ecosystems of all types (13, 15, 22). Russia, Great Britain, and Canada have or are developing natural area systems.

#### **FEDERAL RESEARCH NATURAL AREA PROGRAM**

In the United States, the Federal landholding agencies are leaders in Research Natural Area programs. Their activities are coordinated through the interagency Federal Committee on Research Natural Areas; establishment of a system of preserves representing all significant natural ecosystems in the United States is the Committee's long-

range objective. The Federal Committee issued in 1968 a directory which provides a brief but useful guide to the extensive Federal system (21). The number of preserves has now increased from the 336 Research Natural Areas listed in the guide to over 500.

The Federal Committee is actively involved in an intensive program to greatly expand the number of Research Natural Areas in the next several years, in order to have at least a minimal system incorporating all major ecosystem types. Unfortunately, Federal lands are unevenly distributed, with the bulk lying in the western states and Alaska, and this is reflected in the distribution of existing Research Natural Areas (Fig. 1). Consequently, the Federal Research Natural Area system is most inadequate in areas where man's activities have been most intense, such as the eastern seaboard, Great Plains, and western valleys. Estuaries and aquatic ecosystems are also poorly represented. Because Federal lands are essentially unavailable in such areas, the Federal Committee is working closely with other natural area programs, particularly with the International Biological Program's Conservation of Ecosystems Section, to see that these deficiencies are corrected.

#### **OTHER PROGRAMS**

Many of the more than 20 States which have legally established natural area systems have modeled them after the system pioneered in Illinois. The following provisions are generally included. A commission oversees the system and is empowered to acquire, control, and maintain State

