

(eds.). New York, Springer-Verlag, pp. 71-81.

Schwarzacher, H.G. 1974b. Fluorescence microscopy of chromosomes and interphase nuclei. In: *Methods in Human Cytogenetics*. H.G. Schwarzacher and U. Wolf (eds.), New York, Springer-Verlag, pp. 83-94.

Sharma, A.K. and A. Sharma. 1972. *Chromosome Techniques: Theory and Practice*. Univ. Park Press, Baltimore, 575 pp.

Stern, E.M. 1975. A technique for the preparation of gastropod chromosomes. *Veliger* 17(3): 296-298.

Surriner, A.T., H.J. Evans and R.A. Buckland. 1971. A new technique for distinguishing between human chromosomes. *Nature New Biol.* 232: 31-32.

Surriner, A.T. 1972. A simple technique for demonstrating centromeric heterochromatin. *Exp. Cell Res.* 75: 304-306.

White, M.J.D. 1973. *Animal Cytology and Evolution*. 3rd Ed. Univ. Press, Cambridge, England, 959 pp.

CURRENT TRENDS IN MALACOLOGY:  
ENVIRONMENTAL IMPACT STUDIES AND ENDANGERED SPECIES RESEARCH

*Carol B. Stein*

Museum of Zoology, The Ohio State University  
Columbus, Ohio 43210

and

*Marc J. Imlay*

Office of Endangered Species, U.S. Department of Interior  
Washington, D.C.

Within the past ten years, two major pieces of Federal legislation have brought Washington bureaucratic alphabetese into the field of malacology, and have brought the science of malacology to the attention of many engineers, policy-makers, and even a number of biologists who had never before had contact with this field of study.

The first of these pieces of legislation is the National Environmental Policy Act of 1969, more familiarly known as NEPA. If Congress and the courts continue to uphold this landmark piece of legislation, it could well have as great an impact on this country's next two centuries as the Declaration of Independence and the Bill of Rights have had on the first two centuries.

In passing this act, Congress recognized the profound impact of man's activity on the interrelationships of all components of the natural environment. In Title I of NEPA, the Congress declared that it is the continuing policy and responsibility of the Federal Government to use all practicable means to improve and coordinate Federal plans and programs so that the Nation may --

(1) fulfill the responsibilities of each

generation as trustee of the environment for succeeding generations;

(2) assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;

(3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;

(4) preserve important historic, cultural, and natural aspects of our natural heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice;

(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

At the heart of NEPA is the crucial Section 102

(2) G, which requires that all agencies of the

Federal Government shall "include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official [i.e., the official representative of the agency that is planning the project] on—

- (i) the environmental impact of the proposed action,
- (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
- (iii) alternatives to the proposed action,
- (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
- (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."

This detailed statement has become popularly known as an Environmental Impact Statement, or an EIS. Every time any Federal agency proposes to undertake any action which may have a significant effect on the environment, that agency is required by law to prepare an EIS on the proposed action. Copies of the EIS must be made available to Federal, State, and local environmental agencies, the President, the Council on Environmental Quality, and also to the public. It must accompany the proposal through the existing agency review processes.

At first, NEPA's Environmental Impact Statement requirements caught Federal agencies unprepared. Highway departments, the Corps of Engineers, and other agencies were largely staffed with engineers and designers who had been trained to solve problems in mechanics, design, and construction, but who had little or no familiarity with ecology or the life sciences. This situation is just beginning to change.

The first efforts of Federal agencies to comply with NEPA's EIS requirements were almost entirely directed toward the proposed projects' effects on recreational facilities, commercial and game species of fish, mammals, and birds—the traditional concerns of most state departments of natural resources or conservation. Non-game species and ecosystem diversity were rarely even

mentioned, and their importance to man was little understood or appreciated.

However, the preparation of EIS's did one thing more than require additional agency rubber stamps on project proposals. It gave the public an opportunity to become involved in the governmental decision-making process. Conservation organizations which for years had fumed over inept bureaucratic decisions to destroy natural areas while creating public works projects, landowners whose property was to be condemned, community groups whose neighborhoods were to be sacrificed, and even a very few concerned biologists began to read environmental impact statements and to ask some very searching questions about them.

