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BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER
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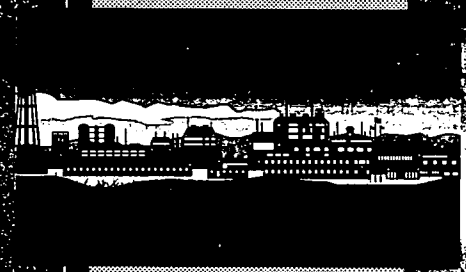

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER

by

C. F. Facemire S. I. Guttman D. R. Osborne R. H. Sperger

DEPARTMENT OF ZOOLOGY
MIAMI UNIVERSITY
OXFORD, OHIO

January 1990

PREPARED UNDER CONTRACT DE-AC05-860R21600

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OAK RIDGE OPERATIONS OFFICE

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EXECUTIVE SUMMARY

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER

June, 1986 - June, 1987

290

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TABLE OF CONTENTS

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERISTICS 1

Herbaceous and Woody Plants 4

Terrestrial Invertebrates 5

Benthic Macroinvertebrates 6

Fish 7

Birds 8

Growth in Doves and Robins 10

Small Mammals 10

Game Mammals and Owls 12

POPULATION GENETICS

Terrestrial Plants 13

Amphibian Tadpoles 14

Benthic Macroinvertebrates and Fish 15

FIGURES 17

290

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EXECUTIVE SUMMARY

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION

This section summarizes field and laboratory studies conducted at the FMPC from June, 1986 through June, 1987. The major items to be accomplished per contract were (1) plan and lay-out permanent transects to be utilized in gathering biological and ecological data, (2) identify aquatic and terrestrial life forms within the environs of the FMPC, (3) prepare a catalog documenting the location and associated habitat of all species found, (4) determine species distribution and abundance, (5) determine the possibility of stress-induced differences between onsite and offsite plant and animal populations using electrophoretic techniques, and (6) interpret the results of the study.

The study area included six major terrestrial habitats within the 425ha of the FMPC site excluding the production area (55ha). The six habitats characterized (Fig. 1) were riparian, deciduous woodlots, pine plantations, reclaimed fly ash pile and grazed and ungrazed pastures. Eleven 600m permanent transects were established for the characterization of terrestrial flora and fauna. Eight onsite sampling stations were established along Paddy's Run (Fig. 2); these were used to quantify fish and benthic communities and to determine possible effects of stress on genetic structure. Offsite populations were used for comparison purposes for several taxonomic groups including benthic macroinvertebrates, fishes, and birds. When used, such

populations were selected on the basis of overall habitat similarity (based primarily upon vegetational and topographic characteristics) to those onsite areas under investigation and (or) the presence of the appropriate taxonomic group(s). Results are discussed with respect to current land use practices, seasonal changes in population or community structure and to other onsite or offsite studies of biotic community structure or environmental stress.

Over 85,000 organisms were tabulated representing the most comprehensive biological site characterization of the FMPC to date. Most were invertebrates (69%), followed by vertebrates (17%) and plants (14%). Appendix A is a seasonal listing of the relative abundance of 601 taxa and includes 190 species of herbaceous plants, 47 species of trees and shrubs, 132 families of terrestrial invertebrates, 47 families of benthic macroinvertebrates, 21 species of fish, 10 species of amphibians and reptiles, 98 species of birds and 8 mammalian species. Appendix B includes a list of incidental sightings of 41 species and Appendix C is an annotated list of terms used throughout this report.

No federally endangered plants or animals were recorded. Cooper's hawks (*Accipiter cooperii*) and the Cincinnati crayfish (*Orconectes sloanii*), listed as threatened in Ohio, were seen frequently in the pine plantations and Paddy's Run, respectively.

Onsite terrestrial plant and animal communities were heavily impacted by current FMPC land management practices.

Most FMPC lands are subject to grazing, mowing, bush-hogging or bulldozing (Fig. 3). These practices cause habitat fragmentation and heterogeneity, as well as the reduction of corridors important in the stabilization of many plant and animal communities. Whereas we know of no other site similar to the FMPC (one where all of these management practices are or have been implemented), the responses noted on the FMPC seem to be those one would expect on a similarly managed site. That is, those areas onsite which are grazed seem to be comparable to offsite grazed areas and so forth. The most severely disturbed terrestrial habitat seemed to be the reclaimed fly ash pile. Relatively undisturbed habitats were restricted to the narrow riparian community along Paddy's Run and to three small isolated woodlots.

