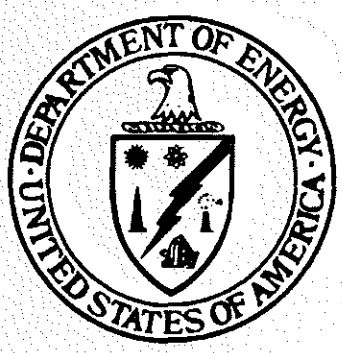
DOE/EA-1113/MAP-97

ANNUAL REPORT

IMPLEMENTATION OF MITIGATION ACTION PLAN FOR DOE/EA-1113: LEASE OF PARCEL ED-1 OF THE OAK RIDGE RESERVATION, OAK RIDGE, TENNESSEE

PRE-DEVELOPMENT ECOLOGICAL SURVEYS



November 1997

U.S. Department of Energy
Oak Ridge Operations Office
Oak Ridge, Tennessee

DOE/EA-1113/MAP-97

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IMPLEMENTATION OF MITIGATION ACTION PLAN FOR DOE/EA-1113: LEASE OF PARCEL ED-1 OF THE OAK RIDGE RESERVATION

PRE-DEVELOPMENT ECOLOGICAL SURVEYS

Submitted
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1.0 INTRODUCTION

In accordance with its National Environmental Policy Act (NEPA) regulations (10 CFR 1021), the U.S. Department of Energy (DOE) issued an environmental assessment (EA) (DOE/EA-1113; 1996a) and a Finding of No Significant Impact (FONSI) in April 1996 for the proposed lease of 957.16 acres (Parcel ED-1) of the Oak Ridge Reservation (ORR) by the East Tennessee Economic Council [ETEC; name subsequently changed to Community Reuse Organization of East Tennessee (CROET)]. In accordance with NEPA regulation 10 CFR 1021.322, DOE also prepared and issued a Mitigation Action Plan (MAP) (DOE 1996b) that describes measures to be implemented to mitigate significant adverse impacts from industrial development by CROET on Parcel ED-1. The FONSI is conditional upon implementation of mitigation specified in the MAP, which emphasizes (1) exclusion of specific environmentally sensitive areas from disturbance and development and (2) pre- and post-development resource surveys and monitoring. The objectives of mitigation are

(1) protection of wildlife habitat, plant communities, threatened and endangered species, water resources, wetlands, and historic and archaeological resources;
(2) maintenance of habitat connections to reduce the ecological effects of fragmentation;
(3) pre- and post-development evaluation of natural succession and the impacts of development by monitoring natural communities and populations; and
(4) identification of additional measures as necessary to remediate observed impacts of development.

This document reports DOE's progress toward meeting these objectives over the period from June 1996 through September 1997. The data and information presented in this report were collected and interpreted by staff of the Oak Ridge National Laboratory (ORNL), Environmental Sciences Division (ESD), under contract to DOE. This progress report, which is the second issued by DOE, presents the methods, data, and interpretation of results for all pre-development surveys of sensitive resources on Parcel ED-1 and describes the delineation of the exclusion area.

In the MAP, DOE prescribes long-term monitoring of terrestrial and aquatic ecosystems on Parcel ED-1 so that future impacts may be evaluated. Surveys of areas to be disturbed during infrastructure development and construction and operation of industrial facilities will be the responsibility of CROET and/or its sublessees, in accordance with the terms of the lease, EA and FONSI. The pre-development surveys described in this report provide the framework and baseline data for this long-term monitoring activity. DOE has achieved the ecological resource exclusions of objectives 1 and 2 by completing the delineation, with field markers, of sensitive areas and habitat connections that must be avoided by CROET and/or its sublessees. Additionally, the pre-development ecological surveys (which partially complete objective 3) have provided information that DOE will submit to the U.S. Fish and Wildlife Service (FWS) and the Tennessee Department of Environment and Conservation (TDEC) to meet conditions specified by these agencies when

they concurred on the Parcel ED-1 FONSI.

2.0 DELINEATION OF THE EXCLUSION AREA

Establishment of the Exclusion Area was designed to protect threatened and endangered (T&E) species listed by the FWS or TDEC and species listed as in-need-of-management by the state. The boundaries of the 491-acre Exclusion Area reported in the EA, FONSI, and MAP were initially based on past research and monitoring activities, walk-through surveys by ORNL ecologists, and consultation with state and federal agencies. Initially, ORNL mapped the Exclusion Area by overlaying the most current (1995) geographic information system (GIS) data for each of the following areas to produce an integrated map outline. The MAP states that the Exclusion Area would include:

1) the 100-year floodplain of onsite streams,
2) terrestrial Natural Areas (NAs) 46 and 47 of the National Environmental Research Park, which include
    a) bottomland hardwood forests
    b) upland hardwood habitat
    c) beech-maple forest
    d) karst hardwood communities,
3) walnut plantations,
4) aquatic NAs,
5) archeological and historic sites,
6) special features, including
    a) caves
    b) springs
    c) wetlands,
7) wildlife corridors, and
8) a 100-ft buffer on each side of streams.

Additionally, the FONSI prescribed that "a natural corridor system, a minimum of 61-meters (m) (200-ft) wide, shall be retained to connect bottomland habitat to upland hardwood habitat north of the parcel; this would maintain continuity of habitat and mitigate the adverse effects of forest fragmentation. This system shall be configured to include the isolated hardwood stands retained on the north side of the parcel...". The natural corridor system was not mapped separately as it was created by the combination of the other layers. Stream buffers (100 ft) on tributaries of East Fork Poplar Creek (EFPC) draining from the northwest created 200-ft wide corridors connecting the bottomland along the creek and the upland hardwood habitat north of the parcel. Due to its relatively large size, EFPC creates a habitat edge (open canopy, disturbance due to annual flooding cycle, barrier to the movement of some species); thus the Exclusion Area was to include a minimum of 200 ft on each side of EFPC in order to function as a natural corridor. However, the combination of the 100-yr floodplain and National Environmental Research Park NAs (terrestrial and aquatic) extended beyond 200 ft on both sides of EFPC, thus forming a sufficient natural corridor.

As newer and more accurate spatial data became available in 1996 and 1997, the boundaries of the Exclusion Area were revised. New data included (1) more accurate GIS coverage for the 100-yr floodplain of EFPC and Bear Creek (BC), which was based on a re-analysis by the Tennessee Valley Authority using 1990 aerial photography; (2) additional raster ortho images of the site, geo-referenced aerial photography for use within the GIS environment, obtained from the Oak Ridge Environmental Information System[1] , and (3) field data from pre-development monitoring activities and Exclusion Area boundary marking that verified the location of specific features (e.g., stream channels, wetlands). With the new information based on the 100-yr floodplain coverage, a net of 31 acres was added to the Exclusion Area. This was offset by revisions based on ortho images and field data, which identified errors in GIS coverages for streams, roads, the Parcel ED-1 boundary, and designated NAs. For example, in the field, one previously GIS-designated stream was found to be non-existent. Subsequently, the stream buffer area for it was removed from the Exclusion Area, resulting in a reduction of 11.34 acres. Corrections to the 100-ft stream buffers and designated NA coverages resulted in a 10.5-acre increase in the Exclusion Area. Overall, revisions made based on new data resulted in a revised Exclusion Area of approximately 521 acres (Figure 1), or an additional 30 acres over that which was defined in the EA.

The boundary of the Exclusion Area was marked in the field by green metal fence posts with attached signs that read "ED-1 Exclusion Area boundary". Signs were placed along the boundary at approximately 400-ft intervals and at points where there is a noticeably sharp change in boundary direction (e.g. corners).

[1] http://www-internal.ornl.gov/~oreis/oreishome.htm

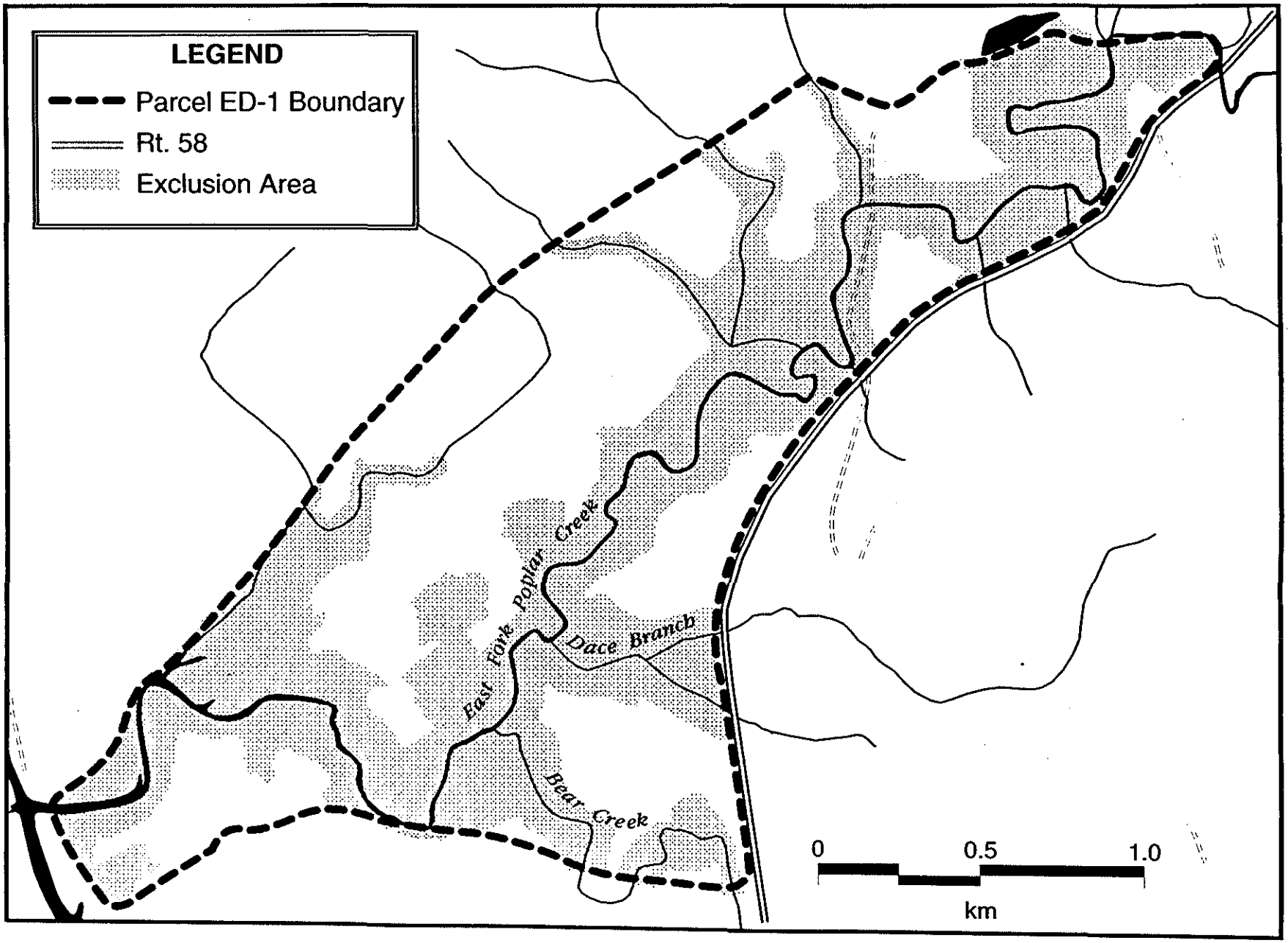

Figure 1. Map of Parcel ED-1 showing revised Exclusion Area

3.0 PRE-DEVELOPMENT SURVEYS

Pre-development monitoring surveys focused on the revised 521-acre Exclusion Area of Parcel ED-1 (Figure 1). Ecological resources in the Exclusion Area are being surveyed prior to development on the parcel to provide baseline data against which future monitoring data and information can be compared. These surveys focused on the Exclusion Area because it was established to include and protect from adverse impacts the habitat of state and federally listed species and environmentally sensitive communities on the site (DOE 1996a).

3.1 TERRESTRIAL VEGETATION (B. Rosensteel, L. Pounds, and D. Awl, JAYCOR)

According to the MAP (U.S. DOE 1996), pre-development ecological surveys and monitoring on Parcel ED-1 were to include surveys and monitoring of vegetation species protected by state and federal legislation, unique or rare plant and plant communities, and wetlands. The objective of the vegetation studies reported here was to collect baseline physical and biological data to document the present condition of vegetation populations and communities which, when compared with reference site data or over time, may be used to detect changes that might result from impacts of development of the Parcel ED-1 site. This section discusses the development and implementation of pre-development monitoring and presents baseline data for threatened and endangered (T&E) plant species, unique or rare plant communities (including wetlands), floodplain and upland vegetation communities, and habitat connections (wildlife corridors) in the Exclusion Area of Parcel ED-1. Detailed field datasheets are included as Appendix A-1.

3.1.1 Study Area and Methods

The pre-development monitoring surveys for terrestrial vegetation were divided into three categories based on the type of resource and the most appropriate approach for assessing its status. These include (1) T&E plant species, (2) sensitive vegetation communities, and (3) general vegetation communities. The general vegetation community surveys were subdivided further into floodplain forest, upland forest, and wildlife corridor assessments. Monitoring sites for each resource type were established in the Exclusion Area. To allow for identification of changes to vegetation independent of Parcel ED-1 development activities, appropriate reference sites for each vegetation type were selected on the ORR outside of the Parcel ED-1 boundary.

3.1.1.1 T&E species surveys

One monitoring site was established for each of the T&E plant species found on Parcel ED-1: *Hydrastis canadensis* (MRP1), *Cypripedium acaule* (MRP2), *Lilium canadense* (MRP3), *Rhynchospora colorata* (MRP4), and *Panax quinquefolius* (MRP5) (Figure 2). Three reference sites each for four species were also established in National Environmental Research Park Natural

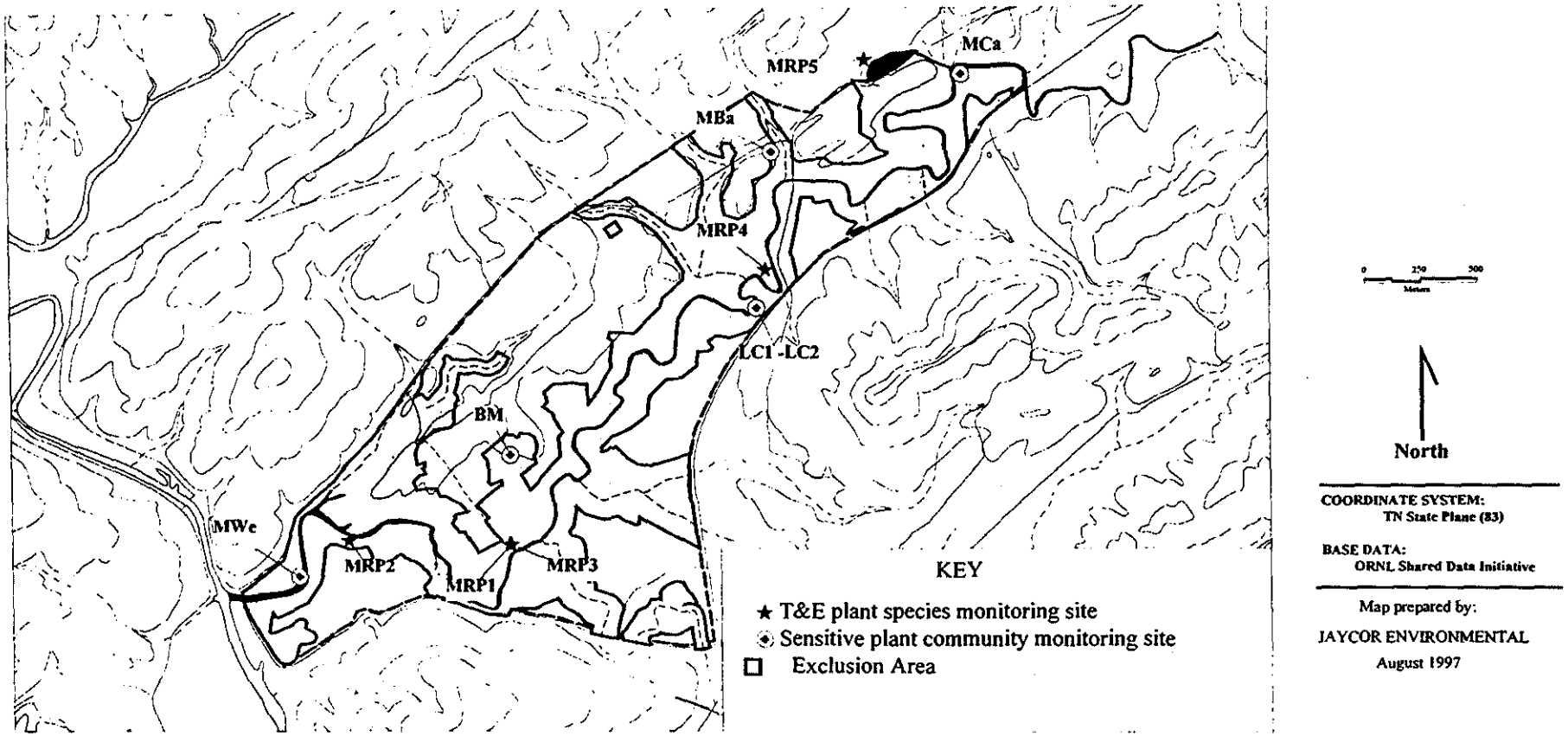

Figure 2. Threatened and Endangered (T&E) plant species and sensitive vegetation community monitoring sites in Parcel ED-1.

Areas (NAs) on the ORR (RRP1 through RRP12). A reference site could not be established for *Rhynchospora colorata* because the population on Parcel ED-1 is the only known occurrence of this species in the region (Figure 3). The coordinates of the T&E plant species monitoring and reference sites are given in Table 1.

The T&E plant species monitoring and reference sites include within their boundaries all, or most, of the population in the vicinity of the site. One exception to this is the *Hydrastis canadensis* site (MRP-1), which contains only one section of a larger population that extends across a forested hillside. The monitoring site and larger population are separated by an old, rarely-used forestry road. The smaller section on the south side of the old forestry road was established as the monitoring site. *Panax quinquefolius* and *Cypripedium acaule* often occur as scattered individuals or in scattered patches within their habitat. Thus, it is possible that some individuals of these species fall outside of the established site boundaries. However, an effort was made to establish the boundaries to contain the main grouping of the population and to ensure that no outlying individuals were excluded.

The boundaries of all monitoring sites were delineated with orange and blue plastic flagging. The flags were not marked, with the exception of the boundary flags of the *Hydrastis canadensis* site, which were consecutively numbered in order to assist in future relocation because the boundary has an irregular shape. The center of each site was marked with a white plastic stake labeled with the site identifier (e.g., MRP1). Length and width at the widest points along the site boundary were measured with a metric tape, and estimated area was calculated. Most of the sites are roughly rectangular. The dimensions and shape of the sites are noted on the field data sheets (Appendix A-1).

Baseline data were collected at monitoring sites in the Exclusion Area and at three reference sites for *Hydrastis canadensis* (MRP1, RRP1-RRP3), *Cypripedium acaule* (MRP2, RRP4-RRP6), and *Panax quinquefolius* (MRP5, RRP10-RRP12) in May and June 1996. Baseline data for the *Rhynchospora colorata* monitoring site (MRP4) were collected in June and July 1996. Baseline data for the *Lilium canadense* monitoring site (MRP3) and reference sites (RRP8-RRP10) were collected in June 1997. *Lilium canadense* was newly found in the Exclusion Area in June 1996. At that time, its leaves were beginning to yellow and senesce. *Lilium canadense* populations at possible reference sites checked during the same time period were also in various stages of senescence. Data collection for this species was, therefore, postponed until the 1997 growing season.

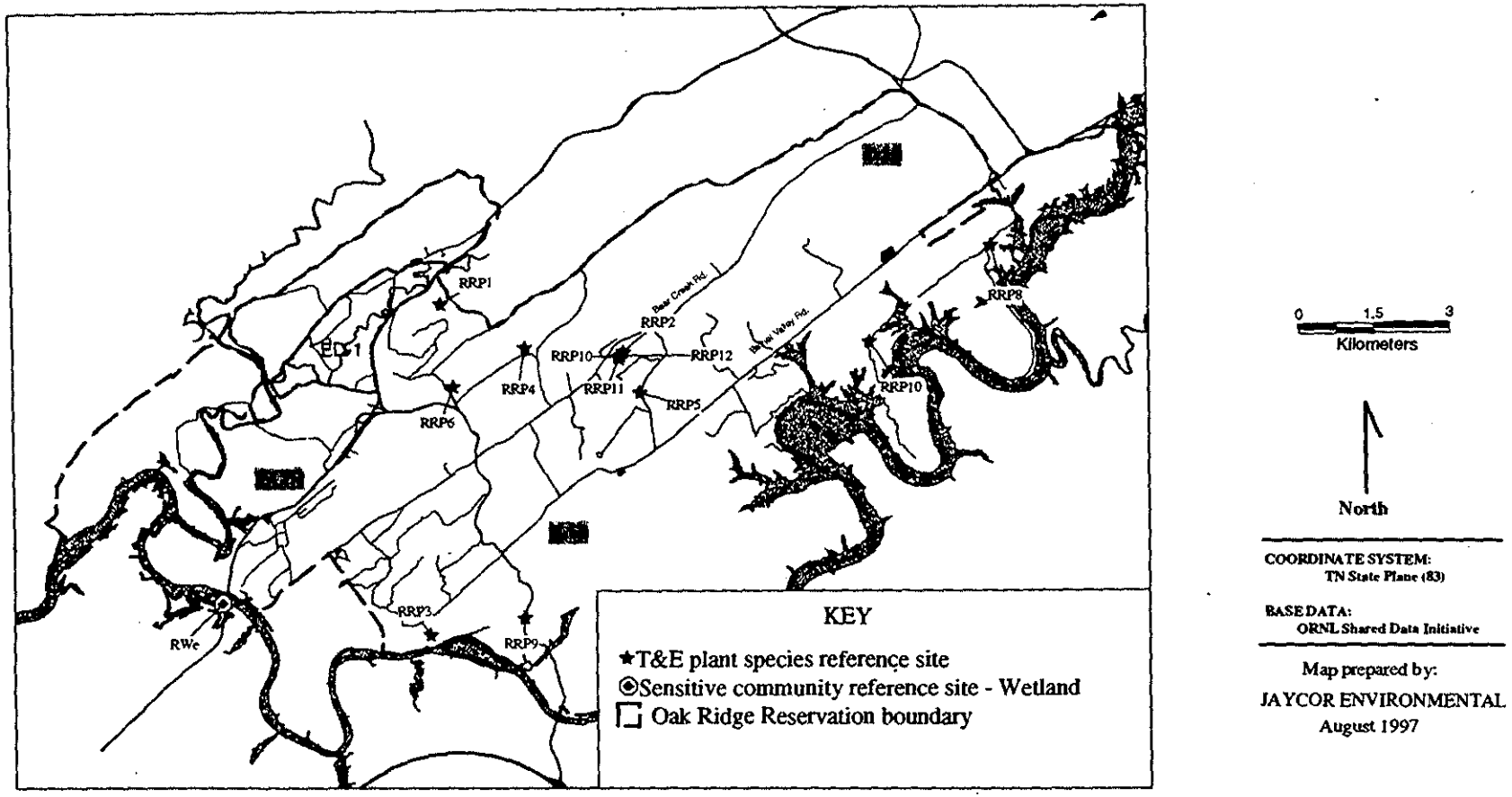

Figure 3. T&E plant species and sensitive vegetation community reference sites on the Oak Ridge Reservation.

Table 1. Coordinates of T&E plant species monitoring sites (MRP) and reference sites (RRP), and the reference wetland site.

MRP2	T&E species	ED-1	-84.3812	35.9518
MRP1	T&E species	ED-1	-84.373	35.9515
MRP5	T&E species	ED-1	-84.3546	35.9711
MRP4	T&E species	ED-1	-84.3598	35.9626
MRP3	T&E species	ED-1	-84.373	35.9515
RRP1	T&E species	NA2	-84.3482	35.963
RRP2	T&E species	NA52	-84.3076	35.9536
RRP3	T&E species	NA6	-84.3523	35.9029
RRP4	T&E species	RA6	-84.3296	35.9547
RRP5	T&E species	NA55	-84.3042	35.9462
RRP6	T&E species	NA24	-84.3458	35.9479
RRP8	T&E species	NA22	-84.225	35.9714
RRP9	T&E species	NA25	-84.3311	35.9057
RRP10	T&E species	NA56	-84.2526	35.9545
RRP10	T&E species	NA52	-84.3088	35.9527
RRP11	T&E species	NA52	-84.3085	35.9524
RRP12	T&E species	NA52	-84.3082	35.953
RWe	Wetland reference	RA24	-84.399	35.9093

[1] Coordinates are in decimal degrees. To convert to "degrees-minutes-seconds": The first two numbers (35 and 84) are the latitude and longitude, respectively. Multiply the number following the decimal point by 60. The first two numbers in the product are the minutes. Multiply the numbers following the product decimal point by 60. The first two numbers of the product are the seconds. Example: -84.3437 = 84 degrees, 20 minutes, 37 sec. (.3437 X 60 = 20.622) and (0.622 X 60 = 37.32)

A modification to the Level 2 monitoring approach of Menges and Gordon (1996) for quantitative tracking of population characteristics in permanently marked plots or transects was used to determine the status of each species at each site. Individuals of T&E species were counted at each site based on growth and reproductive characteristics as follows:

Species	Individuals Counted
Hydrastis canadensis	Plants with fruiting bodies only
Lilium canadense	Plants with two or more leaves only
Rhynchospora colorata	Plants with flowers or seeds
Cypripedium acaule	Plants with one and two leaves
	Plants with fruit capsules (these were a subset of the two-leaved plants)
Panax quinquefolius	Plants with one, two, three, and four leaves.

To ensure the accuracy of data collected, an investigator placed small blue flags on the plants to be counted, then proceeded to walk back through the site, and while retrieving the blue flags, recorded the number of plants found. Species densities were determined from the total plant counts and the approximate area of the marked site.

3.1.1.2 Sensitive community surveys

Representative sites of the following sensitive vegetation community types were selected: beech-maple forest, limestone barren, limestone cliff, wetland, and canebrake. These monitoring sites do not represent the only occurrence of these communities in the Exclusion Area, with the exception of the beech-maple forest, which is found in only one area of the parcel. Sensitive community monitoring sites are shown in Figure 2, with corresponding coordinates in Table 1.

One reference site was established for the wetland community (Figure 3), but none were established for the canebrake, limestone barren, and limestone cliff communities because of uncertainty as to whether appropriate reference sites for these communities existed. The onsite beech-maple forest community, with its specific attributes of slope, aspect, soils, and geology, is the only known occurrence on the ORR, thus a reference site for it was also not established.

Beech-Maple Forest. Three sampling plots were selected along a 100-m transect beginning at the southwest edge of the forest and ending in the middle of the community. A white plastic stake was placed in the center of each plot and marked with an identification code. The first plot (BM1) was located approximately 25 m from the southwest edge of the community (from the vegetation community transition zone). The second plot (BM2) was located 38 m from BM1 toward the interior of the community. The third plot (BM3) was located approximately 55 m from BM2. The methods used to measure tree, sapling, shrub, seedling, and groundcover layers at each of the sampling plots are the same as those used for general vegetation community monitoring (see Section 3.1.1.3). Any deviations from the standard method, such as a different

placement of the groundcover quadrant, were noted on field data sheets.

Limestone Cliff. Two limestone cliffs on the bank of EFPC were established as monitoring sites. The upper and lower corners of each cliff section were marked with white plastic stakes marked MCl1 and MCl2, for the first and second sections, respectively. The upper boundary of the cliff sections were marked with orange flagging. A complete species list was compiled for each cliff section. Dominant species and exotic species were noted.

Limestone Barren. White plastic stakes were placed at the four corners of the barren. The boundary of the barren was marked with orange flagging consecutively numbered from BA1 through BA48. The boundary was based on the dominant groundcover species, with the species common to barrens used as indicators. Length and width measurements were taken to determine the approximate area of the site. Because the barren has a "dogleg" bend, two length measurements were combined to give a total length. The start and end points of the length measurements were marked with white plastic stakes (stakes LM1 through LM4, which are located at boundary flags BA1, BA5, BA6, and BA29, respectively). Six width measurements were taken at flag pairs BA27/31; BA26/34; BA22/37; BA16/41; BA5/45; and BA2/48. An average width was calculated from the six width measurements, the approximate area was calculated. Red cedars (*Juniperus virginiana*) and trees of other species greater than six feet tall were counted. All exotic species were noted.

Wetland. The wetland is located on a narrow peninsula that lies between the Roberts Branch embayment and Watts Bar Lake. A wetland monitoring site was selected in a small embayment on EFPC a short distance upstream from its confluence with PC. Four plots were established along transects that follow the transition from shallow, open water (MWe1) through emergent wetland (MWe2), scrub-shrub wetland (MWe3), and into forested wetland (MWe4). A wetland reference site was located on the northwest side of Gallaher Bridge (Route 58) in National Environmental Research Park Reference Area 24. Three plots were established: Plot RWe1 is in the emergent wetland; Plot Rwe2 is in the scrub-shrub area of the wetland; and plot Rwe3 is in the forested wetland area. At each plot, the dominant vegetation species were identified, and the hydric characteristics of the soil and the site hydrology were described. Data were entered on routine wetland determination data sheets (U.S. Army Corps of Engineers 1987) (Appendix A-2).

Canebrake. The canebrake boundary was double-flagged with orange flagging (Ca1-Ca16) and marked with white plastic stakes (CaA-CaH) at eight of the 16 flags. The flag-stake pairs are: Ca2-CaA; Ca4-CaB; Ca6-CaC; Ca7-CaD; Ca11-CaE; Ca12-CaF; Ca13-CaG; Ca16-CaH. The portion of the boundary comprised of EFPC was not flagged. The approximate area of the canebrake was calculated from width and length measurements. The percent cover of the cane within the established boundary was estimated. The canebrake was qualitatively described with respect to other species present, the presence of exotic species, and the dominant species in the canopy, understory, and groundcover in the surrounding floodplain.

3.1.1.3 General vegetation surveys

General vegetation monitoring sites were established in the Exclusion Area along EFPC at four locations in floodplain forest communities (VM1, VM2, VM3, VM5) and at two locations in upland forest communities (VM4, VM6), as shown in Figure 4. Coordinates of these sites are given in Table 2. In addition, three general vegetation reference sites were established based on similarities to the monitoring sites in geology, topography, and species composition. The reference sites were located in three NAs on the ORR and consist of paired floodplain community and adjacent upland community sites in each NA (Figure 5). One pair of upland and floodplain reference sites (VR1, VR2) was located in NA2 on the southeast side of Hwy. Rt. 58, opposite the northeast end of Parcel ED-1. A second pair of reference sites (VR3, VR4) was located in NA4 adjacent to and within the BC floodplain to the southeast of the intersection of Hwy. Rt. 95 and Rt. 58. The third pair of reference sites (VR5, VR6) was located in NA6 adjacent to and within the Raccoon Creek floodplain along New Zion Patrol Road.

Three plots were established at each general vegetation monitoring and reference site. An arbitrary distance of 75 m was used as the distance between the plots. The compass bearing between sampling plots generally followed the course of the adjacent stream or an elevation contour. At some sites, the distances between plots or the compass heading had to be altered to avoid moving into a different vegetation community (i.e., into an upland forest from a floodplain or a clearcut from an upland forest). The approximate distances and compass headings between plots for all of the monitoring and reference sites are reported in Table 3. An 18" long white plastic stake was placed at the center of each plot. The plot identification was written on the top of the stake. Orange flagging was tied to the stakes and to adjacent trees or shrubs to aid in relocating the plots.

A plotless technique was used to measure basal area and density for the tree strata. At each sampling plot, trees [defined as those with stems >12.4 cm diameter at breast height (dbh)]) were tallied using a 2.5 m^2/ha prism (Zedaker and Nicholas 1990). The species of each tallied tree was identified, and its dbh was measured. If a tree appeared to be "borderline", the limiting distance was calculated by multiplying the distance to the tree (distance from the plot center to the centerline of the tree) by the plot radius factor (0.3162 m radius/cm dbh, for a 2.5 m^2/ha prism). Slope correction was not applied to this strata. Basal area was calculated as the number of trees in the plot multiplied by 2.5.