In a number of cases citizens' groups opposing Federal projects found the agencies' environmental impact statements highly inadequate or misleading. When the agencies refused to change the EIS's, some of the citizens' groups decided to sue the Federal agencies involved in order to force a more realistic evaluation of the impact of the proposed projects. In some such cases, such as the Environmental Defense Fund's suit against the U.S. Army Corps of Engineers over the Cossatot Dam, the courts ruled the EIS was inadequate, and sent the agencies back to get more data. However, when the agencies returned with voluminous documents weighing many pounds, the courts generally weighed the evidence and decided that the impacts of the projects had been adequately described, so the projects could then go ahead.

There is no provision in NEPA which requires a project to be abandoned or modified no matter how adverse its impact may be, so long as the impact is adequately described in the environmental impact statement.

One of the first NEPA cases in which malacology played a role was the Environmental Defense Fund's suit against the U.S. Army Corps of Engineers over the proposed Tennessee-Tombigbee Waterway, a canal project which would channelize the Tombigbee River in Alabama, linking it with the Tennessee River, by excavating more earth than was moved during the building of the Panama Canal. Evidence was presented indicating that five endemic species of Unionidae in the Tombigbee River system would probably become extinct as a result of this project. Other evidence showed that the 253-mile canal

project would seriously disrupt the area's balance of nature and would damage wildlife and recreation along the river. However, this evidence was not enough to enjoin the Corps from building the canal, according to the Federal Court judge, who ruled in the Corps' favor.

In another early NEPA case the Environmental Defense Fund took the Tennessee Valley Authority to court over the issue of two high dams to be built at Normandy and Columbia on the Duck River, the largest and one of the most biologically diverse undammed streams remaining in the Tennessee River system. The possible extinction of native species of unionids and river snails was an issue in this case, and again EDF lost the case and the appeal. Normandy Dam was closed and began impounding water in May this year. Columbia Dam is now under construction, with approximately 10% of the project completed now.

While all of this was going on, a quiet but growing concern for the world's vanishing species was beginning to arouse public attention. The American Malacological Union was one of the first scientific organizations to call attention to this situation, holding a formal symposium on rare and endangered mollusks of North America at its 1968 annual meeting at Corpus Christi, Texas.

The formal involvement of the Federal government in endangered species conservation began with the Endangered Species Preservation Act of 1966. This act required the Secretary of Interior to judge what native species of wildlife were threatened with extinction, and to publish lists of them in the Federal Register. It also authorized him to conduct research on such animals and to use limited amounts of money from the Land and Water Conservation Fund to acquire habitat for these species.

In 1969 a new Endangered Species Conservation Act amended the first act and broadened its coverage to include all vertebrates, mollusks, and crustaceans. Endangered subspecies as well as species were recognized. The new act authorized the acquisition of water as well as land habitat for endangered species, increased the amount of money available for habitat acquisition to \$2.5 million per area and \$5 million per year, and provided significant authority for the conservation of endangered foreign wildlife.

Later the laws were again amended by the passage of the Endangered Species Act of 1973, which states: "The purposes of this Act are to

provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve [these] purposes." The act also states, "It is further declared to be the policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this Act."

This act extends the scope of Federal coverage to species within the entire plant kingdom, and to the whole animal kingdom, with the sole exception of "a species of the Class Insecta determined by the Secretary [of Interior] to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man." Not only species and subspecies, but also isolated and disjunct populations may be listed.

The present law requires the Secretary to publish in the Federal Register lists of all species determined to be either threatened or endangered. These species must be listed by both a scientific name and a common name—a problem for malacologists, since so few molluscan species have common names.

The term "endangered species" means any species which is in danger of extinction throughout all or a significant portion of its range. A "threatened species" is any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The difference between the two categories is essentially one of priority of action.