Floristic and faunistic community structure were most similar within pastured, pine and riparian habitats and highly variable within woodlots. Most of the FMPC was maintained in early stages of succession by mowing and grazing. Woodlots were heavily encroached by neighboring pastures as evidenced by grasses being the dominant ground cover. Litter (leaves, twigs and branches) replaced vegetation as the dominant ground cover in heavily grazed woodlots. Thus, habitat fragmentation and current land use practices accounted for the relatively high overall terrestrial biotic diversity on the FMPC. The narrow undisturbed riparian habitats consistently ranked highest in diversity for any particular biotic group, and were most similar to mature woodlands expected for southwestern Ohio.

Herbaceous and Woody Plants

Summer herbaceous flora consisted of 98 species representing 38 families. FMPC woodlots contained 32-43% fewer species than offsite woodlots. Compared to comparable sites in southwestern Ohio, several species were either absent or present in very low numbers on the FMPC. These included two fern genera (*Botrychium* and *Asplenium*), an orchid (*Lipria*), tick trefoil (*Desmodium* sp.), and bedstraw (*Galium aparine*). More significant was the rarity or absence of several taxa normally common to disturbed or successional communities including honeysuckle (*Lonicera*), dogbane (*Apocynum*), asters (*Aster* spp.), and the fleabanes (*Eriogeron* spp.). Some of the reductions may have been caused by sampling smaller fragmented habitats and by present and historic land management practices at the FMPC.

Spring flora was more species rich, yet less diverse by habitat type than in summer. One hundred and forty-three species of spring flowering plants were recorded; 70 had not previously been reported onsite, and 12, including fringed brome grass (*Bromus ciliatus*), dwarf cinquefoil (*Potentilla canadensis*), blue lettuce (*Lactuca biennis*), broom sedge (*Carex scoparia*), and beggar-ticks (*Bidens vulgata*), had not been documented nearby offsite. Most of these are characteristic of disturbed communities. Ten species, common in offsite woodlots, representing six important plant families, were in extremely low abundance or were missing (e.g., squirrel-corn (*Dicentra canadensis*), and Dutchman's breeches (*D. cucullaria*)).

Thirty-four species of trees were found on the FMPC; 16 (47%) were present as saplings. Each wooded habitat was dominated by a set of different species. The two pine plantations were most similar to each other; the reclaimed fly ash pile was least similar to other FMPC wooded habitats. Riparian habitats lacked the large sycamores, silver maples and cottonwoods typical of a mature riparian system in southwestern Ohio. All of the woodlots were in various successional stages, had high shrub and tree densities, but lacked the large dominant species typical of mature woodlots (e.g., American beech was not recorded and trees seldom averaged over 20 m in height). Several tree and shrub species expected to be found onsite were absent. Perhaps the most notable of these were American beech (*Fagus grandifolia*), alianthus (*Alianthus alianthus*), American hornbeam (*Carpinus caroliniana*), hop hornbeam (*Ostrya virginiana*), mulberries (*Morus rubra* and *M. alba*), tulip tree (*Liriodendron tulipifera*), pawpaw (*Asimina triloba*), and spicebush (*Ledera benzoin*).

Terrestrial Invertebrates

Nearly 24,000 terrestrial invertebrates, representing 127 families and 15 orders, were collected and identified. Plant-eating insects and flies (Diptera) were the most prevalent groups within the habitats studied. Dominant forms included the grasshoppers, leafhoppers and a variety of dipteran families. Relative insect densities were highest for the pastures and lowest for the woodlots. Most invertebrate groups were

represented by only a few individuals, and, even in the pastures, varied considerably within and between habitat types. For example, two habitats with herbaceous plant communities very similar to one another (GP1 and UGP; Coefficient of Similarity=0.705), were least similar when comparing insect communities ($X^2_{(a=0.05,\ df=11)}=1927.78$, $p<0.005$; analysis based upon number of individuals per family).