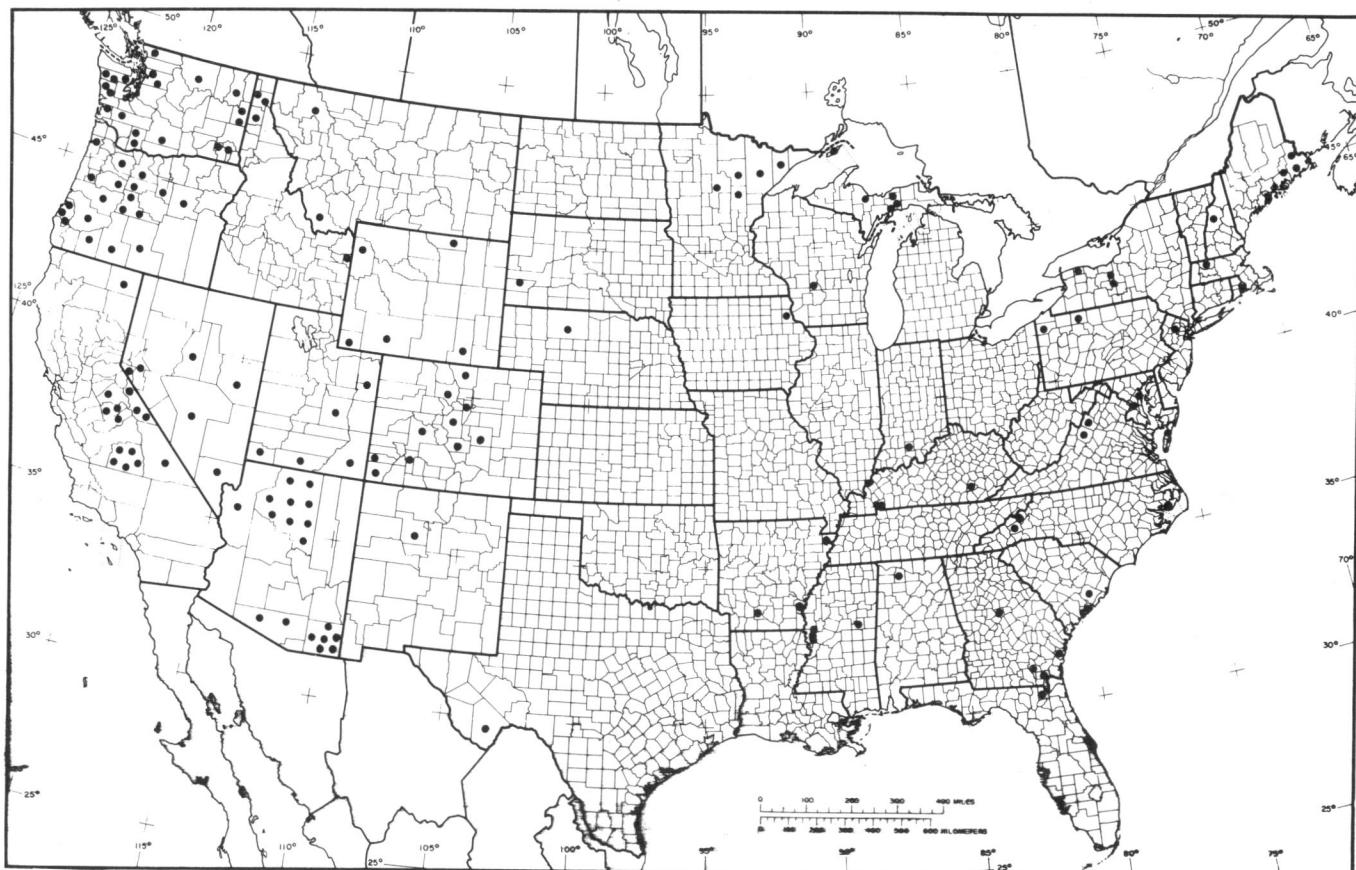


Fig. 1—Location of established Federal Research Natural Areas as of 1968; additional areas have been added since that time.

"nature preserves" and, in some instances, to assist non-governmental groups in similar endeavors. Most States accord designated natural areas special status, regardless of ownership, which extends certain legal protections such as a requirement for public hearings before any action can be taken which would adversely affect their natural area values. There is also a set of rules detailing the sorts of uses which are appropriate or which can be permitted on these areas. Generally, the definition of natural area is somewhat broader than that used by the Federal Committee, but there is often a specific subcategory which approximates a Research Natural Area. Scientific and educational uses are customarily recognized as primary in the case of the best and least disturbed preserves.

In the private sector, The Nature Conservancy is the only major organization which specifically focuses its attention on natural areas suitable for research. It has had a long and successful history of acquiring scientifically valuable areas. Due to the Conservancy's efforts, over 650 natural areas have been preserved in nearly every State and the West Indies. These areas total over 250,000 acres, mostly of considerable ecological significance. Although many of these areas have been transferred to other agencies, most are still under The Nature Conservancy's ownership and management. There is a current guide to their features and locations (12). All of these areas are available for research and educational use by universities and other appropriate groups of individuals, and many have been used in this fashion.

A fourth United States program which we will cite here is that of the Conservation of Ecosystems Section of the U. S. Committee for the International Biological Program (22). This section is conducting a nationwide inventory of protected, scientifically valuable natural areas on lands outside Federal ownership. The purpose is to assess how adequately various types of ecosystems are presently protected and managed in non-Federal natural areas and to assist in developing a cohesive national system. These efforts will synthesize the information which is presently widely scattered, erratic in quality, and often unintelligible.

There are many other organizations or institutions playing significant roles in the natural areas movement. Outstanding among these are several professional societies such as the Society of American Foresters, which has had a formal program since 1947, and the Society for Range Management, which sponsors a program of "Range Reference Areas" (11). These groups have encouraged establishment of areas, developed criteria for their management and use, and periodically published listings of natural areas. Other organizations are involved in local efforts or contribute to natural area activities as a part of broader programs.

There is obviously a need for coordination and mutual assistance between the welter of groups and agencies involved in preservation of natural ecosystems in the United States. There are indications that Congress may initiate a program which could lead to a national system of natural areas, as has been proposed by many scientists (5) and the Public Land Law Review Commission (23). In the meantime, scientists interested in using Research Natural Areas or their non-Federal equivalents will have to look to

several sources for information on their availability and use.

## UTILITY OF RESEARCH NATURAL AREAS IN ENVIRONMENTAL QUALITY PROGRAMS

Two key features make Research Natural Areas invaluable in environmental quality programs. First, *they provide examples of ecosystems in essentially natural condition*. Measurements and studies made in natural systems are essential parts of environmental quality programs, and the necessary sampling sites are increasingly difficult to find. Second, *Research Natural Areas are permanently protected by regulation and, therefore, suitable for long-term studies*. On unprotected areas, there is always a high risk of disruptions which can destroy many years of work. The value of sites committed to research and protected from outside influences cannot be overestimated, even in short-term research programs.