The Secretary may also treat as endangered certain other species which look so much like the listed ones that enforcement personnel would have difficulty in differentiating between them and the listed species. This provision may well prove important in malacology, especially since few law enforcement people have been trained in molluscan taxonomy. The education of these people may well be an important task of malacologists in the future.

Criteria used by governmental officials to determine whether a species should be listed as endangered or threatened include:

- (1) the present or threatened destruction, modification, or curtailment of its

- habitat or range;
- (2) overutilization for commercial, sporting, scientific, or educational purposes;
  - (3) disease or predation;
  - (4) the inadequacy of existing regulatory mechanisms; or
  - (5) other natural or manmade factors affecting its continued existence.

Under Section 5 of the present Endangered Species Act, the Secretary of Interior is directed to establish and implement a program to use all methods and procedures which are necessary in order to bring any endangered or threatened species to the point at which such measures are no longer necessary. "Such methods and procedures include, but are not limited to, all activities associated with scientific resources management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transplantation...."

Under the terms of this act, the U.S. Office of Endangered Species has thus far issued 12 research contracts to researchers in molluscan systematics and zoogeography. The first priority has been to find out what taxa are known to be threatened with extinction, to determine where these taxa now occur, and to learn what is happening or is about to happen to them. A status report must be prepared for each species to answer three basic questions: What is it? Where is it? Why is it in trouble?

Since many of the mollusk species which are potential candidates for listing are highly restricted in distribution and not all are well known, even to malacologists, the investigations supported by these research contracts are providing new information which is aiding in the solution of many taxonomic and zoogeographic problems that otherwise might not even have been tackled until the species was extinct.

As a serendipitous by-product of the field work done under these contracts, malacologists are obtaining new data on distribution and abundance not only for potentially endangered species, but also for many relatively common, widespread taxa. Field studies such as are sponsored by endangered species research contracts are providing valuable base-line data on faunal changes in different regions, which can then be correlated with various environmental modifications. Well-documented specimens taken during

these field surveys and deposited in museum research collections can be used to help solve taxonomic and zoogeographic problems, as well as serving as irrefutable evidence of the survival of the taxon at the time and place of collection. Exact localities and dates of collection are becoming increasingly essential on specimen labels because of the need to carefully document faunal changes in response to environmental alterations.

Attempts to delineate the ranges of endangered species sometimes bring to light new malacological problems which challenge the investigators. As an example, Grimm's studies of endangered land snails brought to light evidence that some land snail species tend to hybridize in disturbed habitat areas between formerly separate ranges, a phenomenon which has also been observed in certain species groups of plants.

A number of studies of the introduced Asiatic freshwater clam *Corbicula* have suggested that this bivalve invades disturbed habitats more readily than unmodified natural streams. It has been hypothesized that maintenance and restoration of natural conditions may be one of the most effective defenses against domination of the benthos by this exotic bivalve.

As endangered species are recognized and identified, it is expected that the research emphasis will gradually shift toward studies of the interrelationships of the various taxa with the many factors comprising their environments. Studies such as Vail's investigations of the survival of *Triodopsis albolabris* in an annually burned woodland, Mackie's investigations of the effects of various environmental factors on sphaeriid natality, and comparative ecological studies of several species occupying similar but not identical niches, such as the investigations reported by Hoagland, Davis, and Cain (all presented at the 1976 AMU meeting) will be needed to determine the particular factors in the environment which are limiting to the endangered species, and which factors must be maintained or modified in order to promote the survival and reproduction of the species.

Studies of the distribution of rare species frequently show that the ranges of two or more endangered or threatened taxa coincide or overlap. In such cases, protection of the natural integrity of a single habitat area can result in protecting more than one endangered species, as

well as the biotic community of which these species are integral components. As an example, the ranges of the endangered Morro Bay Kangaroo Rat and the Banded Dune Snail, *Helminthoglypta walkeri* *n. sp.*, now proposed as an endangered species, coincide. In Ohio, the Big Darby Creek ecosystem which supports the only known population of the Scioto Madtom, a Federal endangered fish species, also supports at least seven additional fish species and four unionid mollusk species on the official state list of endangered wild animals. In the Tennessee River basin, the undammed portions of the Clinch, Powell, Nolichucky, and Duck Rivers each support unique assemblages of endemic bivalve, gastropod, and fish species, many of which have either been listed or are in the process of being listed.