Two families of springtails (Entomobriadae and Sminthuridae: Collembola; small insects which inhabit leaf litter), did not co-exist within the same habitat. Spiders were abundant in the reclaimed fly ash pile and riparian habitats; snails were present only in the deciduous wooded communities. Terrestrial invertebrate patterns on the FMPC seemed to be related to the degree of pasturing and habitat isolation.

Benthic Macroinvertebrates

Sampling of the benthic macroinvertebrate community present in Paddy's Run during November and December, 1986 and again during February, 1987 revealed a relatively rich benthic fauna within the stream. Representatives of some 53 families were identified. Species richness was always greatest at PR1, the site upstream of FMPC input, and least at PR5, located downstream of the waste-pit area.

During the fall of 1986, the non-biting midges (Family Chironomidae) were most numerous at PR8 (~3,000 individuals/meter^2). The density was nearly as great at PR3 (~2800 individuals/meter^2). Of those sites sampled in February,

1987, the sediments at PR3 contained the highest number of individuals with a density of nearly 25,000 individuals/meter^2. PR8 was dry in February, 1987, thus no seasonal comparison is possible for this location. Chironomid larvae dominated nearly all samples during both seasons constituting approximately 75% and 98% of all individuals collected at PR8 (Fall, 1986) and PR3 (February, 1987), respectively. Other studies (Winner et al. 1975, 1980; Sheehan 1980) have shown increased numbers of chironomids in relation to other taxa within the community to be highly correlated with environmental stress.

Shannon-Weiner diversity indices based upon the February, 1987 collection were noticeably depressed primarily due to the preponderance of non-biting midges. For this reason, future monitoring efforts would probably yield more consistent results if carried out later in the spring after emergence of most of the chironomids.

Qualitative sampling at various locations within the stream revealed the presence of sizeable populations of the Cincinnati crayfish (*Orconectes sloanii*). This species is presently listed as threatened by the State of Ohio.

Fish

Fish communities within Paddy's Run were sampled in June, 1986, March, 1987, and June, 1987. Individuals representing 20 taxa were collected. Only two species, creek chubs (*Semotilus atromaculatus*), and central stoneroller minnows (*Campostoma anomalum*), were common to all sites and sampling dates. Johnny

darters (*Etheostoma nigrum*), and bluntnose minnows (*Pimephales notatus*), were the second-most frequently observed species being absent only from PR9 during March, 1987. It should be noted, however, that PR9 was sampled only at that time as sites PR4 through PR10 and PR6 through PR9 were dry during June, 1986, and June, 1987, respectively. PR9 was also the most depauperate as only four species were collected at that location.

Species richness was usually greater at upstream (above PR3) than at downstream (below PR3) sites. The major exception to this occurred in March, 1987, when species richness was greatest at PR11. Paddy's Run exhibited either greater or lesser species richness and diversity than did Harker's Run, an offsite stream used for comparative purposes, dependent upon the time of sampling. Based upon species richness and diversity data, benthic macroinvertebrate data, and electrophoretic analysis, it is clear that animal communities in Paddy's Run were stressed.

Birds

Eighty-two species of breeding birds were recorded. Species richness and species diversity were highest in the riparian habitats during the summer of 1986. Doves, robins and blue jays occurred most frequently and goldfinches, song sparrows and robins were of greatest density. These and other ground foraging species, typical of early successional communities, dominated the avian community. Eleven species

normally present in similar habitat types were absent from the FMPC. Most of these were insectivores (e.g., common nighthawk).

Permanent residents dominated the 36 species of birds wintering onsite. Species richness was depressed 25-72% from summer to winter depending upon habitat type, but, with species diversity, was highest in the three woodlots (Figure 3); average densities were depressed 70%. Fourteen species that normally over-winter, although in small numbers, in the Cincinnati area were absent from the FMPC. The most notable of these were the white-crowned sparrow (*Zonotrichia leucophrys*), swamp sparrow (*Melospiza georgiana*), fox sparrow (*Passerella iliaca*), field sparrow (*Spizella pusilla*), and cedar waxwing (*Bombycilla cedrorum*). The latter two species were expected as both were present in good numbers during the breeding season. As sufficient habitat was available for these and other expected but missing species, we can only assume that they were absent due to food limitations, climate, or other unknown factors.

Species richness and diversity were higher than expected in the pastured areas; probably due to the presence of trees in most grazed areas and to the nearby presence of woodlots. We can offer no explanation why golden-crowned kinglets (*Regulus calendula*), highly abundant in the northern pine area, were virtually absent in the southern pines.

