DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof. Reference herein to any social initiative (including but not limited to Diversity, Equity, and Inclusion (DEI); Community Benefits Plans (CBP); Justice 40; etc.) is made by the Author independent of any current requirement by the United States Government and does not constitute or imply endorsement, recommendation, or support by the United States Government or any agency thereof.

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
P. O. BOX Y, OAK RIDGE, TENNESSEE 37830

March 15, 1977

Energy Research and Development Administration
Oak Ridge Operations
Post Office Box E
Oak Ridge, Tennessee 37830

Attention: Mr. R. J. Hart, Manager

Gentlemen:

Oak Ridge Proposal — National Environmental Research Park

In response to review comments by your staff, we have completed a revised proposal for the establishment of a National Environmental Research Park (NERP) within the ERDA Oak Ridge Reservation. Staff of the ORNL Environmental Sciences Division have discussed necessary changes to be incorporated and drafts have been sent to ORO staff for informal review. These changes have been incorporated in the current revised proposal.

We believe the proposal herein contained meets the requirements and charter from ERDA while simultaneously ensuring that the Oak Ridge NERP will have the flexibility of use recognized as being needed to implement the overall mission in Oak Ridge.

After discussion with ORNL and my staff, I believe that creation of a NERP at Oak Ridge will serve to enhance and strengthen our environmental research program and will provide ERDA/ORO and UCC-ND with an enhanced public image truly reflective of our concern for environmental quality.

Your early finalization and transmittal to ERDA-AES would be appreciated.

Very truly yours,

R. F. Hibbs, President

RFH/WFH/cp

Enclosures

cc: F. L. Culler
C. J. Parks
H. Postma - RC
P. R. Vanstrum

Proposal to Establish a National Environmental Research Park within the ERDA Oak Ridge Reservation

February, 1977

Union Carbide Corporation • Nuclear Division

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

The purpose of this proposal is to recommend that areas within the ERDA Oak Ridge Reservation be designated as a National Environmental Research Park (NERP). The NERP concept is intended to provide research areas, representing different biological communities throughout the United States, to assess the impact of energy-producing technologies upon environmental quality. Oak Ridge is a particularly excellent site, in that it represents the Ridge and Valley Province of the South Appalachians and has an established reputation for excellence in environmental research.

The NERP at Oak Ridge will be formed by selected land and water areas within the ERDA Oak Ridge Reservation which the Environmental Sciences Division, ORNL, has used for many years. Management of the Park by the Oak Ridge Operations will ensure compatibility with ERDA needs and long-range development plans.

INTRODUCTION

Establishment of certain federal lands as National Environmental Research Parks (NERP) has progressed as an outgrowth of the National Environmental Policy Act of 1969, which has demonstrated the need and value of long-term studies related to environmental impact of technology. Four such Parks have been designated previously at ERDA facilities. The objectives of these programs have been to (1) develop methods for the continuous and quantitative assessment of man's activities on the environment, (2) develop models to predict the response of environmental components to proposed technological activities, and (3) provide landscapes, representative of the ecological systems found in that particular region of the United States, which can be used as regional reference and research sites. Thus the NERP can serve science and technology as a protected, controlled outdoor laboratory for investigations by scientists having environmental interests or responsibilities.

Currently, the Energy Research and Development Administration Oak Ridge Reservation consists of approximately 37,000 acres of land in Anderson and Roane Counties, Tennessee. The land is part of an original 92-sq-mile tract purchased in 1942 to serve as an atomic development and production center for the Manhattan Project, Corps of Engineers. Originally the Reservation comprised 59,000 acres but through land transfers to the municipal government and to state and Federal agencies the area has been reduced to its present size. Since 1955, the area has been used extensively for environmental

research conducted by Oak Ridge National Laboratory, and approximately 12,000 acres are allocated to environmental programs.

The Reservation is located 15 miles west of Knoxville, Tennessee. The proximity of the ERDA Oak Ridge Reservation to laboratory and production facilities enhances its value as an environmental research site. Few natural research areas suitable for environmental research are located close enough to maintenance and support facilities to permit sophisticated, intricate, and well-instrumented environmental experiments. Logistics often limit the use of electronic instrumentation in field experiments, but ORNL has developed elaborate monitoring networks which enable the professional staff to measure environmental factors with precision and accuracy over extended real-time periods. Data of this kind are required to effectively model the ecological and environmental processes as they respond to experimental treatment.

We recommend that a National Environmental Research Park be established within the Oak Ridge Reservation. Benefits would assure the continuity of selected land and water resources areas within the Reservation and the continued preservation of areas of undisturbed, natural lands which are protected from external influences. Neither environmental research nor technological operations are mutually exclusive in all instances. Unique biological areas, as well as rare and endangered species, will be protected. Human and environmental health and safety also must be maintained. These health and safety buffer areas are excluded from other unrestricted use and as such are excluded from research park designation. The limitations

of land use and protection of certain areas should and will be compatible with the "Oak Ridge Reservation Land-Use Plan" (USERDA ORO-748)[1]. This plan is based on the concept that primary use of the ERDA land and water resources must be used to implement the overall mission in Oak Ridge.

LOCATION AND GENERAL DESCRIPTION

The Reservation is located 15 miles west of Knoxville, Tennessee. The Tennessee Valley Authority's (TVA) Melton Hill and Watts Bar Reservoirs on the Clinch River form southern, western, and eastern boundaries of the area while the residential portion of the city of Oak Ridge forms the northern boundary.

Four separate nuclear production and research facilities are operated within the Reservation. Three of these, Oak Ridge National Laboratory (ORNL), Y-12, and Oak Ridge Gaseous Diffusion Plant (ORGDP), are operated for the Energy Research and Development Administration by Union Carbide Nuclear Corporation. The Comparative Animal Research Laboratory (CARL) is operated by the University of Tennessee. Additional Federal facilities are located within the city of Oak Ridge. Table 1 summarizes the distribution of acreage among these facilities.

The area has been under government control for thirty years, and has not been unduly disturbed except for experimental use, regulated forest management, highways, and transmission lines.

---

(1) "Oak Ridge Reservation Land-Use Plan", August 1975. Oak Ridge Operations, U.S. Energy Research and Development Administration, ORO-748. 47 pp.

Table 1. Allocation of Land Use Among Installations on the ERDA Oak Ridge Reservation[a]

Administrative Unit	Acres
Environmental Research and Forest Management	16,200
ORNL Plant and Support Facilities	8,843
Y-12 Plant and Support Facilities	3,632
K-25 Plant and Support Facilities	5,645
CARL Research Land and Facilities	3,790
TOTAL	38,110

[a]Data taken from Task Force Report FY-1972 Surveys of Real Property Holdings, AEC-ORO, June 1972, and "Oak Ridge Land-Use Plan", August 1975, ORO, USERDA, ORO-748, 47 pp.

Geology

The Oak Ridge Reservation is within the Ridge and Valley Province of the Southern Appalachians and is characterized by parallel southwest-northeast-oriented ridges of sandstone, shale, and cherty dolomite, separated by valleys underlain by less weather-resistant limestone and shale. Topography of the area is due to differential erosion of severely folded and faulted rocks ranging in age from Early Cambrian to Early Mississippian. Elevations range from 230 to 410 m above mean sea level with a maximum relief of 190 m. The area includes gently sloping valleys, rolling to steep slopes and ridges. Soils developed from the weathered geologic substrate are members of the ultisol group which includes the red and yellow podzolic soils.

Climate

The climate is typical of the humid Southern Appalachian region. The mean annual rainfall is 136 cm, and the mean annual temperature is 14.3°C. Storms generally follow a northwest-southeast track; and the seasonal precipitation pattern is characterized by wet winters, dry summers, wet springs, and dry autumns.

Soils

Soils have developed under forests and contain an A-horizon that is typically light-colored and covers a tougher, clayey subsoil of red, yellow, or mottled color. The major soils are generally silty rather than sandy or clayey. However, considerable clay may be present in the B-horizon. The Knox soils contain koalinite as their principal clay, whereas illite and vermiculite constitute the

bulk of Conasauga clay. Most of the Chicamauga clay occurs as kaolinite and illite, although patches with significant amounts of montmorillonite have been noted. The soils of the Oak Ridge area are relatively infertile and ill-suited to agriculture. Approximately 15% of the land is favorable in productivity, 35% is characterized by medium productivity, and the remaining 50% is not suitable to agriculture. Their extensive clay subsoils channel most of the hydrological input into surface flow. As such, they are characteristic of many forested soils found in the Valley and Ridge Province.

Forests

Five Appalachian forest types are found naturally on the Reservation. The oak-hickory type shares equal prominence with the yellow pine-hardwood type. Cove hardwoods are found interspersed among the dissected ridge systems, and northern hardwoods occur in sheltered areas with northern exposures. A minor type, white pine-hardwood, is found along the northern boundary of the property. Large areas of open land were planted to loblolly pine between 1947 and 1956, thus creating a sixth type. Lands principally for agricultural research (Table 1) and old fields in various stages of succession are also present on the Reservation.

Waterways

A series of limited drainage basins through which small streams feed the Clinch River-Watts Bar Reservoir-Melton Hill Reservoir complex compose the waterways within the Reservation boundaries. The largest of these are Bear Creek and Poplar Creek, both of which receive some effluents from the operation of the Oak Ridge facilities.

Archaeological Features

Archaeological surveys of the Reservation have located 45 sites of aboriginal occupation and several early historic Euro-American homestead sites[2]. One aboriginal site was assigned to the Paleo-Indian period; eight were assigned to the Archaic period; 24 contained Woodland Period material; and five sites were occupied during the Mississippian period. These sites were distributed along the drainage system of the Clinch River with a majority of them located on the main stream. Several sites, however, were located on the tributary streams.

ALLOCATION OF NATIONAL ENVIRONMENTAL RESEARCH PARK LAND AREA

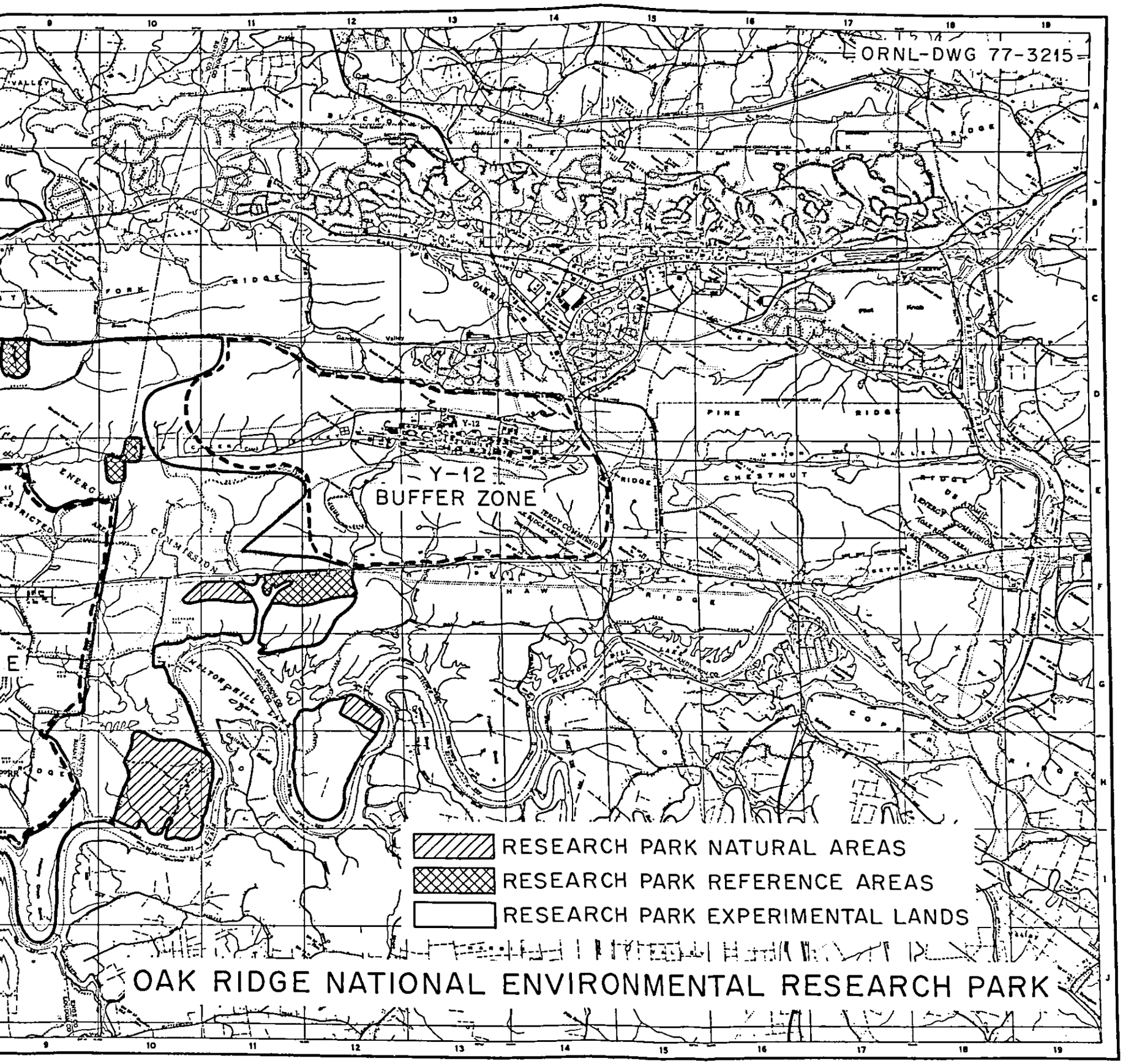
Lands which will form the Oak Ridge National Environmental Research Park are shown in Fig. 1. The shaded areas are those which now constitute Environmental Science Division terrestrial and aquatic research lands (see "Oak Ridge Reservation Land-Use Plan," U.S. ERDA ORO-748 Aug. 1975). The lone exception is the Gallaher Bend section which is administered by CARL. However, its qualities, (a) the presence of a unique bluff area where two endangered plant species can be found, and (b) its potential for research on agroecosystems, are reasons for its inclusion in the Park.

