—NSF.

Microbiologists hunting answers to the riddle: How does life survive in Antarctic cold?

THE FRAGILE BREATH OF LIFE: HOW TO KEEP IT GOING

BY STUDYING NATURE WHOLE

By LELAND J. HAWORTH

THE New Yorker reading with furrowed brow about the water shortage or the Californian expressing uneasy concern about smog may detect little relevance between these immediate problems and the work of a biologist on some faraway mountaintop. Yet the relationship exists, however indirectly and tangentially. Indeed, the findings of environmental biologists may have an important bearing on creating the conditions necessary for man's long-range survival.

Here in the mid-1960s, man's relationships with his environment have become a matter of greater concern than ever before. Water and air pollution are compelling examples. And biologists, geographers, historians, and sociologists point to a growing and convincing assembly of data to indicate that the earth's frontier of its untapped natural resources—renewable and nonrenewable—is rapidly disappearing under the combined impact of population increases and human demands for a greater share of what is available.

Dr. Kenneth Boulding, economist at the University of Michigan, has likened the earth to a manned spaceship traveling through space and time with a limited store of resources on board and receiving a circumscribed input of energy from the sun. The permissible rate of consumption for maintaining life of the occupants of a spaceship obviously cannot exceed the regenerative capacity of the ship. Similarly, if man is to endure on the larger spaceship called earth, he must one day achieve a more rational kind of steady state in which pollution is matched by purification, and consumption of resources is matched by replenishment of resources.

Man must therefore perfect his ability to know in advance the effects of his activities. Only in this way can he provide himself with the options necessary to adjust his ecological system. As the environment becomes less and less able to meet the increasing demands put upon it, the ability to forecast becomes an increasingly high priority matter in the natural, behavioral, social, economic, and political sciences.

In such a setting it is understandable that the word "ecology" has in the past few years been carried from the cluttered desks of a small number of scientists into the magazines, newspapers, and daily speech of the public. Ecology has its roots in the biological sciences, where environmentally oriented biologists have been seeking answers to questions dealing with man's physical surroundings.

How is it possible, for example, for so many biological species to share the same bit of real estate? What regulates natural population densities? Why do old and complex biological communities seem to remain stable and use so efficiently the resources of energy and materials available to them? Why do some of these communities become so unstable when disturbed even slightly by man, while others do not? What useful lessons can be learned from paleoecology, the history of past groupings of biological organisms as reconstituted from fossil remains, and what effect, if any, did human interference have on the recorded changes?

The urgency surrounding many of our current environmental problems has generated active interest at the highest

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levels of government. As a result, the National Science Foundation, holding primary responsibility in the government for support of basic scientific research, has provided support for many of the nation's scientists in seeking answers to these and related questions.

For example, interdisciplinary research is being done with NSF assistance at biological field stations for the study of wild life in its natural habitat. One of these is the unique University of Oklahoma Biological Station on Lake Texoma, one of the largest man-made reservoirs in the United States, with more than 700 miles of shore line.

Lake Texoma provides many unusual opportunities for biological experiment. Because of deposition of sediments and encroachment of plant life upon the shores and into the bottom areas, the anticipated life span of the lake is relatively short—seventy-five to 100 years. Thus it will be possible to study comparatively rapid changes in biological systems. At the present time the situation provides research and study opportunities to about 125 scientists each year in such areas as taxonomy, ecology, natural history, behavior, and those phases of evolution, morphology, and physiology that require extensive and intensive study of organisms in their wild state.

Two other specialized field stations also deserve mention.

The beautiful gorges of the southeastern Blue Ridge escarpment near Highlands, North Carolina, contain biologically diverse plant and animal populations. The gorges constitute an altitudinal transition between the flora and fauna of the piedmont and coastal plain provinces, and those of mountainous areas in the southeastern United States. For these reasons the Highlands Biological Station is conducting a long-term study of the ecology of the escarpment gorges.

The Devon Island Expedition, initiated in August 1960, is similar in that it represents a coordinated multidisciplinary approach to the study of a single key geographical area. The intent of this study is to understand a single area—in the archipelago bordering on Baffin Bay—in depth and thereby to develop broader insights into the dynamics of Arctic regions, as well as to advance oceanographic science generally.