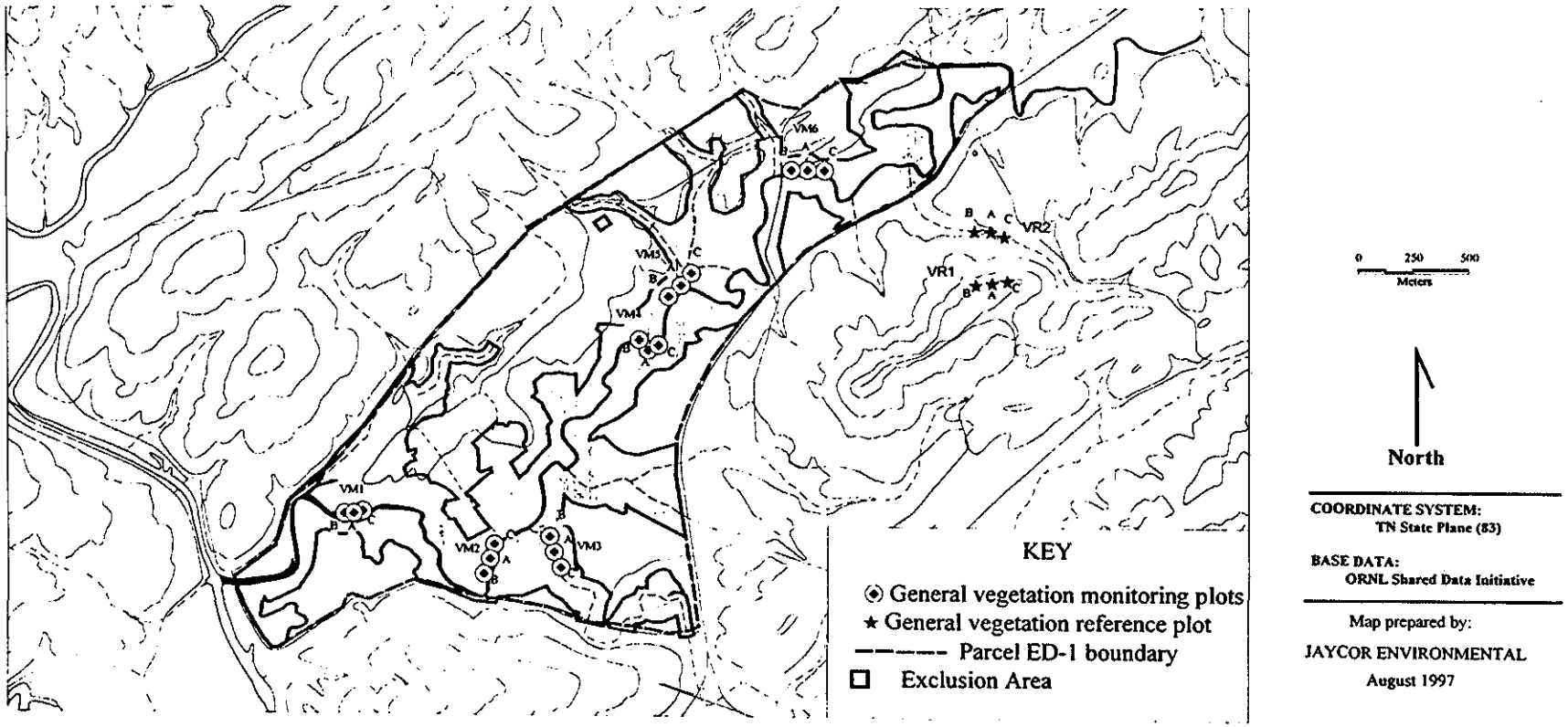

Figure 4. General vegetation community monitoring sites in Parcel ED-1

Table 2. Coordinates of general vegetation community monitoring (VM) and reference (VR) site plots.

Site ID	Location	Longitude[1]	Latitude[1]	Site ID	Location	Longitude[1]	Latitude[1]
VM1A	ED-1	-84.3805	35.9524	VR1A	NA2	-84.3478	35.9617
VM1B	ED-1	-84.381	35.9524	VR1B	NA2	-84.3486	35.9616
VM1C	ED-1	-84.38	35.9525	VR1C	NA2	-84.347	35.9617
VM2A	ED-1	-84.3735	35.9504	VR2A	NA2	-84.3478	35.9638
VM2B	ED-1	-84.3739	35.9498	VR2B	NA2	-84.3486	35.9639
VM2C	ED-1	-84.3733	35.951	VR2C	NA2	-84.3471	35.9636
VM3A	ED-1	-84.3703	35.9507	VR3A	NA4	-84.3503	35.9409
VM3B	ED-1	-84.3705	35.9513	VR3B	NA4	-84.3511	35.9409
VM3C	ED-1	-84.3699	35.95	VR3C	NA4	-84.3518	35.9409
VM4A	ED-1	-84.3635	35.9617	VR4A	NA4	-84.3504	35.9427
VM4B	ED-1	-84.3642	35.9613	VR4B	NA4	-84.351	35.9426
VM4C	ED-1	-84.363	35.9622	VR4C	NA4	-84.3497	35.9429
VM5A	ED-1	-84.3653	35.9591	VR5A	NA6	-84.3441	35.9063
VM5B	ED-1	-84.3657	35.9595	VR5B	NA6	-84.3446	35.9059
VM5C	ED-1	-84.3647	35.9593	VR5C	NA6	-84.3434	35.9063
VM6A	ED-1	-84.357	35.9665	VR6A	NA6	-84.3443	35.9089
VM6B	ED-1	-84.3578	35.9665	VR6B	NA6	-84.3449	35.9085
VM6C	ED-1	-84.3562	35.9664	VR6C	NA6	-84.3437	35.9093

[1] Coordinates are in decimal degrees. To convert to "degrees-minutes-seconds":
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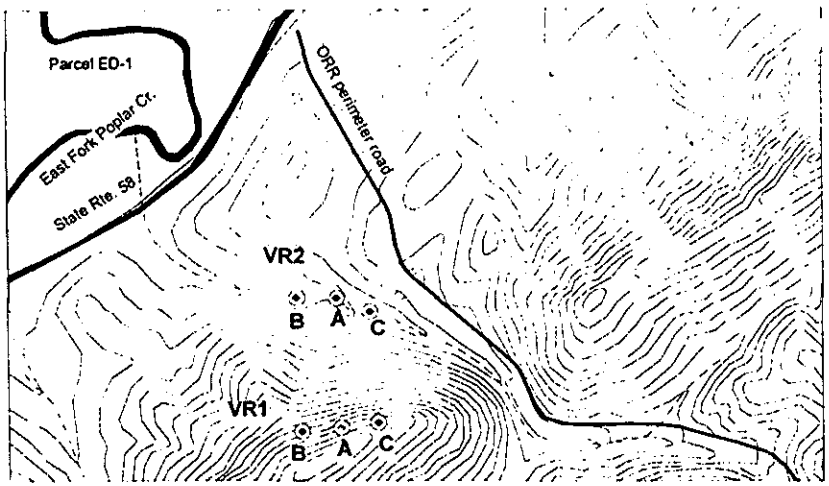

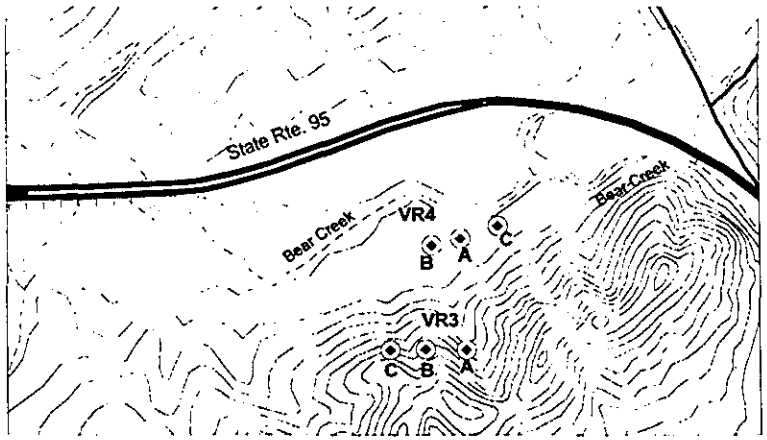

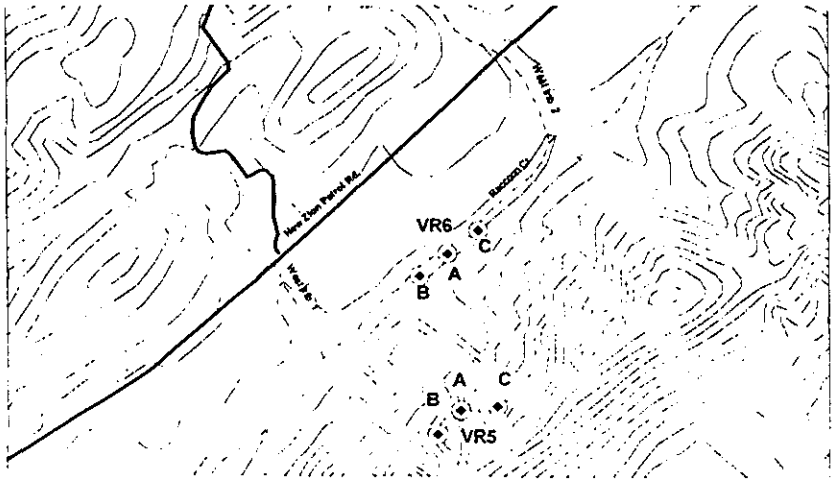

KEY

⊙ General vegetation community reference plots

0 250 500

Meters

North

COORDINATE SYSTEM:
TN State Plane (83)

BASE DATA:
ORNL Shared Data Initiative

Map prepared by:
JAYCOR ENVIRONMENTAL
August 1997

Figure 5. Reference floodplain forest and upland forest community monitoring sites on the Oak Ridge Reservation.

Table 3. Approximate compass headings and distances to the B and C general vegetation community plots from plot A at that site.

Plot	Heading (Degrees)	Distance (m)	Plot	Heading (Degrees)	Distance (m)
VM1B	270	40	VR1B	270	75
VM1C	80	40	VR1C	90	75
VM2B	220	75	VR2B	275	75
VM2C	40	75	VR2C	110	75
VM3B	350	75	VR3B	270	75
VM3C	165	75	VR3C	270	150
VM4B	40	75	VR4B	260	50
VM4C	220	75	VR4C	80	75
VM5B	325	35	VR5B	225	75
VM5C	70	50	VR5C	90	60
VM6B	270	75	VR6B	225	75
VM6C	90	75	VR6C	45	75

Saplings (trees between 2.47 cm and 12.4 cm dbh, inclusive) and shrub species (all sizes) were identified and tallied in a 11.3-m radius quadrant (area=400 m^2) centered on the central plot stake. Seedlings (tree species ≤ 2.47 cm dbh and ≥ 1 ft in height) were identified and tallied in a 5.6 m radius (98.5 m^2) quadrant centered on the central plot stake. Density was calculated for saplings/shrubs and seedlings, respectively, as the total number of individuals of a species within a quadrant divided by the quadrant area.

Corrections of the quadrant areas were made when sapling/shrub and seedling quadrants were on slopes greater than 15%, and these are noted on the individual data sheets (Appendix A-3). To convert to planar quadrant area, the quadrate radius was corrected according to the equation

$$H = S (\cos \propto)$$

where H = horizontal distance, S = slope distance, and $\propto$ = slope angle, in degrees.

One groundcover quadrant was also established in each of the sampling plots. The groundcover quadrant was located at the edge of the 11.3-m radius sapling/shrub quadrant at a heading of 90° east from the central plot stake. It was necessary to change the heading for some quadrants slightly or to alter the quadrant location slightly due to unsuitable conditions for groundcover. Any deviations from the compass heading or quadrant position was noted on the individual data sheets (Appendix A-3). A 1 m^2 square frame was used to demarcate each quadrant and orange, plastic stakes were used to mark each corner to allow relocation.

In each groundcover quadrant, herbaceous species, vines, and woody seedlings were identified to species (when possible) and the percent cover of each was estimated using a pretransformed rating scale (Little and Hills, 1978). To minimize variability, one person was responsible for estimating the percent cover for all of the groundcover quadrants. The total cover was calculated by summing the midpoints of the assigned cover classes. The percent cover of exotic species was calculated as the sum of the midpoints of the exotic species divided by the sum of the midpoints of all species.

To assess vegetation status in narrow wildlife corridors along small streams in the northwestern portions of Parcel ED-1, three line transects were established in each of the three corridors (WC1, WC2, WC3) shown in Figure 6. The transects generally begin at the wildlife corridor boundary and end in the corridor interior, usually at or near the stream, and are numbered T1, T2, and T3 in each corridor(e.g., the three transects in the westernmost corridor are numbered WC1-1, WC1-2, WC1-3). Transect lines follow a specific compass bearing (see data sheets in Appendix A-3), and the beginning and end of each line is marked with either a 1" diameter PVC pipe or a white plastic stake marked with the transect number. To aid in keeping the transect at the correct compass bearing, the line was broken down into smaller units for vegetation measurement. Numbered lengths of PVC pipe were placed at 10-m intervals

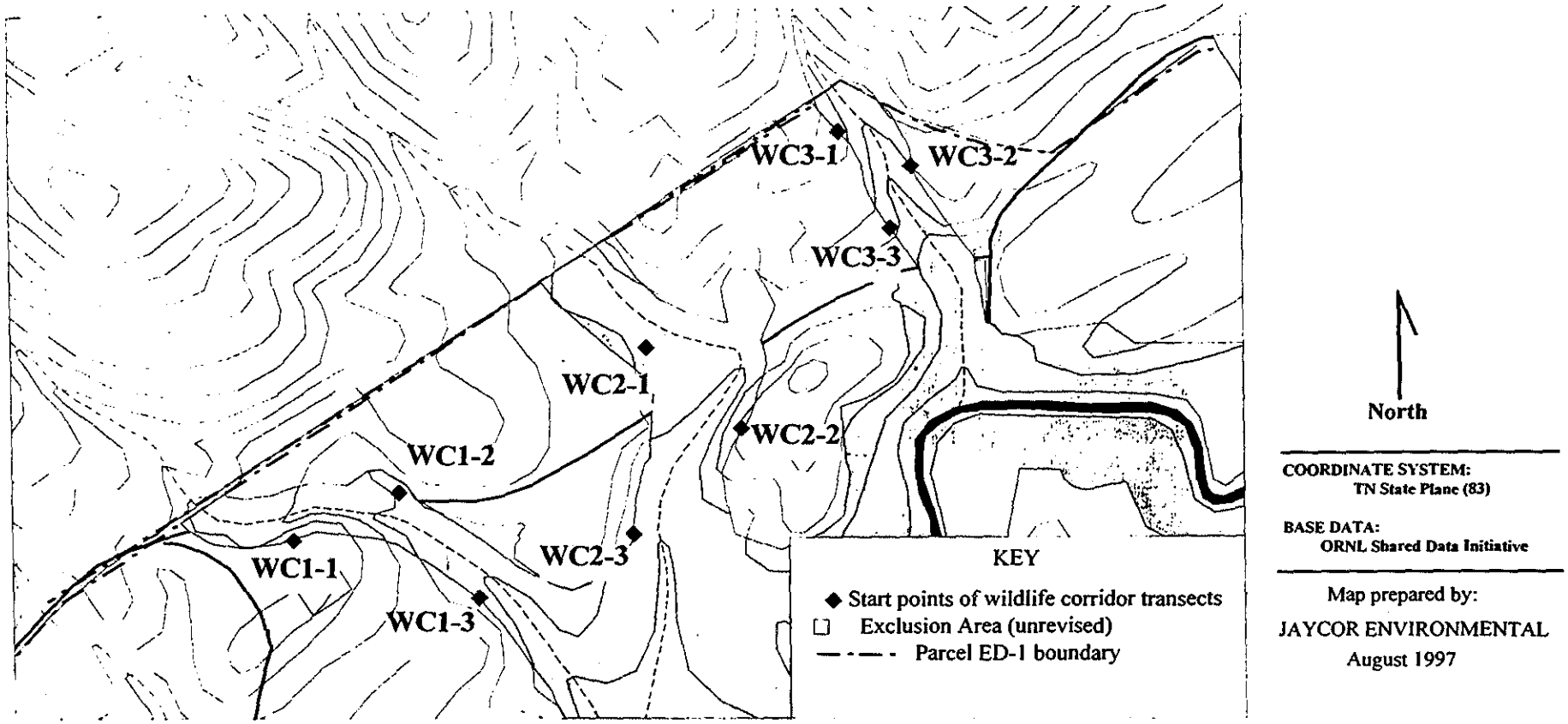

Figure 6. Wildlife corridor transect monitoring sites in Parcel ED-1.

(i.e., WC1-T1 S1 is at 10 m; S2 is at 20 m) along the transect. Trees, shrubs, saplings, and seedlings that intersected the transect line were identified and tallied. The dbh of trees over 12.4 cm dbh was measured. All seedlings, including those less than one foot in height, were counted.

Two groundcover quadrants were established on the right side (viewed from corridor boundary looking toward the interior) of each transect at 3 m (GC1) and 15 m (GC2). The side of the quadrant intersecting with the transect was marked with two 1" diam. sections of PVC pipe. A 1-m^2 frame was placed over the two pipe sections (one in each corner); herbaceous species, woody vines, and small seedlings (≤12" in height) were identified; and the percent cover of each species was estimated in each quadrant (Little and Hills 1978). Seedlings over 12" in height were not included.

3.1.2 Survey Results and Discussion

3.1.2.1 Human impacts and exotic plants as indicators

Vegetation communities in the Exclusion Area include mature mesic forest, immature second-growth forest, pine plantation, black walnut plantation, woody old field, three-year old clearcuts in primary successional stages, limestone cedar barrens, and floodplain forest. Portions of this area have been impacted to varying degrees by human activity. While some areas have begun recovery and regeneration to forest from the agricultural uses of the past, there have been more recent ecological effects resulting from pine plantations, clearcuts, and introduction of exotic species.

The most recent and obvious example of human activity are the clearcuts, which were formerly loblolly pine plantations that were logged in 1993-94 because of infestation by the southern pine beetle. These clearcuts are in an early old-field growth stage and are dominated by Japanese honeysuckle (*Lonicera japonica*) and blackberry (*Rubus* sp.). Common sapling species include tulip poplar (*Liriodendron tulipifera*) and sweetgum (*Liquidambar styraciflua*). These areas will eventually develop into forest, although forest structure, species composition, and function are likely to continue to be influenced by human activity.

A less obvious example of human impact is the invasion of natural communities and recovering natural communities by aggressive exotic species that outcompete and exclude native vegetation thereby reducing overall plant biodiversity and adversely affecting the development and functioning of the community. Introduction of, or changes in, the populations of aggressive exotic species over time and their potential relationship to site attributes, such as canopy closure and distance to development or forest openings, may be used as an indicator of possible direct and indirect effects of site development and other human activities.

Of the 167 exotic plant species known to occur on the ORR, forty-three are considered to be invasive, aggressive species (Awl et al. 1996) (Table 4). These include Japanese honeysuckle,

Table 4. Invasive and aggressive exotic plant species found at four or more locations on the Oak Ridge Reservation.

1. Ailanthus altissima	23. Mentha spicata
2. Allium vineale	24. Mentha x piperita
3. Amaranthus hybridus	25. Microstegium vimineum
4. Arthraxon hispidus	26. Myriophyllum spicatum
5. Celastris orbiculatus	27. Nasturtium officinale
6. Cirsium vulgare	28. Paulownia tomentosa
7. Coronilla varia	29. Plantago lanceolata
8. Dioscorea batatas	30. Poa pratensis
9. Echinochloa crusgalli	31. Polygonum cuspidatum
10. Elaeagnus pungens	32. Polygonum persicaria
11. Elaeagnus umbellata	33. Potamogeton crispus
12. Glechoma hederacea	34. Pueraria lobata
13. Kummero stipulacea	35. Rosa multiflora
14. Kummero striata	36. Rumex conglomeratus
15. Kyllinga brevifoliodes	37. Sorghum halepense
16. Lespedeza bicolor	38. Urtica dioica
17. Lespedeza cuneata	39. Veronica arvensis
18. Ligustrum sinense	40. Veronica officinalis
19. Lonicera japonica	41. Veronica serpyllifolia
20. Lysimachia nummularia	42. Vicia villosa
21. Lythrum salicaria	43. Vinca minor
22. Mahonia bealei	

* Lythrum salicaria (21) is known to occur in only one watershed, but is included because of it's known high potential for rapid spread and severe impacts to native wetland plant communities.

kudzu (*Pueraria lobata*), microstegium (*Eulalia viminea*), privet (*Ligustrum sinense* and *L. vulgare*), cinnamon vine (*Dioscorea batatas*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), privet (*Ligustrum sinense* and *L. vulgare*), and Oriental bittersweet (*Celastrus orbiculatus*).

The introduction of, or population changes in, some exotic species cannot always be directly linked to a specific activity in the immediate area or to specific sources. For instance, privet has been widely planted as an ornamental hedge in residential and commercial areas. Because privet fruits are favored by birds, the seeds can be widely dispersed from their source. In addition, favorable privet habitat includes floodplains where flooding can spread the seeds to downstream areas far from their original source. In this case, the dominance of privet in some areas in the floodplain is an indirect impact of human activities, but the source of the initial introduction and the pattern of subsequent spread would be difficult to determine. In contrast, exotic species that are not readily naturally introduced into new areas because of their dispersal and growth characteristics (i.e., low seed production; not readily dispersed by birds, wildlife, or the wind; shade-intolerant), can be introduced into and spread throughout a new area as a direct result of human activities, such as propagules attached to vehicles and equipment; intentional introduction in landscaping and erosion control, and; forest clearing. In addition, site development may result in habitat alterations that favor the spread of existing exotic species into communities and locations in which they did not occur prior to development.

Exotic species were present in sensitive community sites and in the floodplain forest and upland forest monitoring and reference sites. The density in the sapling/shrub/seedling quadrants and the percent of total cover in the groundcover quadrants were calculated; data are presented in the summary tables for each strata.

3.1.2.2 T&E plant species

Results of the baseline T&E plant species monitoring at both monitoring sites and reference sites are summarized in Table 5 (see Figures 2 and 3 for locations). Although there is considerable variation in specific characteristics, in general, the status of T&E plant populations in the Exclusion Area is similar to that of populations in reference areas. Additional information on the status of T&E plants is provided in Appendix A-3.

Future monitoring of T&E plants in the Exclusion Area should include annual surveys of the monitoring and reference sites on or near the same date each year. The *Hydrastis canadensis*, *Lilium canadense*, and *Cypripedium acaule* sites, in particular, should be re-surveyed no later than the dates of the baseline surveys, as these species either senesce or lose their fruits rapidly after fruiting is completed.

Table 5. Threatened and endangered plant species monitoring (MRP) and reference (RRP) site data summary.

Site ID	Species	Location[1]	Date of Data Collection		Individuals with one leaf	Individuals with two or more leaves	Individuals with flowers	Individuals with fruits	Total number of plants	Area (m^2)[3]	Density (#plants/ m^2)
MRP1	Hydrastis canadensis	EA	6/26/96		-	-	-	13	150[2]	-	
RRP1	H. canadensis	NA2	6/17/96		-	-	-	39	160[2]	37	4.3
RRP2	H. canadensis	NA52	6/26/96		-	-	-	78	-	39	
RRP3	H. canadensis	NA6	6/26/96		-	-	-	12	200[2]	339	0.6
MRP2	Cypripedium acaule[4]	EA	7/18/96		119	154	1	0	273	78	3.5
RRP4	C. acaule	RA6	6/25/96		17	94	14	2	111	180	0.6
RRP5	C. acaule	NA55	6/27/96		10	41	17	0	51	275	0.2
RRP6	C. acaule	NA24	6/27/96		103	42	0	0	145	232	0.6
MRP3	Lilium canadense	EA	5/20/97	-	-	28	-	-	-	15.7	1.8
RRP8	L. canadense	NA22	5/20/97	-	-	90	-	-	-	6.2	14.5
RRP9	L. canadense	NA25	5/25/97	-	-	41	-	-	-	9.2	4.5
RRP10	L. canadense	NA56	5/25/97	-	-	31	-	-	-	3.6	8.6
MRP4	Rhynchospora colorata	EA	6/28/96	-	-	-	40	-	-	2	
			7/11/96	-	-	-	100	-	-	2	

[1] EA = Exclusion Area. NA = National Environmental Research Park Natural Area.

[2] The total number of plants was visually estimated. The estimate for MRP1 is of the monitoring site only, and not the larger population.

[3] The area is estimated from single length and width measurements of the area within the plant site boundary.

[4] For C. acaule: Total number of plants = No. of one leaf plants + No. of two-leaved plants. (The individuals with flower or fruit are included in the count of two-leaved plants).

Table 5 (continued).

Site ID	Species	Location	Date	Individuals with one leaf	Individuals with two leaves	Individuals with three leaves	Individuals with four leaves	Total reproductive	Total number of plants	Area (m^2)	Density[2]
MRP5	Panax quinquifolius[5]	EA	8/4/96	0	5	3	1	9	9	20	0.5
RRP10	P. quinquifolius	NA52	9/9/96	2	2	3	0	4	7	25	0.3
RRP11	P. quinquifolius	NA52	9/9/96	3	3	2	1	4	9	44	0.2
RRP12	P. quinquifolius	NA52	9/9/96	0	2	2	0	3	4	1	4

[5] The total number of plants sum does not include the number for "total reproductive" because they are a subset of "individuals with __ leaves" counts.

3.1.2.3 Sensitive plant communities

Data were collected at the sensitive plant community monitoring and reference sites primarily during the period July-September 1996 (Table 6, see Figures 2 and 3 for site locations).

Beech-Maple Forest. A summary of the baseline data for the tree strata and the sapling/shrub/seedling strata at the beech-maple forest site is presented in Table 7. The forest is surrounded by clearcut (formerly pine plantation) and is bisected by an infrequently-used dirt road. Numerous large (30-79 cm dbh) beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), and oak (*Quercus* sp.) individuals were identified in this beech-maple forest remnant. Based on data from the sapling and seedling quadrants there appeared to be good regeneration of beech and sugar maple. Other species in the sapling and seedling layer included redbud (Cercis canadensis), black cherry (*Prunus serotina*), tulip poplar (*Liriodendron tulipifera*), and flowering dogwood (*Cornus florida*). The groundcover vegetation was sparse. Common species included Virginia creeper (*Parthenocissus quinquefolia*), perfoliate bellwort (*Uvularia perfoliata*), sessile bellwort (*Uvularia sessifolia*), greenbrier (*Smilax* sp.), and seedlings of overstory trees.

Several exotic species were observed at the site, including Japanese honeysuckle and microstegium. Japanese honeysuckle was abundant in the surrounding clearcut areas as well. It was found in one groundcover quadrant (BM2), but the percent of cover was closer to the lower end of cover class 1 (1%-5%). One culm of microstegium was found in the BM3 groundcover quadrant. Microstegium was observed growing along the dirt road bisecting the forest, but with the exception of the culm found in the BM3 groundcover quadrant, was not seen growing in the forest away from the road.

Limestone cliffs. This site was partitioned into two sub-communities based on vertical position. Cliff section 1 is approximately 3-5 m in height and consists of ledges that are breaking up along rock layers at the exposed edges. Cliff section 2 is an overhanging outcrop that is approximately 6 to 7 m in height. The cliffs are separated by roughly 10 ms of steep, vegetated streambank that is not a rock outcrop. A list of plant species identified on each of the two cliff sections is given in Table 8.

The cliffs supported a diverse plant community. Thirty-one species were observed on Cliff section 1, twenty-six of which occurred on the cliff face. Cliff section 2 supported forty-three species, with thirty-two occurring on the cliff face. Wild stonecrop (*Sedum ternatum*) was the dominant species on both cliff sections. The exotic species Japanese honeysuckle and microstegium were found on the cliff face and top. However, both were a minor component of the cliff vegetation community.

Table 6. Dates of establishment and data collection for sensitive plant community monitoring and reference sites.

Site ID	Community	Location	Date of Site Establishment and Data Collection
MWe1[1]	Wetland/open water	EA[3]	7/24/96
MWe2	Emergent wetland	EA	7/24/96
MWe3	Scrub-shrub wetland	EA	7/24/96
MWe4	Forested wetland	EA	7/24/96
MBa	Limestone barren	EA	7/11/96
MBM	Beech-Maple forest	EA	6/19/97
MCa	Canebrake	EA	7/17/96
MCl1	Limestone cliff	EA	7/10/96
MCl2	Limestone cliff	EA	7/10/96
RWe1[2]	Emergent Wetland	RA24[4]	9/18/96
RWe2	Scrub-shrub wetland	RA24	9/18/96
RWe3	Forested wetland	RA24	9/18/96

[1] MWe1 through MWe4 are different wetland classes within the same wetland.

[2] RWe1 through RWe3 are different wetland classes within the same wetland.

[3] EA = Exclusion Area on Parcel ED-1.

[4] RA = National Environmental Research Park Reference Area.

Table 7A. Data summary for the tree strata at the beech-maple forest site.

PLOT ID	BM1		BM2		BM3		MEAN	
TREE SPECIES	N[1]	BA[2]	N	BA	N	BA	N	BA
Acer saccharum	1	2.5	-	-	-	-	0.3	0.8
Carya tomentosa	-	-	1	2.5	1	2.5	0.6	1.6
Fagus grandifolia	3	7.5	2	5.0	3	7.5	2.6	6.6
Fraxinus americana	3	7.5	1	2.5	-	-	1.3	3.3
Liriodendron tulipifera	-	-	-	-	2	5.0	0.6	1.6
Oxydendrum arboreum	-	-	-	-	1	2.5	0.3	0.8
Quercus alba	1	2.5	-	-	1	2.5	0.6	1.6
Quercus coccinea	-	-	-	-	1	2.5	0.3	0.8
Quercus falcata	1	2.5	2	5.0	-	-	1	3
Quercus rubra	-	-	1	2.5	-	-	0	1
[1] Number of individuals of that species in the plot								
[2] Basal area in m^2/ha								

Table 7B. Data summary for the understory and groundcover strata at the beech-maple forest site.

Monitoring Station: Beech-Maple Forest	BM1	BM2	BM3	MEAN
Shrub-sapling-seedling: Total Density: Saplings:	850	600	1100	850
Total Density: Shrubs	0	0	0	0
Total Density: Seedlings	0	914	0	914
Percent Exotic Species	0	0	0	0
Groundcover:				
Number of Species	10	8	8	8.6
Total Cover	25	44	36	35
Percent Exotic Species	0	5.7	7.5	

[1] Density = number of individuals / hectare
Total Cover = Sum of the midpoints of the cover class for each species.

Table 8. List of plant species found at the limestone cliff sensitive plant community site.

Limestone Cliff Section 1

Scientific name	Common name
Acer negundo (1 seedling)	Box elder
Acer saccharum	Sugar maple
Arabis laevigata[1]	Smooth rock-cress
Asplenium rhizophyllum	Walking fern
Bignonia capreolata	Cross-vine
Boehmeria cylindrica	False nettle
Brachyeletrum erectum	no common name
Carpinus caroliniana	Ironwood
Dioscorea quaternata[1]	Wild yam
Galium sp.	Bedstraw
Geum canadense	White avens
Hepatica americana	Round-lobed hepatica
Lonicera japonica[2]	Japanese honeysuckle
Melica mutica[1]	Melica grass
Microstegium vimineum[2]	Nepal grass
Parthenocissus quinquefolia	Virginia creeper
Polygonatum biflorum	Solomon's seal
Polypodium polypodioides[1]	Resurrection fern
Polystichum acrostichoides	Christmas fern
Prunus serotina (1 seedling)	Black cherry
Sanicula sp.	Snakeroot
Sedge (unidentified)	
Sedum ternatum[3]	Wild stonecrop
Smilacina racemose	False Solomon's seal
Smilax sp.[1]	Greenbrier
Solidago sp.	Goldenrod
Spigelia marilandica	Indian pink
Thalictrum thalictroides	Rue-anemone
Toxicodendron radicans	Poison ivy
Ulmus americana	American elm
Waldsteinia fragarioides	Barren strawberry

[1] Found on top of cliff, but not on cliff face.

[2] Exotic species

[3] Dominant species

Table 8 (continued).

Limestone Cliff Section 2

Scientific name	Common name
Acer negundo	Box elder
Acer saccharum	Sugar maple
Aconitum uncinatum	Monk's hood
Allium sp.[1]	Wild onion
Aquilegia canadensis	Columbine
Asimina triloba	Paw-paw
Boehmeria cylindrica	False nettle
Brachyeletrum erectum	no common name
Carex sp.	sedge
Carpinus caroliniana	Ironwood
Carya sp.[1]	Hickory
Cercis canadensis[1]	Redbud
Chionanthus virginicus	Fringe tree
Clematis sp.[1]	
Euonymus sp.[1]	
Fraxinus americana[1]	White ash
Geum canadense	White avens
Hamamelis virginiana[1]	Witch-hazel
Hepatica americana	Round-lobed hepatica
Heuchera americana	Alumroot
Iris cristata	Crested dwarf iris
Lonicera japonica[2]	Japanese honeysuckle
Microstegium vimineum[2]	Nepal grass
Mitella diphylla	Bishop's cap
Ostrya virginica[1]	Hop hornbeam
Oxalis sp.	Wood sorrel
Parthenocissus quinquefolia	Virginia creeper
Pilea pumila	Clearweed
Platanus occidentalis	Sycamore
Polygonatum biflorum	Solomon's seal
Polygonum sp.	
Polystichum acrostichoides[1]	Christmas fern
Quercus muehlenbergii[1]	Chinquapin oak
Sedum ternatum[3]	Wild stonecrop
Smilacina racemose	False Solomon's seal
Solidago sp.	Goldenrod
Spigelia marilandica[1]	Indian pink
Thalictrum thalictroides	Rue-anemone
Thaspium barbinode	Bearded meadow parsnip
Toxicodendron radicans	Poison ivy
Ulmus rubra	Slippery elm
Verbesina alternifolia	Wingstem
Viola sp.	Violet

[1] Found on top of cliff, but not on cliff face.

[2] Exotic species [3] Dominant species

Limestone barren. The limestone barren is approximately 950 m^2 in size (average width = 108 m, average width = 8.8 m). Baseline data for the limestone barren is presented in Table 9.

Individuals greater than six feet in height included 194 red cedars and 73 trees, including tulip poplar, redbud, black oak (*Quercus velutina*), chinquapin oak (*Quercus muehlenbergii*), beech, and serviceberry (*Amelanchier* sp.), and shrubs [Carolina buckthorn (*Rhamnus caroliniana*) and rusty blackhaw (*Viburnum rufidulum)*]. The percent woody cover in the barren was visually estimated as 50%.