---

(2) G. F. Fielder, Jr., An Archaeological Survey with Emphasis on Prehistoric Sites of the Oak Ridge Reservation, Oak Ridge, Tennessee, ORNL/TM-4694, Department of Anthropology, University of Tennessee, 1974.


ORGDP
BUFFER ZONE
EXXON
BUFFER
ZONE
ORNL
BUFFER ZO
OAK RIDGE
BLACK OAK
POPLAR
ORGDP

Fig. 1:



Land Allocation of the Oak Ridge NERP.

The stippled and lined areas are control lands within the Reservation which are representative of the vegetation communities of the Appalachian region or are habitats for rare or endangered species. Activities associated with each type are summarized in Table 2.

GOALS, MANAGEMENT, AND RESEARCH OBJECTIVES OF THE OAK RIDGE NATIONAL ENVIRONMENTAL RESEARCH PARK

The particular objectives of the Oak Ridge National Research Park are to (1) develop methods for the continuous and quantitative assessment of man's activities on the environment, (2) develop models to predict the response of environmental components to proposed technological activities, and (3) provide plans which will aid in making preservation of representative regional natural areas compatible with human technological activities. The programs needed to achieve these goals, as discussed in this section, are intended to outline additional types of research afforded Oak Ridge by the designation of a National Environmental Research Park within the Oak Ridge Reservation.

By preserving portions of the Oak Ridge area in a protective status, areas representative of the Appalachian region will be available as a control to evaluate surrounding ecosystem changes which are bought about by various activities related to energy producing technologies. Other portions of these Research Reference or Natural areas may be subjected to various experimental treatments, but the principal use of these areas will be of a non-manipulative nature. Two features make Research Reference Areas invaluable in environmental research programs. First, they provide examples of ecosystems in essentially natural condition. Second, these areas are permanently protected by

Table 2. National Environmental Research Park Programmatic Activities.

A. Natural Areas:

Protected lands within the Reservation which are habitats for regionally unique plant and animal species. Included are rare or endangered species.

B. Reference or Control Programs:

These are lands within the Reservation which are representative of the vegetation communities of the southern Appalachian region. Collection of baseline data on the plant and animal communities within these areas is essential in establishing comparative reference points of normal ecosystem structure and function.

C. Experimental Research:

Included in this activity category are:

1. Wildlife and habitat management
2. Pollutant transport, and
3. Monitoring of population and community fluctuations.

D. Technology Assessment:

This portion of the NERP is directed toward those anthropogenic activities which affect the Oak Ridge Reservation. Effort is experimental and designed to look at impacts resulting from forest management activities, landfills, cooling towers, etc.

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 is a consideration, even in short-term research programs.

As indicated in the introductory remarks, the NERP should not hamper any ongoing programs for waste management, reactor development, or the production or development of other energy related facilities at Oak Ridge. The inclusion of selected ERDA land within the Research Park will aid in protecting critical habitat and environmentally oriented research program areas. The core of the Research Park will be formed by the land and water areas which the ORNL Environmental Sciences Division has used and protected for long-term ecological projects for many years.

To make the NERP effective, ERDA-ORO proposes that ESD, ORNL appoint an administrator to manage and promote the NERP. DBER should provide funds to cover costs of the administrator's travel in promoting the NERP, and secretarial support should be included, together with miscellaneous expenses incurred in NERP operation, including baseline studies, maps and markers. The administrator will coordinate the research on the NERP.

We have been advised that funding will be available through DBER for support of the NERP.

If the establishment of the National Environmental Research Park at Oak Ridge is approved, we believe its implementation will be straightforward. Subject to Headquarters approval, ORO, working with ORNL's Environmental Sciences Division will:

1. Issue an announcement to the Press.
2. Notify educational institutions, professional societies, and environmental groups describing the NERP, and its objectives.
3. Establish a mechanism for the review by the Oak Ridge Operations Office with ORNL and the Division of Biomedical and Environmental Research (DBER) of proposals for studies on the NERP. Establish ground rules for access and reporting of results by NERP users. Assign administration duties.
4. Advise the U.S. Fish and Wildlife Services, and other appropriate agencies both State and Federal.

Environmental Research Park areas can make major contributions to existing environmental programs in three basic ways: (1) by providing sites for collection of baseline data and for long-term monitoring of various aspects of environmental quality; (2) by providing sites for studies of the structure and function of natural ecosystems; and (3) by serving selected functions in educational and training programs. Each of these is discussed below:

1. In order to maintain the environmental health of the ERDA Oak Ridge Reservation, a nuclear and nonnuclear energy environmental surveillance program will be developed. This program will encompass both the present ERDA facilities, planned energy producing complexes (LMFBR, fuel fabrication and reprocessing facilities), and other nearby industrial sources. In addition to chemical pollutants, measurement of certain physical alterations of the landscape (construction,

powerline and road right-of-way, and forest management practices) will be undertaken to determine not only the extent of change in the structure of the affected plant community but the rates and levels of recovery of these particular communities.

2. In conjunction with the ongoing work discussed in the Natural Area Research program at ORNL we will continue to compile ecological information for the region, including species lists, species sensitivity profiles, population numbers, characterization of ecosystems, and successional stage, as previously described. From a practical viewpoint, one of the most promising future research needs is testing the applicability of realized niche information to the effects on species or communities of habitat management. We feel that this present approach to Research Reference or Natural Areas will fulfill the following objectives of the ERP as outlined in the tentative charter:
   1. Compilation of a regional environmental encyclopedia;
   2. Setting aside and characterizing research reference areas;
   3. Establishment of field and laboratory repositories;
   4. Development of environmental data centers;
   5. Identification of organisms which can serve as indicator organisms;
   6. Development of monitoring networks to identify effects of technological processes on natural ecosystem structure and function.

3. Educational and training opportunities to students, university scientists, and the community will be provided in those areas consistent with the project objectives, namely, resource inventories and pollutant effects. Demonstration areas will be developed for the public at large, illustrating the compatibility of various activities with the environment and the necessity for adequate land-use planning so that all components can operate harmoniously. It is not considered necessary to duplicate excellent facilities such as the University of Tennessee arboretum due to their close proximity to the Oak Ridge Reservation. These could include evenaged stands, uneven aged stands, pine stands, deciduous stands, clear cutting methods, seed-tree method, selection method, and improvement of wildlife habitat by prescribed burning; in other words certain areas could become examples of multiple-use management practices for this area of the southeastern United States. Initial university participation in ESD research programs will be directed toward establishing (a) environmental data bases for the Reservation; a specific characterization of the plant and animal communities including species listing, population data on the Reference Sites, and (b) a program for management of the wildlife resources on the Reservation.

The Environmental Sciences Division at ORNL would serve as the interface with universities or agencies who wish to use the Reservation, and would prepare a descriptive brochure of the Environmental Research

Park for distribution to potential useres of the Park and to interested members of the public. Various opportunities exist for university-based research to be conducted on the Reservation. Research for at least 36 doctoral and master's theses has already been conducted on the Reservation by students from a number of colleges and universities. A majority of these students were assigned to ORNL under the Oak Ridge Graduate Fellowship Program or under other arrangements between specific educational institutions and ORNL. Continued participation by graduate students in this program, now designated the ERDA Laboratory Graduate Participation Program, is anticipated. There is also a precedent for individual faculty members to conduct research on the Reservation. The greatly expanded instrumentation and technical support facilities now available for Reservation-based research should provide attractive opportunities for regional universities wishing to conduct ERDA-related research. The combination of local ecological expertise plus the complex of environmental types offers opportunities to research foundations and Federal agencies which need detailed environmental information for meeting special needs.

Where feasible, the Oak Ridge National Environmental Research Park will offer an extension service to community groups, providing lectures and, tours where the community may, first-hand, observe both long- and short-term effects of specific developmental activities.

It is anticipated that minimum funding of $150,000 annually will be required to successfully implement and complete the following programs:

A. Research Park Administration and Management.

B. Development and layout of an environmental surveillance system to determine the effects of the Oak Ridge and related energy-producing facilities on natural systems.

C. Characterization of Research Reference areas including studies on the niche information of the wildlife within the Park boundary. Initial effort will concentrate on species of special regional concern, i.e., Southeastern shrew, gray bat, gray fox, and white-tail deer in order to establish a comprehensive wildlife habitat management plan.

D. Development of an information system to synthesize and disseminate data collected on the NERP study sites.

It is felt that these research programs will ensure that the NERP is not simply a site to conduct basic ecological research but a planned environmental research program and an assemblage of ecological expertise directed toward achieving ERDA's goal of combining energy development with a quality environment.

Appendices A - G: Further details on the ecology of the ERDA Oak Ridge Reservation.

Appendix A. Description of the Vegetative Communities of the Oak Ridge Reservation

The vegetation of a region frequently is used as the prime interpretative measure of ecosystem and physiographic landscape units. Native plant communities often are a manifestation of combined environmental influences; viz. solar radiation, geology, precipitation, soils, slope, and aspect, and at the same time reflect management and biotic influences. Because natural ecological units of landscapes are determined by vegetation, the character and composition of vegetation are valuable research resources, and determine research opportunities and management policies.

Present analysis of local vegetation types, based on preliminary mapping incorporate seven categories: Pine, Hemlock and/or White Pine, Cedar, Bottomland, Upland, and Northern Hardwoods, and Nonforest. Brief descriptions of each type are in the following paragraphs.

Yellow Pine/Yellow Pine-Hardwoods. This is the most extensive forest type on the Reservation, occupying large areas in all sectors, but particularly abundant in the northwest region. Natural forests dominated by shortleaf pine (Pinus echinata) and Virginia pine (Pinus virginiana) are associated with large tracts of planted loblolly pine (Pinus taeda L.), a valuable timber species. The loblolly pine plantations are monocultures. Associated species in the successional pine forests include oaks (Quercus spp.), hickories (Carya spp.), and tulip poplar (Liriodendron tulipifera).

Hemlock and/or White Pine/Hemlock and/or White Pine with Hardwoods. This type, representing a Southern Appalachian extension of a northern (and higher elevation) forest, is extremely restricted on the Reservation.

Small areas on Pine Ridge, Black Oak Ridge, Haw Ridge, and north of Melton Hill Dam, all on the western half of the Reservation, are virtually all that remain. Total area is estimated to be no more than 99 acres (40 ha). Dominant species are hemlock (Tsuga canadensis) and white pine (Pinus strobus).

Cedar and Cedar Pine/Cedar-Hardwoods. This type is extensive on the Reservation, and occurs predominately in Bethel Valley and in southern areas adjacent or close to the Clinch River and Melton Hill Reservoir. Development is best on limestone (or dolomite) and it appears rapidly following disturbance. The present distribution pattern reflects both substrate and past land-use practices. The dominant species is eastern red cedar (Juniperus virginiana), associated with shortleaf and Virginia pine, tulip poplar, oaks, hickories, redbud (Cercis canadensis), sassafras (Sassafras albidum), and other hardwoods.

Bottom Hardwoods. This type is restricted to small floodplains along creek bottoms, and occurs along Gum Hollow Creek, Bear Creek, and Grassy Creek, with larger areas along White Oak Creek and the East Fork Poplar Creek drainage. The type exists only in the western two-thirds of the Reservation. Dominant are cottonwood (Populus deltoides), sycamore (Platanus occidentalis), elm (Ulmus americana), ash (Fraxinus spp.), willow (Salix spp.), silver maple (Acer saccharinum), and river birch (Betula nigra).

Upland Hardwoods. This type is important on the Reservation and occupies roughly 20% of the total land area. Largest concentrations occur on Black Oak, East Fork, Pine, Chestnut, and Copper ridges.

