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Protection of Endangered Gray Bat (Myotis grisescens) Colonies in Arkansas

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sive water code. The committee's work culminated in the presentation of House Bill 60 and Senate Bill 8 during the 1983 legislative session. During 1982 the Winthrop Rockefeller Foundation founded a public-awareness project, entitled "Arkansas Water: Why Wait for the Crisis?", which has received wide dissemination. Also during 1982 the Arkansas Department of Pollution Control and Ecology received a National Science Foundation grant to fund a scientific policy review for that agency, particularly with respect to improving stream classification, lake management, and hazardous waste disposal. Secondly, it is my experience that the older an individual becomes, the more difficult it is to modify his/her behavior, especially with regard to the environment. Finally, teachers of secondary education need inexpensive resource materials and teaching techniques that will allow them to instruct science in today's world. Accordingly, the purposes of this workshop are to provide teachers with: 1) a broad overview of the interrelationships of water and man; and 2) at least one functional freshwater-ecology unit for classroom use.

In order to serve the maximum number of teachers, the workshop is numbered to provide three semester hours of credit for either upper-level undergraduate or graduate students. Each student is required to participate in class activities, construct a teaching aid (e.g. a sampling device), and develop one water-ecology teaching unit. The teaching unit may emphasize class or field work, or a combination, depending on the constraints of that student in the school where he/she teaches. Additionally, individuals taking the workshop for graduate credit research and develop a report on a particular water use outside the workshop syllabus.

The lecture portion of this workshop is designed to acquaint teachers with the importance of water. A basic ecology unit is followed by units emphasizing water use in agricultural, industrial, recreational and municipal/domestic applications. In each of the latter units the student learns how the water is used, in what quantities, how water quality is affected by that use and what the future prospects are.

The laboratory periods are utilized for a variety of activities. Field trips are made to local streams and the sewage-treatment facility. Students become familiar with plans for constructing inexpensive water-related sampling devices and construct at least one such device. Discussion periods are held during which the students exchange information concerning environmental teaching techniques and activities with which they have had success. A resource room is utilized which has been well provisioned with water-related information. Ideas for science fair projects are developed. Ultimately, these resources are synthesized as each student develops at least one complete freshwater-ecology unit specifically designed for his/her classroom situation.

One example of a free sampling method is effective observation. It is also informative and has wide application. Observations may include the variety of aquatic life, behavior, water turbidity and substrate type. Organisms can be returned to the classroom aquarium for further observation (e.g. air bubble respiration in aquatic beetles). Measuring current speed and volume flow can also be done without expense (Phillips, R. E., Jr. 1984. A field trip to the stream. Carolina Tips. 47[2]:5-6). A thermometer, tea strainer, aquarium dip net and minnow seine bring studies of habitat requirements, species diversity and numerical standing crops within one's capabilities for little expense.

Among the information resources utilized, I have found four to be particularly u.eful in providing ideas and techniques (U.S. Environmental Protection Agency. 1974. Environmental exchange — a beginning. President's Environmental Merit Awards Program, USEPA, Washington, D.C. 21 pp.; Resh, V. H., and D. M. Rosenberg. 1979. Innovative teaching in aquatic entomology. Canadian Spec. Pub. Fish. Aq. Sci. 43. 118 pp; Miller, G. T., Jr. 1982. Living in the environment. Wadsworth Publ. Co., Belmont, CA. 671 pp; and Disinger, J. F. 1983. Learning *in* the environment. Env. Ed. Fact Sheet. No. 2. ERIC Clearinghouse for science, mathematics, and env. ed. Columbus, OH. 2 pp.). The last three contain extensive bibliographies.

Characteristically, teachers have every intention of incorporating new knowledge from their summer courses into their teaching curriculum. However, too much work and too little time often combine to thwart even the most conscientious teachers. The major strength of this workshop lies in its ensuring that each teacher takes a complete water-ecology unit, tailored to his/her specific needs, including budgetary constraints, back to the classroom. This maximizes the probability that this environmental education will be transmitted to the secondary level, where it is sorely needed.

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PROTECTION OF ENDANGERED GRAY BAT *(Myotis grisescens)* COLONIES IN ARKANSAS

The gray bat, *Myotis grisescens,* is one of three Arkansas bat taxa listed as endangered (in danger of extinction throughout all or a significant portion of their range) by both the U.S. Fish and Wildlife Service and the Arkansas Game and Fish Commission. Other Arkansas bats listed as endangered are the Indiana bat, *Myotis sodalis,* and the Ozark big-eared bat, *Plecotus townsendii ingens.*

Gray bats, unlike most bat species, are cave residents throughout the year, although different caves are usually occupied during summer than in winter; few have been found roosting outside caves (Barbour and Davis, 1969). They hibernate primarily in deep vertical caves with large rooms that act as cold air traps. They form tight clusters of up to several thousand individuals and choose hibernation sites where temperatures average 6-11 C (Barbour and Davis, 1969). During summer, female gray bats form maternity colonies of a few hundred to many thousands of individuals. Maternity colonies prefer caves that, because of their configuration, trap warm air (usually 14-25 C) or that provide restricted rooms or domed ceilings that are capable of trapping the combined body heat from clustered individuals (Tuttle, 1975; Tuttle and Stevenson, 1978). Maternity caves are rarely located more than 2 km, and usually less than 1 km, from rivers or reservoirs.