Seven exotic plant species were identified in the barren. With the exception of lyre-leaved sage (*Salvia liatra*), which was found throughout the barren and was dominant in some spots, exotic species occurred in low numbers and infrequently. Microstegium appeared to be moving into the barren from the adjacent woods in which it was widespread. Only one privet shrub was found in the barren, but it was growing throughout the surrounding woods in abundance.

Wetland. The hydrology of both the Parcel ED-1 monitoring wetland site and the reference wetland site is influenced by the fluctuating water levels of Watts Bar Lake. East Fork Poplar Creek becomes an embayment of Watts Bar Lake during the spring and summer months because of the higher summer pool levels maintained in the lake. The reference wetland at Roberts Branch is located on the shoreline of Watts Bar Lake and the emergent and scrub-shrub portions appear to be flooded for most of the year. A summary of the vegetation data for the wetland monitoring and reference sites is given in Table 10.

Twelve tree and shrub species were observed at the monitoring and reference stations, with seven species observed at the monitoring site and nine species at the reference site. Four of these species (box elder, green ash, black willow, and silky dogwood) occurred at both the monitoring and reference sites. Twenty-five herbaceous species were observed to be dominant or highly visible in the plots, with nine species observed at the monitoring site and twenty species observed at the reference site. Common species included Louisiana sedge (*Carex louisianica*), other sedges (*Carex* sp.), false nettle (*Boehmeria cylindrica*), water willow (*Justicia americana*), and smartweed (*Polygonum* spp.). Japanese honeysuckle and microstegium were present at the reference stations, but did not occur in the monitoring stations. Another exotic species, moneywort, occurred at both the monitoring and reference sites.

Canebrake. The percent cover of cane is approximately 98% within much of the canebrake site. Ground ivy was growing in the herbaceous layer. Sycamore, box elder, and American elm were found within the canebrake boundary, and in places formed a canopy over the cane. Privet was also found within the canebrake boundary and within the area of the densest cane cover. Within the marked site boundary were areas of lower density of cane, where a few cane stems have spread out from the main part of the brake. The percent cover of cane in these small sections was approximately 5% to 15%, and the dominant groundcover species are wingstem

Table 9. Data summary for the limestone barren sensitive plant community site.

Dimensions:		
Length (m):	107.9	
Avg. Width (m):	8.8	
Estimated Area (m^2):	949.5	
Woody Vegetation:		
Number of red cedars > 6 ft in height: 194		
Number of other woody species > 6 ft in height: 73		
List of the other woody species:	Amelanchier sp.	(Serviceberry)
	Cercis canadensis	(Redbud)
	Fagus grandifolia	(American beech)
	Liriodendron tulipifera	(Tulip poplar)
	Quercus muehlenbergii	(Chinquapin oak)
	Quercus velutina	(Black oak)
	Rhamnus caroliniana	(Carolina buckthorn)
	Viburnum rufidulum	(Rusty blackhaw)
Estimated percent woody cover: 50%		
Exotic Species:	Daucus carota	(Queen Anne's lace)
	Eulalia viminea	(Microstegium)
	Ligustrum sinense	(Privet)
	Lonicera japonica	(Japanese honeysuckle)
	Pinus taeda	(Loblolly pine)
	Prunella vulgaris	(Heal-all)
	Salvia liatra	(Lyre-leaved sage)

Table 10. Dominant vegetation species in the wetland monitoring and reference sites.

Station ID	Wetland Classification	Scientific Name	Common Name	Type
MWe1	Emergent/ Open Water	Juncus effusus	Soft rush	herbaceous
		Cephalanthus occidentalis	Buttonbush	shrub
MWe2	Emergent	Cephalanthus occidentalis	Buttonbush	shrub
		Carex louisianica	Louisiana sedge	herbaceous
		Polygonum hydropiperoides	Water-pepper	herbaceous
RWe1	Emergent	Acer saccharinum	Silver maple	tree
		Acer negundo	Box elder	tree
		Amorpha fruticosa	False indigobush	shrub
		Typha latifolia	Cattail	herbaceous
		Eulalia viminea	Microstegium	grass; exotic
		Leersia oryzoides	Rice cutgrass	grass
		Polygonum sagittaria	Arrow-leaved tearthumb	herbaceous
		Polygonum caespitosum		herb.; exotic
		Carex louisianica	Louisiana sedge	herbaceous
		Aster ontarionis	Bottomland aster	herbaceous
		Juncus effusus	Soft rush	herbaceous
		Elymus virginicus	Wild rye	grass
		Justicia americana	Water willow	herbaceous
MWe3	Scrub-Shrub	Acer negundo	Box elder	tree; sapling
		Salix nigra	Black willow	tree; sapling
		Cornus amomum	Silky dogwood	shrub
		Cephalanthus occidentalis	Buttonbush	shrub
		Carex louisianica	Louisiana sedge	herbaceous
		Boehmeria cylindrica	False nettle	herbaceous
		Lysimachia nummularia	Moneywort	herb.; exotic
		Apios americana	Groundnut	vine
		Amphicarpea bracteata	Hog peanut	vine
RWe2	Scrub-Shrub	Betula nigra	River birch	sapling
		Acer saccharinum	Silver maple	sapling
		Salix nigra	Black willow	sapling
		Fraxinus pennsylvanica	Green ash	sapling
		Amorpha fruticosa	False indigobush	shrub
		Eulalia viminea	Microstegium	grass; exotic
		Sagittaria australis	Arrowhead	herbaceous
		Scirpus polyphyllus	Leathery sedge	herbaceous
		Polygonum sagittaria	Arrow-leaved tearthumb	herbaceous
		Cinna arundinacea	Woodreed	herbaceous
		Boehmeria cylindrica	False nettle	herbaceous
		Impatiens capensis	Jewelweed	herbaceous
		Lysimachia nummularia	Moneywort	herbaceous
		Polygonum punctatum	Dotted smartweed	herbaceous
		Carex sp.	sedge	herbaceous

Table 10 (continued).

Station ID	Wetland Classification	Scientific Name	Common Name	Type
MWe4	Forested	Platanus occidentalis	Sycamore	tree
		Fraxinus pennsylvanica	Green ash	tree
		Acer negundo	Box elder	tree & sapling
		Cornus amomum	Silky dogwood	shrub
		Boehmeria cylindrica	False nettle	herbaceous
		Elymus virginicus	Wild rye	grass
		Lysimachia nummularia	Moneywort	herb.; exotic
		Carex louisianica	Lousiana sedge	herbaceous
		Cryptotaenia canadensis	Honewort	herbaceous
		Ranunculus recurvatus	Hooked crowfoot	herbaceous
RWe3	Forested	Acer saccharinum	Silver maple	tree
		Ulmus americana	American elm	tree
		Acer negundo	Box elder	tree
		Populus deltoides	Cottonwood	tree
		Acer negundo	Box elder	sapling
		Cornus amomum	Shrub	shrub
		Fraxinus pennsylvanica	Green ash	sapling
		Eulalia viminea	Microstegium	herbaceous
		Elymus virginicus	Wild rye	herbaceous
		Boehmeria cylindrica	False nettle	herbaceous
		Aster ontarionis	Bottomland aster	herbaceous
		Cinna arundinacea	Woodreed	herbaceous
		Bignonia capreolata	Trumpet creeper	herbaceous
		Lonicera japonica	Jap. honeysuckle	herbaceous
		Scirpus polyphyllus	Leathery rush	herbaceous
		Lysimachia nummularia	Moneywort	herbaceous
		Carex sp.	Sedge	herbaceous

(*Verbesina alternifolia*) and ground ivy (*Glechoma hederaceae*), an exotic species. These areas of sparse cane growth were approximately 15% of the total site area. The dominant species in the floodplain in the vicinity of the canebrake were sycamore (*Platanus occidentalis*), American elm (*Ulmus americana*), box elder (*Acer negundo*) in the canopy, box elder in the subcanopy and sapling layer, and wingstem and ground ivy in the groundcover. Deep, gravel-and-rock bottom, flood channels separating the canebrake area from portions of the floodplain dominated by other vegetation. During high flows the canebrake area could become inundated.

3.1.2.4 General vegetation surveys

Summary data for the tree strata at the general vegetation monitoring and reference sites (see Figures 4 and 5) are presented in Table 11. The dominant tree species at the monitoring sites in the floodplain forest plots were green ash (*Fraxinus pennsylvanica*), box elder (*Acer negundo*), sycamore (*Platanus occidentalis*), and elm (*Ulmus americana* and *U. rubra*). Other commonly-occurring species included tulip poplar (*Liriodendron tulipifera*), cottonwood (*Populus deltoides*), hackberry (*Celtis occidentalis*), and ironwood (*Carpinus caroliniana*). Red oak (*Quercus rubra*), black cherry (*Prunus serotina*), red cedar (*Juniperus virginiana*), and shortleaf pine (*Pinus echinata*), which are not typical floodplain species, were found in a slightly higher elevation, less-frequently flooded plot (VM2C). Dominant tree species at the reference site floodplain forest plots included red maple (*Acer rubrum*), box elder, green ash, black walnut, tulip poplar, sycamore, elm, and sweetgum (*Liquidambar styriciflua*).

Tree species at monitoring sites in the upland forest plots included oaks (*Quercus* spp.), white ash (*Fraxinus americana*), and red cedar. Honey locust (*Gleditsia triacanthos*) and black walnut (*Juglans nigra*) occurred at monitoring site VM6. Dominant tree species at reference site upland forest communities included oaks, white ash, sugar maple (*Acer saccharum*), hickories (*Carya tomentosa* and *C. ovata*), tulip poplar, beech (*Fagus grandifolia*), sourwood (*Oxydendrum arboreum*), and magnolia (*Magnolia tripetala*). No exotic species were found in the tree strata at any of the monitoring or reference sites. More detailed data are presented in Appendix A-3.

Summary data for the sapling/shrub/ seedling strata is presented in Table 12. The primary shrub species at the monitoring and reference site floodplain forest plots were spicebush (*Lindera benzoin*), silky dogwood (*Cornus amomum*), and privet (*Ligustrum sinense* and/or *L. vulgare*). Shrub species in the upland forest plots included Carolina buckthorn (*Rhamnus caroliniana*), blueberries (*Vaccinium* spp.), hydrangea (*Hydrangea arborescens*), rusty blackhaw (*Viburnum rufidulum*) and privet. Exotic species as a percentage of total density of saplings, shrubs, and seedlings ranged from zero at reference sites VR1, VR2, VR3, VR4, and VR5 to 66.3% at monitoring station VM1. With the exception of multiflora rose (*Rosa multiflora*), which was found in one monitoring plot (VM6C), privet was the only exotic shrub species at the monitoring and reference sites and was found in thirteen of thirty-six plots.

Table 11. Number of individuals and basal areas of tree species in the general vegetation community monitoring sites.

FLOODPLAIN FOREST MONITORING SITES IN THE PARCEL ED-1 EXCLUSION AREA

PLOT ID	VM1A		VM1B		VM1C		AVERAG		VM3A		VM3B		VM3C		AVERAG		VM5A		VM5B		VM5C		AVERAGE	
TREE SPECIES	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)
Acer negundo	2	5.0	1	2.5	-	-	1	25.0	1	2.5	4	10.0	-	-	1.6	4.2	6	15.0	2	5.0	8	20.0	-	-
Carpinus caroliniana	1	2.5	-	-	-	-	0.3	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Celtis occidentalis	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fagus grandifolia	-	-	-	-	-	-	-	-	-	-	1	2.5	-	-	0.3	0.8	-	-	-	-	-	-	-	-
Fraxinus pennsylvanica	-	-	2	5.0	-	-			-	-	-	-	-	-	-	-	-	-	-	-	2	5.0	-	-
Juglans nigra	-	-	-	-	-	-	-	-	1	2.5	-	-	3	7.5	1.3	3.3	-	-	-	-	-	-	-	-
Juniperus virginiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liriodendron tulipifera	-	-	-	-	-	-	-	-	1	2.5	-	-	-	-	0.3	0.8	-	-	5	12.5	-	-	-	-
Pinus echinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platanus occidentalis	5	12.5	11	27.5	8	20.0	8.0	20.0	-	-	-	-	-	-	-	-	2	5.0	-	-	1	2.5	-	-
Populus deltoides	-	-	-	-	-	-	-	-	-	-	-	-	2	5.0	0.6	1.6	-	-	-	-	-	-	-	-
Prunus serotina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus rubra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ulmus americana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2.5	-	-	-	-	-	-

Table 11 (continued).

UPLAND FOREST MONITORING SITES IN THE PARCEL ED-1 EXCLUSION AREA

PLOT ID	VM4A		VM4B		VM4C		AVERAG		VM6A		VM6B		VM6C		AVERAG		VM6A		VM6B		VM6C		AVERAGE	
TREE SPECIES	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)
Fraxinus americana	-	-	1	2.5	-	-	0.3	0.8	-	-	-	-	-	-	-	-								
Fraxinus sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	2.5	0.3	0.8								
Gleditsia triancanthos	-	-	-	-	-	-	-	-	1	2.5	-	-	-	-	0.3	0.8								
Juglans nigra	-	-	-	-	-	-	-	-	1	2.5	-	-	-	-	0.3	0.8								
Juniperus virginiana	2	5.0	-	-	1	2.5	1.0	2.5	2	5.0	-	-	2	5.0	1.3	3.3								
Platanus occidentalis	-	-	-	-	-	-	-	-	2	5.0	-	-	-	-	0.6	1.6								
Quercus prinus	1	2.5	-	-	-	-	0.3[s]	0.8	-	-	-	-	-	-	-	-								
Quercus rubra	-	-	1	2.5	1	2.5	0.6	1.6	-	-	-	-	2	5.0	0.6	1.6								
Quercus velutina	-	-	-	-	1	2.5	0.3	0.8	-	-	-	-	-	-	-	-								
Ulmus rubra	-	-	-	-	-	-	-	-	1	2.5	-	-	-	-	0.3	0.8								

Table 11 (continued).

FLOODPLAIN FOREST REFERENCE SITES ON THE OAK RIDGE RESERVATION

PLOT ID	VR2A		VR2B		VR2C		AVERAG		VR4A		VR4B		VR4C		AVERAG		VR6A		VR6B		VR6C		AVERAGE	
TREE SPECIES	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)
Acer negundo	-	-	1	2.5	1	2.5	0.6	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acer rubrum									-	-	1	2.5	2	5.0	1.0	2.5	1	2.5	2	5.0	-	-	1.0	2.5
Carya sp.	-	-	1	2.5	-	-	0.3	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Fraxinus sp.	-	-	1	2.5	-	-	0.3	0.8	-	-	-	-	-	-	-	-	2	5.0	-	-	-	-	0.6	1.6
Fraxinus pennsylvanica	1	2.5	-	-	-	-	0.3	0.8	4	10.0	5	12.5	2	5.0	3.6	5.8	-	-	-	-	-	-	-	-
Juglans nigra	-	-	1	2.5	-	-	0.3	0.8									-	-	-	-	-	-	-	-
Juniperus virginiana	-	-	-	-	-	-	-	-									4	10.0	6	15.0	3	7.5	4.3	10.8
Liquidambar styriciflua	-	-	-	-	-	-	-	-			1	2.5			0.3	0.8	1	2.5	-	-	5	12.5	2.0	5.0
Liriodendron tulipifera	4	10.0	1	2.5	4	10.0	3.0	7.5									-	-	-	-	-	-	-	-
Pinus virginiana	-	-	-	-	-	-	-	-									-	-	5	12.5	-	-	1.6	4.2
Platanus occidentalis	1	2.5	2	5.0	2	5.0	1.6	4.2	5	12.5	3	7.5	4	10.0	4	10.0	-	-	-	-	-	-	-	-
Quercus rubra	-	-	-	-	-	-	-	-									1	2.5	-	-	-	-	0.3	0.8
Ulmus americana	-	-	3	7.5	-	-	1.0	2.5									-	-	-	-	-	-	-	-
Ulmus rubra	-	-	-	-	1	2.5	0.3	0.8									-	-	-	-	1	2.5	0.3	0.8
Ulmus sp.	-	-	-	-	-	-	-	-					1	2.5	0.3	0.8	-	-	-	-	-	-	-	-

Table 11 (continued).

FLOODPLAIN FOREST MONITORING SITES IN THE PARCEL ED-1 EXCLUSION AREA

PLOT ID	VM2A		VM2B		VM2C		AVERAG		VM5A		VM5B		VM5C		AVERAGE	
TREE SPECIES	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)
Acer negundo	3	7.5	2	5.0	-	-	1.6	4.2	6	15.0	2	5.0	8	20.0	5.3	13.3
Carpinus caroliniana	-	-	-	-	1	2.5	0.3	0.8	-	-	-	-	-	-	-	-
Celtis occidentalis	-	-	1	2.5	-	-	0.3	0.8	-	-	-	-	-	-	-	-
Fagus grandifolia	-	-	-	-	1	2.5	0.3	0.8	-	-	-	-	-	-	-	-
Fraxinus pennsylvanica	-	-	3	7.5	-	-	1.0	2.5	-	-	-	-	2	5.0	0.6	1.6
Juglans nigra	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Juniperus virginiana	-	-	-	-	4	10.0	1.3	3.3	-	-	-	-	-	-	-	-
Liriodendron tulipifera	1	2.5	-	-	-	-	0.3	0.8	-	-	5	12.5	-	-	1.6	4.2
Pinus echinata	-	-	-	-	1	2.5	0.3	0.8	-	-	-	-	-	-	-	-
Platanus occidentalis	-	-	-	-	-	-	-	-	2	5.0	-	-	1	2.5	1.0	2.5
Populus deltoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Prunus serotina	2	5.0	-	-	-	-	0.6	1.6	-	-	-	-	-	-	-	-
Quercus rubra	-	-	-	-	1	2.5	0.3	0.8	-	-	-	-	-	-	-	-
Ulmus americana	2	5.0	2	5.0	-	-	1.3	3.3	1	2.5	-	-	-	-	0.3	0.8

Table 11 (continued).

UPLAND FOREST REFERENCE SITES ON THE OAK RIDGE RESERVATION

PLOT ID	VR1A		VR1B		VR1C		AVERAG		VR3A		VR3B		VR3C		AVERAG		VR5A		VR5B		VR5C		AVERAGE	
TREE SPECIES	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)	Number of Individuals	Basal Area (m^2/ha)
Acer saccharum	2	5.0	-	-	1	2.5	1.0	2.5	-	-	-	-	1	2.5	0.3	0.8	-	-	-	-	-	-	-	-
Acer rubrum	-	-	-	-	-	-	-	-	1	2.5	-	-	-	-	0.3	0.8	-	-	-	-	1	2.5	0.3	0.8
Aesculus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carya ovata	1	2.5	2	5.0	-	-	1.0	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carya tomentosa	-	-	1	2.5	-	-	0.3	0.8	-	-	-	-	1	2.5	0.3	0.8	-	-	-	-	-	-	-	-
Fagus grandifolia	-	-	1	2.5	-	-	0.3	0.8	-	-	1	2.5	-	-	0.3	0.8	-	-	-	-	-	-	-	-
Fraxinus americana	1	2.5	-	-	-	-	0.3	0.8	-	-	-	-	1	2.5	0.3	0.8	-	-	-	-	-	-	-	-
Fraxinus sp.	-	-	-	-	-	-	-	-	1	2.5	-	-	-	-	0.3	0.8	-	-	-	-	-	-	-	-
Liriodendron tulipifera	-	-	-	-	-	-	-	-	-	-	1	2.5	-	-	0.3	0.8	1	2.5	-	-	-	-	0.3	0.8
Magnolia tripetala	-	-	-	-	-	-	-	-	1	2.5	-	-	-	-	0.3	0.8	-	-	-	-	-	-	-	-
Pinus virginiana																	-	-	1	2.5	-	-	0.3	0.8
Oxydendrum arboreum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2.5	-	-	0.3	0.8
Quercus alba	3	7.5	-	-	-	-	1.0	2.5	1	2.5	-	-	1	2.5	0.6	1.6	1	2.5	-	-	-	-	0.3	0.8
Quercus prinus	1	2.5	-	-	1	2.5	0.6	1.6	-	-	5	12.5	6	15.0	3.6	9.2	-	-	4	10.0	3	7.5	2.3	5.8
Quercus rubra	-	-	-	-	-	-	-	-	-	-	1	2.5			0.3	0.8	2	5.0	-	-	2	5.0	1.3	3.3
Tilia americana	-	-	-	-	1	2.5	0.3	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 12. Estimated density (number/ha) and percent exotic species in the saplings/shrub and seedling quadrats in the general vegetation monitoring and reference sites.

Monitoring Sites in Exclusion Area: Community: Floodplain forest	VM1A	VM1B	VM1C	MEAN	VM3A	VM3B	VM3C	MEAN	VM5A	VM5B	VM5C	MEAN
Total Density: Saplings:	100	175	200	158	425	425	700	517	50	375	25	150
Total Density: Shrubs	2200	2375	2050	2208	800	1925	800	1175	175	500	175	283
Total Density: Seedlings	508	204	914	542	508	1421	0	643	0	102	204	102
Percent Exotic Species[1]	46.3	66.3	49.0	54	0	27.2	8.3	12	0	0	6.2	2
Reference Sites: Community: Floodplain forest	VR2A	VR2B	VR2C	MEAN	VR4A	VR4B	VR4C	MEAN	VR6A	VR6B	VR6C	MEAN
Total Density: Saplings:	1100	375	725	733	825	850	300	658	575	350	550	492
Total Density: Shrubs	750	375	650	592	1250	650	1650	1183	0.0	0.0	525	175
Total Density: Seedlings	6701	2335	4772	4603	711	812	508	677	609	914	609	711
Percent Exotic Species	0	0	0	0	0	0	0	0	0	0	28.2	9

[1] Percent Exotic Species = (Total density of exotic species)(100) / (Total density all species)

Table 12 (continued).

Monitoring Sites in the Exclusion Area: Community: Upland forest	VM2A	VM2B	VM2C	VM2 TOTAL	VM4A	VM4B	VM4C	VM4 TOTAL	VM6A	VM6B	VM6C	VM6 TOTAL
Total Density: Saplings:	550	1250	700	**2500**	375	1000	1450	**2825**	381	434	689	**1504**
Total Density: Shrubs	25	75	100	**200**	350	0	50	**400**	54	2446	79	**2579**
Total Density: Seedlings	203	5381	1117	**2700**	3046	7513	4670	**3225**	2658	3535	3456	**4083**
Percent Exotic Species	3.2	0	5.2		8.6	0	0.8		0	36.4	1.9	
Reference Sites: Community: Upland forest	VR1A	VR1B	VR1C	VR1 TOTAL	VR3A	VR3B	VR3C	VR3 TOTAL	VR5A	VR5B	VR5C	VR5 TOTAL
Total Density: Saplings:	455	650	814	**1919**	398	839	520	**1757**	475	851	669	**1995**
Total Density: Shrubs	0	32	0	**32**	307	0	32	**339**	0	780	0	**780**
Total Density: Seedlings	925	528	825	**1951**	4994	2439	3435	**2096**	1376	3458	5287	**2775**
Percent Exotic Species	0	0	0		0	0	0		0	0	0	

[1] Percent Exotic Species = (Total density of exotic species)(100) / (Total density all species)

Summary data for the groundcover quadrants in each community type are presented in Table 13. The groundcover data reflect the high species diversity in the floodplain and riparian forests and upland forests on the ORR. The percent cover of all vegetation species was highest in the floodplain forest and lowest in the upland forests, especially mature upland forest (Appendix A-3). Exotic species as a percentage of total cover in the groundcover quadrants ranged from zero at VR1, VR3, and VR5 to 93.2% at VM6A. Exotic species were found in 16 of the 18 monitoring site groundcover quadrants, and in nine of the eighteen reference site groundcover quadrants. The primary exotic species in the groundcover quadrants are microstegium and Japanese honeysuckle. These two species are abundant on the ORR and throughout the region, but are much less likely to occur in the interiors of undisturbed mature forests and large forest tracts. Other exotic species in the groundcover quadrants included cornsalad (*Valerianella olitoria*), ground ivy (*Glechoma hederacea*), bluegrass (*Poa pratensis*), cinnamon vine (*Dioscorea batatas*), and lyre-leaved sage (*Salvia lyrata*). Other exotic species that are known to occur in the Exclusion Area and/or Parcel ED-1, but that did not appear in monitoring plots, include moneywort (*Lysimachia nummularia*), Oriental bittersweet, lady's thumb (*Polygonum persicaria*), autumn or Russian olive (*Eleagnus sp.*), and lespedeza (*Lespedeza cuneata*).

Vegetation in the wildlife corridors, as determined from the surveys along transects (see Figure 6), was extremely heterogeneous. Stem density and basal area were not determined for the wildlife corridor transects because of the large heterogeneity. The areas to be protected as stream buffers and wildlife corridors will serve the function of providing relatively safe passages for wildlife between the EFPC area and upland forests on the northwest border of Parcel ED-1. The main purpose of the wildlife corridors is to provide travel pathways for wildlife and to protect water quality. The purpose does not include protection of high-quality vegetation communities since the wildlife corridor areas have already been impacted by human activities, beginning with agriculture in the past to silviculture in the present. However, over time, the vegetation communities in the corridors will continue to grow, develop, and change, while functioning as conduits for movement of wildlife and buffers to protect stream water quality. Continued monitoring of the vegetation along the line-transects may be used to follow vegetation changes and to assess possible impacts related to development of the adjacent land.

Wildlife Corridor 1 (WC1) transects were located in second-growth forest between a clearcut and the gravel road (T1), in second-growth forest (T2), and on the edge of a clearcut (T3). The percentage of cover in the groundcover quadrants represented by the exotic species microstegium and Japanese honeysuckle was 31.3% and 4.7% on T1, 10.8% and 40.9% on T2, and 54.4% and 54.5% on T3. Japanese honeysuckle occurred in all of the groundcover quadrants.

In Wildlife Corridor 2 (WC2), T1 was in a wooded area that graded into a clearcut, T2 was on a relatively undisturbed, forested slope and included several large oaks and a large sugar maple, and T3 was in a seasonally wet area in a clearcut with canopy cover only near the stream. No exotic species intersected the transect in the tree, sapling, shrub, and seedling strata. The

Table 13. Summary of data for the groundcover quadrats in the general vegetation community monitoring and reference sites. monitoring and reference sites.

Monitoring Sites in Exclusion Area: Community: Floodplain forest	VM1A	VM1B	VM1C		VM3A	VM3B	VM3C		VM5A	VM5B	VM5C
Number of Species	8	9	11		5	9	8		5	8	8
Total Cover[1]	114.5	111.0	101.5		20.5	122.0	97.5		175.0	112.0	144.5
Percent Exotic Species[2]	2.2	2.3	64.6		0	0	23.6		52.0	2.2	42.0
Reference Sites: Community: Floodplain forest	VR2A	VR2B	VR2C		VR4A	VR4B	VR4C		VR6A	VR6B	VR6C
Number of Species	12	6	9		6	5	5		11	10	14
Total Cover[1]	140.5	99	76.5		109.5	139	132		68.5	109	145.5
Percent Exotic Species[2]	50.6	2.5	3.3		21.0	65.5	0		7.2	9.6	50.5
Monitoring Sites in the Exclusion Area: Community: Upland forest	VM2A	VM2B	VM2C		VM4A	VM4B	VM4C		VM6A	VM6B	VM6C
Number of Species	5	8	7		9	11	7		6	8	11
Total Cover[1]	184.5	77	58.5		152	81.5	33.5		111.5	111.5	105
Percent Exotic Species[2]	50.7	29.9	39.9		27.1	49.7	38.8		93.2	72.2	39.1
Reference Sites: Community: Upland forest	VR1A	VR1B	VR1C		VR3A	VR3B	VR3C		VR5A	VR5B	VR5C
Number of Species	4	2	5		8	5	9		4	3	5
Total Cover[1]	30.5	13	12.5		20	12.5	67		18	15.5	61.5
Percent Exotic Species[2]	0	0	0		0	0	0		0	0	0

[1] Total cover = Sum of the midpoints the cover class for each species. Values >100 indicates a leaf area index greater than 1. Values can be converted to leaf area index by dividing by 100.

[2] Percent Exotic Species = (sum of the midpoints of all exotic species)(100) / (sum of the midpoints of all species)

percent of exotic species, primarily microstegium, in the groundcover quadrants were 31.5% and 52% on T1, 3.6% and 7.8% on T2, and none on T3. The lack of exotic species in T3 was probably due to site moisture, which excluded the Japanese honeysuckle, a common species in the clearcut surrounding the transect.

Wildlife Corridor 3 (WC3) transects were located north of the gravel road in a mixed hardwood forest. Canopy species include oaks, sweetgum, American elm (*Ulmus americana*), red cedar (*Juniperus virginiana*), and mulberry (*Morus rubra*). The sapling/shrub/seedling layer included elm, sweetgum, oaks, maple, sourwood (*Oxydendrum arboreum*), pawpaw (*Asimina triloba*), redbud, ash, hickory (*Carya* sp.), blackgum (*Nyssa sylvatica*), flowering dogwood, rusty blackhaw, and wild grape (*Vitis* sp.). There were no exotic species identified in the line-transect in the canopy or sapling/shrub/seedling layers.

3.2 SONGBIRDS (J. Mitchell, JAYCOR)

The objectives of the songbird study were (1) to establish permanent monitoring sites for pre- and post- development surveys; (2) to collect baseline data for comparisons of avian populations between pre- and post- development conditions and (3) to gain information that could prevent or minimize potential impacts on songbirds (including presences of threatened and endangered species) from the development of the ED-1 site.

Much of the Exclusion Area consists of floodplain forests. Such areas provide valuable habitat for neotropical migrant songbirds (Pashley and Barrow 1993, Hunter et al. 1993b). Neotropical migrants are those species which breed in North America and winter in the New World tropics. The ORR is a nationally recognized and regionally significant source of biological diversity (e.g., Mann et al. 1996, Mitchell et al. 1996). Responsible land management and stewardship requires protection of these resources where feasible.

3.2.1 Study Area

Two permanent survey routes (Figure 7) were established in Parcel ED-1 to monitor for the presence of migratory and resident songbirds. The Periphery Route (Route One) combined parts of two previously existing Partners-in-Flight[2] routes. This route was adapted to include areas that, for the most part, skirt the upland portions of the Exclusion Area. This route was chosen to provide information on birds that (1) use the edge of the Exclusion Area, (2) move across habitats (in and out of the Exclusion Area) during the breeding season and (3) use this habitat during spring migration. Fifteen of the 19 monitoring posts are within or border the Exclusion Area. Although some areas covered during the survey of this route lie outside of

[2] *Partners-in-Flight* is a national joint venture to monitor neotropical migrant songbirds, in cooperation with the FWS, Tennessee Wildlife Resources Agency (TWRA), ORNL, and other state agencies and institutions.

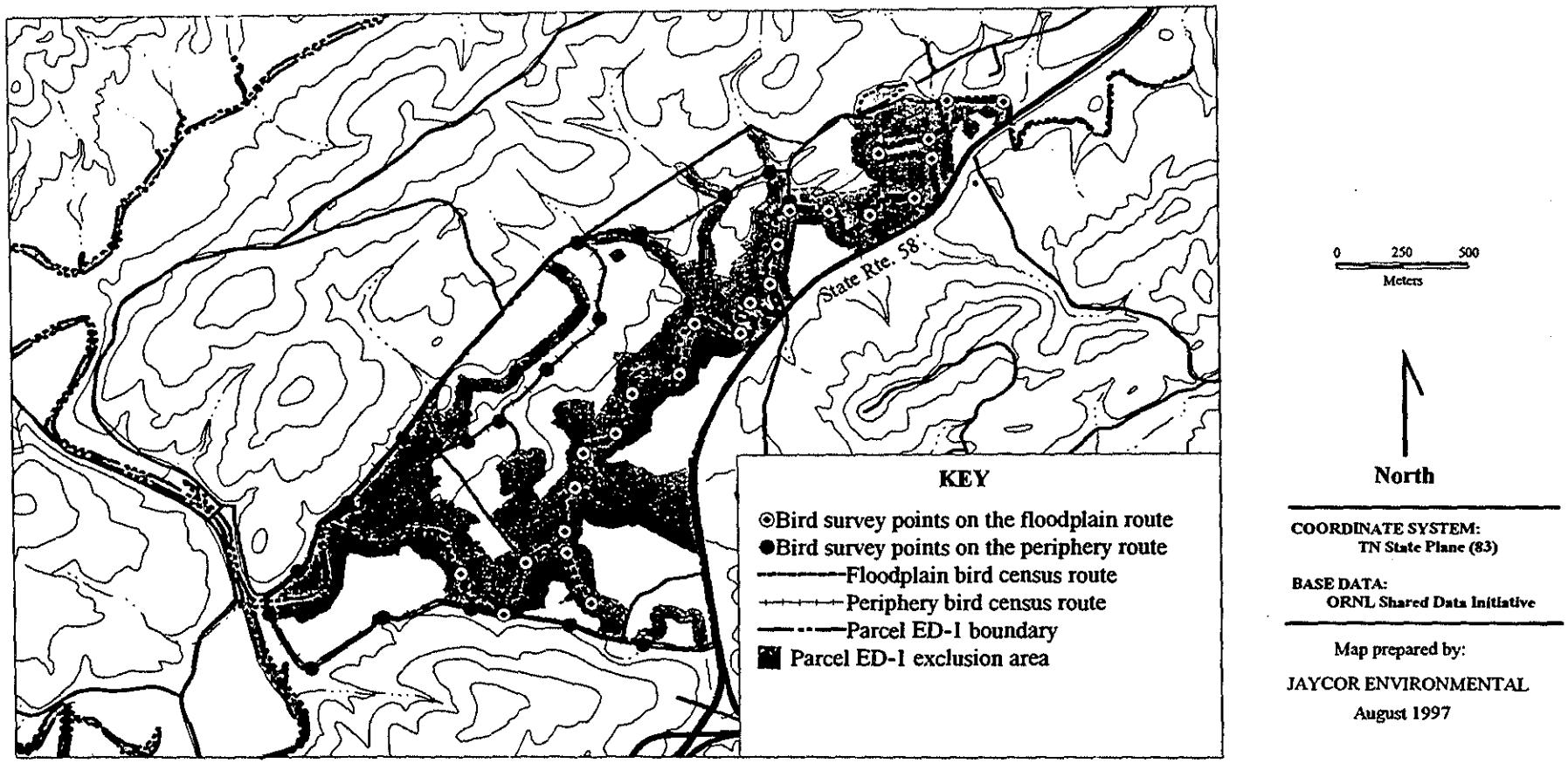

Figure 7. Songbird survey routes in Parcel ED-1

the Exclusion Area, this route proved to be the most efficient and standardized way to sample birds along the edge of the zone. The Floodplain Route (Route Two) was established along the length of the protected floodplain entirely within the ED-1 Exclusion Area. This route was selected to provide information on birds that breed elusively in the Exclusion Area of ED-1 and verify the validity of the Periphery Route. Both routes are approximately 6 km (4 miles) long.