Twelve migrant species of birds were recorded on the FMPC during the spring of 1987. Because of their transient and sporadic occurrence, avian spring migrants are not recommended for monitoring changes in community structure onsite.

Growth in Doves and Robins

Reproductive success and growth parameters of mourning doves and American robins showed species and site specific differences. Hatching and fledging success of doves was significantly lower in the northern as compared to the southern pines. Nestlings of onsite doves did not differ significantly from offsite nestlings in any of the six growth parameters measured. FMPC robin eggs from the northern pines weighed significantly less than robin eggs from the southern pines and from offsite populations. FMPC robins showed significant suppressed growth in four of the five prefledging growth parameters measured as compared to offsite populations. Species differences in suppressed growth are attributed to differences in diet and to potential differences in onsite physiological stress.

Small Mammals

During the summer of 1986, small mammal (voles, mice, shrews, etc.) populations were sampled from each FMPC habitat type. Several unexpected findings resulted, and the significance of each is discussed hereafter.

Short-tailed shrews (*Blarina brevicauda*), present in 8 of 11 FMPC habitats, occurred in greater density than reported in other Ohio or Indiana studies. The capture rate (2.22 individuals per trap night) on the reclaimed flyash pile (RFAP) was 3 to 10 times that of any other FMPC habitat and 4 to >50

times that reported for offsite populations. As those data in the literature do not pertain to reclaimed flyash piles or pits, no direct comparisons were made. Short-tailed shrews are listed as one of the most common small mammals in Butler County, Ohio, however wooded habitats are generally thought to be optimal for the species.

The prairie deer mouse (*Peromyscus maniculatus bairdii*) is the third most abundant mouse in neighboring Indiana. During 3960 trap-nights (TN) in all habitats at the FMPC during July and August, 1986, no prairie deer mice were captured even though more than 55% of the total area of the FMPC was at least marginally suitable habitat. Nearly 30% of the FMPC (in excess of 108 hectares) was ungrazed or only lightly-grazed grassland, and was considered to be good to prime habitat for the prairie deer mouse. The mowed strips and borders in and around the pine plantations should also support moderate to large numbers of deer mice. Based upon the work of others, we expected as many as 5-7 animals to occur within the area of each trapping grid used, but none were caught on the FMPC. When one considers that 'normal' numbers of white-footed mice (*P. leucopus noveboracensis*) were collected in habitat appropriate for this close relative of the deer mouse, the total absence of the latter species is unexplainable at the present time.

The house mouse (*Mus musculus*), which normally occurs with the white-footed mouse, is the most commonly caught species in Indiana and was reported as being present 'everywhere' in Butler County, Ohio. The best house mouse habitat at the FMPC,

exclusive of buildings, would appear to be the ungrazed pasture and grassy borders surrounding the pine plantations followed by the RFAP. In somewhat similar habitat, a capture rate of 0.67-7.90 animals/100TN would be expected in late summer and early winter, respectively. Thus, we expected house mice to be present at the FMPC in large numbers, but none were captured. Considered in isolation, each of the above observations could be nothing more than sampling error. But when one also considers the absence of prairie voles (*M. ochrogaster*), a common species inhabiting the dry uplands of Butler County, Ohio and woodland voles (*M. pinetorum*), relatively common in neighboring Indiana counties and noted as present in Hamilton and Butler Counties, Ohio, onsite small mammal populations appear to be stressed.

Game Mammals and Owls

The FMPC supported clumped distributions of game animals and owls, and inter- and intrahabitat densities varied considerably, but compared favorably with offsite quail, fox squirrel and deer populations as reported in the literature. FMPC rabbit densities were lower than those noted in the literature for similar habitats.

POPULATION GENETICS

Terrestrial Plants

Two species of plants (*Asclepias syriacus*, common milkweed; *Taraxacum officinale*, dandelion) with different reproductive patterns were selected for analysis of population genetic structure. Milkweeds reproduce sexually while this species of dandelion exists as a triploid utilizing asexual reproduction. Twenty milkweed plants were collected from each of four FMPC sites and an offsite sample was obtained near Oxford, Ohio.