Scattered patches occur throughout most of the Reservation area. This forest is essentially an oak-hickory complex, representative of this region of the eastern United States. Important species include chestnut oak (Quercus prinus), white oak (A. alba), black oak (Q. velutina), northern red oak (Q. rubra), scarlet oak (Q. coccinea), post oak (Q. stellata), various hickories (Carya spp.) and ash (Fraxinus spp.), tulip poplar (Liriodendron tulipifera), red maple (Acer rubrum), black gum (Nyssa sylvatica), dogwood (Cornus florida), beech (Fagus grandifolia), and others. A showy vernal flora is characteristic of this type, and many of the common wildflowers in east Tennessee are virtually restricted to upland hardwood forests.

Northern Hardwoods. Northern hardwood forest is extremely rare on the Oak Ridge Reservation. It persists only in small areas on Black Oak Ridge and on Copper Ridge in the western part of the area. Composition is similar to the Upland Hardwood forest, with admixtures of sugar maple (Acer saccarum), hemlock (Tsuga canadensis), basswood (Tilia heterophylla), and buckeye (Aesculus octandra).

Nonforest. This is a variable category that includes primarily grassland, and devegetated and old field areas. Dominants include species of bluestem (Andropogon spp.), fescue (Festuca spp.), and bluegrass (Poa spp.). Cultivated grasslands are lawns and pastures. These predominate in and around the three plant areas (ORNL, Y-12, and ORGDP) and on CARL lands at the eastern extremity of the Reservation. Grasses include fescues, bluegrass, and orchard grass (Dactylis glomerata).

Appendix B. Watercourses of the Oak Ridge Reservation

Bodies of water represent important resources for research, municipal, and industrial activities at Oak Ridge (Fig. 2). Water resources generally originate from contributing springs on the ridge slopes of the Reservation area and, with two exceptions, are small streams with less than 0.57 m^3/sec average discharge rates. One of the two exceptions, the Clinch River, originates in southeastern Virginia. The other exception, Poplar Creek, receives initial flow from the eastern slopes of the Cumberland Mountains some 30 miles northeast of the Oak Ridge facilities. The Clinch River and Poplar Creek have drainage basin areas of 11,430 and 352 km^2, respectively, and average flows of about 130 and 7.7 m^3/sec. Substrates vary from silt-mud to gravel and no permanent riffle areas occur.

The smaller streams on the Reservation (e.g., Kerr Hollow Branch, Scarboro Creek, Whiteoak Creek, and Bear Creek) generally have drainage basins of fewer than 20 km^2 and flow rates less than 0.3 m^3/sec. Stream depths are typically < 1 m, and pools and riffles commonly alternate, with silt-mud and gravel substrates. The East Fork of Poplar Creek has a drainage area of 62 km^2 with riffle-pool habitats along the upper length of the creek. The lower third of the stream is influenced by the pool elevation of Watts Bar Reservoir.

Permanent "ponds" exist upstream of the wiers at various stream monitoring points. These include locations on the East Fork of Poplar Creek, Whiteoak Creek, and Bear Creek.

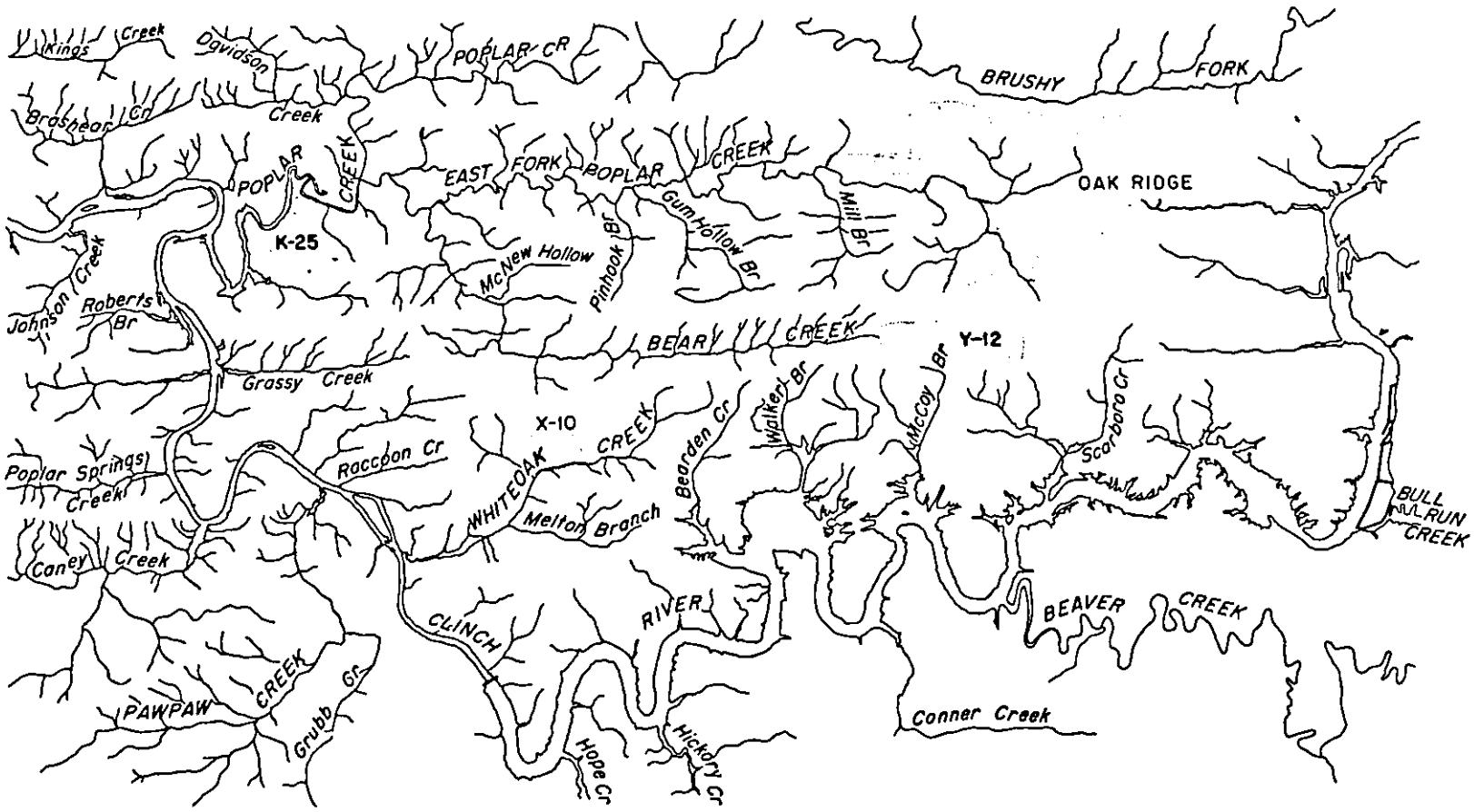


Fig. 2: Watercourses of the Oak Ridge Reservation.

Clinch River

The Clinch River, with a drainage area of 4412 sq miles (11,430 km^2), is the major source of water used in the Oak Ridge area. The section of the Clinch River directly adjoining the ERDA area extends from CRM 41.5 on Melton Hill Reservoir to CRM 11.5 just downstream from the mouth of Poplar Creek. The Clinch River flows into the Tennessee River at Tennessee River Mile (TRM) 567.7.

Scarboro Embayment

Scarboro embayment, formed by Melton Hill Reservoir at CRM 41.2, is about 0.6 mile (1 km) long, with an average width of 328 ft (100 m). It lies roughly parallel to Haw Ridge in Bethel Valley and is separated from the Reservoir proper by a highway fill with two 4.6-ft (1.4-m) diameter culverts. North of Haw Ridge the embayment is further divided, forming an east and a west arm that are connected by a culvert.

The east arm of Scarboro embayment is bordered on the north by the Comparative Animal Research Laboratory (CARL), which consists of a complex of research and livestock-holding facilities. The surrounding fields of this area slope toward the embayment at less than 5%. Haw Ridge, forested by secondary-growth deciduous trees, borders the south shore of Scarboro embayment. The east arm of Scarboro embayment has a maximum depth of 6.6 ft (2 m). The entire embayment is covered with a layer of silty bottom sediments. Scarboro Creek flows into the east arm of Scarboro embayment from a north-northeast direction.

The west arm of Scarboro embayment is bordered by pasture on the north and west and by Haw Ridge on the south. The land use, slopes, water depth, and bottom sediments are similar to those reported for the east arm. Kerr Hollow Branch flows into the western portion of this embayment from a northwest direction.

McCoy Embayment

McCoy embayment is formed by Melton Hill Reservoir at CRM 37.4. McCoy embayment receives flow from McCoy Branch from the northeast, and an unnamed tributary from the northwest. McCoy embayment runs through a gap in Haw Ridge and is separated from the Reservoir proper by a highway fill with two 4.6-ft (1.4-m) diameter culverts. Depth in the embayment is approximately 9.8 ft (3 m). Gravelly substrate exists near the ridge slopes; a mud substrate exists in most other areas. The land surrounding McCoy embayment is forested except for CARL pastures in Bethel Valley to the north.

Walker Branch Embayment - Melton Hill Reservoir

The Walker Branch embayment has a surface area of approximately 9.6 ha and a volume of 6.5×10^5 m^3. It receives runoff from five small intermittent streams, including the combined forks of Walker Branch.

Bear Creek

Bear Creek flows in a southwest direction from the Y-12 Plant to White Wing Road (State Highway 95) through second-growth

hardwood forests and late-successional old fields. At White Wing Road, Bear Creek turns northwest for the final 2 miles (3.2 km) of the approximately 7-mile (11.3-km) course, converging with East Fork Poplar Creek at mile 1.5. Stream width from Y-12 to the mouth of Bear Creek increases from 3 to 15 ft (0.9 to 4.6 m), and depth increases, from 4 in. to 3 ft (0.1 to 0.9 m). Bear Creek basin has a drainage area of 7.4 sq miles (18.3 km^2). About 65% of the basin is wooded; the open land is mostly old fields.

Stream habitat varies little as Bear Creek flows through Bear Creek Valley. The narrow stream flows over clay and rock substrate covered, particularly in the creek's upper reaches, by precipitates and a floc of aluminum hydroxide. The natural water flow in Bear Creek is augmented by discharges of Y-12 industrial wastewater and seepages from Y-12 acid settling ponds and sanitary landfills.

Poplar Creek and East Fork Poplar Creek

Poplar Creek, with a 136-sq-mile (352-km^2) drainage area, is the largest stream flowing into the Clinch River from the Oak Ridge Reservation. Poplar Creek flows generally southwest for 24.8 miles (40 km) from the Cumberland Mountain section of the Appalachian Plateau Province, through the Valley and Ridge Province around Oak Ridge, to the Clinch River (at CRM 12.0). About 65% of the total basin is wooded, and the remainder is largely farmland. Coal mining activities in the Cumberland Mountains significantly affect the water quality of this creek prior to its intersection with the ERDA Oak Ridge Reservation.

The headwaters of East Fork Poplar Creek originate on the northwestern slopes of Chestnut Ridge in the vicinity of the Y-12 Plant. Streamflow is controlled by New Hope Pond, approximately 0.5 acre (0.2 ha), on the east side of the Y-12 Plant which serves as a settling basin.

East Fork Poplar Creek below New Hope Pond runs through the Y-12 Plant area for 0.3 mile (0.5 km) and is confined by 8-ft (2.4-m) high riprapped streambanks of limestone rock. Stream substrate also consists of limestone rocks with some interspersed gravel. The pool immediately downstream from the dam averages about 15 ft (4.6 m) in width and 3 ft (0.9 m) in depth. Pools and riffles alternate, with a maximum depth in the pools of about 2 ft (0.6 m). Stream width varies from 10 to 15 ft (3 to 4.6 m).

East Fork Poplar Creek, after leaving the Y-12 Plant area, flows northwest through densely forested secondary-growth hardwoods. The predominant substrate is 1- to 4-in. (2.5- to 10.2-cm) rocks. Stream width varies from 10 to 25 ft (3.0 to 7.6 m). Average stream gradient is about 21 ft/mile (4 m/km). At the Oak Ridge Turnpike (State Highway 95), East Fork Poplar Creek turns southwest and passes through several large pastures before entering hardwood forests. The Oak Ridge Sewage-treatment plant (west) is located on EFPCM 8.5. Substrates above the sewage-treatment plant are primarily gravel.

White Oak Creek and White Oak Lake

White Oak Creek basin has an area of 6.53 sq miles (16.9 km^2). The headwaters of White Oak Creek originate on the forested slopes of Chestnut Ridge, north of ORNL. Numerous springs intersecting with the

upper reaches of White Oak Creek provide a relatively stenothermic aquatic environment. Stream width varies from 2.0 to 4.0 ft (0.6 to 1.2 m), and depth, from 3.9 to 9.8 in. (10 to 25 cm). Stream bed substrate is predominately rocks of 2.0 to 3.2 in. (5 to 9 cm) diameter with some exposed bedrock.