The Periphery Route consists of a combination of several habitat types including several areas of timber harvest, upland forest and wetlands. Timber was harvested in this area within the last three to five years, and it is now largely comprised of successional old field with scattered dead pines from southern pine beetle infestation. These areas are characterized by piled brush, log debris, snags and sparsely scattered hardwoods and standing dead pines. Dense ground vegetation and is made up of honeysuckle (*Lonicera* spp.), sourwood (*Oxydendrum arboreum*), sumac (*Rhus* spp.), and brambles (*Rubus* spp.). These areas are in various stages of succession to hardwood forest. Sapling and pole-sized hardwood trees are beginning to appear on several of the sites. Upland forest are those areas with mixed deciduous trees located on well drained sites. Three strata are present- canopy, understory or shrub layer and ground cover. Canopy trees include oaks (*Quercus* spp.), hickories (*Carya* spp.), maples (*Acer* spp.), tulip poplar (*Liriodendron tulipifera*) and American beech (*Fagus grandifolia*) in varying combinations depending on slope and aspect. The understory and shrub layer contain saplings and pole-sized trees including dogwood (*Cornus* spp.), oak, hickory, maple and beech. The ground cover consists of seedlings of canopy or understory species, ferns and various herbaceous plants.

The Floodplain Route is composed of a mixed deciduous forests in the valley bottom of EFPC and has generally poorly drained soils. It has at least three strata with varied flora, including canopy, understory or shrub layer, and ground cover. Canopy species include sweetgum (*Liquidambar styraciflua*), American sycamore (*Platanus occidentalis*), box elder (*Acer negundo*), elms (*Ulmus* spp.), ash (*Fraxinus* spp.), black willow (*Salix nigra*) and, infrequently oak and pine (*Pinus* spp.). The understory and shrub layer contains saplings and pole-sized trees of the canopy species, ironwood (*Carpinus caroliniana*), hop hornbeam (*Ostrya virginiana*), and red maple (*Acer rubrum*). The ground cover is dense in most areas and contains grasses, vines and canes. Steep and low exposed banks of bare soil and small rock cliffs and ledges are common.

3.2.2 Materials and Methods

Bird surveys were conducted using standard procedures for avian monitoring (Hamel et al. 1996). Permanent fixed-radius plots were established at 0.3-km (1/6 mile) intervals along each route as monitoring posts for birds. The Periphery Route has 19 points and the Floodplain Route has 25 points. The center of each point was marked with an individual identification number and a 10-cm × 10-cm (4-in × 4-in) orange placard. The location of routes and points along those routes are found in Figure 7. These marked points were used as the center of 50-m (160-ft) circle while conducting counts.

Both routes (Floodplain and Periphery) were surveyed a total of four times each, twice in 1996 and twice in 1997. Sampling each site twice during a given year provided additional records than could be obtained with only one survey per year. Five spring surveys for migrating species were also conducted on the Periphery Route. The Periphery Route was selected in an effort to complete more surveys in a shorter time frame and because during the spring migration bird encounters are opportunistic. Surveys on either route would generally reveal the same species, as many of these birds are not nesting, but using the area as a "stopover" during their migration north. Summer point counts were conducted during the late spring and early summer (May-July). Prime nesting season for most birds is June and this was the preferred time for conducting surveys. Points were visited two times during the nesting season and counts were conducted within the first four hours after sunrise [beginning a few minutes before daylight (~ 0600 h) to observe owls and nightjars; stopping by 0900 was preferred, as bird activity decreases dramatically as daytime temperatures rise]. Counts were not conducted during high winds or heavy rain.

All birds seen or heard both in and outside the 50-m (160-ft) radius were recorded. Birds flushed from within 50-m (160-ft) of point center on approach, and flyovers were also recorded (Appendix B). At their estimated distance and direction from point center, the species of all birds identified in the first three minutes were recorded. The species of new individuals seen or heard in the next two minutes (minutes four and five) were recorded and underlined. This change in recording assisted in determining the efficiency between the three and five minute counts. Four-letter alpha codes were used to record the species on the data sheet (Hamel et al. 1996). Female and immature birds were noted with "F" or "I" respectively (e.g., INBU-F or NOCA-I). General information including time, date, vegetation, and weather was recorded at each stop. In most cases males singing on territory where heard; however, female and immature birds were also observed or heard. Although all birds seen or heard where recorded, only those within 50 m were included in the data analysis.

3.2.3 Survey Results

Tables 14 and 15 present data collected on the Periphery and Floodplain Routes, respectively. Data were summarized by route to yield (1) number of counts on which each species was recorded, (2) total individual birds of each species, (3) total species recorded on each route, and (4) total individual birds on each route. Surveys indicated that 58 species of birds use Parcel ED-1 during the breeding season.

The total individual birds on the Periphery Route ranged from 129 to 231. The total number of individuals on the Floodplain Route ranged from 135 to 236. Although the Floodplain Route had six more point counts the total number of birds was similar on the two routes.

Table 14. Songbirds identified on the Periphery route of Parcel ED-1, 1996-1997

Species	1996 - 1		1996 - 2		1997 - 1		1997 - 2	
	Counts	Birds	Counts	Birds	Counts	Birds	Counts	Birds
Great Blue Heron	0	0	0	0	0	0	0	0
Wood Duck	0	0	0	0	0	0	0	0
Red-shouldered Hawk	0	0	1	1	0	0	0	0
Red-tailed Hawk	1	1	0	0	0	0	0	0
Eastern Wild Turkey	0	0	0	0	1	1	0	0
Northern Bobwhite	0	0	1	1	4	7	2	2
American Woodcock	2	2	0	0	0	0	0	0
Mourning Dove	1	1	1	1	1	1	2	2
Yellow-billed Cuckoo	4	4	1	1	3	4	3	3
Chuck-will's-widow	0	0	0	0	1	2	1	1
Whip-poor-will	1	2	0	0	0	0	0	0
Chimney Swift	3	3	0	0	0	0	0	0
Ruby-throated Hummingbird	0	0	4	4	0	0	0	0
Belted Kingfisher	0	0	0	0	0	0	0	0
Red-bellied Woodpecker	2	2	1	1	0	0	0	0
Downy Woodpecker	2	2	2	2	2	2	0	0
Hairy Woodpecker	0	0	3	3	0	0	1	1
Northern Flicker	1	1	1	2	0	0	0	0
Pileated Woodpecker	0	0	1	2	1	1	0	0
Eastern Wood-pewee	1	1	0	0	3	4	2	2
Acadian Flycatcher	0	0	2	5	2	2	2	2
Eastern Pheobe	1	1	0	0	1	1	1	1
Great Crested Flycatcher	0	0	2	2	0	0	1	1
Blue Jay	0	0	2	2	2	2	5	5
American Crow	1	1	1	6	2	2	3	4
Carolina Chickadee	5	8	5	10	7	8	8	12
Eastern Tufted Titmouse	6	7	4	4	5	5	7	9
White-breasted Nuthatch	3	3	1	1	1	1	2	2
Carolina Wren	0	0	3	3	4	4	2	2
Blue-gray Gnatcatcher	8	8	6	9	7	12	6	8
Eastern Bluebird	0	0	3	7	1	1	1	2
Wood Thrush	3	5	2	4	5	7	4	5
American Robin	0	0	1	1	0	0	0	0
Cedar Waxwing	0	0	0	0	2	16	0	0
White-eyed Vireo	4	4	4	6	7	8	5	5
Yellow-throated Vireo	2	2	0	0	4	4	3	3
Red-eyed Vireo	7	10	2	2	14	18	11	12
Blue-winged Warbler	0	0	0	0	1	1	1	1
Northern Parula	2	3	1	1	3	4	3	4
Yellow-throated Warbler	2	2	0	0	1	1	1	1
Pine Warbler	0	0	0	0	2	2	1	1
Prairie Warbler	7	10	3	3	9	15	9	14
Prothonotary Warbler	0	0	0	0	2	2	1	1
Worm-eating Warbler	0	0	2	2	0	0	0	0
Ovenbird	1	1	0	0	1	1	1	1
Kentucky Warbler	2	3	1	1	5	6	5	6
Common Yellowthroat	3	4	3	4	6	7	3	3
Hooded Warbler	4	4	4	5	5	5	6	6
Yellow-breasted Chat	5	7	2	2	9	12	7	9
Summer Tananger	0	0	0	0	2	2	2	2
Scarlet Tananger	1	1	3	3	4	4	4	4
Northern Cardinal	5	6	6	7	11	12	9	9
Indigo Bunting	6	8	11	16	12	18	11	14
Eastern Towhee	5	5	5	6	8	8	8	8
Field Sparrow	1	1	3	3	8	9	8	8
Common Grackle	0	0	0	0	1	1	1	4
Brown-headed Cowbird	2	4	0	0	4	4	3	3
American Goldfinch	2	2	6	12	4	4	4	9
	35*	129**	37*	145**	43*	231**	41*	192**

Key:
Counts- Number of counts on which each species was recorded in sample of 19 point counts.
Birds- Total number of individuals of a species found in a sample of 19 point counts.
* Total number of species recorded on route.
** Total number of individuals recorded on route.
Zero counts are included for comparisons.

Table 15. Songbirds identified on the Floodplain route of Parcel ED-1, 1996-1997

Species	1996 - 1		1996 - 2		1997 - 1		1997 - 2	
	Counts	Birds	Counts	Birds	Counts	Birds	Counts	Birds
Great Blue Heron	1	1	2	2	2	3	3	3
Wood Duck	1	1	1	1	0	0	0	0
Red-shouldered Hawk	1	1	0	0	0	0	0	0
Red-tailed Hawk	0	0	1	1	0	0	0	0
Eastern Wild Turkey	2	7	0	0	2	4	2	2
Northern Bobwhite	5	5	0	0	6	7	2	2
American Woodcock	0	0	0	0	0	0	0	0
Mourning Dove	0	0	0	0	3	3	0	0
Yellow-billed Cuckoo	3	3	1	1	0	0	0	0
Chuck-will's-widow	1	1	1	1	0	0	1	1
Whip-poor-will	0	0	0	0	0	0	0	0
Chimney Swift	0	0	0	0	1	2	0	0
Ruby-throated Hummingbird	0	0	0	0	0	0	0	0
Belted Kingfisher	0	0	0	0	2	2	3	3
Red-bellied Woodpecker	4	4	3	4	3	3	3	3
Downy Woodpecker	0	0	3	3	1	1	1	1
Hairy Woodpecker	1	1	1	1	1	1	0	0
Northern Flicker	0	0	1	2	1	1	1	1
Pileated Woodpecker	2	2	4	4	5	5	6	6
Eastern Wood-pewee	0	0	0	0	1	1	1	1
Acadian Flycatcher	6	7	8	11	7	7	8	9
Eastern Pheobe	0	0	0	0	0	0	0	0
Great Crested Flycatcher	1	1	0	0	0	0	1	1
Blue Jay	3	4	3	4	3	3	3	3
American Crow	1	1	3	4	1	1	3	4
Carolina Chickadee	7	7	9	10	10	16	8	12
Eastern Tufted Titmouse	5	5	7	7	8	9	9	12
White-breasted Nuthatch	3	4	1	1	4	6	5	5
Carolina Wren	2	2	3	3	6	8	6	6
Blue-gray Gnatcatcher	7	8	4	4	6	9	7	9
Eastern Bluebird	0	0	1	1	0	0	0	0
Wood Thrush	2	3	2	3	2	3	3	3
American Robin	0	0	0	0	0	0	0	0
Cedar Waxwing	0	0	0	0	1	1	0	0
White-eyed Vireo	1	1	0	0	4	4	4	4
Yellow-throated Vireo	2	2	1	1	3	3	3	3
Red-eyed Vireo	18	23	14	16	22	33	15	19
Blue-winged Warbler	1	1	0	0	2	3	3	3
Northern Parula	5	5	2	2	5	6	7	8
Yellow-throated Warbler	8	8	4	4	6	6	7	8
Pine Warbler	1	1	0	0	1	1	1	1
Prairie Warbler	3	3	2	2	6	7	4	4
Prothonotary Warbler	0	0	0	0	1	1	1	1
Worm-eating Warbler	0	0	0	0	0	0	0	0
Ovenbird	0	0	1	1	0	0	0	0
Kentucky Warbler	2	2	1	1	9	9	9	9
Common Yellowthroat	1	2	4	4	3	3	2	2
Hooded Warbler	2	2	0	0	1	1	1	1
Yellow-breasted Chat	2	2	2	2	8	9	7	7
Summer Tananger	1	2	1	1	1	1	2	2
Scarlet Tananger	2	3	2	2	3	4	4	5
Northern Cardinal	6	6	11	13	9	12	5	6
Indigo Bunting	8	9	7	10	12	14	9	9
Eastern Towhee	2	2	3	3	9	10	7	7
Field Sparrow	3	3	1	1	5	7	2	2
Common Grackle	1	1	0	0	0	0	0	0
Brown-headed Cowbird	0	0	0	0	1	1	0	0
American Goldfinch	5	6	4	4	3	5	3	5
	40*	152**	36*	135**	43*	236**	40*	193**

Key:
Counts- Number of counts on which each species was recorded in sample of 25 point counts.
Birds- Total number of individuals of a species found in a sample of 25 point counts.
* Total number of species recorded on route.
** Total number of individuals recorded on route.
Zero counts are included for comparisons.

The total species were also similar on the two routes. The number of species found on each route ranged from 35 to 43 on the Periphery Route and 36 to 43 on the Floodplain Route. These findings support the use of the Periphery Route to monitor bird activity in the Exclusion Area, at least for baseline (pre-development) characterization. Similar habitats along the routes may explain the similarities in species and numbers of birds on the routes.

As expected the number of forest interior species were higher on the Floodplain Route, which is all interior forest (e.g., Acadian flycatcher, red-eyed vireo, northern parula, yellow-throated warbler, wood thrush, ovenbird) and the number of open field species was higher on the Periphery Route (e.g., prairie warbler, common yellowthroat, field sparrow). The most abundant bird on the Periphery Route was the indigo bunting; the red-eyed vireo was the most common species encountered on the floodplain route. Birds strongly associated with water habitats (e.g., great blue heron, wood duck, belted kingfisher were only observed on the floodplain route.

Table 16 provides an overview of all species documented during surveys of the parcel and divides each species into categories by seasonal occurrence. Most species listed in Table 16 are breeding here, while others are only wintering or migrating. Ninety-one species were observed during surveys of the parcel.

The spring surveys found a variety of neotropical migrants utilizing the parcel (Table 16) as grounds for "stopover" as they traveled from the tropics to the northern United States and Canada. Data collected during spring migration counts were only summarized, and no calculations were made. Since sightings are sporadic and documenting mass movements of spring migrants depends heavily on timing of field work, several more spring surveys would be necessary before firm conclusions could be drawn.

Several other observations are noteworthy. There were few species and low numbers for species symptomatic of disturbance (e.g., brown-headed cowbird, common grackle, European starling, European sparrow) on the Floodplain Route. Numbers were slightly higher for some of these species on the Periphery Route. A number of breeding neotropical migrant species were observed on both routes during the breeding season (Table 16). One interesting neotropical species in particular, the blue-winged warbler, was observed at several locations. Currently, documented summer residence for this species in the Ridge and Valley Province is rare and distributions are spotted. Finally, species which were observed during the breeding season and are thought to be declining regionally are noted in Table 16.

Nest parasitism by cowbirds may be a concern with development. Combining all counts from both routes the brown-headed cowbird appeared on eleven occasions on the Periphery Route while only once in surveys of the floodplain. This higher number of cowbirds on the Periphery Route may be attributed to the open/edge habitat along this route. Creation of edge and fragmentation may have allowed an increased number of cowbirds to thrive along this route (Gates and Gysel 1978, Brittingham and Temple 1983).

Table 16. Songbirds encountered and their seasonal occurrences on Parcel ED-1

Common Name	Scientific Name	Neotropical Migrant/ Breeder	Neotropical Migrant/Spring	Permanent Resident	Winter Resident	Declining Species (Breeding)	Spring Observation	Miscellaneous Observation
Great Blue Heron	*(Ardea herodias)*			X				
Canada Goose	*(Branta canadensis)*			X			X	
Wood Duck	*(Aix sponsa)*			X				
Black Vulture	*(Coragyps atratus)*			X		X		X
Sharp-shinned Hawk *	*(Accipiter striatus)*			X				X
Cooper's Hawk *	*(Accipiter cooperii)*			X				X
Red-shouldered Hawk	*(Buteo lineatus)*			X				
Red-tailed Hawk	*(Buteo jamaicensis)*			X				
American Kestrel	*(Falco sparverius)*			X				X
Ruffed Grouse	*(Bonasa umbellus)*			X				X
Eastern Wild Turkey	*(Meleagris gallapavo)*			X				
Northern Bobwhite	*(Colinus virginianus)*			X		X		
Killdeer	*(Charadrius vociferus)*			X				X
American Woodcock	*(Scolopax minor)*			X				
Mourning Dove	*(Zenaida macroura)*			X				
Yellow-billed Cuckoo	*(Coccyzus americanus)*	X				X		
Barred Owl	*(Strix varia)*			X				X
Common Nighthawk	*(Chordeiles minor)*	X						X
Chuck-will's-widow	*(Caprimulgus carolinensis)*	X						
Whip-poor-will	*(Caprimulgus vociferus)*	X				X		
Chimney Swift	*(Chaetura pelagica)*	X						
Ruby-throated Hummingbird	*(Archilochus colubris)*	X						
Belted Kingfisher	*(Ceryle alcyon)*			X				
Red-bellied Woodpecker	*(Melanerpes carolinus)*			X				
Downy Woodpecker	*(Picoides pubescens)*			X		X		
Hairy Woodpecker	*(Picoides villosus)*			X				
Northern Flicker	*(Colaptes auratus)*			X		X		
Pileated Woodpecker	*(Dryocopus pileatus)*			X				
Eastern Wood-pewee	*(Contopus virens)*	X				X		
Acadian Flycatcher	*(Empidonax virescens)*	X						
Eastern Pheobe	*(Sayornis phoebe)*			X				
Great Crested Flycatcher	*(Myiarchus crinitus)*	X						
Eastern Kingbird	*(Tyrannus tyrannus)*	X						X
Blue Jay	*(Cyanocitta cristata)*			X		X		
Amercian Crow	*(Corvus brachyrhynchos)*			X				
Carolina Chickadee	*(Parus carolinensis)*			X		X		
Eastern Tufted Titmouse	*(Parus bicolor)*			X				
White-breasted Nuthatch	*(Sitta carolinensis)*			X				
Carolina Wren	*(Thryothorus ludovicianus)*			X				
House Wren	*(Troglodytes aedon)*	X				X	X	
Ruby-crowned Kinglet	*(Regulus calendula)*				X		X	
Blue-gray Gnatcatcher	*(Polioptila caerulea)*	X						
Eastern Bluebird	*(Sialia sialis)*			X				
Swainson's Thrush	*(Catharus ustulatus)*		X					X
Wood Thrush	*(Hylocichla mustelina)*	X				X		
American Robin	*(Turdus migratorius)*			X				
Gray Catbird **	*(Dumetella carolinensis)*		X				X	
Brown Thrasher	*(Taxostoma rufum)*			X		X		x
Cedar Waxwing	*(Bombycilla cedrorum)*			X				
European Starling	*(Sturnus vulgaris)*			X			X	
White-eyed Vireo	*(Vireo griseus)*	X				X		
Solitary Vireo	*(Vireo solitarius)*		X				X	
Yellow-throated Vireo	*(Vireo flavifrons)*	X				X		

Table 16 (continued).

Common Name	Scientific Name	Neotropical Migrant/ Breeder	Neotropical Migrant/Spring	Permanent Resident	Winter Resident	Declining Species (Breeding)	Spring Observation	Miscellaneous Observation
Red-eyed Vireo	*(Vireo olivaceus)*	X						
Blue-winged Warbler	*(Vermivora pinus)*	X				X		
Northern Parula	*(Parula americana)*	X						
Magnolia Warbler	*(Dendroica magnolia)*		X				X	
Cape May Warbler	*(Dendroica tigrina)*		X					X
Yellow-rumped Warbler	*(Dendroica coronata)*				X		X	
Black-throated Green Warbler	*(Dendroica virens)*		X					X
Blackburnian Warbler	*(Dendroica fusca)*		X				X	
Yellow-throated Warbler	*(Dendroica dominica)*	X				X		
Pine Warbler	*(Dendroica pinus)*			X				
Prairie Warbler	*(Dendroica discolor)*	X				X		
Bay-breasted Warbler	*(Dendroica castanea)*		X				X	
Blackpoll Warbler	*(Dendroica striata)*		X				X	
Cerulean Warbler***	*(Dendroica cerulea)*		X				X	
Black-and white Warbler	*(Mniotilta varia)*	X				X	X	
American Redstart **	*(Setophaga ruticilla)*		X				X	
Prothonotary Warbler	*(Protonotaria citrea)*	X				X		
Worm-eating Warbler	*(Helmitherous vermivorus)*	X						
Ovenbird	*(Seiurus aurocapillus)*	X						
Northern Waterthrush	*(Seiurus noveboracensis)*		X				X	
Kentucky Warbler	*(Oporornis formosus)*	X				X		
Common Yellowthroat	*(Geothlypis trichas)*	X						
Hooded Warbler	*(Wilsonia citrina)*	X						
Wilson's Warbler	*(Wilsonia pusilla)*		X					X
Canada Warbler	*(Wilsonia canadensis)*		X				X	
Yellow-breasted Chat	*(Icteria virens)*	X				X		
Summer Tananger	*(Piranga rubra)*	X				X		
Scarlet Tananger	*(Piranga olivacea)*	X						
Northern Cardinal	*(Cardinalis cardinalis)*			X		X		
Indigo Bunting	*(Passerina cyanea)*	X				X		
Eastern Towhee	*(Pipilo erythrophthalmus)*			X		X		
Field Sparrow	*(Spizella pusilla)*			X		X		
Swamp Sparrow	*(Melospiza georgiana)*				X		X	
White-throated Sparrow	*(Zonotrichia albicollis)*				X		X	
Common Grackle	*(Quiscalus quiscula)*			X				
Brown-headed Cowbird	*(Molothrus ater)*			X		X		
Purple Finch	*(Carpodacus purpureus)*				X			X
American Goldfinch	*(Carduelis tristis)*			X				

* Listed as "In Need of Management" by the State of Tennessee.
** Has been documented breeding in the Ridge and Valley Province, but not on Parcel ED-1.
***Listed as a Federal Species of Concern, U. S. Fish and Wildlife Service.

Key:
Neotropical migrant/breeder- neotropical migrant located during summer surveys that likely breeds within the parcel.
Neotropical migrant/Spring- neotropical migrant documented during spring surveys or miscellaneous observations.
Permanent resident- species which spends summer (breeding) and winter on the parcel.
Winter resident- species which winters on the parcel.
Declining species- breeding species that is declining in the Ridge and Valley Province (Sauer et al. 1997).
Spring observation- bird that was observed during spring surveys.
Miscellaneous observation- opportunistic sighting; bird located on the site while conducting other related tasks.

3.2.4 Protected Species

Two birds which are listed by the State of Tennessee as in need of management (TWRC, 1994) were documented on Parcel ED-1. The Cooper's hawk and sharp-shinned hawk have been sighted on the parcel and are likely nesting there. Also, the cerulean warbler, (federal species of concern) has been observed during spring migration. Currently, recorded nests of the cerulean warbler are located outside of the Ridge and Valley Province.

Undoubtedly, not all species that utilize the parcel are recorded here. Winter and fall surveys were not conducted. Future surveys should encounter more breeding and migrant species. Nearly 200 bird species have been documented on the ORR (Mitchell et al. 1996).

3.2.5 Discussion

Bird populations have been used as ecological indicators to: (1) detect environmental changes, (2) monitor organic pollutants, (3) monitor radionuclide contamination, (4) indicate changes in water quality, and (5) detect changes in prey stock (food webs) (Furness and Greenwood 1993). Population surveys of these birds are essential for evaluating the status of these species to ensure that management is informed (Hamel et al. 1996). Concern over declining numbers of neotropical migratory birds has influenced managers to inventory and monitor these and others nongame birds (Hunter et al. 1993a, Robbins et al. 1989b).

Conservation of birds requires an understanding of their nesting requirements, including area as well as structural characteristics of the habitat. Numerous studies have supported the concept that area in combination with isolation of woodland is one of the most important considerations in maintaining natural diversity of breeding bird populations (Robbins et al. 1989a).

Robbins et al. (1989a) found that, for the neotropical migrants they studied, the probability of occurrence increased as the area of forest increased. Parcel ED-1 consists of nearly 405 ha (1000 acres) and several thousand hectares of forest border this area; thus, many species of area sensitive birds might be expected on the site. The ORR and the surrounding area provides some of the best unfragmented habitat in the region (Mann et al. 1996).

The floodplain area of Parcel ED-1 (EFPC), by its vegetation composition and hydrology, is considered to be a bottomland hardwood forest. Approximately 70 species of birds breed regularly in bottomland hardwood forests; about 30 of these are neotropical migrants (Pashley and Barrow 1993). Bottomland hardwood forest and/or riparian streamside woodlands have been ranked among the highest priority of areas that provide optimal habitat for neotropical migrants (Hunter et al. 1993b). Several species of neotropical migratory birds were found during surveys of Parcel ED-1 (Table 16).

Scientific evidence supports the conclusion that human activities are having dramatic effects on populations of migratory birds. Given the patterns of increasing forest destruction and fragmentation in breeding areas of neotropical migrant birds, it is predicted that populations of migratory forest birds will continue to decline throughout eastern North America (Robbins et al. 1989b, Brittingham and Temple 1983, DeGraaf and Rappole 1995).

Development entails disturbance of wildlife habitat and forests and creation of fragmented patches of woodlots, forest edge and lawns. Forest fragmentation is associated with a number of changes that are harmful to populations of neotropical migrants. These include cowbird parasitism, the loss of habitat, potential barriers to dispersal between woodlots, and increased nest predation (Wilcove 1985).

Avian reproductive performance may decrease along edges because edges attract predators (Gates and Gysel 1978, Patton 1994, Wilcove 1985, Buehler and Miles 1996, Small and Hunter 1988, Yahner and Scott 1988) and nest parasites such as cowbirds (Patton 1994, Gates and Gysel 1978, Brittingham and Temple 1983, Robinson et al. 1995). Landscape fragmentation and creation of edge may allow for higher rates of brood parasitism by the brown-headed cowbird (*Molothrus ater*) (Gates and Gysel 1978, Brittingham and Temple 1983). Cowbirds lay their eggs in the nest of "host" species that hatch and rear the parasite's young at the expense of their own brood (Brittingham and Temple 1983). Areas consisting of either lawns, pastures, bare ground or a combination thereof are used by the cowbirds as feeding areas, thus attracting this species (Robinson et al. 1992).

Predation rates are higher in small woodlots than in large tracts and especially intense in woodlots near suburban neighborhoods. Forest edges appear to be good habitat for many animals that prey on nests of forest-dwelling songbirds (Wilcove 1985). Several feral house cats were sighted during spring and summer surveys. Feral cats may significantly contribute to songbird mortality as well as mortality of other game and nongame species.

Impacts on the state-listed sharp-shinned and Cooper's hawk populations may be minimized by protecting nesting sites located in future surveys. The overall survival of cerulean warbler populations that use the parcel during migration should not be affected. However, land managers should careful plan on a landscape-level before areas are cleared for development. Developing a long-term management plan for species found on this parcel is highly recommended as well as beginning surveys to access avian productivity. Comparisons of nesting success can help determine local habitat effects on population recruitment (Martin and Geupel 1993).

Creation of new openings (e.g., road, gas lines and power lines) should be avoided where possible and allowing existing openings to regenerate to forest will reduce forest edge and fragmentation, creating larger forest blocks. This may increase avian productivity for forest-interior birds within these blocks (Buehler and Miles 1996). Reducing the amount of forest edge by using compact shapes, revegetation using native species and maintaining substantial buffer

zones on the floodplain and wetlands are measures that may help mitigate adverse impacts to wildlife populations.

3.3 BATS (M. J. Harvey, Tennessee Technological University)

The objectives of the bat study were to (1) determine whether federal or state listed species inhabit Parcel ED-1, and (2) determine if other bat species are present. Two bat species listed as endangered by the FWS, the Indiana bat (*Myotis sodalis*) and the gray bat (*Myotis grisescens*), may occur on the ORR. Three species which until recently were under review for possible listing as endangered or threatened (now considered to be of special concern) may also occur in the area. They are the eastern small-footed bat (*Myotis leibii*), southeastern bat (*Myotis austroriparius*), and Rafinesque's big-eared bat (*Corynorhinus rafinesquii*). Eight additional non-listed bat species are possibly present on the ORR: little brown bat (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), eastern pipistrelle (*Pipistrellus subflavus*); big brown bat (*Eptesicus fuscus*); silver-haired bat (*Lasionycteris noctivagans*); eastern red bat (*Lasiurus borealis*); hoary bat (*Lasiurus cinereus*); and evening bat (*Nycticeius humeralis*). Brief descriptions of the 13 species are provided in Appendix C.

3.3.1 Study Area, Materials and Methods

The study was conducted during two periods, May 30-June 6 and July 7-16, 1997 using mist netting. Forty-seven net nights were conducted at 27 sites during 16 nights of netting; two to four net sites per night were netted. Netting sites were scattered throughout Parcel ED-1, with the greatest concentration over or near EFPC (Table 17, Figure 8). Sites were selected based on their obvious potential as bat habitat, wooded areas generally being preferred.

Nets varied in size from single 6 × 3 m to double 12 × 3 m (=12 × 6 m) nets. Single nets were placed between 3.5 m poles; double nets were placed between 7.5 m poles with a rope and pulley arrangement used to raise and lower nets. Nets used were 2 ply, 50 denier nylon, with a mesh of about 3.8 centimeters (cm).

Each net was in place from one to four nights; most sites were netted for two consecutive nights. Nets were positioned to cover potential bat travel corridors such as over streams and roads through forested areas. Netting was done from sunset until about 5 hours after sunset; nets were checked every 20-40 minutes, depending on location. All captured bats were identified, their sex determined, weighed, measured (forearm length), and banded with numbered plastic bands for future identification. Techniques followed the "Guidelines For Netting Indiana Bats" (U.S. FWS 1997) developed by the Indiana Bat Recovery Team.

Table 17. Mist-netting sites, dates, and equipment used on Parcel ED-1, 1997 bat survey.

Site	Net Types and Dates
B1	Double 9 x 3 m net over Bear Creek in heavily wooded area; 5/30, 5/31, 6/1, 6/2.
B2	Single 6 x 3 m net on Poplar Ck. road bridge over Bear Creek in wooded area; 5/30, 5/31, 6/1, 6/2.
B3	Double 6 x 3 m net across little-used road lined with trees; 6/1, 6/2.
B4	Single 9.1 x 2.1 m net hung below bridge over EFPC; 6/1, 6/2.
B5	Double 9 x 3 m net over EFPC approx. 100 m below bridge on Oak Ridge Turnpike in heavily wooded area; 6/3, 6/4.
B6	Double 6 x 3 m net over EFPC near Oak Ridge Turnpike in heavily wooded area; 6/3, 6/4.
B7	Single 9.1 x 2.1 m net over EFPC near Oak Ridge Turnpike in heavily wooded area; 6/3, 6/4.
B8	Single 6 x 3 m net over road rut on East Fork Road in wooded area; 6/5.
B9	Single 6 m net over road rut on East Fork Road in wooded area; 6/5.
B10	Double 9 x 3 m net over EFPC near mouth of Bear Creek in heavily wooded area; 7/7, 7/8.
B11	Single 9.1 x 2.1 m net over EFPC near mouth of Bear Creek in heavily wooded area; 7/7, 7/8.
B12	Single 6 x 3 m net across mouth of Bear Creek in heavily wooded area; 7/7, 7/8.
B13	Double 9 x 3 m net across little-used road in heavily wooded area; 7/9, 7/10.
B14	Single 6 x 3 m net across little-used road in wooded area; 7/9, 7/10.
B15	Single 6 x 3 m net across little-used road in wooded area; 7/9, 7/10.
B16	Double 12 x 3 m net over EFPC near Gaging Station bridge in heavily wooded area; 7/11, 7/12.
B17	Single 6 x 3 m net over EFPC in heavily wooded area; 7/11, 7/12.
B18	Single 9.1 x 2.1 m net over EFPC near Oak Ridge Turnpike in heavily wooded area; 711, 7/12.
B19	Single 6 x 3 m net over EFPC in heavily wooded area; 7/13.
B20	Single 9.1 x 2.1 m net over EFPC in heavily wooded area; 7/13.
B21	Single 6 x 3 m net over EFPC in heavily wooded area; 7/13.
B22	Single 6 x 3 m net across East Fork Road in wooded area; 7/14.
B23	Single 6 x 3 m net across East Fork Road in wooded area; 714.
B24	Single 9.1 x 2.1 m net across Poplar Creek Road in wooded area; 7/14.
B25	Single 9.1 x 2.1 m net over road rut on little-used road west of quarry in heavily wooded area (approx. 50 m outside of ED-1 boundary); 7/15.
B26	Single 6 x 3 m net across little-used road south of quarry in wooded area; 7/15.
B27	Single 6 x 3 m net across trail southeast of quarry in wooded area; 7/15.