Heterozygosity (having the two genes at corresponding loci on homologous chromosomes different for one or more loci) in a population is one of major methods for maintaining population genetic variability. The observed amount of heterozygosity was lower than expected in all milkweed populations, including the offsite population, surveyed. Heterogeneity tests did not indicate unusual changes in the FMPC samples.

Dandelions were sampled from 13 FMPC sites (20/site) representing four habitat types and an offsite sample was obtained near Oxford, Ohio. Since these plants are triploid asexuals, individuals with the same genetic composition represent members of a single clone. Significant differences were noted among dandelion samples from different habitats reflecting land management effects on population genetic structure. We found many clones at each sample site with the exception of a site near the old incinerator, located near the sewage treatment plant, where 10 of 20 plants were identical;

the population at this site had the lowest observed heterozygosity (8%) of any sampled. Some unknown stressor(s) at this location may be acting as selective agents with the dominant clone being able to survive stress better than other clones.

Amphibian Tadpoles

Two amphibian species (*Bufo americanus*, American toad; *Hyla crucifer*, spring peeper) were found breeding onsite. In May, 1986 we collected 50 toad tadpoles from a pool immediately south of the northern pine plantation and sampled an offsite population from Hueston Woods State Park near Oxford. At the same time, we captured 60 spring peeper tadpoles from an ephemeral pond in the waste pit area; while we were not able to obtain an offsite treefrog sample in 1986, in 1987 we resampled the waste pit pond and also found an offsite site for spring peeper tadpoles near Reily, Ohio. The two toad populations were significantly different at 42% of the variable loci studied; these differences might be attributable to environmental factors or aspects of toad breeding behavior. Toads did not breed in the FMPC pool in spring, 1987.

Spring peeper tadpoles from the waste pit area pond were unique. There was a significant deficiency of heterozygotes at a lactate dehydrogenase locus. A null (inactive) allele was found at the glucose phosphate isomerase (GPI) enzyme locus in significant frequencies (approximately 20%) each year; this allele did not occur in the offsite sample collected

approximately 15 km from the FMPC. Null alleles at this locus have not been reported in other amphibian populations; when they have been found in other organisms they have invariably been lethal in the homozygous condition. Alleles arise due to point mutations. This null allele may have resulted from a mutation occurring in treefrogs found in the waste pit area. If two frogs heterozygous for the null allele mate, and this allele is lethal when homozygous as in humans and *Drosophila*, then 25% of these frogs' offspring will die. Since heterozygous tadpoles hatched each year, the null allele is being propagated. Laboratory experiments are necessary to prove whether the null GPI allele is lethal when homozygous and additional sampling from ponds immediately around the FMPC must occur before the site where the null GPI allele originated can be unequivocally determined. Adult treefrogs live in wooded areas offsite and although they tend to exhibit a fidelity to their natal pond, each generation there is gene flow into adjacent ponds.

Benthic Macroinvertebrates and Fish in Paddy's Run

Investigation of benthic macroinvertebrates and fish in Paddy's Run indicated the existence of at least two locations (between sites 2 and 3; between sites 5 and 11) where stress may be selectively eliminating aquatic life. Significant changes in population genetic structure were evident in both mayflies and fish communities between sites 2 and 3. Differences in habitat or other stream characteristics were not observed over this short distance. In addition, significant alterations in

population genetic structure of mayflies occurred between sites 5 and 11 in Paddy's Run; the exact location(s) of stress remain(s) to be determined for this latter occurrence. Although significant shifts in population structure were not evident in every season, they were present during more than one sampling interval.