Appendix C. Special Habitats

Caves

Caves are fairly common in the limestones of east Tennessee and several are known to exist in the Knox dolomites of the Oak Ridge Reservation. Although some caves were inundated by the impoundment of the Clinch River to form Melton Hill Lake, at least three are still accessible on the Reservation. No sampling of animal species indigenous to caves has been done on the Reservation. However, many species of bats, invertebrates, fish, amphibians, and the Allegheny wood rat (Neotoma nagister) are known to occur in Tennessee caves. One of the larger caves and the surrounding area has been established as a natural area.

Old Fields

Mowing every 2 to 5 years maintains many areas of the transmission line corridors on the Reservation in a perpetual shrub phase. Old homesites on the Reservation, abandoned in 1942 after purchase by the Federal government, tend to be composed of tree seedlings and rapidly growing shrubs and woody vines. Ground-cover species are still generally those of the perennial grass phase with some more shade-tolerant forest species becoming established. In addition to species native to

the area, many plants introduced at the homesites throughout the Reservation have been persistant. White poplar (Populus alba) and hemlock (Tsuga canadensis) (which occurs rarely in the area) were often planted in yards. Periwinkle (Vinca minor) and daffodils (Narcissus pseudo-narcissus) mark the locations of virtually all old homesites while bridal wreath (Spiraea sp.), rambling roses (Rosa sp.), and daylilly (Hermerocallis fulva), are also quite common.

Waterfowl Refuge

The ponds on the south side of ORGDP, including the adjacent lowlands, have been designated as area 0811 and are reserved for natural wildlife refuge (Fig. 3, area 25). They provide habitat for Canada geese and populations of other waterfowl and also as a natural study location for ecological observation and experimentation.

Appendix D. Environmental Natural Reference Areas

The significance of the Reference area program is the commitment to preserve unique or representative biotic features of the Reservation for research and education of present and future generations. The protection of the Oak Ridge Reservation has resulted in the preservation of many areas whose species composition and/or state of development make them of considerable scientific value.

Natural areas on the Reservation are shown in Fig. 3 and described below.

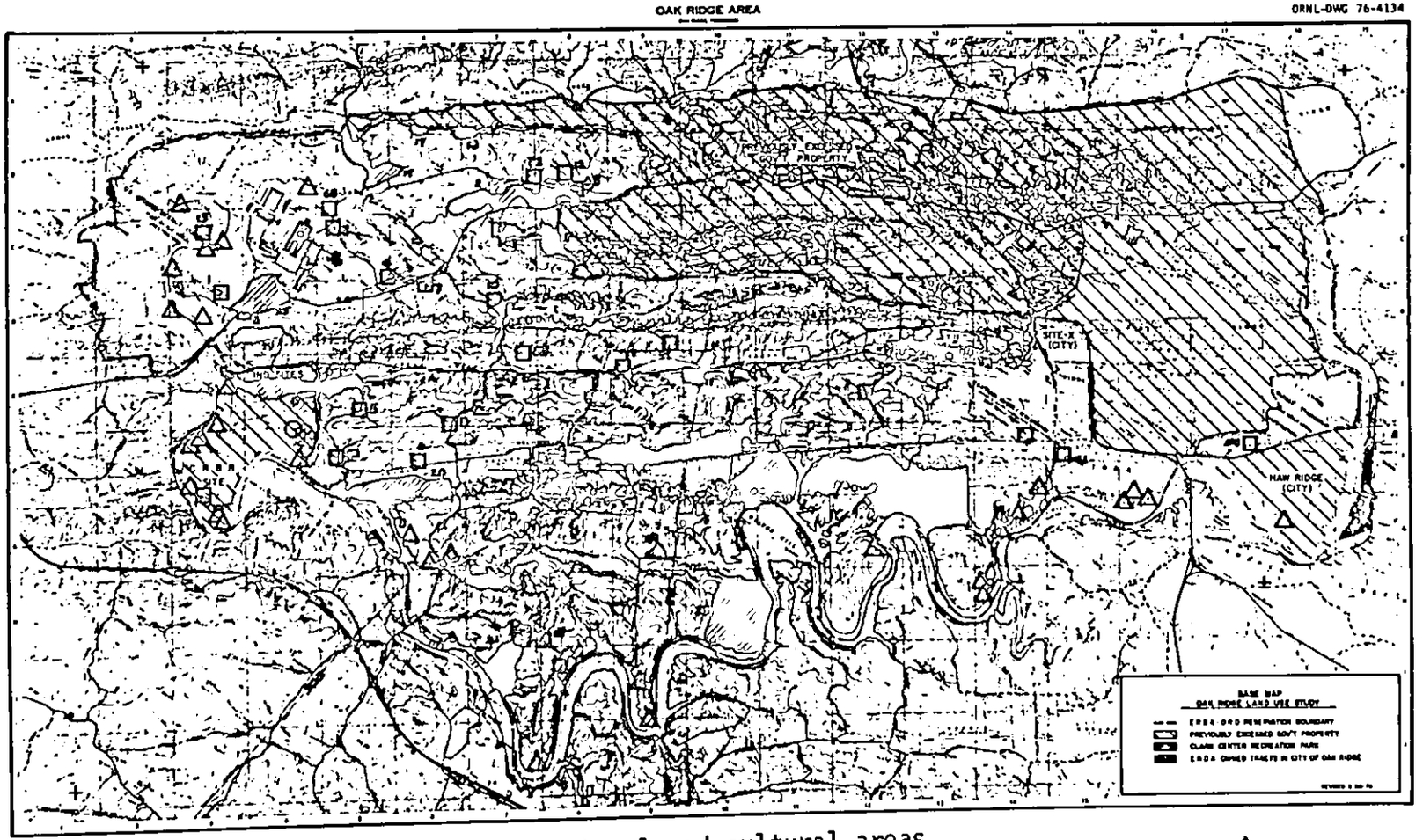


Fig. 3. Map 6. Unique natural and cultural areas

Key to Figure 3. Important Natural Areas (Map 6)

1. MM*: Basswood-maple-buckeye-rhododendron (25 acres, 10 ha)
2. Sycamore-box elder floodplain (120 acres, 50 ha)
3. MM*: Beech-basswood-poplar-buckeye (40 acres, 15 ha)
4. McNew Swamp (10 acres, 4 ha)
5. MM*: Beech-mountain laurel (5 acres, 2 ha)
6. MM*: Basswood-maple-buckeye (110 acres, 45 ha)
7. Red cedar (4 acres, 2 ha)
8. Canebreaks (15 acres, 6 ha)
9. Old-field sassafras (30 acres, 12 ha)
10. Lichen and moss (10 acres, 4 ha)
11. MM*: White pine-holly (30 acres, 12 ha)
12. Red cedar (5 acres, 2 ha)
13. Red cedar (75 acres, 30 ha)
14. White oak (20 acres, 8 ha)
15. MM*: Hemlock-rhododendron (30 acres, 12 ha)
16. Chestnut oak-spring ephemeral forbs (10 acres, 4 ha)
17. MM*: Hemlock (10 acres, 4 ha)
18. Red maple (15 acres, 6 ha)
19. MM*: Beech-poplar-mountain laurel (40 acres, 15 ha)
20. MM*: Hydrastis canadesis-beech (135 acres, 55 ha)
21. MM*: White pine-beech (75 acres, 30 ha)
22. Red cedar (105 acres, 45 ha)
23. Old-field homesites (270 acres, 110 ha)
24. Red cedar (205 acres, 85 ha)
25. Waterfowl refuge (95 acres, 40 ha)

*Mixed mesophytic forest types as described by E. Lucy Brown, Deciduous Forests of Eastern North America, Blakiston, Philadelphia, 1950.

Red Cedar (7, 12, 13, 22)[a]

Red cedar stands occur throughout the Reservation on calcareous soils. One example is a relatively pure stand of cedar in area 7; cedar is dominant, accompanied by white pine (Pinus strobus) and Virginia pine (Pinus virginiana). Associated tree species are winged elm (Ulmus alata), black walnut, oaks, redbud, hackberry (Celtis sp.), and ash (Fraxinus sp.). The area has a park-like appearance with the trees widely spaced and the ground cover mostly grasses (Andropogon sp.). Scattered species of aster, goldenrod (Solidago sp.), beggar ticks (Desmodium sp.), and yucca (Yucca smalliana) are present also. Cacti (Opuntia compressa), aloe (Agave virginica), and rosinweed (Silphium terebinthinaceum) are herbaceous plants that occur in similar areas on other parts of the Reservation. Redbud (Cercis caroliniana) is also common. Limestone ledges breaking through the shallow soil in this and other areas support a rich flora of mosses, lichens, and algae (Nostoc sp.). Numerous forested cedar areas also occur within the Reservation boundaries (areas 22 and 24).

Sassafras-Black Locust (9)

On the upper slope and top of Copper Ridge overlooking the western end of the Reservation is an extensive old-field area containing several pure stands of sassafras; many of the trees are 5 in. in diameter or larger. Several mixed sassafras-black locust (Robinia pseudo-acacia) stands containing an abundance of locust stump sprouts also occur on the ridge top. Because sassafras is known to inhibit the invasion of

---

[a] Numbers refer those on Key to Fig. 3.

many other species, these unusually extensive stands will probably be persistent.

Lichens (10)

West of Bearden Creek embayment is an unusual old-field site dominated by pine and with extensive mats of lichens and mosses forming the dominant ground cover. Reindeer moss (C. subtenius) is the most conspicuous lichen, but British soldiers (Cladonia cristatella) are abundant. Windswept moss (Dicranum sp.) is the most common moss. Another lichen, old man's beard (Usnea sp.), is unusually abundant in this area and covers the lower branches of many of the trees.

White Oak (14)

White oak (Quercus alba) was one of the original major associations found in the Valley and Ridge Province prior to settlement. A few areas on the Reservation are still dominated by this species. The south slope of Chestnut Ridge north of Bethel Valley quarry contains a watershed system that is dominated by large second-growth white oak. This area has evidently not been disturbed for many years except perhaps by grazing livestock prior to 1942. The trees are widely spaced and not deformed by fire or wind damage. Pure stands of white oak and mixed white oak, chestnut oak, black and red oaks, and sugar maple (Acer saccharum), all 1 to 2 ft in diameter, cover an area several acres in extent.

Mixed Mesophytic Forests (1, 3, 5, 6, 15, 17, 19, 21)

Mixed mesophytic forest associations occur throughout the Reservation. These associations are some of the most varied and luxuriant in the eastern deciduous forests.

Plant species found in Braun's mixed mesophytic forest association commonly occur in cooler, more moist regions in the mountains and to the north, but are unusual in this area. Many of the relatively undisturbed steep, north-facing slopes, steep-sided coves, and some gently sloping sheltered coves on the Reservation contain some combination of these species.

Area 15 is dominated by chestnut oak. Large tulip poplar, beech (Fagus grandifolia), and sugar maple are common; two species of magnolia (Magnolia acuminata and M. tripetala) and basswood (Tilia americana), white pine, and hemlock (Tsuga conadensis) also occur. The understory is very dense with extensive thickets of locally rare maple leaf viburnum (Viburmum acerifolium) and pawpaw (Asimina triloba) and one thicket of rhododendron (Rhododendron maximum). Herbaceous groundcover species observed in the fall include several species of ferns [maidenhair (Adiantum pedatum), walking fern (Asplenium rhizophyllum), Christmas fern (Polyslichum aerostichoides), etc.], hepatica (Hepatica americana), saxifrage, and many species of mosses and lichens growing over the vertical limestone outcroppings.

Two areas (1 and 6) contain species and communities that are rare locally and are typical of Braun's generalized mixed mesophytic association found in the Appalachian Plateau. On the lowest part of the slopes, basswood, sugar maple, and buckeye (Aesculus sp.) are

dominant, with magnolias, oaks, elm (Ulmus americana), cherry (Prunus serotina), and tulip poplar as codominants. The shrub layer is very dense, and is composed mainly of pawpaw and sugar maple seedlings.

Further up the slope of area 6, the overstory changes to sugar maple with a few hickories and oaks. There is an occasional beech, sweet gum, buckeye, and ironwood (Ostrya virginiana). The shrub layer is composed mainly of sugar maple seedlings but also contains spice bush (Lindera benzoin), strawberry bush (Euonymus americanus), hydrangea, and buckeye seedlings. Ground cover in this area is composed of bugbane, foam flower (Tiarella cordigolia), and a different species of little brown jub (Hexastylis ruthii).

The upper slope (area 6) is yet another mixed mesophytic association with beech and sugar maple as codominants. In this drier zone, cedars, hickories, tulip poplar, flowering dogwood, and sassafras also occur. The shrub layer is composed primarily of overstory tree seedlings. Extensive patches of parasitic beech-drops [Epifagus virginiana (L.)] occur under beech trees, but little other ground cover is present (mainly scattered Christmas fern and Virginia creeper).

Another unusual beech area (area 5) is in a gap through Pine Ridge. The canopy on this northwest-facing slope is composed mainly of beech. Mountain laurel (Kalmia latifolia) forms dense thickets under the beech, oaks, tulip poplar, and sourwood, and excludes most herbaceous vegetation. Downslope from the laurel, witch hazel (Hamamelis virginiana L.) borders the small stream flowing through the gap. This extensive laurel growth is the largest on the Reservation.