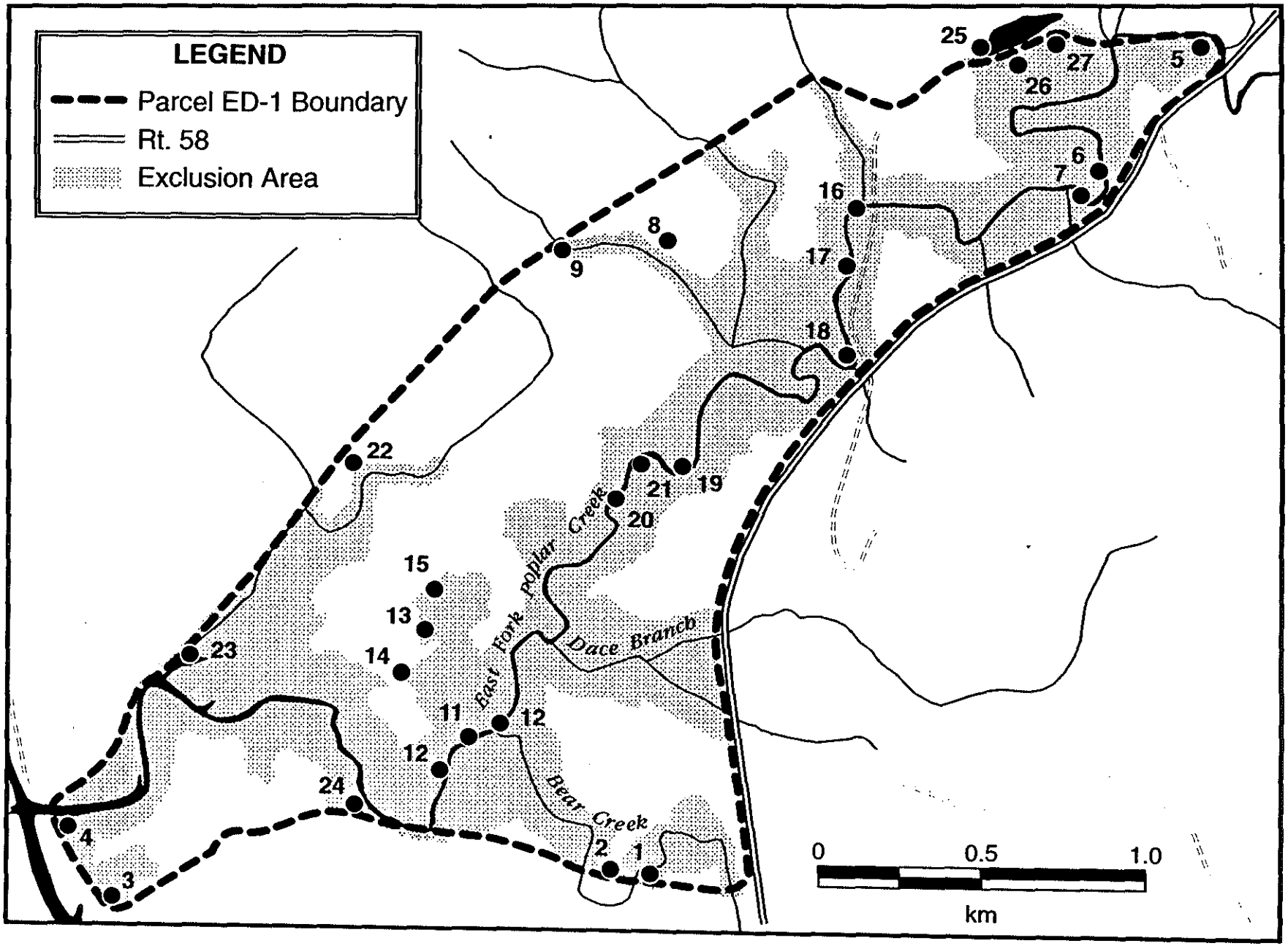

Figure 8. Bat mist-netting sites in Parcel ED-1

3.3.2 Survey Results and Discussion

A total of 14 bats was captured during the study. No endangered, threatened, or special concern species were captured. Species and numbers captured were as follows: 6 big brown bats, 3 red bats, 2 eastern pipistrelles, 1 evening bat, 1 northern long-eared bat, and 1 silver-haired bat. Thirteen bats were actually handled; one, a big brown bat, escaped from the net before it could be removed. Table 18 summarizes bat captures.

Although there is a potential for Indiana or gray bats to reside on Parcel ED-1, no evidence was found of their presence. Relatively little bat activity was observed over the stream. Had colonies of Indiana or gray bats been present in the area, more bat activity would very likely have been observed over the stream. Much of the area along EFPC in Parcel ED-1 appeared to be typical Indiana bat summer habitat. Considerable riparian forest with large trees containing cavities and dead trees with exfoliating bark was present along much of the creek. Because gray bats inhabit caves during summer, and because no bat caves are known to be present in the study area, typical gray bat roost sites were not available. Typical gray bat foraging habitat was present, however, over EFPC.

These results showing minimal bat activity in the area are supported by results of a similar study conducted during May 1992 in this area (Harvey, 1992). As part of that study, seven net nights during three nights of netting on Parcel ED-1 resulted in the capture of only four bats, three eastern red bats and one eastern pipistrelle.

Similar surveys were conducted during recent years at several sites in Tennessee, Kentucky, and Indiana by the field investigator who conducted this survey for DOE. During most of these studies, a greater number of individual bats were captured than on Parcel ED-1. However, the total of six species collected on Parcel ED-1 is the highest number recorded during studies of this type. In summary, there was no evidence of the presence of Indiana or gray bats, or other bat species of special concern on Parcel ED-1 of the ORR.

Table 18. Summary of bat captures in Parcel ED-1 during 1997 study.

Date	Site No.	Species	Sex
1 - 2 June	4	*Eptesicus fuscus*	♂
3 - 4 June	5	*Pipistrellus subflavus*	♂
	6	*Nycticeius humeralis*	♂
4 - 5 June	5	*Pipistrellus subflavus*	♀
	6	*Lasionycteris noctivagans*	♂
5 - 6 June	8	*Lasiurus borealis*	♂
	8	*Lasiurus borealis*	♀
8 - 9 July	12	*Eptesicus fuscus*	♀
9 - 10 July	14	*Lasiurus borealis*	♂
	14	*Myotis septentrionalis*	♀
	15	*Eptesicus fuscus*	♂
	15	*Eptesicus fuscus*	♀
10 - 11 July	15	*Eptesicus fuscus*	♂
14 - 15 July	22	*Eptesicus fuscus*	?

3.4 LEPIDOPTERA (J.W. Webb and S. R. Mellon, ORNL)

The purpose of this study was to characterize the Lepidopteran communities in the Exclusion Area of Parcel ED-1. The order Lepidoptera (butterflies, moths, and skippers) includes more than 5000 species that occur in the eastern U.S. (U.S. Dept. of Agriculture 1985). Because Lepidoptera represents the second largest order of insects (Borror and DeLong 1964), it is a potentially valuable indicator of environmental balance.

The order Lepidoptera consists of primary consumers that in turn provide food for a variety of avian and other predators (Scoble 1992). Lepidoptera also participate in ecological processes by continually recycling and increasing the nutrient content of soil by consuming leaf fragments (Barbosa 1989). The larvae of the order Lycaenidae consume lichens, which are important indicators of pollution (Scoble 1992). In addition, Lepidoptera are responsible for the pollination of a variety of flora (Kevan et al. 1984). Abundance of Lepidoptera is directly proportional to the availability of resources; therefore, they are a key ecological indicator of overall floristic habitat quality (Huffaker et al. 1984). Lepidoptera would be likely to respond to changes in environmental conditions prior to more highly visible degradation of vegetation (Scoble 1992). Members of the order Lepidoptera naturally cover large tracts and are highly sensitive to habitat fragmentation (Hansson 1992).

3.4.1 Study Area and Methods

Lepidoptera surveys were conducted during June and July 1997 using "malaise" traps, light traps, and visual observations along permanent walking transects. Malaise traps consist of open-fronted tents of cotton or nylon net, usually black or green (Southwood 1966), that create an ascending structure with a collecting receptacle at its highest point. The malaise interception trap is most effective for Diptera and Hymenoptera but can provide a means for obtaining Lepidoptera without damaging the scales of the wings, thus making identification easier. Fermented sugar was used as bait to enhance capture. Two traps were deployed in the Exclusion Area, which proved somewhat effective for wood satyrs and nymphalids (hackberry butterflies).

Light traps with "Vapor Tape II" as the killing agent were used to evaluate the moth fauna. Light trap efficacy is affected by the lunar cycle (Bowden and Church 1973) and by weather conditions (Kato et al. 1995). Generally, it is difficult to discriminate whether the distribution of light-trapped insects are a reflection of their actual residences or merely their migration routes (Kato et al. 1995).

Walking transect surveys consisted of compiling individual specimens encountered while walking at a steady and constant pace on a predetermined course according to the methods of Pollard and Yates (1993). Two transects were surveyed, one in a relatively open area and another in a woodland (Figure 9). All butterflies encountered within a 3-m distance were recorded. Butterflies encountered above the recorder were not included. Each transect count began around

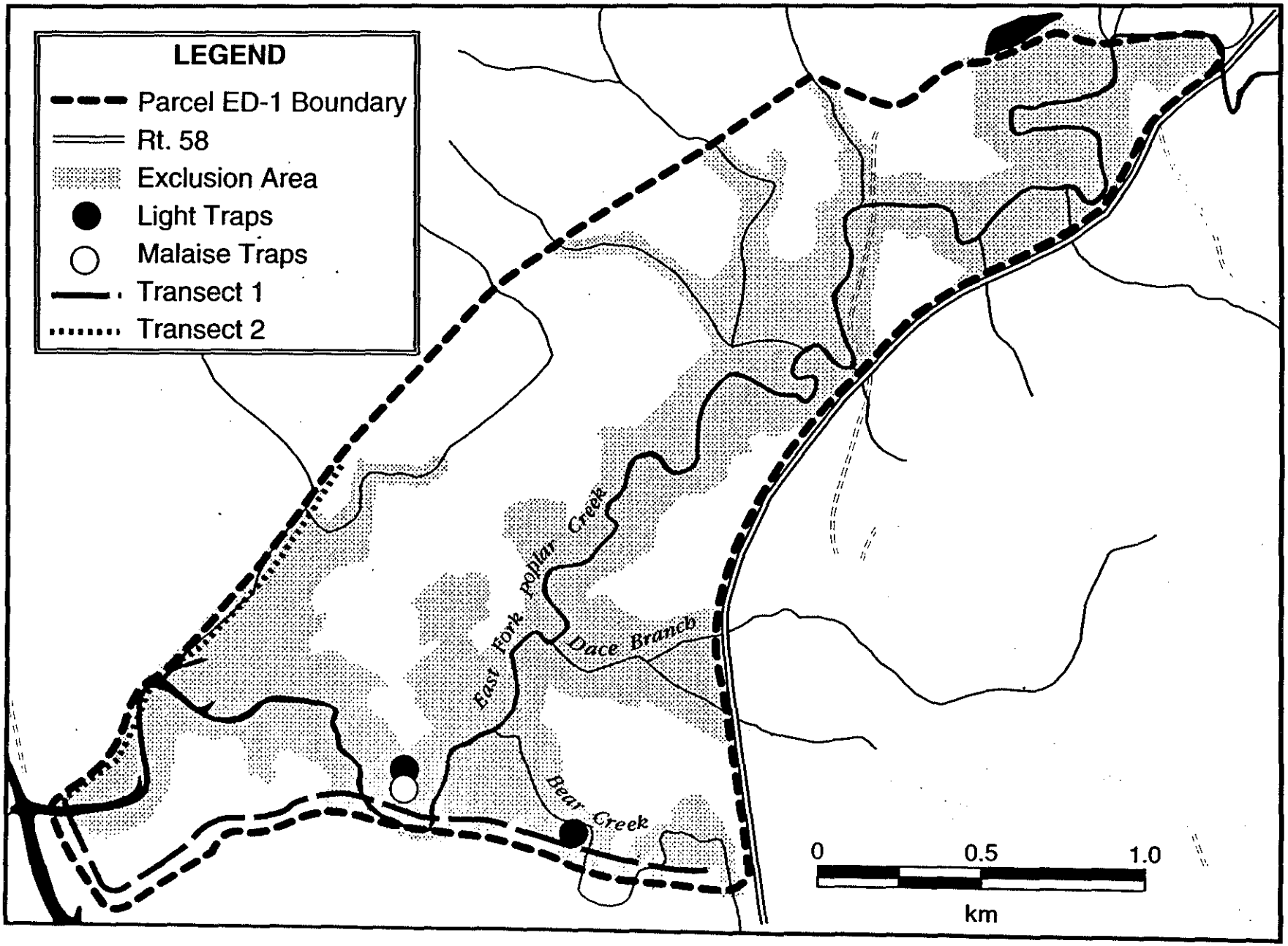

Figure 9. Lepidopter sampling and survey sites in Parcel ED-1

11:00 am and lasted $\geq$ 45 minutes.

3.4.2 Results and Discussion

Results of the Lepidoptera surveys, including the number of taxa observed and their host plants, are given in Table 19 (butterflies) and Table 20 (moths). The high plant diversity in the area supports a high diversity of Lepidopterans. The most commonly observed butterfly species were the pearl crescent, snout, hackberry, and blues/Lycaenidae. The most common moths were the banded tussock, white flannel, and curve-toothed geometer. Observations were considerably fewer on the last two July dates than during the late June and early July moth surveys, possibly because many species had completed their annual reproductive cycle.

These results are sufficient to suggest the importance of the Parcel ED-1 Exclusion Area to Lepidoptera and animals that feed on them (e.g., birds and bats). Species recorded reflect the abundance of both overstory and understory hardwood host plants; e.g., hackberry, elm, birch, tulip poplar, dogwood, and redbud. The results also provide a benchmark against which to compare any future surveys. For example, clearing within (e.g., for trails, roads, and stream crossings) and adjacent to the Exclusion Area would be expected to shift Lepidoptera faunal abundance towards species using sunloving annuals such as asters.

These results are incomplete, because the survey period was restricted (i.e., no sampling was conducted in the spring), and truly interior forest Lepidopterans (e.g., wood nymphs) were under sampled. Future surveys would be more comprehensive if studies were begun in April, if interior forest transects were surveyed, and if larval stages were included.

Table 19. Number of observations of butterfly species and host plants on Parcel ED-1.

Species	Host Plant	Date														
		6/24	6/25	6/27	6/30	7/1	7/2	7/3	7/4	7/8	7/10	7/11	7/14	7/15	7/16	7/17
Pearl Crescent *Phyciodes phaon*	Asters	5	3	2	14	8	7	6	6	9	16	13	5	2	6	9
Lesser Skipper *Pellicia bromias*	Grasses/Sedges	0	0	1	2	1	2	2	1	0	1	1	2	0	1	1
Harvester *Feniseca Tarquinius*	Beech	1	0	0	1	0	0	0	0	1	0	0	1	0	2	0
Snout *Lybytheana bachmanni*	Hackberry	23	18	3	20	2	11	0	0	2	9	5	8	5	12	1
Great Spangled Fritillary *Speyeria cybele*	Violets	9	12	8	1	0	4	1	1	4	0	3	0	2	1	0
Hackberry *Asterocampa celtis*	Hackberry	7	4	4	23	6	5	11	11	9	15	7	11	2	4	1
Red Admiral *Vanessa atalanta*	Nettles	0	0	0	2	2	2	3	2	3	0	1	3	2	1	2
American Painted Lady *Vanessa viriniensis*	Everlasting	0	0	0	0	0	3	0	0	1	2	0	2	0	0	0
Comma/Question Mark *Polygonia* spp.	Elm/Hackberry	0	0	5	9	2	7	12	12	4	5	2	5	8	5	5
Swallowtail *Papilio* spp.	Papaw	0	2	3	1	3	0	0	1	1	0	1	1	1	0	1
Blues/Lycaenidae *Plebiinae*	Milkweed Willow Dogwood	0	3	2	14	22	14	12	12	7	3	6	10	9	2	1

Table 19 (Continued).

Species	Host Plant	Date														
		6/24	6/25	6/27	6/30	7/1	7/2	7/3	7/4	7/8	7/10	7/11	7/14	7/15	7/16	7/17
Sulfurs *Colias* spp.	Clovers	1	2	0	2	1	2	1	1	7	4	5	4	8	3	1
Gemmed Satyr *Euptychia gemma*	Grasses	0	0	2(MT)	0	0	1	0	0	1	1	1	1	1	0	1
Wood Nymph/Satyridae *Cercyonis pegala alope*	Grasses	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
Red Spotted Purple *Limenitis arthemis astyanax*	Birch	0	0	0	2	0	4	0	2	5	2	2	7	3	1	1

Table 20. Number of observations of various moth species and host plants on Parcel ED-1

Species	Host Plant	Date			
		6/27	7/2	7/10	7/22
Painted Lichen *Hypoprepia fucosa*	Lichens	4	0	0	0
Io *Automeris*	Birches/Maples	3	1	0	0
Grape leaf folder *Desmia funeralis*	Evening Primrose	5	1	1	0
White Flannel *Norape ovina*	Hackberry/Redbud	6	5	0	0
Spiny Oakworm *Anisota stigma*	Oak/Hazelnut	1	7	0	0
Banded Tussock *Halysidota tessellaris*	Tuliptree/Birches	8	12	2	0
Tulip-tree Beauty *Epimecis hortaria*	Poplars/Papaw	1	0	0	0
Spotted Apatelodes *Apatelodes torrefacta*	Ashes/Maples/Oak	5	2	0	0
Large maple spanworm *Prochoerodes transversata*	Apple/Cherry	1	0	0	0
Curve Toothed geometer *Eutrapela clemataria*	Elms/Birches/Poplar	8	2	0	2
Clymene *Haploa clymene*	Oaks/Peach/Willow	0	7	0	0
Blinded sphinx *Paonius ecaecatus*	Birches/Elm/Poplar	0	3	0	0
Nessus sphinx *Amphion floridensis*	Grapes	1	0	0	0
Waved sphinx *Ceratomia undulosa*	Ashes/Lilac/Oak	1	1	0	0
Imperial *Eacles imperialis*	Birch/Cedar/Oak	0	0	1	1

Table 20 (Continued).

Species	Host Plant	Date			
		6/27	7/2	7/10	7/22
Drexel's Datana *Datana drexelii*	Birch/Blueberry	0	1	2	1
Spiny oak-slug *Euclea delphinii*	Beech/Maple/Oak	0	0	1	0
Common gray *Anavitrinella pampinaria*	Elm/Poplar	0	1	1	2
Signate Melanolophia *Melanolophia signataria*	Poplar/Birch/Maple	0	0	1	0
Walnut sphinx *Laothoe juglandis*	Butternut	0	0	2	0
The Bad-wing *Dyspteris abortivaria*	Grapes	0	0	0	2

3.5 SMALL MAMMALS, REPTILES, AND AMPHIBIANS (E. M. Schilling and W. K. Roy, ORNL)

The objectives of this study were to (1) characterize the small mammal, reptile, and amphibian communities in the Exclusion Area of Parcel ED-1, and (2) determine if any T&E species of small mammals, reptiles, or amphibians inhabit Parcel ED-1. Several state- and federally-listed threatened and endangered (T&E) vertebrate species are known to occur on the ORR (Kroodsma 1987, Mitchell et al. 1996), and habitat requirements are favorable for these species in Parcel ED-1. The EA reports the known presence of one state-listed species in-need-of-management on Parcel ED-1, the southeastern shrew (*Sorex longirostris*).

Parcel ED-1 includes a wide diversity of habitat types for small mammals, reptiles, and amphibians, including extensive riparian areas and bottomland forest habitat. Bottomland forest habitat is limited on the ORR (Burgess 1975) and is declining in the region as a whole. The loss of bottomland forest decreases species diversity by decreasing food availability and shelter, and by increasing stream temperatures and silt loads to streams. Parcel ED-1 provides the most extensive areas of bottomland forests on the ORR, and thus, it is of great ecological importance.

3.5.1 Study Area and Methods

A total of 16 sites was selected in an effort to sample major habitat types occurring on Parcel ED-1 that are likely to include populations of any federally or state listed species. Site designation, trap type, habitat type, and sampling locations are given in Table 21 and are shown in Figure 10. Sampled habitat included bottomland forest, beech-maple forest, oak-hickory-ash limestone woodland, clearcut, limestone cliff, and hardwood plantations, which are described in U.S. DOE (1996a). Bottomland forest sites were located in floodplain areas and consisted of assemblages of sycamore (*Plantanus occidentalis*), boxelder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), and black willow (*Salix nigra*). Beech-maple forest was dominated by mature American beech (*Fagus grandifolia*) and sugar maple (*A. saccharum*). Oak-hickory-ash limestone woodland included species of chinquapin oak (*Quercus muehlenbergii*), Shumard oak (*Q. shumardii*), white oak (*Q. alba*), white ash (*F. americana*), pignut hickory (*Carya glabra*), and eastern red-cedar (*Juniperus virginiana*). Clearcut areas were predominately pine plantations until the summer of 1993 when they became infested with the southern pine beetle (*Dendroctomus frontalis*) and were subsequently clearcut. The limestone cliff area was characterized by bare limestone rock, with sparse vegetation surrounding a quarry. Hardwood plantations consisted of either yellow poplar (*Liriodendron tulipifera*) or black walnut (*Juglans nigra*).

The surveys of small vertebrate species focused particularly on federally-listed and state-listed T&E species and those deemed "in-need-of-management" by the State of Tennessee (TWRA 1997a, 1997b, TWRC 1994), collectively referred to as T&E species and listed in Table 22. The target species list was developed based on the following criteria: (1) state- or federally-

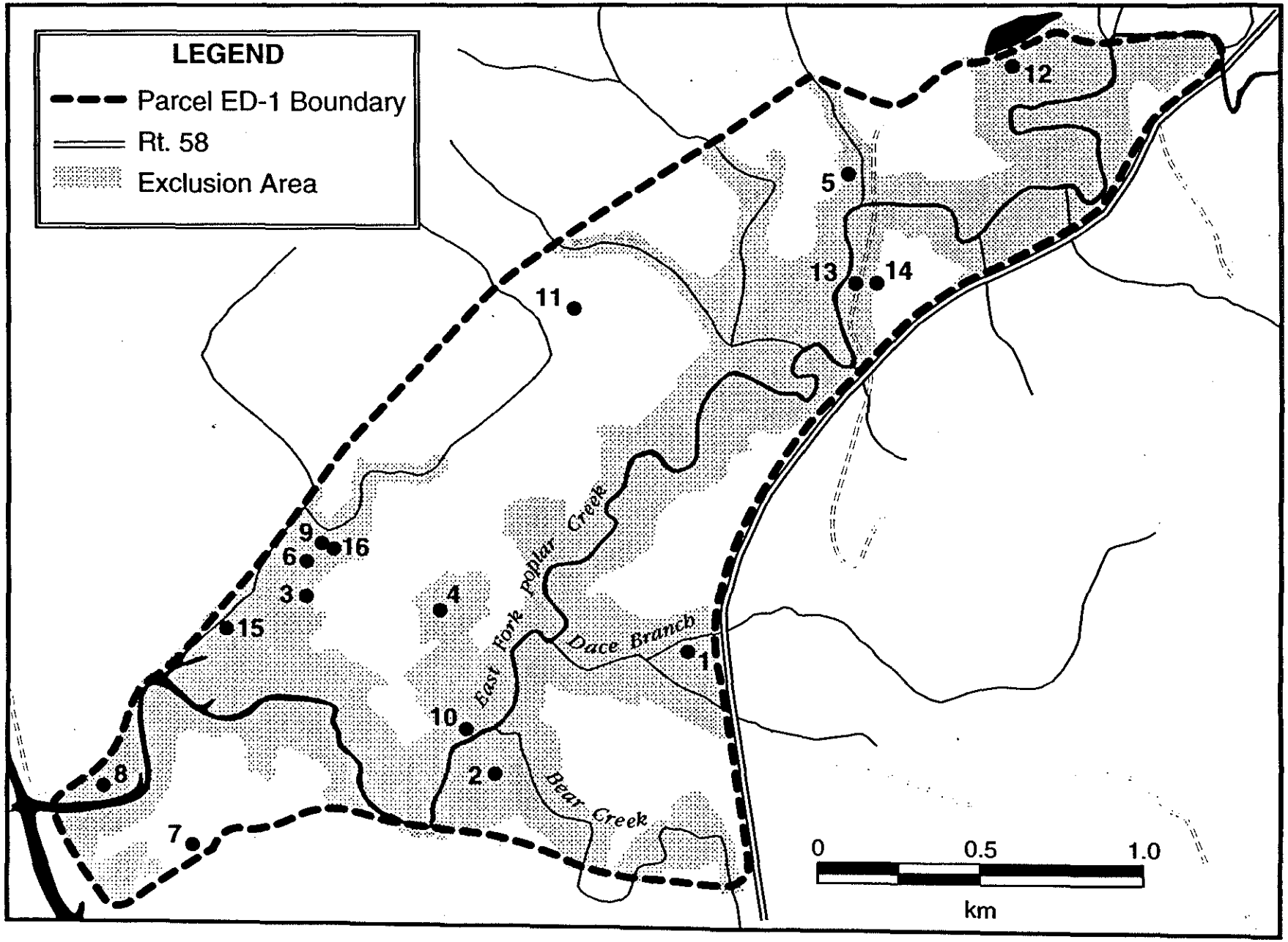

Figure 10. Small mammal, reptile, and amphibian trapping sites in Parcel ED-1

Table 21. Small mammal, reptile, and amphibian sampling site, trap type, and latitude/longitude location on Parcel ED-1.

Site	Trap types	Habitat type	Location
MRA-1	Array with pitfalls Sherman traps (2) Coverboards (2)	Bottomland Forest	LAT 35°57'13.0" N; LON 84°21'56.3" W LAT 35°57'12.3" N; LON 84°21'57.6" W LAT 35°57'14.4" N; LON 84°21'56.6" W LAT 35°57'14.6" N; LON 84°21'56.7" W LAT 35°57'13.6" N; LON 84°21'56.8" W
MRA-2	Array with pitfalls Sherman traps (2) Coverboards (2)	Bottomland Forest	LAT 35°57'01.5" N; LON 84°22'21.2" W LAT 35°57'01.9" N; LON 84°22'21.4" W LAT 35°57'02.1" N; LON 84°22'17.9" W LAT 35°57'01.9" N; LON 84°22'21.4" W LAT 35°57'04.6" N; LON 84°22'23.7" W
MRA-3	Array with pitfalls Sherman traps (2) Coverboards (2)	Oak-Hickory-Ash Limestone Woodland	LAT 35°57'22.4" N; LON 84°22'44.7" W LAT 35°57'21.3" N; LON 84°22'41.1" W LAT 35°57'19.7" N; LON 84°22'42.0" W LAT 35°57'21.5" N; LON 84°22'42.3" W LAT 35°57'21.5" N; LON 84°22'40.8" W
MRA-4	Array with pitfalls Sherman traps (2) Coverboards (4)	Beech-Maple Forest	LAT 35°57'15.5" N; LON 84°22'22.8" W LAT 35°57'15.9" N; LON 84°22'24.3" W LAT 35°57'17.2" N; LON 84°22'22.6" W LAT 35°57'18.6" N; LON 84°22'24.8" W LAT 35°57'17.7" N; LON 84°22'23.2" W LAT 35°57'20.1" N; LON 84°22'21.1" W LAT 35°57'15.6" N; LON 84°22'22.0" W
MRA-5	Array with pitfalls Sherman traps (2) Coverboards (2)	Bottomland Forest	LAT 35°58'04.9" N; LON 84°21'34.5" W LAT 35°58'03.5" N; LON 84°21'32.1" W LAT 35°58'01.1" N; LON 84°21'31.0" W LAT 35°58'04.4" N; LON 84°21'32.7" W LAT 35°58'06.8" N; LON 84°21'40.0" W
MRA-6	Transect with pitfalls Sherman traps (2, 1 in adjacent Oak-Hickory-Ash Limestone Woodland) Coverboards (2)	Clearcut	LAT 35°57'25.8" N; LON 84°22'41.2" W LAT 35°57'29.3" N; LON 84°22'42.9" W LAT 35°57'26.9" N; LON 84°22'38.7" W LAT 35°57'25.6" N; LON 84°22'43.3" W LAT 35°57'25.6" N; LON 84°22'40.5" W
MRA-7	Coverboards (4)	Hardwood Plantation	LAT 35°56'56.8" N; LON 84°22'48.9" W LAT 35°56'55.0" N; LON 84°22'46.5" W LAT 35°56'54.7" N; LON 84°22'45.2" W LAT 35°56'59.9" N; LON 84°22'46.9" W
MRA-8	Coverboards (4)	Hardwood Plantation	LAT 35°57'02.2" N; LON 84°23'04.4" W LAT 35°57'02.4" N; LON 84°23'04.9" W LAT 35°57'02.3" N; LON 84°23'07.3" W LAT 35°57'02.6" N; LON 84°23'08.0" W

Table 21 (Continued)

Site	Trap types	Habitat type	Location
MRA-9	Coverboards (4)	Sinkhole -Oak-Hickory-Ash-Limestone Woodland	LAT 35°57'23.8" N; LON 84°22'40.6" W LAT 35°57'28.2" N; LON 84°22'38.9" W LAT 35°57'27.0" N; LON 84°22'38.6" W LAT 35°57'27.3" N; LON 84°22'39.1" W
MRA-10	Coverboards (4)	Bottomland Forest	LAT 35°57'03.5" N; LON 84°22'24.7" W LAT 35°57'03.2" N; LON 84°22'25.0" W LAT 35°57'04.2" N; LON 84°22'15.6" W LAT 35°57'03.1" N; LON 84°22'23.8" W
MRA-11	Coverboards (2)	Clearcut	LAT 35°57'45.3" N; LON 84°22'00.6" W LAT 35°57'49.7" N; LON 84°22'02.6" W
MRA-12	Coverboards (2)	Limestone Cliff	LAT 35°58'13.8" N; LON 84°21'11.0" W LAT 35°58'11.1" N; LON 84°21'11.4" W
MRA-13	Coverboards (4)	Bottomland Forest	LAT 35°57'51.2" N; LON 84°21'32.3" W LAT 35°57'56.4" N; LON 84°21'35.0" W LAT 35°57'49.1" N; LON 84°21'34.4" W LAT 35°57'56.6" N; LON 84°21'32.3" W
MRA-14	Coverboards (4)	Clearcut	LAT 35°57'52.7" N; LON 84°21'30.8" W LAT 35°57'49.5" N; LON 84°21'27.5" W LAT 35°57'53.1" N; LON 84°21'31.0" W LAT 35°57'52.9" N; LON 84°21'30.6" W
MRA-15	Sherman traps (3)	Bottomland Forest	LAT 35°57'09.7" N; LON 84°22'57.5" W LAT 35°57'14.8" N; LON 84°22'56.5" W LAT 35°57'26.8" N; LON 84°23'02.4" W
MRA-16	Pitfalls (12)	Sinkhole -Oak-Hickory-Ash-Limestone Woodland	Loccated approximately 50 m southeast of Site HM-9

Table 22. Federal and State listed mammals, reptiles, and amphibians targeted in surveys on Parcel ED-1.