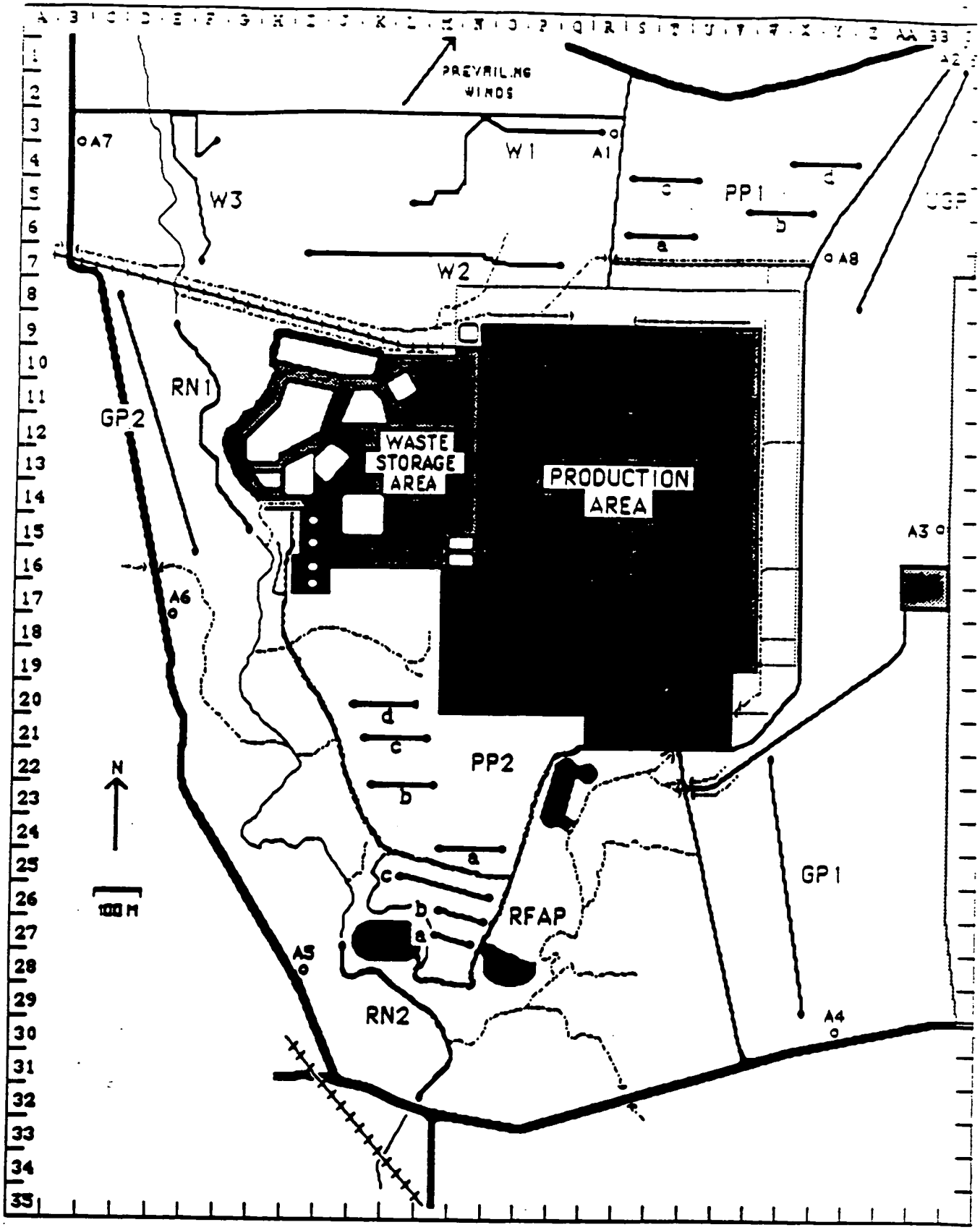

Figure 1. Locations of the permanent transects established and air monitoring stations(A) at the FMPC. UGP=ungrazed pasture; GP=grazed pasture; PP=pine plantation; RFAP=reclaimed fly ash pile; W=woodlot; RN=riparian.