In contrast to these wild state studies, NSF has assisted in the support of a limited number of controlled-environment facilities. The biotron of the University of Wisconsin, now nearing completion, will be the largest and most sophisticated such center in the world. Its controlled spaces include extensive animal and plant rooms, a wind tunnel, controlled humidity rooms, a high-intensity light room, and many others.

The types of problems to be investigated cover a wide range of physiological, ecological, pathological, climatological, and other interests. Among those under consideration are the relation of environmental factors to the biosynthesis and activity of specific hormones that regulate size, form, and reproduction in animals and plants; the role of the environment in determining patterns and other aspects of behavior; and the biochemical and physiological results of exposure of organisms to air pollutants.

A two-unit regional facility of the controlled-environment type is the phytotron now under construction on the campuses of North Carolina State University at Raleigh and Duke University at Durham. The unit at Raleigh will provide specially quarantined areas for maximum protection against cross-contamination by pathogens or insect pests. The unit at Duke will accommodate numerous small rooms, high light intensities, and high-ceiling chambers to accommodate trees and tall plants like maize.

Tagging turtles in advance of transatlantic migration.

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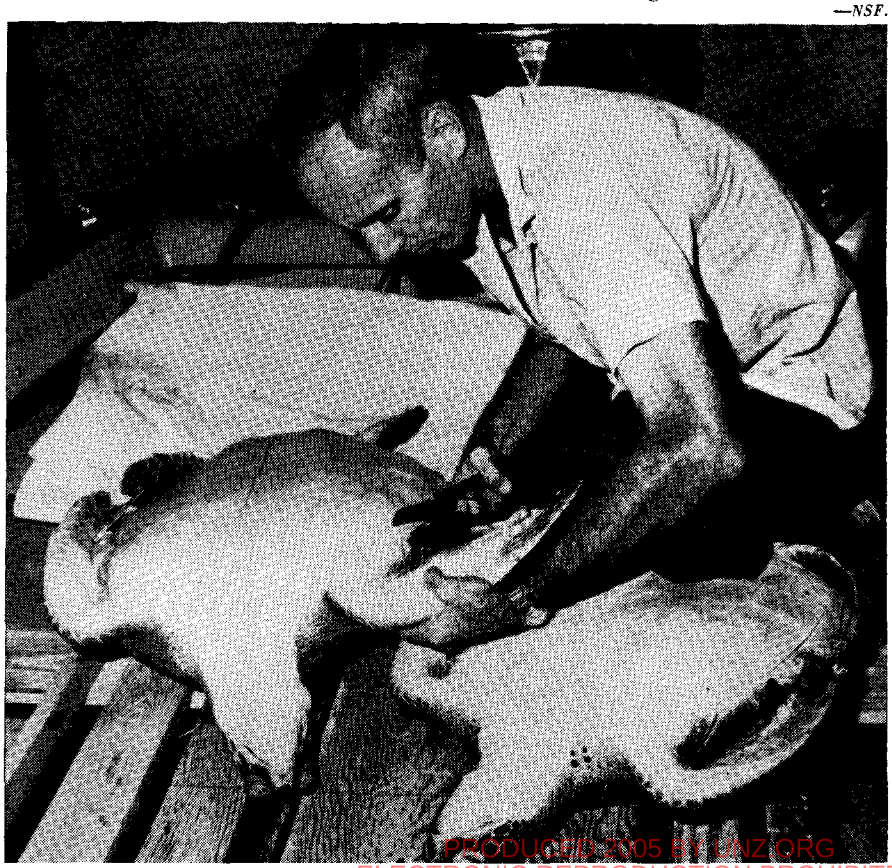


NSF conceives of environmental biology as a broad field, covering or impinging upon many related areas of biological interest. In marine biology, for instance, many exciting research projects are in progress.

For example, the work of Dr. Howard Saunders of Woods Hole Oceanographic Institution—on the biological content of bottom ooze in deep oceans—has shown that what were thought to be biological deserts sustain as many species per unit volume as almost any other area on earth.

Three other scientists working with NSF support—Dr. Gordon Riley (then at Yale) and Drs. E. R. Baylor and W. H. Sutcliffe of Woods Hole Oceanographic Institution—have studied the formation in the oceans of particulate organic matter from dissolved organic molecules, and have reached the conclusion that this matter comes from the plankton and forms into flakes at the sea-air interfaces. The flakes (which are thought to be the "marine snow" often reported but never understood by bathyscaphe operators) carry bacteria intimately associated with the processes of particle formation. Both the particles and the dissolved organic matter represent a hitherto unknown and so far unevaluated food material in the marine food webs.