		Legal Status[1]	
		Federal	State
Class Mammalia			
masked shrew	*Sorex cinereus*		INM[2]
smoky shrew	*Sorex fumeus*		INM
southeastern shrew[3,4]	*Sorex longirostris*		INM
gray bat[4]	*Myotis grisescens*	E[5]	E
Indiana bat	*Myotis sodalis*	E	E
eastern small-footed bat	*Myotis leibii*		INM
southeastern bat[6]	*Myotis austroriparius*		
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*		INM
eastern woodrat	*Neotoma floridana*		INM
southern bog lemming	*Synaptomys cooperi*		INM
yellownose (rock) vole	*Microtus chrotorrhinus*		INM
woodland jumping mouse	*Napaeozapus insignis*		INM
Class Reptilia			
bog turtle	*Clemmys muhlenbergi*	C2[7]	T[8]
green anole	*Anolis carolinensis*		INM
eastern slender glass lizard	*Ophisaurus attenuatus longicaudus*		INM
northern pine snake	*Pituophis melanoleucus melanoleucus*	C2	T
Class Amphibia			
eastern hellbender[4]	*Cryptobranchus alleganiensis alleganiensis*		INM
mole salamander	*Ambystoma talpoideum*		INM
black mountain salamander	*Desmognathus welteri*		INM
four-toed salamander[4]	*Hemidactylium scutatum*		INM
green salamander[6,9]	*Aneides aeneus*		
Tennessee cave salamander	*Gyrinophilus palleucus*	C2	T

[1]source http://www.state.tn.us/twra/nongmain.html (& nong002.html)
[2]in need of management
[3]collected on Parcel ED-1
[4]previously collected on Oak Ridge Reservation
[5]endangered
[6]contiguous state listing, source http://www.tva.gov/moreinfo/rnhp/etaindex.htm
[7]candidate for possible federal listing
[8]threatened
[9]previously listed INM in Tennessee

listed T&E or candidate species, (2) existence of known or potential habitat on Parcel ED-1, (3) close proximity to the known geographical distribution of the listed species, (4) recent sightings on or near the ORR, and/or (5) historical basis for suspected presence.

A variety of survey approaches were used, including pitfall trap arrays and transects with and without drift fences, artificial covers, Sherman traps, and active searches. Pitfall traps with and without drift fences are commonly used to monitor amphibians and reptiles (Corn 1994). Pitfall traps range in volume from about 4 liters (L) to 19 L, depending on the size of the target species. Pitfalls capture some species more readily than others. Amphibian species that are strong climbers (most cricket frogs, true frogs, and treefrogs; *Acris* spp, *Rana* spp, and *Hyla* spp, respectively) are more difficult to trap than are species such as true toads and spadefoot toads, *Bufo* spp. and *Scaphious* spp., respectively. Pitfall traps are also effective in the capture of small mammals (Spencer and Pettus 1966, Briese and Smith 1974, and Williams and Braun 1983). Additional survey methods, such as providing artificial cover and conducting active searches, were used to increase the probability of capturing rate species. The presence of larger mammals that were observed, but not targeted, was also recorded.

Sampling was conducted from March to July 1997. Initially, sampling was conducted every other weekday. In an effort to reduce animal mortality, the sampling effort was changed beginning in May. The traps were left open for three consecutive days and checked daily. When traps were not in use, they were deactivated by placing an escape stick in the trap. For each sampling, site, date, time of day, surveyors' initials, trap type and species trapped were recorded. Animals were identified to lowest taxon possible according to Conant and Collins (1991), Burt and Grossenheider (1980), and Barbour and Davis (1974). The absence of fauna was also recorded.

Pitfall traps were installed in arrays at sites MRA-1 to 3, and MRA-5 (see Table 21 and Figure 10 for description and location of all sites), each array consisting of 15 m of 0.3 m-high fabric fence, constructed in a Y shape, with three pitfall traps in the center of the array, and one pitfall trap at each end of the Y (modified from Corn, 1994). Each leg of the Y was 5 m in length, and approximately 120° from adjacent legs. The pitfall traps consisted of 4 L containers (No. 10 tin cans) buried in the ground with the opening flush with the ground. Plywood boards were placed approximately 3 to 5 cm above each can to reduce the amount of water entering the pitfalls during precipitation and to reduce overheating of trapped animals.

An additional pitfall trap array was located in the beech-maple forest (MRA-4, Table 21). This array consisted of a total of 15 m of 0.3 m-high fabric fence constructed in a Y shape, with one pitfall trap in the center of the array, and one pitfall at each end of the Y. Each trap consisted of an empty 5-gal (19 L) plastic bucket with the opening buried flush with the ground.

At site MRA-6, a 9-m transect with four 4-L traps (one on each end and two approximately 3 m from each end) was installed in a clearcut. A series of twelve 4-L pitfall traps were also located in a sinkhole within an oak-hickory forest at site MRA-16. Plywood boards were placed approximately 3 to 5 cm above each trap.

Artificial covers that provided micro-habitats for a variety of small mammals, reptiles, amphibians were used in surveys. From two to four plywood cover boards (3038 to 10,285 cm^2 in size) were placed directly on the ground at sites MRA-1 to -14. These boards were checked during the sampling of the pitfall trap arrays, with all species identified to lowest taxon possible.

Two Sherman live traps (for small mammals) were set at each pitfall trap array site (sites MRA-1 to 5) and at the pitfall trap transect (site MRA-6). Traps were placed near fallen logs or animal runways. Three additional Sherman live traps were placed in the vicinity of a beaver pond, site MRA-15. Traps were baited with peanut butter and checked during the pitfall trap surveys. Sherman traps were opened on the first day of the week that pitfalls were checked, and closed on the last day of the week that pitfalls were checked.

Active searches were conducted at sites MRA-1 to 5 and MRA-11 and 12. Surveyors actively searched for small mammals, reptiles, and amphibians in leaf litter, woody debris and under rocks and logs. Active searches were conducted on June 6 and July 15, 1997. The time spent searching, date, surveyors initials, species found, and the number of each species was recorded.

3.5.2 Results and Discussion

Forty-nine (49) mammal, reptile, and amphibian species were either trapped or observed during the March-July survey period (Table 23). Of these, 36 species were trapped, and 13 were observed. The 36 captured species include 15 mammals, 10 reptiles, and 11 amphibians. Observed species included 12 mammals and 1 reptile, the northern black racer (*Coluber constrictor constrictor*).

Only one T&E species of concern, the southeastern shrew (*Sorex longirostris*), was collected. This species has no legal status at the federal level (Redmond 1996), but is deemed in need of management by TWRA (1997b). The southeastern shrew was the third most commonly collected species in this study, exceeded only by the *Peromyscus* complex (a collective reference to deer mice, white-footed mice, and unidentified *Peromyscus* species) and the shorttail shrew (*Blarina brevicauda*). Mitchell et al. (1996) collected 14 southeastern shrews on the ORR during their study, and described this mammal as possibly being "more common than regional records suggest". Barbour and Davis (1974) describe it as being one of the least known of all the mammals of eastern North America.

Table 23. Small mammals[1], reptiles, and amphibians observed or trapped on Parcel ED-1 by habitat type, March-July, 1997.

	Bottomland Forest	Beech-Maple Forest	Oak-Hickory-Ash Limestone Woodland	Clearcut	Limestone Cliff	Hardwood Plantation
'itfall trap-nights (# pitfalls)	806 (18)	148 (4)	240 (6)	158 (4)	0 (0)	0 (0)
Sherman trap-nights (# traps)	245 (9)	71 (2)	80 (2)	61 (2)	0 (0)	0 (0)
of coverboards	14	4	6	8	2	8
Active searches	210 min.	60 min.	85 min.	144 min.	60 min.	0
outheastern shrew (*Sorex longirostris*)	15	1	2			
ast shrew (*Cryptotis parva*)	1			2		
horttail shrew *Blarina brevicauda*)	9	8	11			
accoon *Procyon lotor*)	2					
mink *Mustela vison*)	1					
striped skunk *Mephitis mephitis*)				1		
omestic dog *(Canis familiaris*)	1					
oyote[2] (*Canis latrans*)						
ray fox (*Urocyon cinereoargenteus*)				1		
omestic cat *Felis domestica*)	1					
woodchuck[2] *Marmota monax*)						
eastern chipmunk *Tamias striatus*)	1		2			
eastern gray squirrel *Sciurus carolinensis*)	1					
outhern flying squirrel[3] (*Glaucomys volans*)						

Table 23 (continued).

	Bottomland Forest	Beech-Maple Forest	Oak-Hickory-Ash Limestone Woodland	Clearcut	Limestone Cliff	Hardwood Plantation
beaver (*Castor canadensis*)	1					
deer mouse (*Peromyscus maniculatus*)	19	5		1		
white-footed mouse (*Peromyscus leucopus*)	12	1	2			
Peromyscus[4]	11	9	1			
pine vole (*Pitymys pinetorum*)	1	1				
muskrat (*Ondatra zibethica*)	1					
eastern cottontail (*Sylvilagus floridanus*)	2					
whitetail deer (*Odocoileus virginianus*)	2					
Class Reptilia						
eastern box turtle (*Terrapene carolina carolina*)	2	1	1			1
ground skink (*Scincella lateralis*)	2		2	3		2
five-lined skink (*Eumeces fasciatus*)			3	2		1
northern brown snake *(Storeria dekayi dekayi)*	1			2		
northern redbelly snake (*Storeria occipitomaculata occipitomaculata*)				1		
eastern garter snake (*Thamnophis sirtalis sirtalis*)	1					
smooth earth snake (*Virginia valeriae*)	1			1	1	
northern ringneck snake (*Diadophis punctatus edwardsii*)			5	1		
eastern worm snake (*Carphophis amoenus amoenus*)			7	2		1

Table 23 (continued).

	Bottomland Forest	Beech-Maple Forest	Oak-Hickory-Ash Limestone Woodland	Clearcut	Limestone Cliff	Hardwood Plantation
northern black racer (*Coluber constrictor constrictor*)	2			1		
black rat snake (*Elaphe obsoleta obsoleta*)	1		1	1		
Class Amphibia						
northern dusky salamander (*Desmognathus fuscus fuscus*)	5					
northern slimy salamander (*Plethodon glutinosus*)	1	1				
northern two-lined salamander (*Eurycea bislineata*)	1					
eastern spadefoot (*Scaphiopus holbrookii holbrookii*)	1	2	2	1		
American toad (*Bufo americanus*)		1	2			
Fowler's toad (*Bufo woodhousei fowleri*)			1			
upland chorus frog (*Pseudacris triseriata feriarum*)	1					
bullfrog (*Rana catesbeiana*)	1					
green frog (*Rana clamitans melanota*)	2					
southern leopard frog (*Rana utricularia utricularia*)	1					
pickerel frog (*Rana palustris*)	1					
total # of species	32	9	13[5]	14	1	4
total # of individuals	104	30	42	20	1	5

xclusive of bats

one observation in pine plantation habitat

one observation in mixed mesophytic forest habitat

eromyscus = either deer mouse or white-footed mouse (not identified to species)

of species could be 14 if *Peromyscus* is a deer mouse

Both southeastern and shorttail shrews were found in bottomland forest, beech-maple forest, and oak-hickory-ash limestone woodland habitats. Least shrews were found in bottomland forest and clearcut habitat. Most shrews were collected in bottomland forest habitat (Table 23), which may be due, in part, to the increased number of pitfall traps in this habitat, rather than the species preference for it. With almost equal trapping effort, only two shrews were collected from clearcut habitat, while nine were collected from beech-maple habitat, reflecting the higher quality of the latter. Least shrews were the only shrews found in clearcuts in this study. Burt and Grossenheider (1980) identify least shrew habitat as "open grass-covered areas, which may have scattered brush". Burt and Grossenheider (1980) also mention the southeastern shrew's preference for moist fields and woodlots, but note that they are not confined to a specific habitat. Survey results indicate that southeastern shrew probably avoids dry clearcut areas, and as with Mitchell et al. (1996), increased trapping effectiveness was observed in conjunction with rainfall. The southeastern shrew could be affected by industrial development on Parcel ED-1, because some of its habitat lies within areas targeted for development. However, the population of the southeastern shrew and available habitat in the Exclusion Area on the parcel should offset the effects of development on the species overall.

Peromyscus spp. were the most abundant group of vertebrates trapped and were found in each habitat in which Sherman traps were set. Five individuals were also caught in pitfall traps. Sixty-one individuals (some were recaptures) were found among bottomland forest, beech-maple forest, oak-hickory-ash limestone woodland, and clearcut (Table 23). Oft those captured, 25 were deer mice (*P. maniculatus*), 15 were white-footed mice (*P. leucopus*), and 21 were unidentified. None of these appeared to be the golden mouse (*P. nuttalli*), which has been reported on the ORR by Mitchell et al. 1996 and Parr and Evans, 1992.

Many mammals reported in this were identified by visual observation rather than trapping, including the raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), woodchuck (*Marmota monax*), eastern gray squirrel (*Sciurus carolinensis*), southern flying squirrel (*Glaucomys volans*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethica*), whitetail deer (*Odocoileus virginianus*), domestic dog (*Canis familiaris*), and domestic cat (*Felis domestica*). No large mammals are listed as T&E species (Table 22) and were not the focus of this study; thus, few are listed in Table 23, and their presence or absence in a given habitat type does not reflect their population sizes in the area.

Habitats with the fewest observed individuals were limestone cliffs and hardwood plantations (Table 23), in which no mammals or amphibians were collected or observed. These habitats were the least frequented by surveyors, and they contained no pitfall or Sherman traps. The sole reptile species found in limestone cliff habitat was the smooth earth snake (*Virginia valeriae*), one of three collected during the study. This individual was found after a 60-min of searching. Hardwood plantations contained four reptiles, and all but one, the eastern box turtle (*Terrapene carolina carolina*), were under cover boards. The other species were ground skink

(*Scincella lateralis*), five-lined skink (*Eumeces fasciatus*), and eastern worm snake (*Carphophis amoenus amoenus*).

No protected reptile species (Table 22) were located on Parcel ED-1. Two threatened reptiles, the bog turtle (*Clemmys muhlenbergi)* and northern pine snake (*Pituophis melanoleucas melanoleucas)* are not known to occur on the ORR. The nearest bog turtle colony is in Johnson County, Tennessee (Personal commuinication from B. W. Tryon, Knoxville (Tennessee) Zoo, to E. M. Schilling and W. K. Roy, Ornl Environmental Sciences Division, August 21, 1997) approximately 230 km to the northeast of the ORR. The nearest recorded northern pine snake was reportedly sited at the Catoosa Wildlife Management Area about 50 km west of the ORR (Kroodsma 1987).

A threatened amphibian, the Tennessee cave salamander (*Gyrinophilus palleucus)* is not known to occur on the ORR, although another cave salamander (*Eurycea lucifuga*) has been reported here (King et al 1994; Mitchell et al, 1996; Parr and Evans 1992). Tennessee cave salamanders generally inhabit caves in the Ridge and Valley Province which have streams and pools (Kroodsma 1987). This species has been recorded in Roane County (Redmond and Scott 1997), but not in Anderson County (Personal communication from R. L. Wyatt, TWRA, with E.M. Schilling and W. K. Roy, ORNL Environmental Sciences Division, August 22, 1997). As Mitchell et al (1996) have reported, habitat for the Tennessee cave salamander on the ORR should be further surveyed.

Another protected amphibian, the four-toed salamander (*Hemidactylium scutatum*), has been reportedly found in the McNew Hollow area approximately 2 km east of the Parcel ED-1 tract/ One specimen was collected, photographed, and released in December 1995 (Mitchell et al. 1996). Because the four-toed salamander is an autumn breeder (Johnson 1992), it was unlikely to be found during the March to July period in which sampling occured. Thus, fall sampling is recommended in future surveys. Its habitat is moist woodlands, as well as woodland ponds and riparian areas which are critical to the aquatic larval stage (Conant and Collins 1991, Johnson 1992). If such habitat is disturbed and if this species is present, its population may be adversely affected by development on Parcel ED-1.

Two previously unreported species, the pickerel frog (*Rana palustris*) and the northern redbelly snake (*Storeria occipitomaculata occipitomaculata*), were identified in this survey. Other species, such as the opossum (*Didelphis marsupialis*) and the northern water snake (*Nerodia sipedon*), are common on Parcel ED-1, but given time and cost constraints, were not observed, nor adequately sampled for, in these surveys. Mitchell et al. (1996) identified 75 herp-mammal species on the ORR, but indicated that this was not a complete taxonomic record. Similarly, the species identified in this survey are not purported to be a comprehensive listing of the resident terrestrial vertebrate fauna on Parcel ED-1.

3.6 STREAM FISH (M. G. Ryon, ORNL)

The objectives of the stream fish study were (1) to characterize spatial and temporal patterns in the distribution and abundance of fishes in EFPC, in lower BC, and in smaller tributaries to these streams; (2) to document the presence of any federally or state listed threatened, endangered, or protected (T&E) fish species in Parcel ED-1 streams; and (3) to locate and characterize any suitable habitat that may support or provide spawning areas for T&E species.

Fish population and community studies provide information on the ecological effects of changes in water quality and habitat. Such studies offer several advantages over other indicators of environmental quality (see Karr et al. 1986, Karr 1987) and are especially relevant to assessment of the biotic integrity of creeks within the ED-1 parcel. Monitoring of fish communities has been used since 1984 by the ORNL Biological Monitoring and Abatement Program (BMAP) for evaluating impacts in receiving streams at ORNL (Loar et al. 1991), the former K-25 Site (Loar et al. 1992; Ryon 1993a), the Portsmouth Gaseous Diffusion Plant (Ryon 1994d), the Paducah Gaseous Diffusion Plant (Ryon 1997), and the Y-12 Plant (Loar et al. 1989; Ryon 1992; Southworth et al. 1992). Impacts to fish communities in these systems (Ryon 1993b, 1994b) as well as their recovery (Ryon 1994a,c) are documented.

3.6.1 Study Area

Quantitative sampling of the fish community was conducted at five sites within or adjacent to ED-1 and at four offsite reference streams (Figure 11). Two sites are located on EFPC [East Fork kilometer (EFK) 6.3 and EFK 2.3], two sites on lower BC [Bear Creek kilometer (BCK) 0.7 and BCK 0.1], and one site on a small tributary, Dace Branch, to EFPC [Dace Branch kilometer (DBK) 0.3]. The offsite reference locations (Figure 12) include Brushy Fork kilometer (BFK) 7.6, Hinds Creek kilometer (HCK) 20.6, Ish Creek kilometer (ISK) 0.6, and Mill Branch kilometer (MBK) 1.6. The reference sites span a range of stream sizes comparable to the streams studied on ED-1 and are also part of BMAP fish community studies conducted for other projects.

Qualitative samples were taken in the majority of streams and aquatic habitats of ED-1 to identify presence of T&E species. These included EFPC, BC, and the small tributaries, as well as spring-fed pools and beaver ponds located in the floodplain of EFPC (Figure 11). Samples were also taken in aquatic areas outside of the quantitative sample sites.

East Fork Poplar Creek

EFPC is a moderately wide (approximately 10 to 20 m), fourth-order stream and is bordered by a riparian zone of mixed hardwoods with little recent development or agricultural land use. Approximately 7 stream-kilometers (stream-km) of EFPC are found on Parcel ED-1 of the total stream length of 26 km. EFPC originates within the Y-12 Plant, where it has sustained considerable contamination, primarily with mercury and polychlorinated biphenyls (PCBs), in the

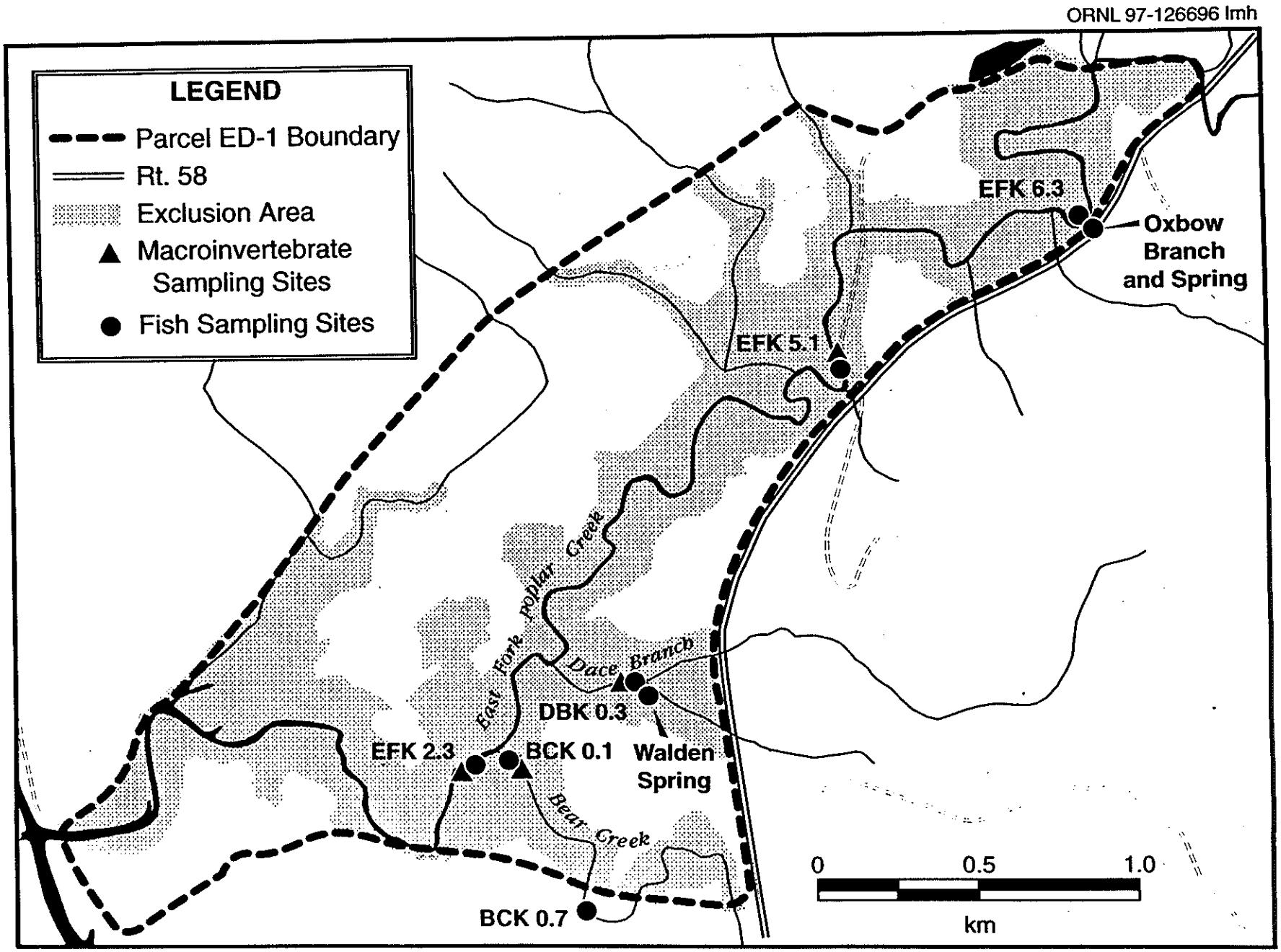

Figure 11. Stream fish and benthic macroinvertebrate sampling sites in Parcel ED-1

Stream Reference Sites

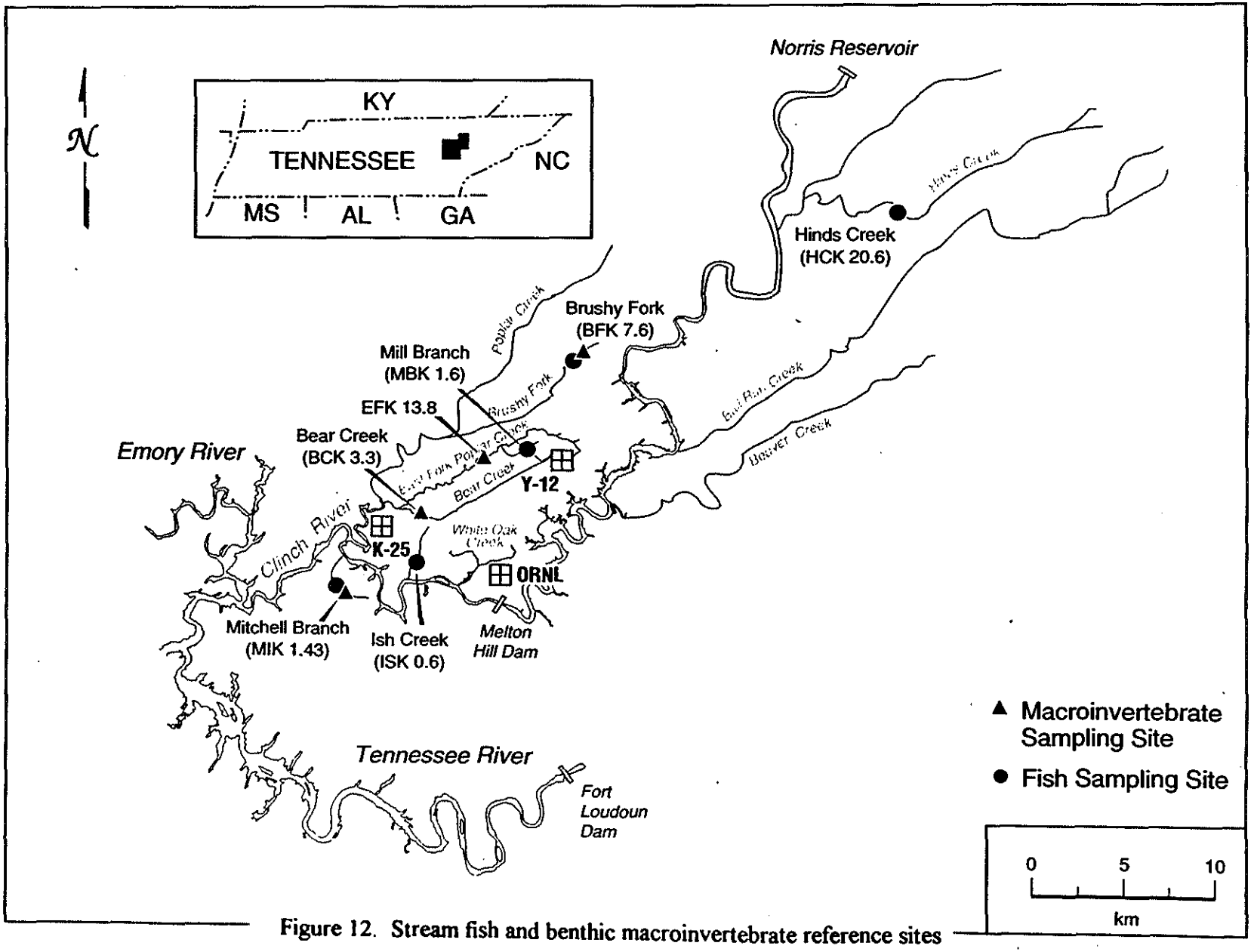

Figure 12. Stream fish and benthic macroinvertebrate reference sites

50+ years that the plant has operated. Due to urbanization as EFPC passes through Oak Ridge, it is susceptible to high flows with considerable sediment transport. The predominant substrates include gravel and cobble in riffles, with softer sediments in the deep pools. Bedrock and larger substrates occur intermittently throughout the watershed.

Remedial actions that are planned in EFPC upstream of Parcel ED-1 involve the removal of contaminated floodplain sediments and continued efforts at the Y-12 Plant to reduce contaminant releases. In late 1996, flow augmentation of EFPC was initiated at the Y-12 Plant to double the base flow of EFPC from 3.5 million gallons per day (MGD) to 7.0 MGD, and dilute contaminant concentrations in the stream. These remedial actions have reduced contaminant loading of EFPC, and a measurable downstream recovery of aquatic communities has been noted.

Bear Creek, a tributary to EFPC, is a narrow (3 to 10 m), third-order stream. Within Parcel ED-1, BC is bordered by hardwoods, cleared pine plantations, and an access road. Approximately 1.8 stream-km of BC are present on ED-1 of a total stream length of 12.5 km. Bear Creek originates just west of the Y-12 Plant and has also received a variety of contaminant stressors, including heavy metals, PCBs, uranium, and organic compounds. Remedial actions at the headwaters of BC have focused on capping disposal ponds and springs, although groundwater contamination is still a problem. Bear Creek has predominantly gravel and bedrock substrate and is not as deep as EFPC. Springs in the upper portions of BC contribute most to its flow. As with EFPC, during periods of heavy rain, considerable sediment is added to the stream as it flows through Bear Creek Valley.

Seven tributaries to EFPC and a sinkhole stream in Parcel ED-1 are all small, first- or second-order streams that are narrow (generally <1 m in width) and shallow (<0.5 m in depth). All seven streams enter EFPC within ED-1 and some lie almost totally within the parcel. The three northern tributaries and the sinkhole tributary are more seasonal in nature, with subsurface flow and surface drying during periods of limited rainfall. The southern tributaries are spring-fed and are intermittent only during the very driest conditions. These streams are bordered by road surfaces, mixed hardwoods, and/or pine plantations. They are, however, minimally contaminated by Y-12 Plant operations, though some flow through state-approved City of Oak Ridge sewage sludge application areas on the parcel.

3.6.2 Materials and Methods

Quantitative Sampling

Quantitative sampling of fish was conducted by electrofishing during the periods of September-December 1996 and March-May 1997. Data were used to determine species richness, population size (numbers and biomass per unit area), and community structure. Most quantitative sampling was conducted using one to three Smith-Root backpack electrofishers, depending on stream size. Each unit delivers up to 1 amp (average) pulsed direct current to stun fish. At EFK 2.3, two backpack electrofishers were operated in combination with a Smith-Root GPP

electrobarge unit, which delivers up to 8 amp (average) pulsed direct current and is designed for use in larger streams.

At most sites, 64-cm-mesh seines were placed across the upper and lower boundaries of the sampling site to restrict fish movement. However, at EFK 2.3, stream size was too large and flow was too fast to allow the use of block nets. Here, the upper and lower boundaries were located at shallow riffles in order to minimize fish movement in or out of the sample reach. After site boundaries were set, a two- to 12-person sampling team electrofished the site in an upstream direction on two or three consecutive passes. Stunned fish from each pass were collected and stored in seine-net holding pens (0.64-cm-diam mesh) or buckets.

Collected fish were anesthetized with MS-222 (tricaine methanesulfonate), identified, measured (total length), and weighed with Pesola spring scales. Individuals were recorded by size-class and species. After ten individuals of a species size-class had been measured and weighed, others in that size-class were measured only. At sites with extremely high densities, specimens of some species were merely counted after a sufficient number of lengths and weights had been obtained. Length-weight regressions, based on the measured individuals, were used to estimate missing length and weight data.

After fish collected on all passes were processed, they were allowed to fully recover from the anesthesia and were returned to the stream. Mortality that occurred as a result of processing was noted. Following completion of fish sampling, the length, mean width, mean depth, and pool-to-riffle ratio of the sampling reach were measured at each site.

Quantitative species population estimates were calculated using the method of Carle and Strub (1978). Biomass was estimated by multiplying the population estimate by the mean weight per size-class. To calculate density and biomass per unit area, total numbers and biomass were divided by the surface area (m^2) of the study reach. These data were compiled and analyzed by a comprehensive Fortran 77 program developed by ORNL (Railsback et al. 1989).

Qualitative Sampling

Qualitative fish sampling was conducted by electrofishing and seining from June-August 1997. Data from these samples were used to determine species richness and number of specimens (relative abundance), based on sampling a known length of stream over a recorded time period. Several sampling techniques were used, all of which corresponded to standard operating procedures (Schilling et al. 1996). For the lower sections of EFPC and at the confluence with PC, a large Smith Root electrofishing boat with forward positioned arrays was used to deliver 8-11 amps of pulsed direct current. Timed sampling runs were made; all stunned fish were netted, identified, and counted. Other timed sampling runs were made through the same habitat in search of additional species, particularly T&E species. In this sampling, the number of specimens was not recorded. In sections of EFPC where wading was possible, timed sampling runs were made using the barge electrofisher. All stunned fish were examined and identified, but not counted. Seine

sampling was also used in these areas to identify specific micro-habitats of smaller T&E species that may have been overlooked with the electrofishing. Seine samples were timed, and a species list was recorded.

Qualitative samples of the remaining habitats, including lower BC, spring pools, and small tributaries were taken using one or two backpack electrofishers. For one large spring pool, Oxbow Spring, the barge electrofisher was used. A two- to six-person sampling team electrofished the stream or pool, collected, identified, and counted all stunned fish. Most specimens were identified in the field, but a few species were preserved in 10% formaldehyde and taken to ORNL for positive identification. The duration of the electrofishing effort (in minutes) and/or the length of stream sampled (in ms) were recorded.

Qualitative samples were compared as to total number of species, number of specimens, and catch per unit effort (fish/minute electrofishing). Both quantitative and qualitative samples were analyzed for community composition, which involved looking at trophic level and at sensitivity to stressors of the individual fish species, following guidelines provided by Karr et al (1986), Ohio EPA (1988), and Miller et al. (1988). Regional compilations of species information are summarized in Appendix D.

Habitat Evaluation

In August 1997, the substrate, flow, and embeddedness (or amount of silt covering the substrate) of riffle habitat were measured to determine its potential as a spawning site for T&E species that are typically not present during non-reproductive seasons. Eight riffles were measured, distributed among stream locations EFK 2.3, EFK 5.1, and EFK 6.3. Each riffle was divided into 10 transects 5 m apart. Across each transect, 6 flow/depth measurements were taken with a Marsh McBirney flow meter, and 3 sets of substrate and embeddedness measurements were made on the transects along a 1-m interval. Within this 1 m, the dominant substrate type and the degree of embeddedness was estimated for each 10-cm interval using guidelines developed by Platts et al (1983).

Habitat data were analyzed by PROC MEANS, PROC FREQ, and PROC GLM (SAS 1988) to calculate means, standard deviations, and range for flow and depth; to summarize frequencies of individual substrate types; and to statistically compare mean embeddedness and flow between riffles.

3.6.3 Results: Community Composition, Abundance, and Biomass

A comparison of data collected for stream sampling sites on Parcel ED-1 indicates that their physical characteristics were fairly stable between the fall and spring sampling periods (Table 24). The most variable characteristic was the pool-to-riffle ratio, which was probably influenced by slightly greater flow and deeper water conditions in the Spring 1997 sample compared to Fall 1996. The study sites had a greater range in dimensions (width and depth) than did the reference

Table 24. Stream physical characteristics at fish sampling sites[a] in ED-1, September-December 1996 and March-May 1997.