Some of the largest beeches on the Reservation occur in area 3. Beech, white oak, and white pine exceeding 30 in. in diameter are on

the lower slopes of this north-facing watershed draining into Poplar Creek. Tulip poplar and chestnut oak are also abundant in this area, and ash, sugar maple, cherry, hickories, sourwoods, and hemlock are other canopy species. Shrub and herbaceous species include beech and red maple seedlings, greenbrier, Christmas fern, foam flower, anemone, rattlesnake orchid (Goodyera pubescens), pipissewa (Chimaphila moculata), and poison ivy.

Hemlock (15, 17)

Another major grouping of the mesic hardwood type is the community dominated by hemlock (Tsuga canadensis). The community is unusual in this portion of the Valley and Ridge Province because it normally occurs in the higher elevations. Especially in area 15 extensive patches of both laurel and rhododendron are found. The hemlock community provides habitat for a rare parasitic shrub species, Buckleya sp.

White Pine (11, 21)

White pine (Pinus strobus) occurs as an occasional canopy tree in most of the mixed mesophytic associations, but it assumes a dominant role in only a few areas on the Reservation. White pine is the dominant in area 11 with tulip poplar and white oak codominants. Many of these trees are over 2 ft in diameter, a rarity in this region because of extensive lumbering. Other canopy trees include hickories, beech, oaks, red maple, and sugar maple. The understory is composed of strawberry bush and tree seedlings, most of which are sugar maple and white pine. Holly (Ilex opaca) occurs frequently in the shrub stratum of some white pine areas on the Reservation.

Floodplain (2)

There are many small floodplain areas on the Reservation, but the Poplar Creek floodplain is unique because no trees have been harvested from it since the land was purchased in the early 1940's. The banks of the main channel are lined with large sycamore and occasional oaks and sugar maples. Extensive stands of box elder (Acer negundo L.), ash, willow, and sycamore with an occasional hackberry and black walnut cover the floodplain. Cane or dogwood form impenetrable thickets in some areas. In more open areas, the surface of the ground is covered with sparse grass (Microstegium and Elymus sp.). Species of asters and other composites and lobelia (Lobelia cardinalis and Lobelia siphilitica) are abundant in localized areas. This floodplain is probably one of the few of comparable size remaining undisturbed by agriculture in the eastern part of the state. Associated with Poplar Creek in area 16 is a high limestone bluff along Bear Creek before its convergence with Poplar Creek.

Swamps (25)

Many swampy areas occur on the Reservation, but none are extensive. Therefore the few areas present contribute to a valuable ecological resource, and it is essential that they are preserved in an undisturbed condition. There is a swampy area (about 0.5 acres) on the Watts Bar floodplain below Gallaher Bridge (part of area 25), which is probably the largest on the Reservation. Also included in area 25 are the ponds near ORGDP that serve as resting and feeding areas for many migratory bird species. Numerous species of ducks use them, and both Canada and snow geese were sighted this past year.

Area 8 contains the most extensive canebreaks on the Reservation. Another less disturbed, although much smaller, marshy area occurs in McNew Hollow (area 4).

Old Fields (23)

Old-field communities in various successional stages, most of them containing arboreal components, occur throughout the Reservation and are composed of different species, depending on edaphic factors and land use at the time of ERDA acquisition. These successional areas serve as an important source for biological materials for ecological research on natural communities.

It should be emphasized that while conservation of the areas discussed above is the major objective, such areas are also important as sites for ecological research. In particular, some of these areas can act as ecological baselines. Long-term observations may be carried out to evaluate natural and anthropogenic induced changes and trends on the Reservation in particular and in the southeast region in general. The unique and natural areas are useable for nonmanipulative research, and preservation of these areas can also provide supervised educational and training opportunities to students, university scientists, and the community at large.

Appendix E. Description of the Wildlife of the Oak Ridge Reservation

The variety of wooded and open areas, as well as extensive edge communities, creates favorable habitats for a wide variety of mammalian

and avian species residing on the Oak Ridge Reservation. An important factor in determining whether a given species will, in fact, occur in a given area is the nature of the habitat in the area. Small mammals, such as rodents, may be confined to a single habitat type. Larger sized species, on the other hand, may range over several habitats in order to fulfill their existence requirements.

Sampling of small-mammal populations on the Reservation has usually been conducted as a part of collection programs for laboratory experiments. Six species common in oak-hickory, chestnut oak, and pine forest types are the white-footed mouse, eastern chipmunk, golden mouse, short-tailed shrew, flying squirrel, and house mouse. Both the red and the gray fox are common predators throughout the area. Opossum, raccoon, striped skunk, and bobcat inhabit numerous areas throughout the Reservation. They roam extensively through the upland forest areas. Whitetail deer are also inhabitants of upland and bottomland forests.

The upland hardwood forest provides habitat for a large number of songbirds. In addition, many raptorial birds use the woodlands on the Reservation for nesting and hunting. Red-shoulder, redtailed, and broad-winged hawks are common throughout the area.

A recent survey of the small-mammal inhabitants of pine stands and an associated transmission right-of-way indicates that only three species use the pine habitat to any great extent, the white-footed mouse, golden mouse, and short-tail shrew. Additional species were present (pine mouse, cotton rat, and harvest mouse), but their presence appeared to be a function of the edge community created by a transmission-line corridor. Large mammals, gray squirrels, opossum, deer, and predators probably take shelter in this type of habitat.

Avian species had a low preference for the pure pine areas bordering the transmission-line corridor. The pine warbler (Dendroica pinus) and the white-throated sparrow (Zonotrichia albicollis) were very common, but few other species were heard or seen during the early morning surveys.

Mammalian species inhabiting old-field or disturbed areas are quite similar, whether the vegetative cover is early grass-forb or the later tree seedling-woody shrub successional stages. The small-mammal communities indicative of these habitats were determined for a 0.4-acre (0.2-ha) area in the vicinity of the Oak Ridge Gaseous Diffusion Plant. Small mammals recently trapped from this habitat type were cotton rats, white-footed mice, golden mice, rice rats, short-tailed shrews, and eastern harvest mice. Early grassland stages of old-field areas are used by some game birds, such as quail, for courtship displays and breeding purposes. Raptorial species generally use the old-field areas for hunting purposes.

Selection by bird species for old-field and grassland habitat was similar to that observed on many of the transmission-line corridors, particularly when the corridor runs through another habitat type. Sparrows, towhees, blue grosbeaks, and other field species tend to select for the vegetation within the corridor.

The southern bald eagle (Haliaeetus l. leucocephalus) has been sighted numerous times, most recently along both Melton Hill Lake (Feb. 1976) and Watts Bar Lake (May 1974). It nests in large trees along waterways, but no nest has been observed, and its status on the Reservation is unknown.

Appendix F. Aquatic Biota of the Oak Ridge Reservation

Flora

Macrophytes. Macrophytes are categorized as aquatic plants that posses a multicellular structure with cells differentiated into specialized tissue. Herbaceous hydrophytes common in the Tennessee River Valley usually grow in soils covered with water during a major portion of the growing season. These can be conveniently divided into three major growth forms:

emergent - typically with some of the vegetative parts extending above the water surface;

floating - typically having the entire plant or some of the vegetative parts floating on the water surface;

submerged- typically with the vegetative parts largely submerged.

Habitat differences account for species changes that are most noticeable in the herbaceous forms. Small streams and springs with lotic water usually contain emergent plants that are perennial. The relatively uniform environment tends to produce somewhat permanent communities of plants and associated animals. These species include watercress (Nasturtium officinale) and false loosestrife (Ludwigia alternifolia, L. palustris, L. p. americana). The most noticeable annuals are pondweed (Potamogeton sp.) and cattail (Typha latifolia) which also invade lentic habitats.

Ponds, reservoirs, and other lentic waters in the Oak Ridge area contain predominantly submerged species in the shallow areas. Extensive growths of waterweed (Elodea canadensis) and milfoil (Myriophyllum

sp.) have invaded embayments and sections of the main channel of the Clinch River. These species, in addition to Potamogeton sp. and bushy pondweed (Naias flexilis), inhabit pool areas in many streams high in nutrients. Aquatic moss (Fontinalis sp.) provides colonization areas and food for the aquatic invertebrates in streams with rocky substrate or bedrock and with moderate to swift current.

Phytoplankton

Phytoplankton in the Clinch River probably originate from a number of different habitats. Major sources are phytoplankton populations in Melton Hill Reservoir and dislodged benthic algae. River plankton populations, in general, are highly variable in time and in space. However, the basic successional pattern observed is probably typical for the Tennessee area. Crysophyta (mainly diatoms) dominate the phytoplankton during winter, decreasing somewhat in both numbers of species and proportions of total individuals per species in summer. Cyanophyta (blue-green algae) may increase and become dominant during the summer, but this increase depends upon rainfall and river water levels. A summer increase in Chlorophyta (green algae) is also common. In early to mid-autumn, blue-green and green algae decrease and the diatoms again become the dominant phytoplankton group. Only limited data are available on phytoplankton communities of other area streams. White Oak Lake is characterized as having high phytoplankton productivity, and a relatively diverse flora.

Fauna

Benthic macroinvertebrates. Macroinvertebrate species are emphasized in aquatic ecological surveys because these organisms are relatively sessile, undergo short life cycles (usually less than one year), and reflect changes in environmental quality by virtue of changes in either species diversity, abundance, or presence of "indicator organisms".

The invertebrates that live on, in, or near the substratum of running waters include representatives of almost every taxonomical group that occurs in fresh water: principally Turbellaria, Bryozoa, annelids, crustaceans, and insects.

The assemblage of benthic macroinvertebrates found in riffle areas of small streams in the Oak Ridge area appears typical for hard-substrate benthic communities in running waters. Insects were the most diverse group represented in collections made in 1974, of which Diptera (principally Chironomidae), Ephemeroptera, and Trichoptera were most prevalent. Crustacea were represented predominantly by the crayfish Cambarus sp., which is widely distributed throughout a variety of habitats. Adult aquatic Coleoptera (beetles) were seldom found in stream samplings, except for representatives of the family Elmidae, which are commonly selected as indicators of areas not exposed to organic pollutants.

Only eight taxa of benthic macroinvertebrates were commonly found in the mud-silt substrata. The lower number of taxa found on soft substrata vs hard substrata is representative of lentic habitats. Muddy substrata in general may be higher in biomass but

not in diversity of species. Hexagenia, Chironomidae, and Oligochaeta, were the most prevalent groups of organisms collected in samples from Whiteoak Lake, Poplar Creek, and Clinch River. Tubificidae, Chironomidae, burrowing mayflies (Ephemeridae), Gastropods, and Pelecypoda (Unionidae and Sphaeridae) are considered characteristic fauna of soft mud-silt substrates. Aquatic Oligochaeta (e.g., Lumbricidae, Tubificidae, and Naidae) generally abound in mud at the bottom and along the shores of most bodies of fresh water. Certain Chironomids are able to inhabit essentially the entire spectrum of habitat types.

Zooplankton

Species composition and abundance of zooplankton in the Clinch River in the vicinity of the ORGDP are dependent primarily on recruitment of zooplankton from Melton Hill Reservoir and on displacement from "quiet" areas with little or no flow, such as creeks and backwaters. Rotifers are nearly always the dominant zooplankton in larger rivers, and are commonly represented by truly planktonic forms such as Keratella, Synchaeta, Polyarthra, Asplanchna, and Brachionus. Crustaceans are rarely numerous in the open water areas of rivers. Those that are found usually belong to the genera Cyclops or Bosmina. Collections from the Clinch River seem to coincide with these general observations. No recent data are available on zooplankton communities of other Reservation streams.

Fish

The Oak Ridge Reservation is within a 2-hr drive of 12 large reservoirs constituting better than 500,000 surface acres of water and more than 10,000 miles of shoreline. Therefore, Oak Ridge and surrounding

areas maintain a relatively large population of sport and commercial fishermen and water-sports enthusiasts. Fish species found in area waters are of three basic groups: rough, forage, and game species.

Commercial fishing is primarily confined to reservoirs and rivers, with fish usually taken by means of netting, trot lines, and slat baskets. A few commercial fish are also taken on rod and reel. Tennessee laws prohibit commercial fishing in Melton Hill Reservoir; however, the Clinch River immediately below Melton Hill Dam and the entire reaches of Watts Bar Lake are popular with commercial fishermen. The two most important species taken commercially are smallmouth buffalo (Ictiobus bubalus) and channel catfish (Icalurus punctatus). Other species such as the bigmouth buffalo (Ictiobus cyprinellus), black buffalo (Ictiobus niger), shorthead redhorse (Moxostoms breviceps), black redhorse (Moxostoma duguesnei), golden redhorse (Moxostoma erythrurum), blue catfish (Ictalurus furcatus), and flathead catfish (Pylodictis olivaris) are taken commercially in less quantities.