The ecosystem approach toward endangered species restoration is clearly mandated. By acquiring and protecting the critical habitats for such species, additional plant and animal taxa native to these habitats but not now recognized as endangered may well be protected as a kind of by-product. In addition, forms occurring in these areas which are not now endangered can be given living-space which may prevent them from becoming endangered in the future. The study of these natural ecosystems and their functions may well provide new insights by which man can better utilize the resources of his agricultural ecosystems.

Few molluscan taxa are so large and spectacular that zoos feel a need to maintain and propagate them. Few of them are so well-studied that the necessary conditions for survival and reproduction are known. Preservation of captive populations of animals in aquaria, terraria, and gardens; introductions outside the native range; and artificial mass production programs have proven chancy and subject to the fickleness of the budgetary process—especially during times of war or energy crisis. In the long run, the genetics of a captive population may change, variability is lost, and behavior patterns adaptive to survival in the wild may disappear. Introductions of endangered species into new habitats may either fail or be hazardous to the native species already occupying those habitats.

One of the most important parts of the Endangered Species Act of 1973 is Section 7, which reads:

The Secretary shall review other

programs administered by him and utilize such programs in furtherance of the purposes of this Act. All other Federal departments and agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species...and by taking such action necessary to insure that actions authorized, funded, or carried out by them do not jeopardize the continued existence of such endangered species and threatened species or result in the destruction or modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with the affected States, to be critical.

Although there is no requirement in the National Environmental Policy Act which requires Federal agencies to do anything beyond writing an environmental impact statement, Section 7 of the Endangered Species Act clearly directs these agencies to take such action as is necessary to insure that their activities do not further jeopardize the continued existence of listed species.

Twenty-five mollusk species have now been officially listed as endangered, and 37 others have been listed in the Federal Register as proposed endangered species. This is still far short of the 250 mammal species and 209 bird species now listed as endangered, or the more than 1,700 plant species currently proposed for listing (8% of the seed plants and ferns in the nation). However, over 400 additional molluscan species are currently under consideration and may be proposed when there is sufficient data available on their status.

Federal agencies now will be required to include information about the probable impact of their proposed projects in each EIS. The inclusion of endangered mollusks on the Federal list may provide new ammunition for the Environmental Defense Fund and other citizens' groups in court trials on controversial public works projects.

Just last month the U.S. Soil Conservation Service held a preliminary hearing on their proposal to channelize the Paint Rock River in Alabama. AMU member Dr. Paul Yokley and

biologist Bruce Bell of the U.S. Fish & Wildlife Service's Decatur office, using data from past malacological literature and from recent Ohio State University Museum of Zoology records, informed the SCS that four endangered unionid species occur in the Paint Rock River. Consequently, the SCS will now contact the Department of Interior to determine what action must be taken, under the terms of the Endangered Species Act, to prevent further jeopardization of the continued existence of these species.

Research into new technologies of flood damage reduction, water supply, erosion control, and waste management is needed in order to provide better alternatives to the costly public works engineering projects we have been using. By utilizing ecological approaches to the solution of such problems, we may find cheaper and more efficient ways of utilizing natural processes to

convert "wastes" to resources. Perhaps we may find ways to utilize various molluscan species in solving these problems. Bivalve mollusks, for example, have been suggested as living monitors of water quality in streams. Some of them may one day be employed as living filters to process organically enriched wastewaters into usable proteins.

The preservation of the genetic variability which will make such developments possible in the future depends largely on how effectively NEPA and the Endangered Species Act are used to protect this resource. The Phylum Mollusca constitutes a major segment of Earth's animal life. Malacologists of today face a major challenge and obligation to make a real contribution both in research and in educating the agencies, the courts, and the citizens of the planet about the importance of preserving natural ecosystems and genetic diversity of living forms.