It appears to us that Research Natural Areas can make major contributions to environmental quality programs in four ways: (i) by providing sites for collection of baseline data and for long-term monitoring of various aspects of environmental quality; (ii) by providing sites for studies of the structure and function of natural ecosystems; (iii) by preserving gene pools of natural organisms, including those that are rare or endangered; and (iv) by serving selected functions in educational and training programs. We will elaborate on each of these functions in following sections.

### Baseline and Monitoring Sites

Research Natural Areas allow us to examine parameters of environmental quality in an undisturbed system, and compare them with those encountered in systems which have been affected by man. Such parameters can be measured directly or indirectly by the use of biological indicators. Necessary baseline data may be collected on Research Natural Areas as part of a monitoring program involving repeated samplings or as part of a comparison of environmental conditions in untreated (or natural) areas and in areas directly influenced by man—i.e., as controls in comparative studies. The latter approach may involve essentially "instantaneous" comparison or may be so long-term as to resemble a monitoring program.

### MONITORING

Most environmental quality monitoring programs will be directed toward observing conditions and trends and insuring compliance with laws where human beings live, work, and recreate, rather than within relatively undisturbed ecosystems. The U. S. water quality monitoring network is an example of this type; its primary purpose is measurement of various parameters of water quality within the Nation's rivers and streams, not the determination of natural baselines (16).

It is essential to environmental quality programs, however, that changes in background levels of various materials and pollutants be observed throughout the biosphere. Examples of such substances include atmospheric CO<sub>2</sub>, radionuclides, pesticides, and heavy metals in soil, water,

and organisms. Research Natural Areas are eminently suited for long-term monitoring of background levels of many such materials. Although the direct impact of man in such areas is minimal, Research Natural Areas are all affected to some degree by human activities. For example, various pollutants will be present at levels which reflect human activities throughout the world, as well as in adjacent areas. Some tracts, particularly those which are larger and more remote, are especially suited to monitoring general regional or continent-wide background levels. Others are particularly suited to observing more localized trends in pollutant levels.

Monitoring programs utilizing Research Natural Areas will vary in their purpose and, consequently, in their scope and methods. Some of the monitoring can be relatively straightforward—i.e., chemical or physical measurements aimed at specific problems such as novel molecules in the environment or changes in concentrations of natural molecules which are increasing or decreasing at marked rates. Samples of soil, water, or plant materials collected from permanent locations can be analyzed directly for data on concentrations of specific heavy metals (e.g., mercury, lead, arsenic, or copper), radionuclides, or pesticides. Fatty tissues from widespread animals, such as the deer mouse (*Peromyscus maniculatus*) can be periodically collected and analyzed for pesticides and pesticide derivatives. In comprehensive monitoring programs, it might be desirable to collect and preserve small samples of soil or organic materials for future reference, i.e., analysis at some later date for materials not presently of interest or perhaps even known. Such "voucher" collections can assist in evaluating the duration and seriousness of recently-recognized pollutants such as mercury and polychlorinated biphenols (PCB's).

Of equal importance are monitoring activities involving biological measurements of changes in numbers, distribution, or status of certain kinds of organisms. Jenkins has elaborated in detail the types of organisms and measurements presently known as useful for indicating changes in environmental conditions, including concentrations of man-produced contaminants. (Dale W. Jenkins. 1971. Biological monitoring of the global chemical environment. Unpublished Report, Smithsonian Institution. 54 p.) He recognizes "sentinel, bioassay, indicator, and bioaccumulator organisms," each group being useful in specific ways for assessing effects of those environmental contaminants which cannot be monitored as well by physical or chemical methods alone. A major advantage of the biological approach is that it utilizes the ability of organisms to integrate effects of the various environmental factors and thus avoids some difficult problems in relating simple chemical or physical measurements to biological effects.

Specific monitoring activities on Research Natural Areas might involve periodic observations of population levels or reproductive success in avian populations, a group of organisms long known for their sensitivity to various pesticides. Observed changes in the composition of the plant component of ecosystems may also reflect changes in background levels of pollutants; conifers, in particular, and higher plants in general, react to low levels of ozone and SO<sub>2</sub>. The epiphyte communities, which grow on branches, stems, and leaves of higher plants, are

also known to be particularly sensitive to some types of air pollution (8, 18).