An exceptionally high number of sport fishermen are active annually. In general, however, spring (February through June) migrations of walleye (Stizostedion vitreum vitreum), white bass (Morone chrysops), white crappie (Pomoxis annularis), black crappie (Pomoxis nigromaculatus), and sauger (Stizostedion canadense) constitute the most productive seasonal takes. Heavy migrations of white bass (Morone chrysops) occur into Poplar Creek and hence onto the Reservation proper. Melton Hill Dam serves as a peaking hydroelectric unit, and therefore does not provide the types of stable currents necessary for ideal spawning conditions.

Water temperatures are usually slightly warmer in tributary streams such as Poplar Creek, establishing these as more favorable spawning sites.

During the past five years, tournament fishing for largemouth bass (Micropterus salmoides), smallmouth bass (Micropterus dolomieui), and spotted bass (Micropterus punctulatus) has become popular throughout the United States. Watts Bar Reservoir has established itself as a popular area for tournaments, with Oak Ridge and the surrounding area now supporting more than 25 local bass clubs.

Angling for panfish is the predominant sport during the summer (June through August). The bluegill (Lepomis macrochirus) is the most abundant species taken; however, the redear sunfish (Lepomis microlophus) has recently become popular.

Two species, the rockfish (Morone saxatilis) and rainbow trout (Salmo gairdneri), are not native to Tennessee Reservoirs. However, they have been stocked in sufficient numbers to establish a large following of fishermen. Melton Hill Reservoir sustains a high population of rainbow trout, and Watts Bar Reservoir carries a good population of rockfish. On occasion, muskellunge (Esox masquinongy) are taken.

Appendix G. Environmental Research at Oak Ridge

The environmental research programs on the Oak Ridge Reservation provide an integrated approach to ecological problems associated with energy research and development. Areas used for research purposes include the range of habitat diversity typical of the region. They are further delineated to include experimental conditions (e.g., relief, geology, soils, water quality, stream characteristics, and specific

biotic associations) required for the likely range of research objectives. The nature of the research often requires long-term commitment of the area.

Terrestrial and aquatic research areas are shown on Figs. 4 (Map 7) and 5 (Map 8). The numbered sites are identified and acreages are given in the Keys to Figs. 4 and 5. Brief descriptions of some of these areas follow:

Watershed Research: Current research on the Walker Branch Watershed area (area 0919) (Fig. 4) is addressed to the movement of natural and man-caused soluble and insoluble particulates and materials in the environment. As a research facility, the watershed is unique and should be protected. It is a calibrated watershed used as an environmental study site and is located on the north side of Bethel Valley Road on Chestnut Ridge. Walker Branch flows from the watershed into Walker Branch embayment on Melton Hill Dam. Research at Walker Branch deals with the fundamental behavior of mineral cycles and the distribution of elements in natural ecosystems. The watershed area is used to quantify the movement of foreign and natural materials through the vegetation, soil, forest floor, and aquatic systems. Research is also directed toward determining effects on the environment of toxic airborne and waterborne materials, including heavy metals from fossil-fuel power plants, and entrance of these materials into the life cycles of animals and man. The research being conducted on Walker Branch contributes to the basic knowledge of biogeochemical cycles in typical forested landscapes of eastern deciduous forest types. The watershed also serves as a site where investigations on the function and structure of bird and small mammal communities are carried out.

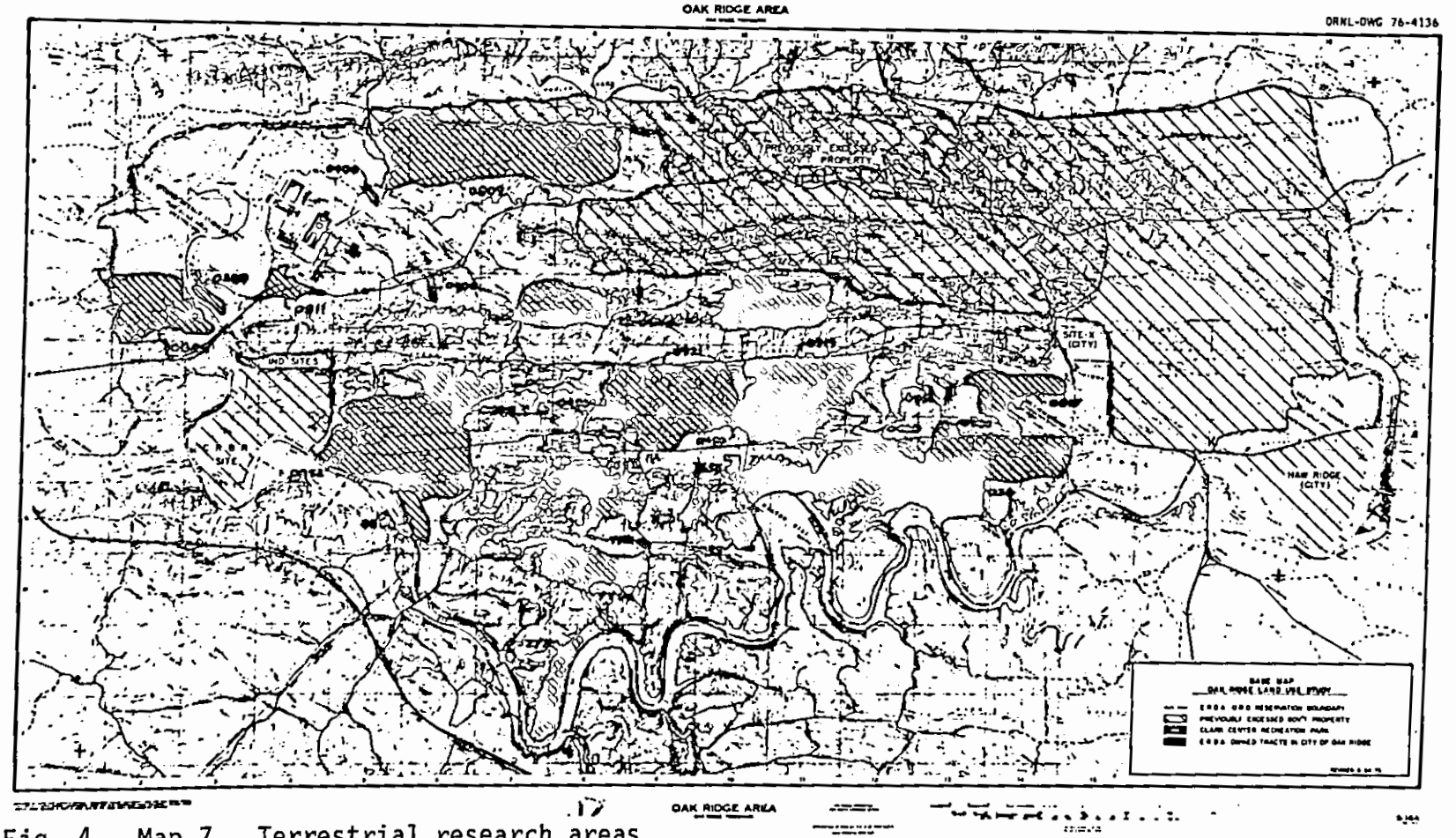


Fig. 4. Map 7. Terrestrial research areas

Key to Figure 4. Environmental Research Areas: Terrestrial Research Areas

0090 Mammal study area south of Lagoon Rd. (5 acres, 2 ha)

0100 Environmental monitoring area (20 acres, 8 ha)

0400 Transmission-line management area (35 acres, 15 ha)

0450 Transmission-line corridor effects study (30 acres, 12 ha)

0800 Postattack research area--NOAA Meteorological Research Area (125 acres, 50 ha)

0801 Raccoon Creek watershed (1060 acres, 430 ha)

0805 "0" -segment tree nursery area (115 acres, 45 ha)

0809 Cooling-tower drift study area (920 acres, 370 ha)

0810 Tritium study area (20 acres, 8 ha)

0852 Grubb Island embayment animal collection area west of Raccoon Creek embayment (10 acres, 4 ha)

0913 McNew Hollow watershed (proposed) (165 acres, 65 ha)

0914 Laboratory water supply and Chestnut Ridge control (4 acres, 1.6 ha)

0915 Walker Branch power-line research area, Bird and mammal studies (north edge of 0919) (15 acres, 6 ha)

0916 Northern cove animal collection area northeast of 0919 (60 acres, 25 ha)

0917 Forest contamination area (135 acres, 55 ha)

0919 Walker Branch watershed (515 acres, 210 ha)

0921 White Oak Creek watershed (735 acres, 300 ha)

0923 Gumm Branch watershed (330 acres, 135 ha)

0924 Bethel Valley quarry (10 acres, 4 ha)

3599 Environmental monitoring area (10 acres, 4 ha)

4552 Environmental monitoring area (65 acres, 25 ha)

7565 Environmental monitoring area (70 acres, 30 ha)

7650 Radioisotope-tracer study area (15 acres, 6 ha)

Key to Figure 4. (continued)

7655 Radioisotope-tracer study area (2 acres, 1 ha)

7660 Melton Hill embayment (410 acres, 165 ha)

7730 Animal population collection areas (145 acres, 60 ha)

7733 Melton Hill Lake and aquatic monitoring area (75 acres, 30 ha)

7754 Terrestrial radionuclide cycling area (155 acres, 65 ha)

7851 Environmental monitoring area (60 acres, 25 ha)

7950 Radioisotope-tracer area (5 acres, 2 ha)

7951 Radioisotope-tracer area (3 acres, 1.2 ha)

Not on map

0812 Terrestrial and environmental quality research areas

0918 Animal population and collection area

0922 Terrestrial and environmental quality research areas

7732 Animal population and collection area

7734 Animal population and collection area

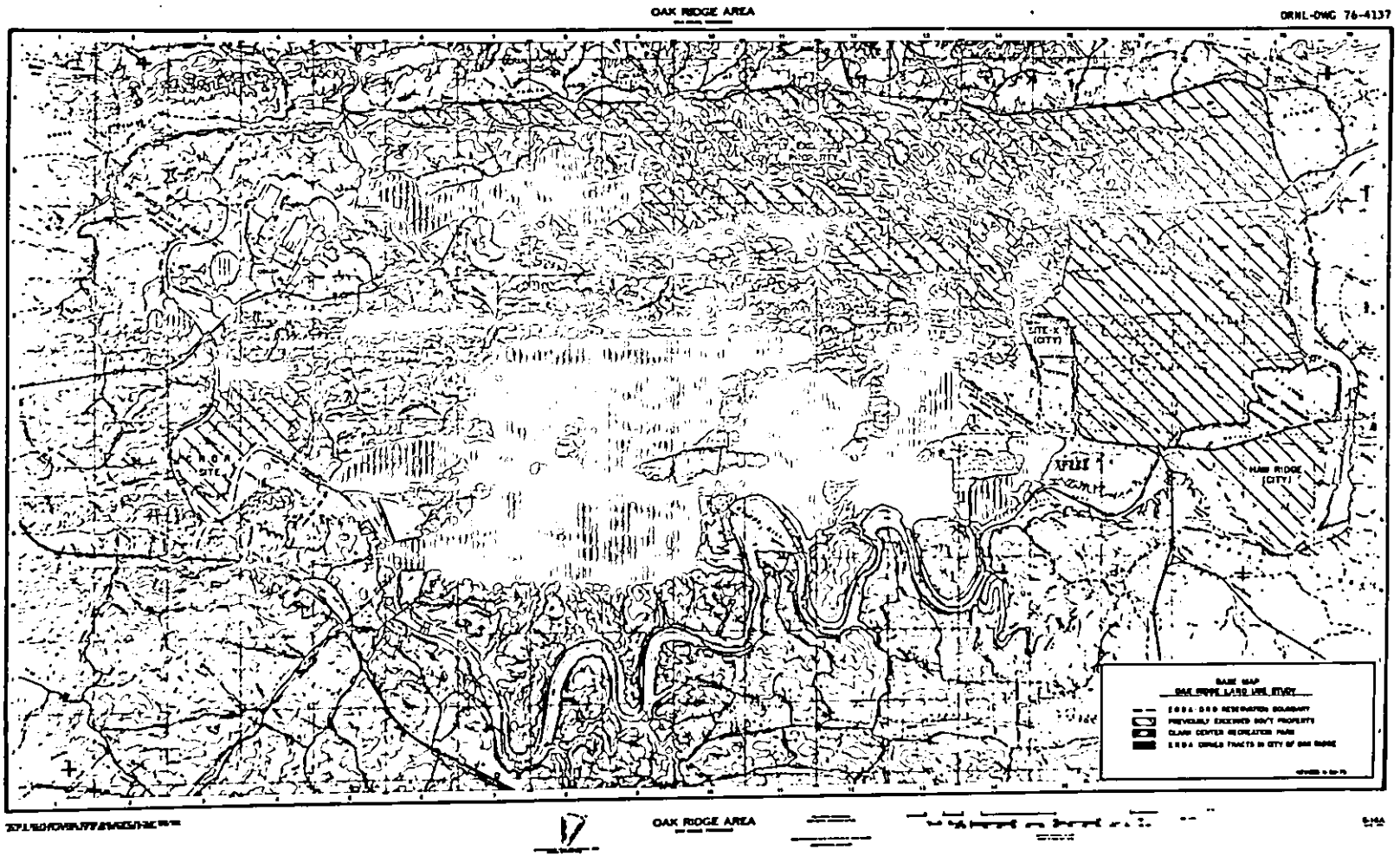


Fig. 5. Map 8. Aquatic research areas

Key to Figure 5. Environmental Research Areas: Aquatic Research Areas

I. Lambert quarry (140 acres, 55 ha)

II. McCoy Branch, Bethel Valley quarry and associated watershed (430 acres, 175 ha)

III. Walker Branch, Melton Hill embayment and associated watershed (750 acres, 305 ha)

IV. White Oak Creek watershed, White Oak Creek, White Oak Lake, Melton Branch, Melton Branch watershed, and White Oak Creek embayment (2750 acres, 1115 ha)