Sampling periods/ parameters	EFK 6.3	EFK 2.3	BCK 0.7	BCK 0.1	DBK 0.3	ISK 0.6	MBK 1.6	HCK 20.6	BFK 7.6
Sept-November 1996:									
Length (m)	106	200	96	140	92	64	114	118	114
Width (m)	10.5	11.9	4.9	4.7	1.2	3.0	4.8	7.7	8.3
Depth (cm)	39.6	36.2	15.6	15.7	8.5	11.9	13.6	28.0	26.9
Area (m^2)	1115	2388	449	656	114	192	548	910	943
Pool:riffle	12.3	5.1	1.3	1.1	9.2	0.4	5.3	3.1	7.8
March-May 1997:									
Length (m)	105	204	88	115	100	67	117	103	122
Width (m)	10.4	12.2	5.9	5.3	1.3	2.3	3.5	8.5	8.7
Depth (cm)	49.6	39.2	15.8	18.5	8.1	14.8	17.4	33.5	44.2
Area (m^2)	1096	2498	520	611	133	154	408	874	1060
Pool:riffle	9.5	0.9	0.5	0.6	2.3	0	1.7	2.1	0.8
Combined dates									
(means):	105.5	202	89.5	127.5	96	66	115.5	110.5	118
Length (m)	10.5	12.0	5.4	5.0	1.2	2.6	4.2	8.1	8.5
Width (m)	44.6	37.7	15.7	17.1	8.3	13.4	15.5	30.8	35.6
Depth (cm)	1106	2443	484	634	124	173	478	892	1002
Area (m^2)	10.9	3.0	0.9	0.8	5.8	0.2	3.5	2.6	4.3

[a]East Fork Poplar Creek (EFK), Bear Creek (BCK), Dace Branch (DBK), and the reference streams: Ish Creek (ISK), Mill Branch (MBK), Hinds Creek (HCK), and Brushy Fork (BFK); site locations are indicated by stream kilometers.

sites, but in general, the smaller reference sites were comparable to the DBK 0.3 site, and the larger reference sites were comparable to EFK 2.3, and EFK 6.3. The BC sites were within the stream sizes represented by the reference streams. The quantitative and qualitative surveys of the Parcel ED-1 streams indicate a diverse fauna of fishes (Table 25).

Community Composition

A total of 52 fish species were documented for the ED-1 streams, with minnows (13), suckers (9), sunfish (8), and perch (8) having the greatest diversity of species. EFPC had the most species diversity (51), followed by BC (26). As expected, less-polluted downstream sites on EFPC and BC had more species than upstream sites, but there was considerable overlap among them (Table 26). The smaller streams also demonstrated a substantial number of species, despite their size. More species were found in EFPC than its reference stream, while BC and the smaller habitats had species diversity comparable to similar-sized reference streams (Tables 25 and 26).

The influence of the fish communities in PC and the Clinch River is more evident in EFPC than at other sampling sites due to fish migrating from these larger habitats into EFPC for feeding or spawning activities. For all streams sampled, the influence of upstream impacts, such as urbanization or DOE plant operations, was less than expected as evidenced in the species richness of lower EFPC and BC sites. This species richness indicates a healthy fish community in these streams.

Differences were noted in community composition between Parcel ED-1 sites and reference streams. At EFK 6.3, the community includes more species that indicate stressed conditions than were found at reference stream sites BFK 7.6 and HCK 20.6 (Appendix D, Tables D-2 thru D-5). EFK 6.3 had more tolerant species (6-7) than the references (3-4); fewer sensitive species (7-9) than the references (8-11); and fewer benthic insectivore species (5-7) than the references (4-10). These parameters suggest adverse conditions, such as sedimentation, that affect specialized fish species at EFK 6.3 more than at the reference sites.

For EFK 2.3, there is less difference between it and reference sites for all examined parameters, including sensitive and tolerant species as well as trophic groups such as piscivores, omnivores, and benthic insectivores. This may partly reflect the larger stream size at EFK 2.3. The primary difference is the slightly greater variability in these parameters at EFK 2.3 than at the reference sites.

The two BC sites are intermediate for most parameters between the smaller reference sites and the larger reference sites, similar to their intermediate position in stream size. BCK 0.1 and BCK 0.7 had more pollution-tolerant species (4-6) than at the reference sites (3-4), reflecting some disturbance of the fish community. This pattern did not extend to benthic insectivores (see Sect. 3.7) or sensitive species.

The fish community at the smaller Dace Branch site showed signs of impact when

Table 25. Fish species composition in streams in Parcel ED-1, including East Fork Poplar Creek (EFK[a]), Bear Creek (BCK), Dace Branch (DBK), and spring pools, and at the reference sites, including Ish Creek (ISK), Mill Branch (MBK), Hinds Creek (HCK), and Brushy Fork (BFK) for the period September 1996 to August 1997. Numbers represent the number of sampling periods (n=2) that a given species was collected at that site. An X indicates that the species was taken during qualitative sampling only.

Species	EFK 6.3	EFK 2.3	BCK 0.7	BCK 0.1	DBK 0.3	Spring pools	ISK 0.6	MBK 1.6	HCK 20.6	BFK 7.6
Petromyzontidae										
Unidentified lamprey[b,c] (*Ichthyomyzon sp*)		1								
American brook lamprey (*Lampetra appendix*)										2
Lepisosteidae										
Spotted gar (*Lepisosteus oculatus*)		X								
Clupeidae										
Gizzard shad (*Dorosoma cepedianum*)	1	2								
Threadfin shad (*D. petenense*)		X								
Cyprinidae										
Central stoneroller (*Campostoma anomalum*)	2	2	2	2	2		2	2	2	2
Grass carp (*Ctenopharyngedon idella*)		X								
Spotfin shiner (*Cyprinella spiloptera*)	2	2[b]	2	2	2	X	1			1
Steelcolor shiner (*C. whipplei*)		2[b]								
Common carp (*Cyprinus carpio*)		1				X				
Striped shiner (*Luxilus chrysocephalus*)	2	2	2	2	2		2	2	2	2
Rosefin shiner (*Lythurus ardens*)	2	2[b]	2	2						2
Bigeye chub (*Notropis amblops*)	1	2							2	
Emerald shiner (*N. atherinoides*)		X								

Table 25 (Continued).

Species	EFK 6.3	EFK 2.3	BCK 0.7	BCK 0.1	DBK 0.3	Spring pools	ISK 0.6	MBK 1.6	HCK 20.6	BFK 7.6
Tennessee dace (*Phoxinus tennesseensis*)					2	X	2	2		
Bluntnose minnow (*Pimephales notatus*)	2	2	2	2	1		1		2	
Blacknose dace (*Rhinichthys atratulus*)	1	2	2	2	2	X	2	2	2	2
Creek chub (*Semotilus atromaculatus*)	2	1	1	2	2	X	2	2	2	2
Catostomidae										
River carpsucker (*Carpiodes carpio*)		1								
Quillback (*C. cyprinus*)		1								
White sucker (*Catostomus commersoni*)	1				1	X		1	2	2
Northern hog sucker (*Hypentelium nigricans*)	2	2	2	2			2		2	2
Smallmouth buffalo (*Ictiobus bubalus*)		1								
Spotted sucker (*Minytrema melanops*)	1	1				X				
Silver redhorse (*Moxostoma anisurum*)		X								
Black redhorse (*M. duquesnei*)	2	2		X					2	2
Golden redhorse (*M. erythrurum*)	2	2[b]		1					1	1
Ictaluridae										
Yellow bullhead (*Ameiurus natalis*)	1	2		2					2	
Channel catfish (*Ictalurus punctatus*)		1								
Flathead catfish (*Pylodictis olivaris*)		X								
Cyprinodontidae										
Blackstripe topminnow (*Fundulus notatus*)										2

Table 25 (Continued).

Species	EFK 6.3	EFK 2.3	BCK 0.7	BCK 0.1	DBK 0.3	Spring pools	ISK 0.6	MBK 1.6	HCK 20.6	BFK 7.6
Poeciliidae										
Western mosquitofish (*Gambusia affinis*)			2	1	1	X				
Atherinidae										
Brook silversides (*Labidesthes sicculus*)		1								
Cottidae										
Banded sculpin (*Cottus carolinae*)		2	2	2	2	X	2		2	2
Percichthyidae										
White bass (*Morone chrysops*)		1								
Yellow bass (*M. mississippiensis*)		1								
Striped bass (*M. saxatilis*)		X								
Centrarchidae										
Rock bass (*Ambloplites rupestris*)	1	2	2	2					2	2
Redbreast sunfish (*Lepomis auritus*)	2	2	2	2	1				2	2
Green sunfish (*L. cyanellus*)	2	2	2	2	2	X	1			
Warmouth (*L. gulosus*)	2	2		1		X				
Bluegill (*L. macrochirus*)	2	2	2	2		X	1	2	2	2
Smallmouth bass (*Micropterus dolomieu*)		1	1							
Spotted bass (*M. punctulatus*)	2	1	1	1	1			1	1	
Largemouth bass (*M. salmoides*)	1	2		1		X		2	2	

Table 25 (Continued).

Species	EFK 6.3	EFK 2.3	BCK 0.7	BCK 0.1	DBK 0.3	Spring pools	ISK 0.6	MBK 1.6	HCK 20.6	BFK 7.6
Percidae										
Greenside darter (*Etheostoma blenniodes*)		1							2	2
Black darter (*E. duryi*)								1[b]		
Blueside darter (*E. jessiae*)		1		1					2	2
Stripetail darter (*E. kennicotti*)		2	2	2				2	2	
Redline darter (*E. rufilineatum*)	1		2	1					2	1
Snubnose darter (*E. simoterum*)	2	2	2	2			2	2	2	2
Yellow perch (*Perca flavescens*)		1								
Logperch (*Percina caprodes*)	2	2	2	2						
Dusky darter (*P. sciera*)		2[b]								
Sciaenidae										
Freshwater drum (*Aplodinotus grunniens*)	1	1								
Total species (site)	28	48	20	25	13	13	12	12	22	20
Total species (EFPC)		51								
(BC)				26						
(EF Tribs/springs)						18				
(Sm Refs)								17		
(Lg Refs)										26

[a]Site locations are indicated by stream kilometers.
[b]Species identifications were verified by D. A. Etnier, Department of Zoology, University of Tennessee, Knoxville.
[c]The species of lamprey could not be determined; characteristics were intermediate between the Chestnut lamprey (*Ichthyomyzon castaneus*) and the Ohio lamprey (*I. bdellium*).

Table 26. Total species richness, fish density (individuals/m²), and total biomass (g/m²) for quantitative fish sample sites[a] in Parcel ED-1, September-December 1996 and March-May 1997.

Sampling periods/ parameters	EFK 6.3	EFK 2.3	BCK 0.7	BCK 0.1	DBK 0.3	ISK 0.6	MBK 1.6	HCK 20.6	BFK 7.6
September-November 1996									
Species richness	18	28	18	20	13	11	12	22	19
Density	0.30	0.65	1.34	1.36	5.54	2.48	0.98	2.36	0.48
Biomass	4.33	30.20	6.16	6.93	11.45	8.10	3.93	13.89	5.79
March-May 1997									
Species richness	27	38	19	22	8	9	10	20	18
Density	0.33	0.39	0.81	1.28	3.93	1.46	0.66	1.91	0.27
Biomass	10.04	66.95	5.85	9.72	16.43	6.68	1.77	15.29	4.85
Means									
Species richness	22.5	33	18.5	21	10.5	10	11	21	18.5
Density	0.32	0.52	1.08	1.32	4.73	1.97	0.82	2.14	0.38
Biomass	7.19	48.58	6.01	8.33	13.94	7.39	2.85	14.59	5.32

[a] East Fork Poplar Creek (EFK), Bear Creek (BCK), Dace Branch (DBK), tributary to East Fork Poplar Creek, and the reference streams: Ish Creek (ISK), Mill Branch (MBK), Hinds Creek (HCK), and Brushy Fork (BFK); sites are indicated by stream kilometer.

compared to reference sites at Mill Branch and Ish Creek. DBK 0.3 had fewer sensitive species (1 v 3), more tolerant species (6-4 v 3), and fewer benthic insectivores (1 v 3-4) than the reference sites. Based on a subjective examination of stream habitat, Dace Branch appears to have more clay substrates, more siltation, and slower flows than either of the reference streams. Such conditions would not favor specialized benthic feeders or sensitive species such as darters. Conditions may be the result of natural geomorphology or subtle impacts from pine plantation and waste management activities that occur within the watershed of Dace Branch.

Abundance

Fish densities and biomass values, computed from quantitative samples, were scaled to the surface area of each sampling site to allow a direct comparison between study and reference sites. Surveys indicate that the larger sites on lower EFPC have relatively low densities when compared to the HCK 20.6 reference site (Table 26), but similar densities as BFK 7.6. The noticeably higher densities at reference HCK 20.6 are due mostly to the contribution of riffle species, such as central stoneroller, banded sculpin, and snubnose darter (Appendix D, Tables D-3 and D-5). Although the sites have similar pool-to-riffle ratios (Table 24), there is a greater run-habitat component in the riffle category at EFK 6.3, EFK 2.3, and BFK 7.6 than at HCK 20.6. This is indicated by the greater variability in the pool-to-riffle ratio at these sites, while the HCK 20.6 pool-to-riffle measurement is more consistent from sample to sample. Thus, the more stable riffles at HCK 20.6 provide better riffle habitat, thereby increasing the abundance (as measured by density) of riffle species.

Abundance data also provide another evaluation of community composition when densities of sensitive species, tolerant species, and benthic insectivores are compared (Appendix D, Tables D-1 through D-5). At lower EFPC sites, the proportional density of sensitive species (i.e., the density of sensitive species divided by total site density) was low (29-42%) when compared to that of the reference sites (41-69%). However, the proportional density of tolerant species was higher in EFPC (36-48%) than at reference sites (6-15%), and the proportional density of benthic invertebrates was similar (15-30%). These data suggest a slight adverse impact to community composition, as was suggested by the species richness data.

In BC, the total densities at BCK 0.1 and BCK 0.7 (1.08-1.32 fish/m^2) were intermediate between the densities of the smaller reference sites (0.82-1.97 fish/m^2) and the larger references (0.38-2.14 fish/m^2). Similarly, the proportional density of sensitive species was intermediate at the BC sites (21-40%) between the smaller reference sites (4-21%) and the larger reference sites (41-69%). However, the proportion of tolerant species was high in BC (37-51%) compared to the MBK 1.6, HCK 20.6 , and BFK 7.6 sites (6-20%). One of the smallest reference sites, ISK 0.6, had a very high proportion of tolerant species (64-78%), due to the dominance of the community by the striped shiner, which was not evident at the other reference sites. As with EFPC sites, BC sites had proportional densities of benthic insectivores similar to those seen at reference sites.

Densities at the small ED-1 tributary, Dace Branch, were very high (Table 26), more than

twice the densities at any reference site. This abundance was based on the densities for blacknose dace and banded sculpin (Appendix D, Tables D-2 and D-4). The success of these species in DBK 0.3 could be a result of spring flow into the tributary and the resulting cool temperatures, as well as the more headwater nature of the stream, factors that suit both species. The proportional densities of sensitive species, tolerant species, and benthic insectivores at DBK 0.3 closely matched the patterns seen in the reference streams. The great disparity in the proportion of tolerant species seen at other ED-1 sites when compared to references was noticeably absent. Thus, abundance data indicate a more healthy fish community composition in Dace Branch than that indicated by species richness data.

Biomass

The quantitative data provide good estimates of the biomass of individual species and fish communities. These data provide an indication of the productivity of the sites and the overall importance to the community of low-density, high-biomass species.

The greatest biomass was shown at EFK 2.3 (Table 26) and was based on the biomass of gizzard shad in the Fall 1996 sample (Appendix D, Table D-2) and the biomass of various large sucker species in the Spring 1997 sample (Appendix D, Table D-4). Although these were not always the numerically most abundant species, they represent a significant proportion of the community based on their large individual size. The presence of the gizzard shad in lower EFPC reflect the filter-feeding activities of this species, while the spring abundance of suckers is a measure of the spawning activity of these species. Because species such as quillback, smallmouth buffalo, and river carpsucker are usually found in reservoirs or larger rivers, their large presence in lower EFPC signifies the importance of this locale for their reproductive cycle. Many sucker species move upstream into smaller streams to spawn in riffle and run habitats (Etnier and Starnes 1993).

Two additional sites with high biomass were the HCK 20.6 reference site and unexpectedly, the DBK 0.3 tributary site (Table 26). The primary contributors to biomass at these sites included more minnow species as well as the banded sculpin (Appendix D, Tables D-2 through D-5). Biomass at other ED-1 sites and the reference sites was similar, with means ranging from 2.85 to 8.33 g/m^2 (Table 26). Again, the contribution of minnow and sunfish species provided the majority of the biomass. For these sites, biomass reinforced the significant role indicated by density measurements of these species.

The relatively high biomass values at most Parcel ED-1 sites suggest that productivity at higher trophic levels is substantial. The large biomass of the herbivore species, gizzard shad and central stoneroller, indicate that some enrichment upstream of ED-1 could be enhancing primary productivity. Similarly, the biomass of surface and mid-water invertivores, such as the sunfish, and the omnivore species, like the striped shiner, suggests that substantial terrestrial insect input occurs in the streams. Further, much of the biomass is contributed by sucker species that consume a variety of benthic food sources, including benthic invertebrates and organic material with

associated bacteria. The only group with minimal biomass are the specialized benthic insectivores, whose low productivity may indicate that conditions are not ideal for these species.

Although, biomass studies can be used to estimate production, a size-class analysis, based on several annual samples of fish communities at ED-1 sites, would be more useful. Such an analysis would provide information on how production changes over an annual cycle and whether a population is accumulating or merely maintaining a specific level of biomass.

Qualitative Surveys

The qualitative surveys of EFPC, BC, Dace Branch, and other aquatic habitats within Parcel ED-1 also provide comparative information on species richness (Appendix D, Tables D-6 through D-8) and densities. The electrofishing surveys of EFPC identified 26 to 29 species and included seven species not identified in quantitative sampling (Table 25). Most notable were the larger species such as spotted gar, grass carp, striped bass, silver redhorse, and flathead catfish. These species are typical of larger river or reservoir habitats and indicate that lower EFPC is utilized by the fish communities in these connected habitats. The qualitative survey of BC also located a species not found in quantitative surveys, the black redhorse. The qualitative surveys of the EFPC tributaries indicate that, although these systems are small and some quite limited in length, they contain unique species such as the Tennessee dace (Sect. 3.6.4; Appendix D, Table D-7). Similarly, the surveys of spring pools found a more diverse community than expected (Appendix D, Table D-8). Walden Spring contained Tennessee dace, and Oxbow Spring had a species richness of 11, with a large population of white suckers.

Species densities determined from the qualitative surveys of lower EFPC near the confluence with PC (Appendix D, Table D-6); of Dace Branch below DBK 0.3 (Appendix D, Table D-7); and of BC between sites BCK 0.1 and BCK 0.7 (Appendix D, Table D-8) were all similar. The catch per unit effort (fish/min) at these sites increased slightly from 2.13 fish/min (lower EFPC) to 2.40 fish/min (BC) and to 3.92 fish/min (Dace Branch) as stream size decreased. This trend supports the pattern found in quantitative data (Table 26), but with a smaller range. The spread in abundance between the four permanent southern tributaries to EFPC was much greater (Appendix D, Table D-8). Catch per unit effort ranged from a very low 0.62 fish/min at Oxbow Branch up to 4.16 fish/min at Frog Branch. This partially reflects stream length, as Oxbow Branch is quite short, and Dace Branch and Frog Branch were the longer tributaries. Conversely, the highest catch per unit effort in the spring and pool habitats was in Oxbow Spring, which feeds Oxbow Branch. This spring-fed pool is adjacent to Oak Ridge Turnpike on the border of Parcel ED-1 and appears to be an old meander of EFPC that was isolated by the turnpike. The catch per unit effort in Oxbow Spring was 2.52 fish/min, which was higher than either Walden Spring (2.47 fish/min), which enters Dace Branch, or the spring-fed beaver pond (2.22 fish/min) adjacent to EFPC (Appendix D, Table D-8).The similar abundance in these springs indicates that these habitats are perhaps more uniform than other aquatic features in the ED-1. Habitat variables such as temperature, flow, and dissolved oxygen are probably very similar in these springs.

3.6.4 Protected Species

One of the objectives of this monitoring was to determine if and where protected fish species might occur in streams of Parcel ED-1. These include those species designated as endangered, threatened, or in need of management by either the federal government (FWS) or the State of Tennessee (TDEC). This survey focused on those protected and T&E species reported in the EA (U.S. DOE 1996a).

Target T&E species, current status, regional distribution near ED-1, and preferred habitat are listed in Table 27. Three of the target species are minnows, two are suckers, and the other two are a madtom catfish and a darter. The yellowfin madtom and the spotfin chub are both listed as threatened by the FWS; all other species are state-listed. Likely streams for the spotfin chub, yellowfin madtom, and ashy darter were the lower reaches of BC and the middle sections of EFPC (EFK 3 to 6). The highfin carpsucker and blue sucker both reside in larger rivers during most of the year, but they utilize gravel or cobble riffles in smaller rivers or larger streams to spawn. Thus, the lower sections of EFPC were sampled for these species. The Tennessee dace and the flame chub typically inhabit smaller tributaries or springs; thus, the surveys of such habitats on Parcel ED-1 were aimed in part at these species.

Historically, the blue sucker and highfin carpsucker have been collected in the Clinch River near ED-1, and the flame chub had been collected in BC upstream of ED-1 (Table 27). The Tennessee dace is relatively common on the ORR, and had been found previously on ED-1 (Ryon and Loar 1988). After extensive qualitative and quantitative sampling of the streams and springs on ED-1, no T&E species other than the Tennessee dace were found.

Spotfin chub

Although suitable habitat (large boulders or slab rocks in swift current) was located for the spotfin chub, no specimens were taken. This may be related to the higher turbidity of EFPC than in most streams that contain the chub (Etnier and Starnes 1993). The absence of spotfin chub from EFPC reflects the trend for a continual decline in its distribution in Tennessee.

Flame chub

Some of the springs and spring-fed streams on Parcel ED-1 appeared suitable for the flame chub, but a population was not located. The flame chub is sporadically distributed in the ridge and valley and is slowly disappearing from east Tennessee. The historic (a 1930's sample) population in BC was probably extirpated during construction or peak operations of the Y-12 Plant, which is located on the headwaters of BC.

Blue sucker and highfin carpsucker

The blue sucker and highfin carpsucker species were not located in repeated samples of EFPC. Given its general rarity in Tennessee, the possibility is remote that the blue sucker would be found in the ED-1 area. The combined effects of the impoundment and increased siltation in

Table 27. Status, regional distribution, habitat use and occurrence near Parcel ED-1 of protected fish species that were targeted for ED-1 surveys during 1997.

Species	Status[a]	Regional distribution[b]	Potential habitat used in ED-1	Documented near ED-1 area
Spotfin chub (*Cyprinella monacha*)	E-TN T-US	Emory River; Whites Creek in Roane County	Swift current - boulders (adults) or moderate current-gravel (juveniles)	No
Flame chub (*Hemitremia flammea*)	IM-TN	Tennessee River	Springs and spring runs with vegetation	Record from 1941 in Bear Creek (BC)[c]
Tennessee dace (*Phoxinus tennesseenesis*)	IM-TN	Small tributaries of upper Tennessee River	Pools in small to medium woodland streams	Widespread in BC and East Fork Poplar Creek tributaries
Highfin carpsucker (*Carpiodes velifer*)	IM-TN	Clinch River	Gravel areas in larger streams (spawning)	Clinch River[d]
Blue sucker (*Cycleptus elongatus*)	T-TN	Clinch River	Bedrock and cobble at 1-2 m depth and flows of 1.8 m/sec (spawning)	Clinch River prior to Melton Hill Reservoir[d]
Yellowfin madtom (*Noturus flavipinnis*)	E-TN T-US	Upper Tennessee and Clinch Rivers	Pools with brush, leaf piles, bedrock crevices, or water willow	No
Ashy darter (*Etheostoma cinereum*)	IM-TN	Emory River; Little River	Slab boulders, water willow, slow current, but relatively silt free areas	No

[a]Protected status includes Endangered (E), Threatened (T) and In Need of Management (IM) as determined by state (TN) or federal (US) agencies.
[b]Regional distribution indicates the closest areas to ED-1 where the species has been found (Etnier and Starnes 1993).
[c]Etnier (1978).
[d]Fitz (1968).

the Tennessee River system has greatly reduced the state distribution and abundance of this once common species (Etnier and Starnes 1993). However, the highfin carpsucker would be much more likely to be found in the EFPC within ED-1, as it uses riffles for spawning activity. The spring quantitative sample at EFK 2.3 contained large numbers of the closely related quillback and river carpsucker, with many individuals in spawning condition. Although it was not found in these surveys, the highfin carpsucker could be present in ED-1 streams. It persists in the Clinch River and is thought to be increasing in the overall Tennessee River drainage (Etnier and Starnes 1993).

Yellowfin madtom

The yellowfin madtom is a variable species that inhabits streams ranging from small clear mountain trout streams to larger, slower, warmer siltier valley rivers. Although it occupies a variety of aquatic systems, the yellowfin madtom can be quite sensitive to chemical disturbances, like most of the madtom species. Appropriate micro-habitats (Table 27) were searched by electrofishing and seining, with no success. The general decline of this species throughout Tennessee (Etnier and Starnes 1993) suggests that it is probably not present in ED-1 streams.

Ashy darter

The ashy darter occupies shallow habitat with slow currents, minimal silt, slab rocks, and vegetative cover, which was not present in Parcel ED-1 streams. In the streams studied, shallow areas with suitable rock or vegetative cover contained significant amounts of silt. The absence of silt-free pools is a primary reason for the decline of this species in Tennessee streams (Etnier and Starnes 1993). Thus, the ashy darter is probably not present in ED-1 streams.

Tennessee dace

During this survey, the Tennessee dace was found in three aquatic habitats on Parcel ED-1 (Table 25, Appendix D, Tables D-7 and D-8). It was previously reported in smaller, southern tributaries to EFPC (Ryon and Loar 1988), and its presence was confirmed by this survey, as specimens were collected in Dace Branch, Frog Branch, and Walden Spring. The dace is also widely distributed in upper BC (Southworth et al. 1992 and Hinzman et al. 1996) and may occasionally occur in the BC on ED-1. Dace have been found in previous quantitative samples of EFK 6.3 and EFK 10.0 during monitoring for the Y-12 Plant BMAP (M. G. Ryon, unpublished data). Such transitory use of lower EFPC may occur as individuals migrate between smaller tributaries.

The dace's preferred habitat is pools in small to medium woodland streams. Normally, dace are distributed through the stream during most of the year at low to medium densities (Appendix D, Tables D-2 through D-5). However, in the spring. the species forms spawning aggregations and concentrates in suitable gravel riffles and runs to spawn over creek chub and central stoneroller nests (Schilling and Ryon 1993). For reproduction to be successful, small streams must not have barriers such as weirs, small dams or culverts with significant drops in stream elevation, as they prevent the migration necessary to form suitable spawning aggregations.

The dace is also sensitive to siltation, particularly during the spawning season, therefore, buffer zones should be established along stream channels and access should be maintained throughout the streams. With the implementation of these measures, the existing population of Tennessee dace on Parcel ED-1 can be successfully managed.

Evaluation of Habitat for Protected Species

As part of the survey for protected species, habitat surveys were made in lower EFPC focusing on riffles thought suitable for spawning activities of sucker species. Some effort was also made to quantify boulder or slab rock frequency in areas suitable for the spotfin chub. The data on dominant substrate types indicate different riffle types depending on stream location (Appendix D, Table D-9). At the downstream end of EFPC, near EFK 2.3, the riffles were predominantly gravel (47-63%) and cobble (15-25%), with some woody debris. Further upstream, at EFK 5.1, the riffles shifted to more cobble (61%) and small boulder (14%), with one small riffle being dominated by bedrock (45%). At the most upstream section of EFPC, near EFK 6.3, the riffles continued to be dominated by cobble (37-68%), but had more variety in the substrates, with small boulder (13-25%), gravel (8-14%), large boulder (14%), rough bedrock (13-16%), and woody debris (13%) being important components, depending on the individual riffle. Certainly the gravel and cobble substrates would be appropriate for sucker spawning, including the highfin carpsucker. The presence of substantial amounts of small and large boulders would suggest that some habitat is present for the spotfin chub, although it may not be extensive enough to support a population.

Flow data from Parcel ED-1 riffles indicate that the mean flow for most riffles was very comparable, ranging from 0.19 m/sec to 0.24 m/sec (Appendix D, Table D-10). One riffle, the most downstream riffle at EFK 2.3, had significantly greater flow rates, with a mean flow of 0.30 m/sec. The maximum flow rates for the riffles ranged from 0.46 m/sec to 0.88 m/sec. The fastest flow occurred at EFK 6.3. Depths were also similar for most riffles, with means ranging from 22 cm to 47 cm and maximum depths of 46 to 84 cm. When compared to published values for blue sucker (Table 27), these depths and flows are insufficient to accommodate spawning. Data on appropriate depths and flow for spawning in the highfin carpsucker were not available; preferred depths for the similar quillback species were as low as 15 cm (Becker 1983). As indicated by several publications (Becker 1983; Etnier and Starnes 1993) the highfin and other related carpsuckers utilize small streams for spawning, such as EFPC, and it appears the range of flows, depths, and types of substrate would be appropriate for spawning. For the spotfin chub, flow and depth appear to be satisfactory for habitation by adults, but perhaps insufficient for spawning (Jenkins and Burkhead 1994).

Statistical comparisons of the embeddedness and flow data indicate that there is some variation between riffles within Parcel ED-1. For flow, the most downstream riffle (1) at EFK 2.3 appears to have significantly more flow than riffles 2,3,4, and 7 (Appendix D, Table D-11). For embeddedness, there are significant differences between several riffles, mostly riffles 1, 3 and 6. Riffle 3 seems to have the least embedded substrate, which is probably a function of the types of substrate, cobble and boulder that predominated in it. The fact that no embeddedness less than 5%

was found in EFPC riffles within ED-1 indicates that siltation is quite common in this area.

3.6.5 Discussion

Data from fish community monitoring of streams on Parcel ED-1 portray a diverse assemblage of species with some unique inhabitants. Species richness, community composition, and abundance data indicate previous adverse impacts, as evidenced by the presence of fewer sensitive species and more tolerant species when compared to reference streams. Despite a general weakness in quality of species richness, high biomass and occasionally high densities in ED-1 streams suggest that the existing fish communities are in generally good condition.

Monitoring of upstream sites in EFPC has shown a pattern of recovery—there has been greater species richness and colonization by more sensitive species over the last decade (Ryon 1993c; M. G. Ryon, unpublished data). Some of the sensitive species that have only recently been collected in the EFPC system, include the redline darter, greenside darter, and bigeye chub. These species were also represented in this survey at many of the larger sites in BC and EFPC, suggesting that the recovery occurring at upstream EFPC locations is also occurring in the streams within ED-1. The utilization of lower EFPC by fish species from larger streams indicates that EFPC continues to function as an interface between smaller upstream habitat and altered, impounded sections of the Clinch River, further reinforcing the value of EFPC within ED-1. However, the absence of extremely sensitive species (i.e., protected and T&E species) suggests the upper limit of recovery in EFPC, including that portion of the stream within Parcel ED-1, may not soon be a return to pre-development communities. With adequate planning and mitigation during the construction and operation of industrial facilities on ED-1 and the continued improvement of Y-12 operations, a return to conditions represented by reference stream sites (those having moderate impact related to agricultural and urbanization) may be achievable. Under such conditions, utilization of riffles for spawning by the highfin carpsucker may also occur. Nevertheless, EFPC may continue to be impacted by continued urbanization of Oak Ridge, which is beyond DOE control.

The smaller streams and unique spring habitats on ED-1 are also quite diverse and robust for their size. Species richness, abundance, and biomass data support the conclusion that these habitats are at least average in overall condition. The presence of the Tennessee dace in several of these habitats suggest that conditions remain favorable for some sensitive species. The continued success of healthy fish communities in these smaller aquatic features is largely dependent on adequate protection during development of Parcel ED-1. Sufficient buffers must be maintained to prevent excessive runoff and stream sedimentation and a reduction in forest canopy, which would result in elevated stream temperatures and/or increased algal growth. Data collected in this survey should be used as a baseline for monitoring the effects of industrial development on ED-1.

3.7 STREAM MACROINVERTEBRATES (J. G. Smith, ORNL)

The objectives of the stream benthic macroinvertebrate study were to: (1) characterize the benthic macroinvertebrate communities of EFPC, BC, and Dace Branch within Parcel ED-1 prior to development of the site, and (2) confirm the presence/absence of federally and/or state listed T&E aquatic invertebrates in streams on Parcel ED-1. Currently, listed species that could potentially occur on or near the ORR include seven species of mussels and one snail species that is listed by FWS as one of "special concern" (Table 28).

Benthic macroinvertebrates are those organisms lacking spinal columns that are large enough to be seen without the aid of magnification and that live on or among the substrate particles of flowing and non-flowing bodies of water. The limited mobility and relatively long life spans (a few months to more than a year) of most taxa make them ideal for use in following long-term ecological trends associated with natural or unnatural changes in the environment (Platts et al. 1983). Thus, the composition and structure of the benthic macroinvertebrate community reflects the relatively recent past and can be considerably more informative than methods that rely solely on water quality analyses.