Because some Research Natural Areas are situated in agricultural or urban areas, they will more clearly reflect local trends in environmental quality than region- or continent-wide trends. Such areas are also useful in monitoring programs. For example, the Cogswell-Foster Reserve of The Nature Conservancy (12) is located near the site of a new paper mill. The various communities of epiphytic mosses, lichens, and liverworts found on the oaks (*Quercus*) and ashes (*Fraxinus*) at this site were observed and described, and chemical analyses of various species were carried out before the mill began operation. Trends in air quality should be reflected in changes in both chemical and community composition.

The kinds of studies outlined here will provide necessary background or baseline data on environmental parameters and indications of trends under essentially natural conditions. However, there are some limitations. Foremost is the necessity of collecting sufficient data over long enough time spans so that the amount and nature of the variation inherent in natural systems in the absence of interference can be identified. In interpreting long-term changes in populations or community composition, it is necessary to understand and take account of those due to natural successional processes. These must be distinguished from changes which are responses to alterations in environmental quality or the consequence of activities on adjacent landscapes.

#### NATURAL CONTROLS

Monitoring, as used in this article, implies an intent of observing change in some aspect of an ecosystem over a period of time. However, Research Natural Areas may also be used in short-term studies relating to environmental quality. Of course, some of these "one-time" measurements may, if properly collected, be repeated at some future date and provide evidence of trends.

The most common short-term use of Research Natural Areas in environmental quality programs will be as a natural control in comparisons with other systems which have been disturbed. For example, Research Natural Areas can provide the natural controls in determining the effects of logging, roadbuilding, or grazing on suspended sediment, bedload, nutrient loads, and temperatures in streams. It has been suggested that Research Natural Areas be specifically established as part of large public works or similar projects. Their effectiveness as experimental controls would be enhanced by choosing tracts having maximum similarity to the areas to be altered, and the necessary monitoring could be borne as a cost of the project; environmental impact statements and predictions could be better evaluated as well. Such an approach seems to us to have considerable promise in implementing the Nation's environmental quality policies.

#### Sites for Integrated Ecosystem Research Programs

Rational decision on matters involving environmental quality, at all levels, is dependent upon a thorough understanding of the structure and functioning of natural ecosystems. As Snow (19) has stated:

One of the most formidable obstacles to the development of ecostrategies is the absence of sufficient quantitative data and theoretical understanding of the natural environment. Yet, without adequate knowledge of the structure and resiliency of the natural ecosystems that support life, it is hard to assess the impact of technological stresses. Particularly crucial is whether nature can find new points of stability under the stresses imposed by man, or whether modern technology must itself give way. Unraveling the complex aspects of this enormous system of trade-offs is, however difficult, one of the most essential tasks that modern man must undertake.

Many of our environmental problems have stemmed from unexpected side effects of man's activities. Development of the ability to predict or anticipate the effects of man's activities beforehand is the essential requirement. Research of the type needed has begun only within the last few years; it is exemplified by the Biome programs within the U. S. International Biological Program's Analysis of Ecosystems Activities (22).

Research Natural Areas provide sites suitable for integrated research programs on natural ecosystems. Because these areas are permanently protected, the body of knowledge accumulated from them in such studies takes on special meaning. For several reasons there are few natural areas being used for such studies at present: the earliest studies are, in many respects, experimental and often involve destructive sampling; the large numbers of scientists and masses of equipment involved also can have considerable detrimental impact on natural conditions, particularly on the more fragile Research Natural Areas.

However, as early programs reach fruition with the development of ecosystem and subsystem models, there will be more and more opportunity and need to use natural areas for validation or testing of these models. In many cases the natural areas will be used to examine ecosystem model components in systems different from those initially studied. The use of two pristine tracts by the Coniferous Forest Biome (a component of the U. S. International Biological Program) in the development and validation of their ecosystem models, exemplifies their potential. On one of these (the Wildcat Mountain Research Natural Area) selected system compartments, material transfers, and environmental variables are being non-destructively studied as part of a characterization of coniferous forest responses across a broad environmental field. On the other, a subalpine lake basin not formally recognized as a natural area, the material and energy transfers between the terrestrial and aquatic subsystems are being quantified and modeled.

#### Gene Pools

Research Natural Areas serve *in situ* as reservoirs for two distinct but related kinds of gene pools. First, some serve as preserves of rare or endangered species, and second, most act as gene pools for ordinary wild or unaltered organisms.