In the field of fresh-water biology, Dr. W. T. Edmondson of the University of Washington has meticulously documented since the 1950s the biological and chemical changes associated with the spoiling and subsequent rejuvenation of Lake Washington, a twenty-mile body of water east of Seattle. His work is becoming an international classic for understanding the recovery of a lake following pollution abatement.

Over much of the habitable earth, the countryside is increasingly being cut up into small islands bounded by farms, urban communities, suburban shopping centers, and interstate highway systems. There is no reason to anticipate a reversal in this checkerboard trend of human expansion, and we do not know the minimum size at which a natural ecological unit can sustain all of its component species.

Dr. R. H. MacArthur of Princeton University and Dr. E. O. Wilson of Harvard, studying the fauna of natural islands, find that the differences of richness in species on otherwise similar islands can be attributed to factors influencing the equilibrium level between immigration and extinction on the islands. They have paid particular attention to the birds and insects of the Pacific islands. From theoretical calculations they have shown how it would be possible to more than double the numbers of species on isolated islands by a slight artificial increase in the immigration rates.

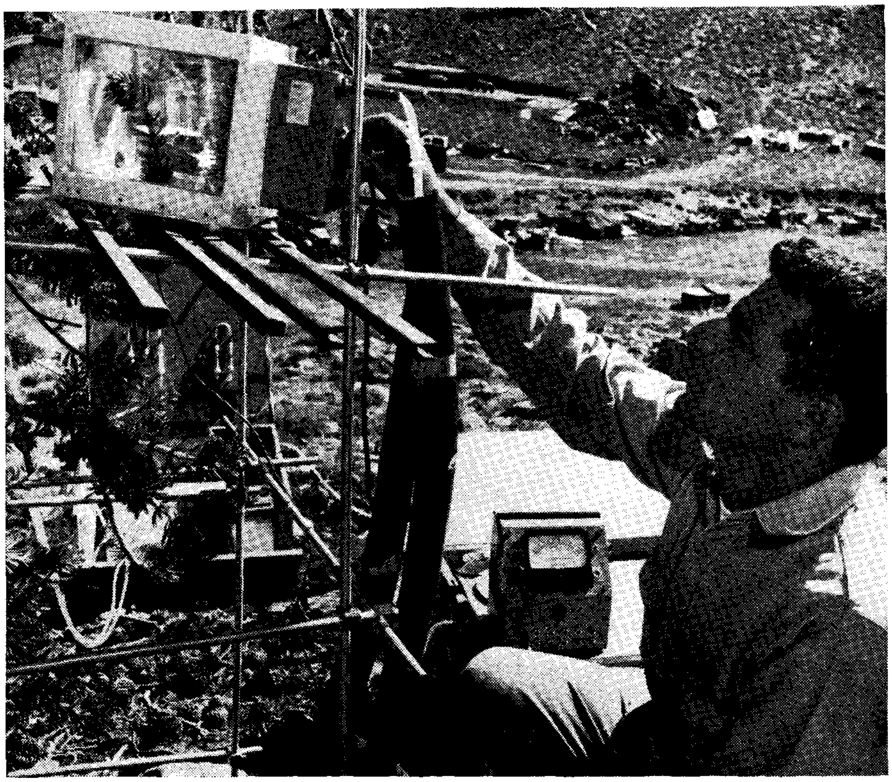
An equally important objective is to find a scientific basis both for preserving species from extinction and for understanding how to maintain healthy, harvestable species in forestry, grazing, fisheries, and wildlife. A large number of studies are in progress on such matters as predator-prey relationships, population regulation, and the physiological bases of drought, heat, cold, or pest tolerance. The recycling of inorganic nutrients between the web of living organisms and the nonliving environment also is a topic of great interest.

Because of the growing contribution of physical scientists to understanding the complex interdependencies of the biological environment, NSF late last year established within itself a division of environmental sciences. This new division embraces the atmospheric sciences, the earth sciences, and the special national research program in the Antarctic. Environmental biology generally was not included because NSF's activity in that area is traditionally focused on "biology" rather than on "environment"; however, the synthesis of all these directions of research support may be seen in the program for Antarctica.