290

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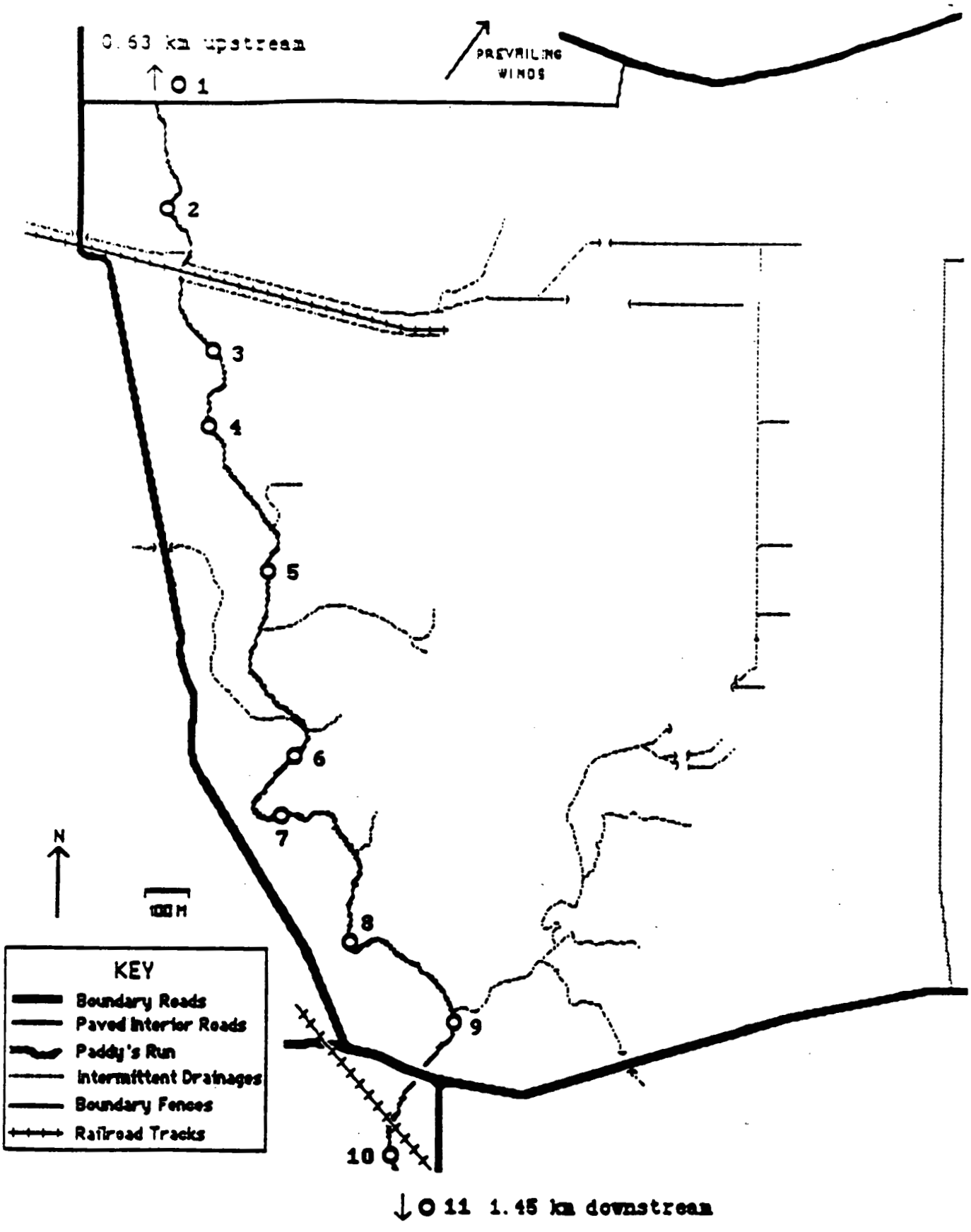

Figure 2. Fish and benthic sampling sites on Paddy's Run.