During spring and autumn transient periods, gray bats occupy a wider variety of caves. During all seasons, males and yearling females seem less restricted to specific cave and roost types. Because of their highly specific habitat requirements, fewer than 5% of available caves are suitable for occupation by gray bats (Tuttle, 1979).

Gray bats forage primarily over water along rivers or near lake shores. Most foraging occurs within 5 m of the surface. Mayflies are apparently a major item in their diet.

Approximately 250,000 gray bats hibernate in only four Arkansas caves, over 99% of these in a single Baxter County cave. During summer, ca. 150,000 gray bats occupy 40 caves scattered throughout the Arkansas Ozarks. Approximately 100,000 migrate to summer colony caves in Missouri, Oklahoma, and Kansas. Ten maternity colonies are known in Arkansas, nine of which are on private lands.

A major factor in the decline of gray bat populations has been human disturbance to gray bat colonies in caves. Hibernating gray bats, when disturbed by humans entering their hibernation caves, arouse, using up previous fat needed to survive the winter. If disturbed more than a very few times, they may starve to death before insects become available in the spring.

Maternity colonies are very intolerant of disturbance, especially when nonvolant young are present. If disturbed, baby bats may be dropped to their deaths or abandoned by panicked parents. The protection of gray bat caves from human disturbance is of foremost importance in the survival of this extremely beneficial bat species.

The following summarizes efforts made thus far to protect important Arkansas gray bat caves. Some of these efforts have been previously reported (Harvey, 1975, 1976a, 1976b, 1979, 1980; Harvey et al., 1979).

The very important gray bat hibernaculum located in the Ozark National Forest of Baxter County was gated by the U.S. Forest Service in 1975. The gate was subsequently redesigned to better fit the particular conditions at the cave and a replacement gate was installed during the summer of 1980. Five Buffalo National River caves have been fenced by the National Park Service to protect gray bat (and Indiana bat) colonies. One cave located on a private housing development in Benton County has been fenced by the developer to protect a gray bat summer colony. The U.S. Army Corps of Engineers recently constructed an artificual entrance into a gray bat cave located on Beaver Lake in Benton County, since the natural entrance is sometimes inundated during high lake levels.

In addition to the above measures, the Arkansas Game and Fish Commission, U.S. Fish and Wildlife Service, U.S. Forest Service, and National Park Service have placed warning/interpretive signs at several gray bat caves. Other agencies and organizations involved in the gray bat conservation effort include the Nature Conservancy, Arkansas Department of Parks and Tourism, Arkansas Natural Heritage Commission, National Speleological Society, Cave Research Foundation, Association for Arkansas Cave Studies, and Ozark Underground Laboratory.

Important gray bat hibernacula and summer caves will be monitored for the next several years. Additional measures will also be taken to protect other important gray bat caves. Hopefully, the conservation effort will result in removal of the gray bat from the endangered species list.

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SURVIVAL OF *TRYPANOSOMA CRUZI* IN DEAD CHRONICALLY INFECTED MICE

Trypanosoma cruzi (Chagas, 1909), the cause of Chagas' disease, is a flagellate protozoan found throughout most of Central and South America where it infects approximately 12 million people (World Health Organization, 1960). In the United States this agent has been reported in wildlife mammals in California, Arizona (Kofoid and Whitaker, 1936), Texas (Packchanian, 1941), New Mexico (Dias, 1951), Minnesota (Hedrick, 1955), Virginia (Tromba, 1951), Maryland (Walton *et al.*, 1956), Georgia, Florida (McKeever *et al.*, 1958), Alabama (Olsen *et al.*, 1964), and Louisiana (Yeager and Bacigalupo, 1960). Cited reservoir hosts include such common mammals as the raccoon *(Procyon lotor)*, opossum *(Didelphis virginiana)*, grey fox *(Urocyon cinereoargenteus)*, and striped skunk *(Mephitis mephitis)* (McKeever *et al.*, 1958).

The normal transmission of *T. cruzi* occurs when a bug (Hemiptera:Reduviidae) takes a blood meal and deposits feces containing trypomastigotes on the skin. The parasites enter the bite wound and invade cells of many organs throughout the body as they circulate in the blood for approximately 30 days or longer. Upon entering a cell, the trypomastigote typically loses its flagellum and transforms into an amastigote which reproduces by binary fission. During the acute phase amastigotes produced intracellularly are released by cell lysis and either reinvade new cells or transform into trypomastigotes and reenter the circulation. The cells most often attacked are reticuloendothelial cells of the liver and spleen, cells of cardiac, smooth and skeletal muscle and certain cells of the nervous system. Animals surviving the acute phase typically develop chronic infections in which amastigotes form pseudocysts in the host's tissues producing only limited cell lysis. In the chronic infection, trypomastigotes in the blood are scanty and difficult to demonstrate by microscopic examination.

Epidemiologic studies of zoonoses, such as Chagas' disease, contribute to the basic understanding of the biology of the etiologic agents and provide information relating to both geographic distribution and transmission. Such information can be useful in prevention and control of these diseases which may pose a threat to man, domestic animals and wildlife. Often studies of this nature have required the capture and, in some cases, the sacrifice of potential wildlife reservoirs.

Meurer (1980), in a preliminary study, demonstrated that *T. cruzi* could be detected in dead chronically infected mice by inoculating a modified