V. ORNL spring water supply and associated watershed (425 acres, 170 ha)

VI. West Branch of White Oak Creek and associated watershed (95 acres, 40 ha)

VII. Raccoon Creek and associated watershed (310 acres, 125 ha)

VIII. Scarboro embayment and Kerr Hollow watershed (100 acres, 40 ha)

IX. Bear Creek drainage basin (710 acres, 285 ha)

X. Clinch River and Poplar Creek research areas and monitoring stations (385 acres, 155 ha)

- X-2. Roberts Branch embayment (65 acres, 25 ha)
- X-3. Embayment pond (20 acres, 8 ha)
- X-4. Poplar Creek (45 acres, 20 ha)
- X-5. CRM 11 sampling station (40 acres, 15 ha)
- X-6. Mouth of Ellis Creek (35 acres, 14 ha)
- X-7. Convergence of East Fork Poplar Creek with Poplar Creek (25 acres, 10 ha)
- X-8. Grassy Creek embayment (60 acres, 25 ha)

XI. East Fork Poplar Creek (755 acres, 305 ha)

XII. Melton Lake waterfowl habitat (135 acres, 55 ha)

Associated with the Walker Branch watershed is the Melton Hill embayment (area 7660) which is currently being studied to delineate the movement of nutrient materials from terrestrial to aquatic systems. Future research on Walker Branch and the embayment will focus on the transport and fate of trace contaminants associated with both fossil-fuel and nuclear-fuel cycles.

Radioisotope Tracer Areas: Radionuclides are used within seven forested areas south and east of ORNL and on the crest and slopes of Chestnut Ridge southeast of Y-12. These research areas include 0810, 0917, 7754, 7655, 7650, 7951, and 7950 and total approximately 335 acres (136 ha). They are used for an ongoing program of radionuclide cycling studies in natural forested ecosystems.

Tritium studies have been conducted in a forested area (0810) on the north side of the ERDA Reservation. The western portion is also being used to monitor trace contaminants transported in ORGDP cooling-tower plumes which drift over the area. The remaining sections of area 0810 are needed for potential program expansion.

Numerous studies of radionuclide behavior in aquatic and terrestrial environments have been carried out in the White Oak Creek watershed. Beginning on Chestnut Ridge and flowing through the ORNL compound, White Oak Creek passes by several burial grounds and sites contaminated with radioactive waste. This entire watershed is invaluable for radionuclide cycling studies that explore questions about the long-term fate of radioactive wastes placed in surface geological formations. Both Melton Branch and White Oak Creek receive chronic and low concentrations of radionuclides and heavy metals in effluents

from laboratory operations. Contaminated White Oak Lake is used for determining cycling and the effects of radioactive and toxic elements on aquatic organisms.

Animal Population and Collecting Areas: Areas 0852, 0916, and 7730, south of the Tower Shielding Facility (TSF), are used for the collection of mammals for laboratory experiments or as field sites for studies on the relation of structural forest parameters and small-mammal population dynamics. These areas provide opportunity for program expansion in the 1892 acres (766 ha) located on diverse terrain and habitat, including grassland portions of the ERDA Reservation managed by the CARL. Area 0900 is currently being used to establish the dissemination of radionuclide waste from a waste-disposal area by small-mammal populations. This area is also being used to correlate small-mammal species and the structural components of the plant community that they inhabit.

Transmission-Line Research Areas: Six management areas designated as 0400 have been established in cooperation with TVA to evaluate alternative techniques of power-line right-of-way maintenance. Ecological studies of various combinations of cover plants, represented by both shrubs and grasses, are being conducted. Alternative techniques are being compared for their effectiveness in protecting the site and their potential for sheltering and feeding small game and rodents. Studies are being conducted under varying conditions and habitat, so the results may be generally applied to regional problems of power-line maintenance. Approximately 65 acres (26 ha) are devoted to these studies. Additional areas marked as 0915 and 0450 are being used to determine the effects on

small-mammal and bird communities of the modification of forest habitats for transmission-line corridor construction and maintenance.

Cooling-Tower (ORGDP) Drift Study Areas : Areas downwind and northeast of ORGDP within area 0809 east, in the valley floor traversed by Blair Road and Poplar Creek, are used to study the distribution and the effects of water and chemical additives from cooling towers. Additional land for these studies is also needed in the 0 segment across the river from the plant. Part of the area scheduled for study lies in the buffer zone around ORGDP. Area 0809 contains approximately 920 acres (372 ha).

Habitat for Aquatic Research: Several quarries, small streams with associated watersheds, and miscellaneous habitats are located on the ERDA Reservation. These sites are used for various aquatic ecology research and need to be protected.

1. Lambert quarry (Fig. 5) is isolated, and access can be controlled. There is a small associated watershed. Research on fish tracking and the cycling of trace contaminants is in progress at Lambert quarry.

2. McCoy Branch, Bethel Valley quarry, and the associated watersheds (Fig. 5) are being studied to determine transports of trace contaminants that are released from a fly-ash tailings pond east of Fanny Knob. Research will continue on transport, cycling, and effects of trace contaminants from fly ash in aquatic ecosystems at this site.

3. Although highly impacted by drainage from acid pits near Y-12, Bear Creek (Fig. 5) is a valuable aquatic habitat because of the opportunity to study recovery following cessation of acid and nitrate pollution. The creek has several monitoring stations, and the backlog of data will provide the basis for before-and-after comparisons during the recovery process.

Clinch River and Poplar Creek. The embayment of the Clinch River and a section of Poplar Creek are used for fish-population studies and as aquatic monitoring stations (Fig. 5).

1. Roberts Branch embayment (area X-2) located just below Gallaher Bridge across the river from ORGDP is used for fish population studies and is one of the best areas for collecting spawning carp.

2. Embayment Pond (area X-3) just below Grassy Creek and above Gallaher Bridge is used for collecting spawning carp.

3. Poplar Creek (area X-4), approximately 183 m upstream from the mouth, is used for fish population studies and as an aquatic monitoring station for the three-plant assessment.

4. Clinch River Mile 11 (area X-5) is used for fish population studies and as an aquatic monitoring station for the three-plant assessment.

5. Mouth of Ellis Creek (area X-6), located at mile 4.3 on Poplar Creek, is used for fish population studies and as an aquatic monitoring station for the three-plant assessment.

6. Poplar Creek (area X-7), 55 m above the convergence with the East Fork of Poplar Creek, is used for fish population studies and as an aquatic monitoring station for the three-plant assessment.

Natural Areas: Many sections of land and waterways are not affected by the operation of the ERDA facilities and serve as control sites for many large-scale research programs. Conservation of these natural areas is a major objective. However, such areas are also important as sites for ecological research.

Our scientific approach is to look at each of the previously discussed natural areas as being "unique" in terms of surrounding forest

Clinch River and Poplar Creek. The embayment of the Clinch River and a section of Poplar Creek are used for fish-population studies and as aquatic monitoring stations (Fig. 5).

1. Roberts Branch embayment (area X-2) located just below Gallaher Bridge across the river from ORGDP is used for fish population studies and is one of the best areas for collecting spawning carp.

2. Embayment Pond (area X-3) just below Grassy Creek and above Gallaher Bridge is used for collecting spawning carp.

3. Poplar Creek (area X-4), approximately 183 m upstream from the mouth, is used for fish population studies and as an aquatic monitoring station for the three-plant assessment.

4. Clinch River Mile 11 (area X-5) is used for fish population studies and as an aquatic monitoring station for the three-plant assessment.

5. Mouth of Ellis Creek (area X-6), located at mile 4.3 on Poplar Creek, is used for fish population studies and as an aquatic monitoring station for the three-plant assessment.

6. Poplar Creek (area X-7), 55 m above the convergence with the East Fork of Poplar Creek, is used for fish population studies and as an aquatic monitoring station for the three-plant assessment.

Natural Areas: Many sections of land and waterways are not affected by the operation of the ERDA facilities and serve as control sites for many large-scale research programs. Conservation of these natural areas is a major objective. However, such areas are also important as sites for ecological research.

Our scientific approach is to look at each of the previously discussed natural areas as being "unique" in terms of surrounding forest

types or as "representative" of certain types in the Appalachian region. This approach requires us to (1) determine the structure of the community, (2) relate the structural composition to environmental parameters, i.e., slope, moisture, etc., and (3) compare not only the community to the surrounding communities or buffer areas but to other natural areas on the Reservation. To accomplish these goals we are employing a number of classification and ordination techniques (clustering, principle component, and canonical analysis) to statistically analyze information. This method should also supply valuable information regarding forest succession for these particular types and will provide an excellent data base for future studies relating habitat structure with the animal and bird communities which inhabit these communities. These areas will complement the existing Walker Branch watershed 97.5-ha project which is providing baseline data on primary productivity, mineral cycling, and various land-water interactions.

Wildlife Research: In addition to the small-mammal research described previously, a number of programs, in cooperation with the Tennessee Wildlife Resources Agency, are under consideration under the NERP project. In view of the restricted nature of portions of the Reservation (fencing, restricted entry, etc.), there may be special significance for investigations involving both game and nongame species. The Oak Ridge Reservation can afford wildlife researchers the opportunity to conduct investigations in a controlled situation. Data collected on the Reservation will provide baseline information on various species for comparison with populations outside the plant. Comparisons could result in the evaluation of various factors which are thought to be limiting.

In addition to the above-mentioned research possibilities the Reservation can lend itself to various surveys and data collection activities such as upland game bird or waterfowl capture and banding. Information generated from such activities could aid in the management of species in Tennessee (e.g., help determine time and length of season for migratory species such as woodcock).

The Oak Ridge ERP will also serve as an area for the restoration of various species. Trapped wild turkeys could be released and would provide the breeding nucleus for the establishment of a refuge flock. From this flock, birds could be trapped and released into suitable habitats for the further restoration of the wild turkey in Tennessee. Specific research in conjunction with the release and development of a refuge flock could furnish data which would aid in the formulation of future management practices for this species.

Information collected by the University of Tennessee (U.T.) indicates that the white-tail deer population is still relatively low on the area but that habitat alterations and the species biotic potential may combine to produce an accelerated expansion of the deer population. At such time that the Reservation deer herd provides a surplus, animals will be trapped and removed and utilized in restoration programs by Tennessee Wildlife Resources Agency (TWRA) to establish new populations in other areas. The U.T. work is being continued by Environmental Research Park personnel to capture and mark as many animals as possible to aid in herd evaluation and management.

In 1972, 80 Canada geese were released on the Melton Hill Reservoir. At the present time the lake supports a resident flock of about 125

SELECTED ENVIRONMENTAL SCIENCES DIVISION PUBLICATIONS (1971-1976)

Because the Environmental Research Park program is recent activity, much of the initial research is only now reaching the publication stage and much of our work has either been submitted for publication, is in the ESD internal review system, or has been presented orally before various groups. These are included here under Environmental Research Park Series publications to illustrate the direction and variety of the existing NERP programs.

Other publications have been selected from the over 800 articles published by ESD personnel over the last twenty years representing the various expertise of the ESD staff at ORNL.

A. Environmental Research Park Publications

Land and water resources for environmental research on the Oak Ridge Reservation. 1976. R. C. Dahlman and J. T. Kitchings (eds.). ORNL/TM-5352. Oak Ridge National Laboratory, Oak Ridge, Tennessee. (in review).

Mann, L. K., and M. W. Bierner. 1975. Oak Ridge, Tennessee, Flora: Habitats of the vascular plants - Revised inventory. ORNL/TM-5056. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 141 pp.

McConathy, R. K. 1976. Land-use changes on the proposed Clinch River breeder reactor demonstration project site: 1924 to 1972. ORNL/TM-4838. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 25 pp.

Kitchings, T. and L. K. Mann. 1976. A Description of the terrestrial ecology of the Oak Ridge Environmental Research Park. ORNL/TM-5073. Oak Ridge National Laboratory, Oak Ridge, Tennessee. (in review).

Kitchings, J. T., J. D. Joslin, and J. Yeiser. 1976. Use of numerical classification to define research natural areas. (submitted to Environmental Management).