3.7.1 Study Area

Benthic macroinvertebrate communities in three streams on Parcel ED-1 (Figure 11) and several off-site reference streams (Figure 12) were surveyed. Two sites were sampled in EFPC: one approximately 100 m downstream of the mouth of BC (EFK 2.3), and one approximately 5.1 km upstream of the mouth of EFPC (EFK 5.1). A third site on EFPC, upstream of Parcel ED-1 and about 13.8 km from the mouth of the stream (EFK 13.8), served as an upstream reference site; EFK 13.8 has been found to be only slightly impaired compared to nearby reference streams (Smith and Dickinson 1996). Brushy Fork, off the ORR just north of the City of Oak Ridge, was used as an offsite reference stream for EFPC. One survey site on BC was located approximately 120 m upstream of the mouth of the stream (BCK 0.1). A second survey site on BC, located at KM 3.3 from the mouth of the stream (BCK 3.3), was sampled concurrently and served as an upstream reference. Past studies of the macroinvertebrate community at BCK 3.3 have shown no detectable evidence of impact (Cada et al. 1996). A single site on Dace Branch was also sampled. This small tributary stream flows into EFPC about 0.5 km upstream of the mouth of BC; the site sample was located at KM 0.3 from the mouth of the stream (DBK 0.3). A single site on nearby Mitchell Branch, located just east of the former DOE Oak Ridge Gaseous Diffusion Plant (now called East Tennessee Technology Park), served as an off-site (i.e., off of the parcel) reference for Dace Branch. This site was used as a reference rather than an upstream location on Dace Branch because it was similar in size, had similar substrate characteristics, and has a long-term, historical

Table 28. Aquatic invertebrates listed as threatened or endangered by the U.S. Fish and Wildlife Service and the State of Tennessee that could occur on the Department of Energy's Oak Ridge Reservation.[a]

Species	Common Name	State Status	Federal Status
Epioblasma torulosa gubernaculum	Green-blossom pearly mussel	Endangered	Endangered
Fusconaia cor	Shiny pigtoe	Endangered	Endangered
Fusconaia cuneolus	Fine-rayed pigtoe pearly mussel	Endangered	Endangered
Lampsilis orbiculata orbiculata	Pink mucket pearly mussel	Endangered	Endangered
Lampsilis virescens	Alabama lamp pearly mussel	Endangered	Endangered
Quadrula cylindrica strigillata[b]	Rough rabbitsfoot	-	Endangered
Villosa perpurpurea[b]	Purple bean	Endangered	Endangered
Io fluvialis	Spiny riversnail	-	Special Concern

[a]Source: Burch 1973; Cummings and Mayer 1992; Fuller 1985; Parmalee 1967; Saylor et al. 1990; L. A. Barclay, U. S. Fish and Wildlife Service, Cookeville, TN, personal communication to R. L. Kroodsma, ORNL, Oak Ridge, TN, June 13, 1990.

[b]Species thought to be extirpated from lower Clinch River by reservoirs (Rodgers 1996).

data set available that provides information on the range of natural variation in small streams on the ORR (Smith 1995).

The focus of the macroinvertebrate T&E survey was primarily on the two largest streams that flow through Parcel ED-1: EFPC and BC (Figure 11). Species of aquatic invertebrates currently listed as T&E or of special concern were not anticipated to occur in streams any smaller than these two streams since these and similar taxa generally inhabit only medium to large bodies of flowing water (Burch 1982; McMahon 1991). However, short reaches (≈100 m to 300 m in length) of the downstream most portions of two of the largest tributaries to EFPC (other than BC) were also surveyed. These small streams included Dace Branch, located about 100 m upstream of the mouth of BC, and Lambert Tributary (formerly unnamed), located approximately 500 m downstream of Hwy. 58 on the far east end of Parcel ED-1.

Those portions of BC and EFPC that are located on Parcel ED-1 were surveyed in their entirety. The survey of BC included that portion of the stream from its confluence with EFPC upstream to the point where the stream flows under Hwy. 58 in a culvert. The survey of EFPC included that portion of the stream from its confluence with PC upstream to Hwy. 58. Brushy Fork, located just north of the Oak Ridge city limits, served as a reference stream and was surveyed as well. The survey of Brushy Fork included a reach of approximately 400 m beginning at a point located about 7.3 km upstream of the stream's confluence with PC near Oliver Springs, Tennessee. This stream is known to have several species of snails and bivalves (Smith and Tolbert 1993), and was therefore considered a good control to ensure that the survey techniques were effective.

3.7.2 Materials and Methods

For the quantitative macroinvertebrate sampling, two different sampling devices were used to collect samples during two different periods (October 1996 and April 1997). This was done to provide continuity with sampling protocols followed in studies that have been ongoing at the reference locations for over 10 years (Cada et al. 1996; Smith 1995). During each sampling period, a Surber sampler (0.093 m^2 or 1 ft^2) equipped with a 363-µm mesh net was used to collect samples in triplicate from BC, Dace Branch, and Mitchell Branch. In EFPC and Brushy Fork, five random samples were collected with a Hess stream bottom sampler (0.086 m^2) fitted with a 363-µm mesh net. Samples were collected from riffles only, because this habitat often has the greatest variety of benthic organisms (e.g., Hynes 1970; Platts et al. 1983), and limiting collections to a single type of habitat reduces inter-sample variability (e.g., Plafkin et al. 1989; Resh and McElravy 1993). Samples were placed in pre-labeled, polyurethane-coated, glass jars and preserved with 95% ethyl alcohol. To avoid sample decomposition caused by dilution of the original preservative, the ethanol in each jar was replaced within seven days of collection.

Just before sample collection, water depth, location within the riffle (distance from permanent head-stakes on the stream bank), visual estimate of the relative current velocity (very

slow, slow, moderate, or fast), and substrate types (visual estimate) based on a modified Wentworth particle size scale (Loar et al. 1985), were recorded for each sample. During the April 1997 collection period, dissolved oxygen, conductivity, and temperature were measured with a YSI Model 85 meter. A detailed description of the procedures employed for site evaluation and sample collection, storage, and maintenance can be found in Smith and Smith (1995). The outcome of these measurements can be found on the field data sheets included in Appendix E. Raw data are also presented in tabular form in Appendix E.

In the laboratory, each sample was first placed in a U.S. Standard No. 60-mesh (250-μm openings) sieve and rinsed with tap water. Small aliquots of a sample were then placed in a white tray partially filled with water, and the organisms were removed from the sample debris with forceps. This process was repeated with the remaining sample material until it was entirely sorted. Organisms were identified to the lowest practical taxon and enumerated. Details of laboratory sample processing procedures are available in Smith and Smith (1995).

Data were managed, and all descriptive statistics were calculated, using Statistical Analysis System software and procedures (SAS 1985a, 1985b). A copy of the raw data are presented in Appendix E.

The survey for T&E species was conducted between June 23, 1997 and July 9, 1997. The survey was limited to visual, qualitative searches, and was restricted to mollusks (bivalves and snails) since no other groups of aquatic invertebrates are listed by the state or federal government as threatened or endangered. The surveys were made by two individuals walking in an upstream direction so that disturbed sediments flowed downstream without impairing clarity of the water in front of the surveyors. In lower EFPC, where the water was too deep to wade, the surveyors walked on the bank along the edge of the stream. For surveys of bivalves, the primary focus was on the shallow riffles and runs where the bottom of the stream could be seen and which is generally the preferred habitat type (McMahon 1991); midden piles left by muskrats or racoons on exposed structures (e.g., banks, logs, large roots) along the shore; and deposits of gravels along the waters edge. Surveys for snails were restricted to shallow riffles and stable structures in the water along the shore (e.g., boulders, bedrock, logs). Whenever bivalve shells other than those of the common, exotic Asiatic clam (*Corbicula fluminea*) and fingernail clams (Sphaeriidae) were observed, an area of the stream bottom of approximately 3 m^2 within the vicinity of the observed shells and the next riffle/run upstream was gently disturbed by foot to a depth of approximately 3-5 cm, and then visually examined for additional shells and live specimens. Specimens of bivalves were submitted to Steve Ahlstedt, U.S. Geological Survey, Knoxville, Tennessee, for taxonomic identification.

3.7.3 Quantitative Survey Results

A taxonomic checklist of the benthic macroinvertebrates collected from streams on Parcel ED-1 and the associated reference streams is presented in Appendix E. Most major taxonomic

groups typically found in streams were represented in collections at all sites on Parcel ED-1 and at reference sites. Included at most sites was a mixture of taxa generally considered as tolerant [e.g., oligochaetes (worms) and true midges (Chironomidae)] or intolerant [e.g., mayflies(Ephemeroptera) and stoneflies (Plecoptera)] of poor water quality. The only site where stoneflies were not collected was EFK 5.1. Another notable observation was that at least two times more stonefly taxa were collected from BCK 3.3, BCK 0.1, DBK 0.3, and MIK 1.43 than at the EFPC and Brushy Fork sites.

The fewest number of taxa, 42, were collected from EFK 5.1 and EFK 2.3, which was 12 less than at either of the EFPC reference sites (BFK 7.6 and EFK 13.8). The most taxa were collected from MIK 1.43 (73), DBK 0.3 (70), and BCK 3.3 (69); the total number of taxa collected from BCK 0.1 (49) was comparable to the total numbers collected from the EFPC sites and Brushy Fork.

Densities of invertebrates at EFK 2.3, EFK 5.1, and BFK 7.6 were similar during both the October and April sampling periods, with average values ranging from 228 individuals/0.1 m^2 to 500 individuals/0.1 m^2 (Figure 13). During the October sampling period, the density at EFK 13.8, the upstream reference site on EFPC, was only slightly higher than at the two EFPC sites on Parcel ED-1, but in April, the density at EFK 13.8 was at least six times higher. Densities of invertebrates at BCK 0.1 and BCK 3.3 were similar during the October sampling period, while during the April sampling period, the density of invertebrates at BCK 3.3 was almost twice that of BCK 0.1. At Dace Branch (DBK 0.3) in October, the total density was almost two times higher than at the reference site on Mitchell Branch (MIK 1.43). However, in April, the density at Dace Branch was only slightly higher than at Mitchell Branch.

In October, the Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (EPT taxa) accounted for more than 10% of the total density at all Parcel ED-1 and reference sites (Figure 14). In April, the EPT taxa accounted for more than 30% of the total density at all but the EFPC sites, where they accounted for only 2.5% or less. The chironomids were also consistently one of the most abundant groups across all sites and sampling dates. This group comprised over 10% of the total density at all sites during each sampling period, except BFK 7.6 in October and April and EFK 5.1 in October. The oligochaetes contributed considerably to the total densities at the three EFPC sites during the April sampling period when they accounted for >37% at all three sites. In contrast, the relative abundances of the oligochaetes at the other sites were no greater than 8.5% in either sampling period. Other taxa accounting for over 10% of the total density at some sites included the beetle (Coleoptera), *Optioservus,* at Brushy Fork (>40% in both sampling periods) and Dace Branch (>10% in both sampling periods); the Asiatic clam, *Corbicula fluminea,* at Brushy Fork in October (19.2%) and April (10.2%), at

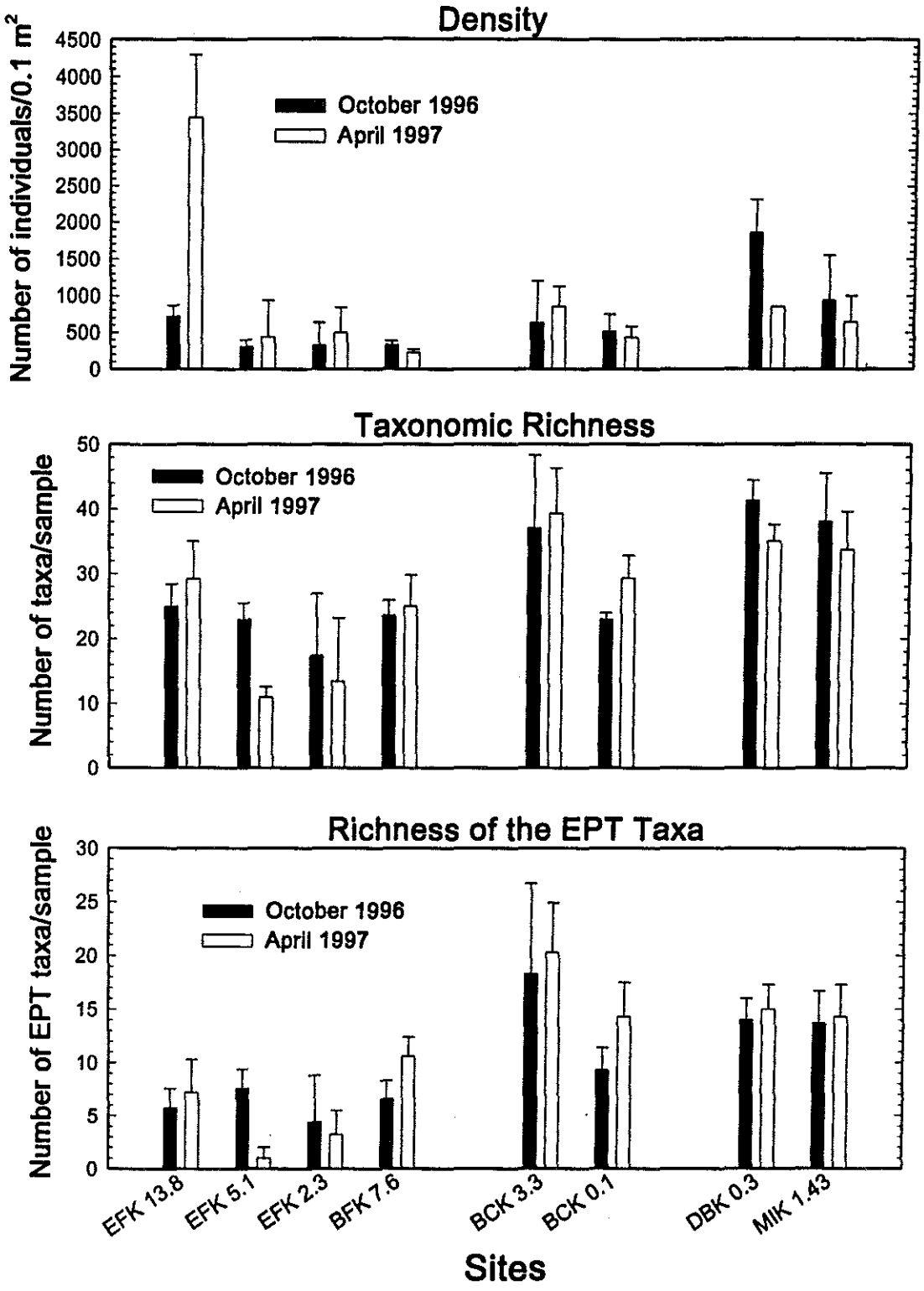

Figure 13. Mean desnity, taxonomic richness, and richness of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) of stream benthic macroinvertebrate communities in Parcel ED-1 and associated reference sites

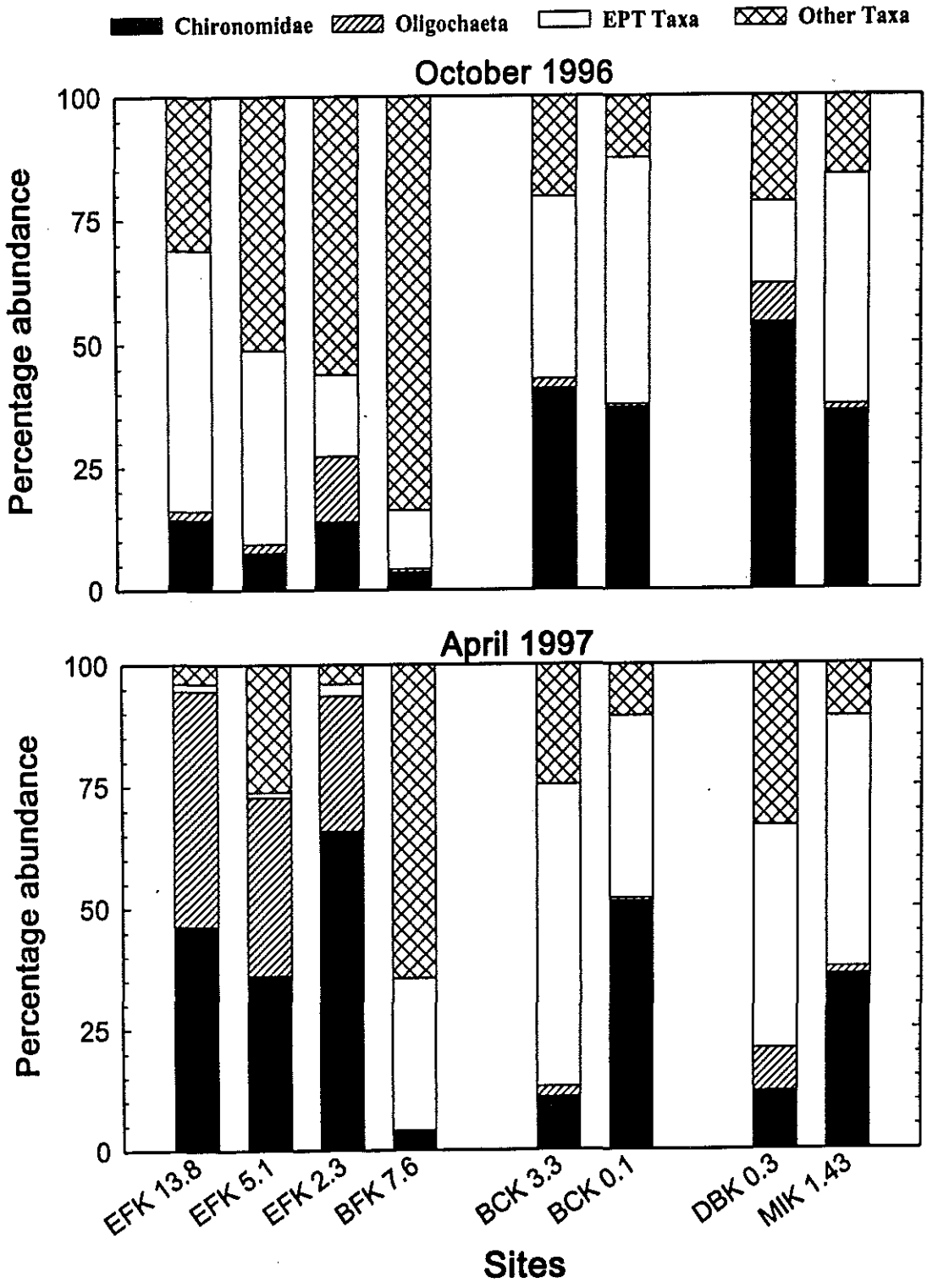

Figure 14. Mean percentage abundance (percent of total density) of selected benthic macroinvertebrate taxonomic groups in Parcel ED-1 and reference streams

EFK 5.1 in October (25.7 %) and April (12.5 %), and EFK 2.3 in October (26.4 %); the snail, *Pleurocera,* at EFK 5.1 in October (10.6 %); and the Nemertea (proboscis worms) at EFK 2.3 in October (15.1%).

During the October sampling period, mean total taxonomic richness (i.e., mean number of taxa/sample) among the EFPC sites and Brushy Fork differed by less than a factor of 2× (Figure 13). During the April sampling period, however, total richness was approximately 2× higher at EFK 13.8 and BFK 7.6 than at either EFK 2.3 or EFK 5.1. Although the difference between BCK 3.3 and BCK 0.1 in total richness was < 2×, total richness at BCK 3.3 still exceeded richness at BCK 0.1 by ≥10 taxa/sample during both sampling periods. The average values for total richness at DBK 0.3 and MIK 1.43 were generally comparable during both sampling periods, differing by no more than 6 taxa/sample in either period. Richness at Dace Branch and Mitchell Branch was also comparable to richness at BCK 3.3.

Values for EPT richness (i.e., number of Ephemeroptera, Plecoptera, and Trichoptera taxa/sample) were low at the two EFPC sites on Parcel ED-1 compared to reference values except in October at EFK 5.1 (Figure 13). EPT richness at EFK 5.1 exceeded 5 EPT taxa/sample in October only, while at the reference sites, EPT richness averaged ≈6 EPT taxa/sample or more. At the other four study sites, in contrast, the average number of EPT taxa/sample exceeded 13 during both sampling periods except for October at BCK 0.1 when EPT richness averaged 9.3 taxa/sample.

3.7.4 Protected Species

A list of the protected taxa collected from Parcel ED-1 and Brushy Fork is presented in Table 29. This list includes only mollusks because no other taxonomic groups are currently listed as threatened or endangered by the state or federal government. No mollusks were observed in either Dace Branch or Lambert Tributary. The shells of two listed species of bivalves were found during the surveys: *Fusconaia cor* in EFPC and *Villosa perpurpurea* in Brushy Fork. The outer layer of the shell of the collected specimens was heavily eroded, and the inner layer (i.e., nacre) was extensively "chalky", thus, indicating that they had been dead for an extended period of time (Steve Ahlstedt, U.S.Geological Survey, Knoxville, Tennessee, personal communication, August 18, 1997). Excessive outer-shell erosion and inner-shell chalking was also observed on all other specimens of unionid bivalves (see Table 29) collected from EFPC and BC indicating that they too had been dead for an extended period. In BC, live specimens of both *Corbicula fluminea* (very common) and *Sphaerium* (rare) were found throughout the reach surveyed, while in EFPC, only live specimens of *C. fluminea* (very common) were found. In Brushy Fork, only live specimens of *C. fluminea* (very common) and *Sphaerium* (rare to common) were found, but several "fresh" (i.e., those that had recently been alive) specimens of *V. iris* were found in numerous midden piles; these appeared to be fresh as indicated by the absence of extensive

Table 29. List of aquatic mollusks collected from streams on Parcel ED-1 and Brushy Fork, June 23 - July 9, 1997.[a,b]

Taxon	EFPC[c] 1	EFPC[c] 2	EFPC[c] 3	BC	DB	LT	BF
Bivalvia (mussels/clams)							
Corbiculidae							
Corbicula fluminea	A	X	X	X	-	-	X
Sphaeriidae	A	-	-	X	-	-	X
Sphaerium sp.	A	-	-	X	-	-	X
Unionidae							
Actinonaias ligamentina	A	-	X	-	-	-	-
Fusconaia barnesiana	A	X	X	X	-	-	-
Fusconaia cor[d]	A	-	X	-	-	-	-
Fusconaia subrotunda	A	X	-	-	-	-	-
Lampsilis fasciola	A	X	-	-	-	-	-
Ptychobranchus fasciolaris	A	X	-	-	-	-	-
Villosa iris	A	-	X	X	-	-	X
Villosa perpurpurea[d]	A	-	-	-	-	-	X
Villosa vanuxemensis	A	-	X	X	-	-	X
Gastropoda (snails)							
Pleuroceridae							
Elimia sp.	A	X	X	X	-	-	X
Pleurocera sp.	A	X	X	X	-	-	X

[a]An "A" indicates water was too deep to wade and effectively survey in stream, but no specimens were observed along the shore in sediment deposits or middens; "X" indicates presence of live specimen or shell; and "-" indicates the taxon was not collected or observed during the survey.

[b]EFPC = East Fork Poplar Creek; BC = Bear Creek; DB = Dace Branch; LT = Lambert Tributary.

[c]"1" = Reach of EFPC from km 0.0 to km 2.0; "2" = reach of EFPC from km 2.0 to km 5.1; and "3" = reach of EFPC from km 5.1 to Hwy.. 58 bridge.

[d] Shaded entries are listed by the State and Federal Governments as endangered;

erosion of the outer shell and the presence of a shiny, smooth and pink inner nacre.

Neither the shells nor live specimens of the spiny river snail (*Io fulvilis*), a species of snail listed as of "special concern" by the federal government, were found on Parcel ED-1 or in Brushy Fork. This species of snail is thought to have been extirpated from the lower Clinch River due to the presence of reservoirs (Rodgers 1996). Two snails (*Elimia* sp. and *Pleurocera* sp.) with widespread distribution on the ORR were found throughout the area surveyed in BC and Brushy Fork, and irregularly throughout EFPC, particularly upstream of BC; none were observed in Dace Branch or Lambert Tributary. The abundance of these two snails in EFPC appeared to be influenced by water depth and flow, as no snails were observed in approximately the downstream most 2 km of the stream. It is possible that their occurrence is closely related to operations of Watts Bar Reservoir because this reach of stream is the most heavily affected by the reservoir.

3.7.5 Discussion

Compared to its reference site (MIK 1.43), Dace Branch (DBK 0.3) had a taxonomically diverse and healthy macroinvertebrate community. This site consisted of a high proportion of Ephemeroptera, Plecoptera, and Trichoptera (EPT), taxa that are generally intolerant of poor environmental conditions (Lenat 1988). As is typical of other reference streams on and adjacent to the ORR (Cada et al.1996; Smith 1995; Smith 1993; Southworth et al. 1994), the combined densities of these three groups in Dace Branch accounted for >10% of the total density. Similarly, the proportions of chironomids and oligochaetes were also within ranges typical of local reference streams (i.e., <50% and 10% respectively; Smith and Dickinson 1996; Smith 1993; Smith 1995). Large numbers of chironomids and oligochaetes are usually associated with poor environmental conditions (e.g., Wiederholm 1984; Hynes 1970), and in impacted streams on the ORR, these two groups typically account for over 70% of the total density. Finally, the combined richness of the EPT taxa and total taxonomic richness were also well within the ranges typical for similarly sized reference streams on and adjacent to the ORR, with respective values ranging from 6-18 EPT taxa/sample and 20-35 taxa/sample (Cada et al. 1996; Personal communication from L.A. Kszos, ORNL Environmental Sciences Division, to M. M. Stevens and C. K. Valentine, ORNL Environmental Compliance Division, Jan. 31, 1997; Personal communication from L. A. Kszos, ORNL Environmental Sciences Division, to M. M. Stevens and C. K. Valentine, ORNL Environmental Compliance Division, July 31, 1997; Peterson, M. J., ORNL Environmental Sciences Division, to M. L. Coffey, ORNL Environmental Management Division, Jul. 31, 1995).

As observed in Dace Branch, the proportion of EPT taxa at BCK 0.1 was comparable to BCK 3.3 and other reference locations on and adjacent to the ORR (i.e., > 10%; Cada et al. 1996; Smith and Dickinson 1996). However, total and EPT richness values were notably lower at BCK 0.1 than at BCK 3.3 during both sampling periods, and EPT richness was at the lower end of the range historically exhibited at BCK 3.3 and typical of other comparably-sized reference streams (i.e., 9-20 EPT taxa/sample; Cada et al. 1996). The reason for the extent of difference between BCK 0.1 and BCK 3.3 is not known. However, in the absence of any known significant human

disturbances between BCK 3.3 and Parcel ED-1 (see Smith and Wojtowicz 1996), the differences are most likely the result of one or more natural factors (e.g., substrate composition, flow, food availability, competition, predation, etc.).

In April, the two EFPC sites showed clear differences from reference sites in the composition and structure of the macroinvertebrate community that were indicative of poor environmental conditions; in October, differences were more subtle. In October, the proportions of the EPT taxa were within the range shown by the reference sites (BFK 7.6 and EFK 13.8), and were within the range typically observed in other reference streams on and near the ORR (Cada et al. 1996; Smith 1993; Smith and Dickinson 1996).Total and EPT richness values at EFK 5.1 were also within the range of reference conditions for similarly sized reference streams (15-35 taxa/sample and 8-13 EPT taxa/sample), but at EFK 2.3, total richness was at the lower end of the normal range and EPT richness was slightly less (Smith and Dickinson 1996). In April, not only were EFK 2.3 and EFK 5.1 numerically dominated by oligochaetes and chironomids, EFK 13.8 was as well. However, total and EPT richness values for EFK 13.8 were within normal range of reference streams, whereas, values from EFK 2.3 and EFK 5.1 fell well below the normal ranges. These results clearly show that the invertebrate communities at EFK 2.3 and EFK 5.1 are impacted, and that some impact exists at EFK 13.8 as well. The presence of extensive urban, rural, and industrial development in the EFPC watershed, and the discharge of treated sewage downstream of EFK 13.8 all likely contribute to the observed impacts. Finally, this study also shows the importance of having more than one sampling period in characterization and monitoring studies. With but one sampling period, the condition of the macroinvertebrate community and a stream can easily be over or under stated.

Although the qualitative survey could not determine the presence or absence of T&E aquatic invertebrates on Parcel ED-1, it was sufficiently thorough enough to provide strong evidence to conclude that if any such species still exist in the stream on the parcel, they are extremely rare. Most likely, most if not all unionid mussels have been extirpated from these streams because of multiple stresses over the last several decades such as the influence of reservoirs, effluent discharges (industrial and sewage), and extensive development (industrial, urban and rural) in the upper and mid-watershed of the streams. It is well documented that this family of bivalves is very sensitive to pollutants such as those associated with industrial effluents, sewage treatment effluents, and sedimentation/siltation associated with construction, agriculture, and stream channelization/alteration (McMahon 1991).

In conclusion, the results of the stream macroinvertebrate surveys in combination with the availability of extensive, historical data sets from these and other reference locations, provide the baseline data needed for future studies for verifying the effectiveness of best management practices associated with industrial development and operations on Parcel ED-1.

3.8 GAME SPECIES (J. W. Webb, ORNL)

The objective of this study was to use data from ongoing surveys conducted by the TWRA to characterize the populations on Parcel ED-1 of three game species specifically noted in the MAP: whitetail deer (*Odocoileus virginianus*), wild turkey (*Meleagris gallopavo*), and wood duck (*Aix sponsa*). The available data allow Parcel ED-1 specific comments for turkey and wood duck, and general area comments for whitetail deer.

3.8.1 Whitetail Deer

Attempts in 1997 to conduct deer census on Parcel ED-1 by spotlighting and pellet counts were unsatisfactory. The assessment of deer population status on Parcel ED-1 is therefore drawn from deer hunt harvest records and records of deer-vehicle collisions (road kills). The current deer population of the ORR is not precisely known, but is probably around 1500, with an average density in suitable habitat of, roughly, 1 deer per 15 acres. On this basis, Parcel ED-1 might be expected to support at least 60 deer.

Harvest data (annual ORR deer hunts) are taken from compartment-level records (compartments are 1-sq-mile units on the administrative grid) for kill location from 1985 through 1993. During this period, the five compartments which include portions of Parcel ED-1 had average harvests of 18 deer per compartment per year, ranging from 13 to 24 per compartment per year. In comparison, all 51 gun-hunted compartments on the ORR averaged 13 deer harvested per compartment per year (median 13), ranging from one to 37 deer harvested per compartment per year. Although these data are confounded somewhat by unknown hunter effort, Parcel ED-1 probably supports a deer population that is probably above average compared to the ORR as a whole. With withdrawal of the area from hunting and creation/maintenance of edge habitat, it appears likely that the population will increase, probably leading to an increase in deer-vehicle collisions.

Records of deer-vehicle collisions on State Highway 95 bordering Parcel ED-1 support this conclusion. Road kills bordering Parcel ED-1 in 1985, when hunts were first instituted, were 16 (6% of total), but dropped steadily in the four following years, averaging 6.5. From 1990 through 1995, road kills have averaged 2.5, about 1.7% of the total. During this period, total road kills of deer on the ORR, including the City of Oak Ridge, ranged from 143 to 165 per year. These data suggest that hunting on Parcel ED-1 has successfully reduced deer-vehicle collisions in the area through population control and that the parcel continues to support a relatively stable population. Cessation of hunting, improved deer habitat conditions, and increased traffic, could alter this apparent balance in the area.

3.8.2 Wild Turkey

Wild turkeys were re-introduced to the ORR in the mid- to late-1980s. From zero population in 1985, numbers have increased to perhaps 1500 in 1997 (estimated) for the entire ORR. Consistent with introduction locations, observations have been concentrated primarily in the southern part of the ORR. Wild turkey were first observed on Parcel ED-1 in 1992. In each year since, hens with poults, lone jakes, and/or lone hens have been observed on Parcel ED-1. Observation numbers (e.g., number of hens with poults and number of poults) have been generally similar to observations elsewhere on the ORR. It appears that Parcel ED-1 consistently supports one or more (up to four) hens with poults. Hunt records from 1997 support this conclusion: 11 turkeys were harvested from compartments which include Parcel ED-1, comprising 12% of the total birds killed (90). The five compartments which include portions of Parcel ED-1 form approximately 10% of the ORR. Thus, Parcel ED-1 currently provides average or better-than-average habitat conditions for wild turkey.

3.8.3 Wood Duck

From 1993 to the present, TWRA (Jim Evans, ORR Wildlife Officer) and ORNL staff and associates (Kelly Roy, Jason Mitchell, Warren Webb) have conducted June canoe surveys for wood duck on lower EFPC, from about 1.25 miles above its confluence with PC (where it parallels Poplar Creek Road on Parcel ED-1) to the PC boat ramp on the west side of the ETTP (K-25) site. Although wood duck recovery has been encouraged elsewhere on the ORR and casual observations are recorded, this is the only systematic survey undertaken.

June canoe surveys from 1993 through 1997 have revealed a pair with young and/or a hen with young (from three to nine young for each observation) on EFPC within Parcel ED-1 in three of the five years. Juveniles, with or without adults, have been observed in four of the five years. Lone drakes and hens have been observed in all 5 years. Taken by year, the numbers are similar to those found on PC below its confluence with EFPC. Thus, it appears that the lower reaches of EFPC provide consistently suitable habitat for at least one or two family groups, which are an important part of wood duck survival on the ORR.

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