Buried beneath the now desolate Antarctic ice cap lie the remains of once flourishing forests and seas. Petrified tree trunks, leaf imprints, coal seams, and crustacean remains have been found, indicating that millions of years ago the Antarctic climate was temperate. This means either that the earth's climate has changed drastically, or, more probably, that Antarctica was not always at the bottom of the earth. Either the pole or the continental mass has shifted. Questions of this kind illustrate the intimate connection between biology and other environmental sciences—in this case, geology.

North of the continent of Antarctica is an oceanic environment. Within this zone lies a phantom coast of pack-ice and an almost inconceivable richness of sea life about which relatively little is known.

On the continent itself, the small areas that remain clear of ice and snow are rugged, austere, and inhospitable. Low temperatures challenge life even during the summer period of full sunlight. To survive, organic life must endure winter temperatures often lower than 77 degrees below zero. Vegetation is sparse, and insects dominate the local fauna. The fact that plant and animal life can survive at all under such conditions is of obvious interest to ecologists.



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A California pine cone gets a custom-built living room.

THE future course of life on earth necessarily depends on the planet's young people. How many of them are prepared or can be encouraged to become active, practicing environmentalists?

For the current fiscal year, NSF's environmental biology program carries research grants for about 450 research assistants. More than 85 per cent of these are students seeking advanced degrees; about half of them will go on to doctorates. In addition, there are more than 100 NSF-supported research associates (at least half of them post-doctoral), sixty-five undergraduate assistants, twenty-two research assistants under direct research-training grants, twenty to thirty research fellows, and approximately a dozen research trainees. From these various categories, NSF assists in the education of between fifty and sixty Ph.D's in environmental biology who are added yearly to the scientific manpower pool.

At lower levels in the educational system, NSF operates both to increase the number of young people interested in the possibilities of environmental biology as a career and to increase the number of students who, though choosing other careers, are well-informed about the rudiments of environmental biology. These efforts include support for up-to-date biology textbooks and updating courses for high schools.

In ways such as these, the important problems of our environment and its effects on animal, plant, and human life are being brought to people at every level. Popular support is thus generated for creative technology and applied research to attack the visible problems man has created for himself in modifying his environment in the name of progress. But even crash approaches to the known and the identifiable may prove inadequate to meet new and unforeseen problems as they appear over the edge of the horizon.

It seems clear that basic research, the quest for fundamental knowledge, must be further stimulated. Obviously we cannot know what fundamental breakthroughs in the social sciences, the physical sciences, the earth sciences, or the biological sciences will provide major advances in our continuing concern with environmental quality. Expenditures for basic research must be made on faith, but such faith has brought us rich returns in the past and can be expected to do so again in the future. And just as we do not know which items of fundamental research will provide the keys to unlock the future, neither do we know whether any particular key will be turned by the physicist, the biologist, the chemist, the social scientist, or the engineer. The magnitude of our ignorance of ecology, and the opportunity to dispel it, appear to guarantee a bright future for all who are attracted by the challenges of environmental biology.

BY SIMULATING CATASTROPHE

By ROBERT M. WHITE

RECOGNITION of the need for confronting our planetary environmental problems on a planetary scale resulted last year in formation of a new Environmental Science Services Administration (ESSA) in the Federal government. Set up within the U.S. Department of Commerce, ESSA combines the former Weather Bureau, Coast and Geodetic Survey, and Central Radio Propagation Laboratories of the National Bureau of Standards. While not intended to be the sole official agency in the field of geophysics, ESSA does provide a single governmental organization whose interests, capabilities, and services encompass all of the scientific disciplines required for the study of the physical environment.

One of the key fields of physical and mathematical science which is central to ESSA's ability to understand, predict, and ultimately control the phenomena of the physical environment is geophysical fluid dynamics. The hurricane draws its energy from the release into earth's atmosphere of heat latent in condensing water vapor drawn from the sea below. The seismic sea-wave is an oceanographic phenomenon generated by earthquakes. The drought is caused by abnormalities in the planetary wind systems, characterized by the rate and manner in which the atmosphere is heated by the sun and the oceans. Thus all these catastrophies result from motions and instabilities of the gases and liquids in earth's fluid envelope, which reaches from the outermost limit of the atmosphere to the bottoms of the oceans. And even the earthquakes may occur because of the slow convective processes of the fluid core of the earth far beneath the seas.