Any species of organism may be potentially important to man. There are numerous examples of species once believed useless, but later found to have exceptional im-

portance in solving human problems. California's citrus industry depends on rootstocks from a hybrid variety once considered worthless, but which later proved to have the only obtainable resistance to a pathogenic root rot. The *Cactoblastis* moth was the previously unvalued agent for controlling the outbreak of pricklypear cactus in Australia. Only recently a primitive corn was discovered in South America which may be utilized to improve the nutritional value of present hybrid corns (2).

There are equally pragmatic reasons for preserving abundant germ plasm of organisms not necessarily in danger of extinction, and natural areas provide a practical means for in-place preservation of genetic diversity. The needs are particularly apparent in the case of species which are extensively cultivated or are ancestral stock of domestic cultivars. Even laymen intuitively recognize the dangers of very narrow genetic bases for our domestic animals and crops. Agronomists fret over the breeding system that gave us the male-sterile corn so recently attacked by the southern corn blight; foresters worry over the dangers of pine and poplar monocultures; wheat farmers hope geneticists can keep one step ahead of rapidly mutating strains of wheat rust.

Obviously, we will have future use or need of the genetic diversity preserved within Research Natural Areas. Extensive use of the Harvey Monroe Hall Research Natural Area has already been made for basic genecological studies of climate races of several plant groups (6). More such uses are appropriate and can be expected in the future. Research Natural Areas may provide the genetic stock needed as geneticists search for desirable traits among the ancestral species of highly bred domesticated plants and animals.

#### Educational Function of Research Natural Areas

Research Natural Areas serve as educational or training facilities in environmental quality. Central to the theme of educational utility is the need to train future generations of natural scientists, biologists, and environmentalists to carry on the research activities which our society increasingly requires. For this reason, observational or nondestructive research activities associated with advanced educational programs in natural sciences would be encouraged within Research Natural Areas.

Furthermore, students and practitioners in the natural sciences professions need to see examples of natural environments and communities and know first hand the initial conditions and changes, both beneficial and detrimental, which have been wrought in our environment. Generations of scientists and land managers now owe their appreciation and understanding of natural ecosystems, their complex interrelationships and their diversity, to the vital educational resources represented in natural areas.

Research Natural Areas also stimulate public appreciation of natural phenomena. Although parts of natural areas may be closed to the public, many other parts are open for nondestructive activities such as hiking. Simple interpretive displays, signs, or printed materials are sometimes provided. These opportunities to utilize natural areas in public informational programs should not be underestimated.

## INTRINSIC CONTRIBUTION OF RESEARCH NATURAL AREAS TO ENVIRONMENTAL QUALITY

Although we have emphasized the utilitarian values of Research Natural Areas, it is important to recognize that these tracts also contribute to environmental quality simply by existing. Natural areas may act as ecological buffers, helping sustain and modulate the biosphere and the environments within which man lives. Some Research Natural Areas are important hydrologically, contributing to flood control or aquifer recharge. Odum (14) has suggested a certain proportion of such "protective" areas is essential to maintenance of a stable urban-industrial environment. Although Research Natural Areas cover a relatively small acreage, they may be disproportionately important because of the maximal degree to which they are protected.

Aside from practical uses, the organisms preserved within Research Natural Areas are important to the aesthetic and psychological needs of man. Our society is increasingly concerned with preserving the rare and endangered organism; what is rare is treasured, and we realize that the wanton destruction of a species is an act of extreme arrogance. Our attempts at preservation may have elements of altruism, curiosity, or nostalgia. In any case, humans do have significant emotional links to wildlife, and activities which contribute to the maintenance of biological diversity also contribute to the quality of our lives.

Perhaps the intrinsic contributions of Research Natural Areas to environmental quality can be summarized in the context of the National Environmental Policy Act of 1969. This act states that our policy is to "...preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choices" (20).

Research Natural Areas make major contributions to such lofty goals, while at the same time serving both life and natural scientists as living laboratories. We have stressed the numerous and diverse uses to which such areas have and can be put. Other unforeseen uses will no doubt develop in the future. So, while today's Research Natural Areas are underutilized, we actively seek to enlarge the program and to fill in gaps. We seek as well to relate existing natural areas programs one to another; such coordination may lead to a national system of Research Natural Areas. However they are structured or organized, Research Natural Areas will be invaluable for the collection of ecological baseline data essential in any effort to improve the quality of man's environment.

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