Story, J. D. White-tail deer on the ERDA Oak Ridge Reservation: 1969-1975. ORNL/TM-5172 (in review). Oak Ridge National Laboratory, Oak Ridge, Tennessee.

B. Fundamental Ecological Studies

Anderson, S. H., and H. H. Shugart, Jr. 1974. Habitat selection of breeding birds in an east Tennessee deciduous forest. Ecology 55(4): 828-837.

Ausmus, B. S. 1975. Assessment of microbial communities in a forest ecosystem. Ecology (56)3: 762-763.

Cox, T. L., J. P. Witherspoon, and R. C. Dahlman. 1972. Production mortality and nutrient cycles in root systems of Liriodendron seedlings. EDFB/IBP-72/8. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Dueser, R. D., and H. H. Shugart. 1975. Structural niches in a forest floor small-mammal community. ORNL/TM-5004. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Edwards, Nelson T., and Phillip Sollins. 1973. Continuous measurement of carbon dioxide evolution from partitioned forest floor components. Ecology 54(2): 406-12.

Elwood, J. W., and G. S. Henderson. 1975. Hydrologic and chemical budget at Oak Ridge, Tennessee. pp. 31-51. IN A. D. Hasler (ed.), Coupling of land and water systems. (Ecological Studies, Vol. 10.) Springer-Verlag, New York-Heidelberg-Berlin. 309 pp.

Gehrs, C. W., and A. Robertson. 1975. Use of life tables in analyzing the dynamics of copepod populations. Ecology (56)3: 665-672.

Grigal, D. F., and R. A. Goldstein. 1971. An integrated ordination-classification analysis of an intensively sampled oak-hickory forest. J. Ecol. 59: 481-92.

Harris, W. F., P. Sollins, N. T. Edwards, B. E. Dinger, and H. H. Shugart. 1975. Analysis of carbon flow and productivity in a temperate deciduous forest ecosystem. pp. 116-122. IN D. E. Reichle, J. F. Franklin, and D. W. Goodall (eds.), Productivity of world ecosystems. National Academy of Sciences, Washington, D.C. 166 pp.

Henderson, G. S. 1974. Land use and water resources. Ecology 55(4): 915-916.

Henderson, G. S., and W. F. Harris. 1975. An ecosystem approach to characterization of the nitrogen cycle in a deciduous forest watershed. IN B. Bernier and C. H. Winget (eds.), Forest soils and forest land management. Les Presses de L'Universite Laval, Quebec, Canada. 675 pp.

Kelly, J. M., G. M. Van Dyne, and W. F. Harris. 1974. Comparison of three methods of assessing grassland productivity and biomass dynamics. Am. Midl. Nat. 92(2): 357-369.

Kroodsma, R. L., and H. H. Shugart. 1975. Potential effects of whole-tree harvesting on bird populations of Appalachian Mountain hardwood forests. Proc., Logging Residues Conf., Morgantown, W. Virginia, June 3-6, 1975.

Mankin, J. B., R. V. O'Neill, H. H. Shugart, and B. W. Rust. 1975. The importance of validation in ecosystem theory. Simulation (in press).

Olson, J. S. 1975. Productivity of forest ecosystems. pp. 33-43. IN D. E. Reichle, J. F. Franklin, and D. W. Goodall (eds.), Productivity of world ecosystems. National Academy of Sciences, Washington, D.C. 166 pp.

Olson, J. S. 1971. Primary productivity: Temperate forests, especially American deciduous types pp. 235-58. IN P. Duvigneaud (ed.). Productivity of Forest Ecosystems. UNESCO, Paris.

Olson, J. S. 1971. Vegetation and ecosystem mapping. pp. 318-24. IN Encyclopedia of Science and Technology, vol. 14. McGraw-Hill Book Co., New York.

O'Neill, R. V. 1975. Modeling in the Eastern Deciduous Forest Biome. pp. 49-72. IN B. C. Patten (ed.), Systems Analysis and Simulation in Ecology, Vol. III, Academic Press, New York.

O'Neill, R. V. 1975. Management of large-scale environmental modeling projects. pp. 251-282. IN Clifford S. Russell (ed.). Ecological modeling in a resource management framework. Resources for the Future, Inc., Washington, DC. 394 pp.

Reichle, D. E. 1971. Energy and nutrient metabolism of soil and litter invertebrates, pp. 465-77. IN P. Duvigneaud (ed.), Productivity of Forest Ecosystems. UNESCO, Paris.

Reichle, D. E. 1974. Forest ecosystems. pp. 196-201. IN McGraw Hill Yearbook of Science and Technology. McGraw Hill Book Company, New York.

Shugart, H. H., Jr., and B. G. Blaylock. 1973. The niche-variation hypothesis: An experimental study with Drosophila populations. Amer. Nat. 107(956): 575-79.

Shugart, H. H., R. D. Dueser, and S. H. Anderson. 1974. Influence of habitat alterations on bird and small mammal populations. pp 92-96. IN J. P. Slusher and T. M. Hinckley (eds.), Timber-wildlife management symp. proc. Missouri Acad. Sci. Occas. Paper 3, Columbia.

Shugart, H. H., Jr., R. A. Goldstein, R. V. O'Neill, D. L. DeAngelis, J. B. Mankin, J. R. Kercher, and R. S. Booth. 1974. Environmental analysis in the Eastern Deciduous Forest Biome. p. 161. IN R. M. Dmowski (ed.), Systems analysis and modeling approaches in environment systems. Institute of Applied Cybernetics, Polish Academy of Sciences, Warsaw, Poland. 607 pp.

Shugart, H. H., Jr., D. E. Reichle, N. T. Edwards, and J. R. Kercher. 1975. A model of calcium cycling in an east Tennessee Liriodendron forest: Model structure, parameters, and frequency response analysis. Ecology (in press).

Taylor, F. G., Jr. 1974. Phenodynamics of production in a mesic deciduous forest. pp. 237-254. IN H. Lieth (ed.), Phenology and seasonality modeling. (Ecological Studies, Vol. 8.) Springer-Verlag, New York-Heidelbert-Berlin. 444 pp.

Van Winkle, W. 1975. Comparison of several probabilistic home-range models. J. of Wildlife Management (39)(1): 118-123.

C. Environmental Contamination Studies

Anderson, S. H., G. J. Dodson, and R. I. Van Hook, Jr. 1975. Comparative retention of ^{60}Co, ^{109}Cd, and ^{137}Cs following acute and chronic feeding in bobwhite quail. Proc. 4th Nat. Symp. Radioecology. Corvallis, Oregon, May 12-14, 1975. (in press).

Andren, A. W., S. E. Lindberg, and L. C. Bate. 1975. Atmospheric input and geochemical cycling of selected trace elements in Walker Branch Watershed. ORNL/NSF/EATC-13. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 68 pp.

Auerbach, S. I., H. A. Vanderploeg, S. V. Kaye, and J. P. Witherspoon. 1974. Significance of ecological analyses in the interpretation of environmental releases of radionuclides. IEEE Trans. NS-21(1):18-22.

Auerbach, S. I., P. B. Dunaway, and R. C. Dahlman. 1973. Final report on postattack ecology. ORNL/TM-3837. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 81 pp.

Baker, C. E., and P. B. Dunaway. 1975. Elimination of ^{137}Cs and ^{59}Fe and its relationship to metabolic rates of wild small rodents. J. of Experimental Zoology 192(2): 223-236.

Barton, C. J. and S. V. Kaye. 1975. Evaluation of radiological exposure from Plowshare applications, 1967-1975. ORNL-5071. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Blaylock, B. G. 1973. Chromosome aberrations in Chironomus riparius developing in different concentrations of tritiated water. pp. 1169-1173 in Nelson, D. J. (ed.). Radionuclides in ecosystems. Proc. of the Third National Symposium on Radioecology. ERDA (previously AEC) Symposium Series. CONF-710501, Technical Information Center, Oak Ridge, Tennessee. 1268 pp.

Coutant, C. C. 1975. Temperature selection by fish - A factor in power-plant impact assessments. pp. 575-597. IN Environmental effects of cooling systems at nuclear power plants. IAEA-SM-187/11. International Atomic Energy Agency, Vienna, Austria.

Coutant, C. C., and S. S. Talmage. 1975. Thermal effects. J. Water Pollution Control. (47)6: 1656-1711.

Coutant, C. C. 1975. Effects of power plants. Science 189: 132-133.

Elwood, J. W. 1975. Pollution indicators. Science 189: 281-282.

Eraslan, A. H., W. Van Winkle, R. D. Sharp, S. W. Christensen, C. P. Goodyear, R. M. Rush, and W. Fulkerson. 1975. A computer simulation model for the striped bass young-of-the-year population in the Hudson River. Introduction, Ch. 3, ORNL/TM-4771. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Eyman, L. D. 1974. Changes in ^{137}Cs concentration in fish flesh during preparation for human consumption. Health Physics 28: 477-479.

Frank, M. L. 1974. Relative sensitivity to different developmental stages of carp eggs to thermal shock. pp. 171-176. IN J. W. Gibbons and R. R. Sharitz (eds.), Thermal ecology. ERDA (previously AEC) Symposium Series. CONF-730505. Technical Information Center, Oak Ridge, Tennessee.

Gehrs, C. W., L. D. Eyman, R. L. Jolley, and J. E. Thompson. 1974. Effects of stable chlorine-containing organics on aquatic environments. Nature 249(5458): 675-676.

Gehrs, C. W. 1974. Vertical movement of zooplankton in response to heated water. pp. 285-290. IN J. W. Gibbons and R. R. Sharitz (eds.), Thermal ecology. ERDA (previously AEC) Symposium Series. CONF-730505. Technical Information Center, Oak Ridge, Tennessee.

Huckabee, J. W., and B. G. Blaylock. 1974. Microcosm studies on the transfer of Hg, Cd and Se from terrestrial to aquatic ecosystems. pp. 219-222. IN D. D. Hemphill (ed.), Trace substances in environmental health - VIII. Univ. Missouri, Columbia.

Huckabee, J. W., C. P. Goodyear, and R. D. Jones. 1975. Acid rock in the Great Smokies: Unanticipated impact on aquatic biota of road construction in regions of sulfide mineralization. Trans. Am. Fish. Soc. (in press).

Johnson, W. C. 1975. Surface mining in North Dakota. Ecology (56)2: 506-507.

Kaye, S. V. 1973. Assessing potential radiological impacts to aquatic biota in response to the National Environmental Policy Act (NEPA) of 1969. pp. 649-661. IN Environmental Behavior of Radionuclides Released in the Nuclear Industry. Proc. IAEA Seminar, Vienna, Austria.

Reichle, D. E., D. J. Nelson, and P. B. Dunaway. 1971. Biological concentration and turnover of radionuclides in food chains: A bibliography. ORNL/NSIC-89. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 42 pp.

Reichle, D. E., D. A. Crossley, Jr., C. A. Edwards, J. F. McBrayer, and P. Sollins. 1973. Organic matter and ^{137}Cs turnover in forest soil by earthworm populations: Application of bioenergetic models to radionuclide transport. pp 240-46. IN D. J. Nelson (ed.), Radionuclides in ecosystems. Proc. of the Third National Symposium on Radioecology. ERDA (previously AEC) Symposium Series. CONF-710501, Technical Information Center, Oak Ridge, Tennessee. 1268 pp.

Reichle, D. E., R. V. O'Neill, S. V. Kaye, P. Sollins, and R. S. Booth. 1973. Systems analysis as applied to modeling ecological processes. Oikos 24: 337-343.

Shriner, D. S. 1976. Effects of simulated rain acidified with sulfuric acid on host-parasite interactions. Proc. 1st Int. Symp. on Acid Precipitation in a Forest Ecosystem, Ohio State U., May 12-15, 1975. (in press).

Tamura, T. 1974. Sorption phenomena significant in radioactive waste disposal. pp. 318-330. IN Underground waste management and environmental implication. Memoir No. 18, Am. Ass. Petrol. Geol.

Till, J. E. 1975. A comparison of environmentally released recycle uranium-233 HTGR fuel and LMFBR plutonium fuel. Proc. 4th Natl. Symp. Radioecology. Corvallis, Oregon, May 12-15, 1975. (in press).

Van Hook, R. I. 1974. Cadmium, lead, and zinc distributions between earthworms and soils: Potentials for biological accumulation. Bull. Environ. Contam. Toxicol. 12(4): 509-512.

Van Hook, R. I., and A. J. Yates. 1975. Transient behavior of cadmium in a grassland arthropod food chain. Environ. Res. 9: 76-83.

Witkamp, M., and V. A. Merchant. 1973. Effects of light, temperature, and soil fertility on distribution of manganese-54 and cesium-137 in producer-consumer microcosms. pp. 204-208. IN Nelson D. J. (ed.), Radionuclides in ecosystems. Proc. of the Third Nat. Symp. on Radioecology. ERDA (previously AEC) Symposium Series. CONF-710501, Technical Information Center, Oak Ridge, Tennessee. 1268 pp.