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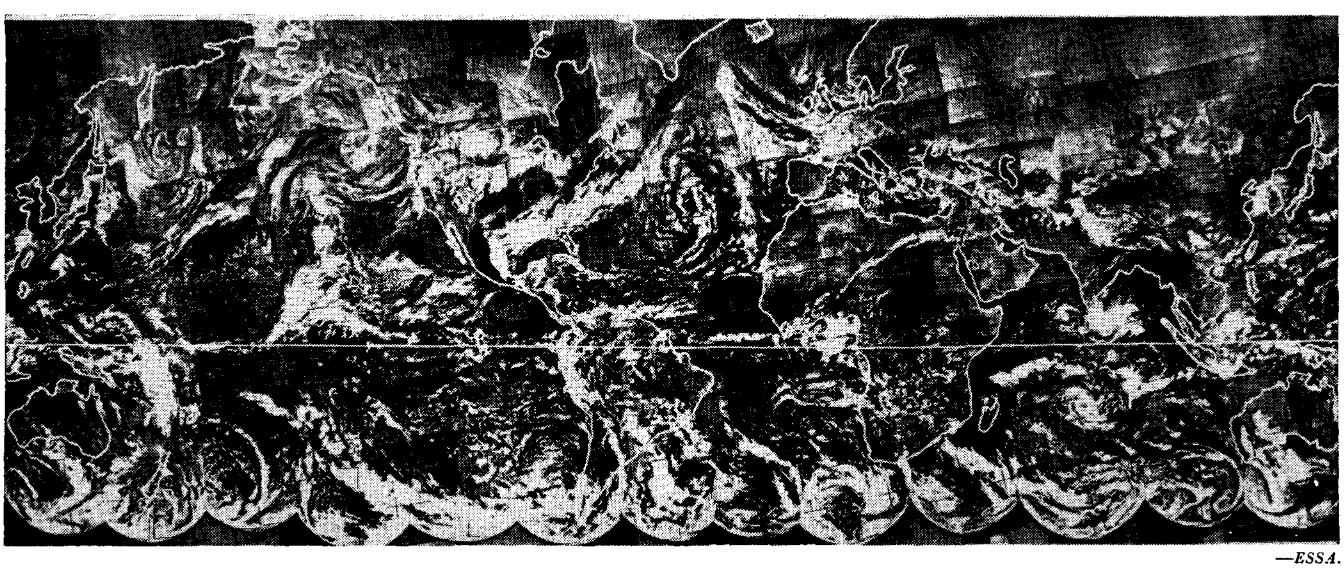
To understand these phenomena and, hopefully, to lessen their ravages through adequate warning or control, we must deal with them as adjustments of the fluid envelope to the forces that set it in motion. Whether we are concerned with the tornado, the hurricane, the seismic sea-wave, the storm surge, the flood, or the severe winter blizzard, we are concerned with processes whereby energy either locally, regionally, or globally is being released or redistributed or transmitted from one place to another.

In grand outline, the earth's fluid envelope maintains the habitable range of temperature and moisture throughout the world. Without its energy redistribution properties, the polar areas would be lifeless in uninhabitable cold and the tropics lifeless in unimaginable heat. The sustenance of life is due not only to the fact that the envelope is in motion; the chemical composition of the fluid regulates the amount and types of energy received. The ozone of the upper atmosphere shields us from the deadly ultraviolet radiation of the sun. The electrified shells of the ionosphere protect the surface of the planet from bombardment by particle radiation from the sun and enable us to use the electrical properties of the ionosphere for telecommunication. The carbon dioxide blanketed in the atmosphere acts as a greenhouse glass to retain the sun's heat and so to insure adequate warmth at the earth's surface.

In regulating the manner in which the fluid envelope is heated and cooled, the chemical composition of the envelope determines the gross nature of the motions of the fluid. The motions in turn insure the homogenous distribution of the chemical composition of the fluid.

Scientists understand only dimly the global forces acting on this restless environment. They have labored under the handicap that the principal laboratory in which they have to work has been the earth's fluid envelope itself—uncontrolled, uncontrollable, and observable only imperfectly. Given these circumstances, it is indeed remarkable that man has learned so much.

Geophysicists now feel that the key to future research and technology is development of a capability for simulating the



—*ESSA.*

Man got his first look at weather everywhere around the earth from the above montage, made by imposing weather satellite photographs on a standard geographical map of the globe. The satellite: Tiros IX. The date: February 13, 1965.