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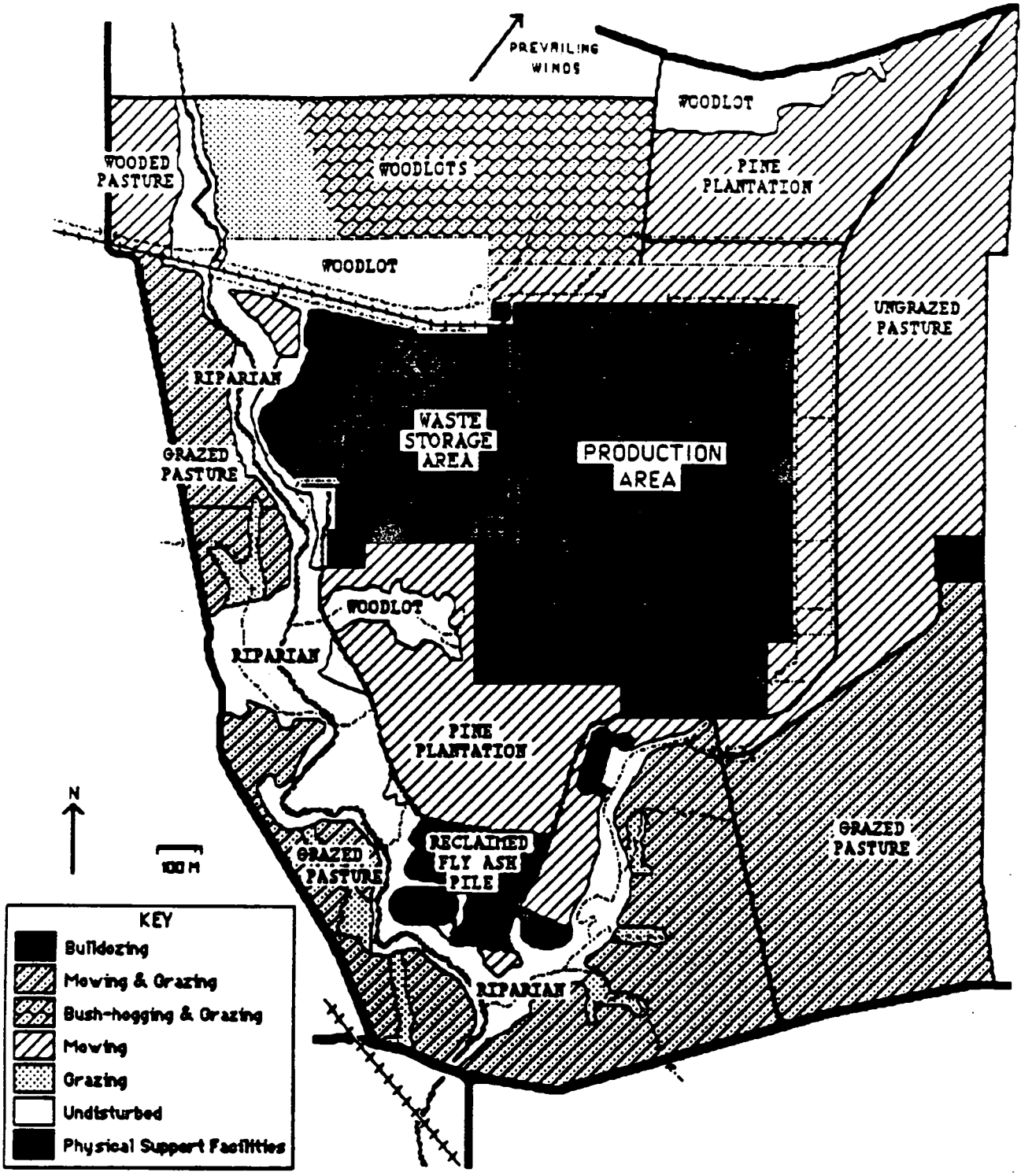

Figure 3. Land management practices on the FMPC.

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SECTION I

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER

June-August, 1986

290

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TABLE OF CONTENTS

RESOURCE PERSONNEL	1
INTRODUCTION	2
STUDY SITE AND HABITATS	4
TRANSECTS	4
FLORA AND FAUNA	5
Herbaceous Vegetation	7
Woody Vegetation	10
Terrestrial Arthropods	20
Fish	27
Amphibians and Reptiles	33
Birds	34
Small Mammals	46
Game Wildlife Populations	52
Threatened and Endangered Species	59
Environmental Population Genetics	60
SUMMARY AND CONCLUSIONS	77
ACKNOWLEDGEMENTS	85
FIGURES	87
TABLES	96

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INTRODUCTION

The purpose of this study was to gather baseline data regarding the environment of the Feed Materials Production Center (FMPC) site. Five major tasks were identified:

(1) Plan and lay-out permanent transects to be utilized in gathering present and future biological and ecological data.

(2) Identify aquatic and terrestrial life forms within the environs of the FMPC.

(3) Determine species distribution, abundance and quality.

(4) Prepare a catalog documenting the location and associated habitat of all species found.

(5) Determine the possibility of stress induced differences between onsite and offsite plant and animal populations using electrophoretic techniques.

Previous baseline studies on the plants and animals at the FMPC site are not adequate for the analysis of long-term trends. The only study known relating to the area prior to the beginning of FMPC operations is that of Tarzwell (1952) which provided a census of fish and benthic organisms in Paddy's Run, and fish in the Great Miami River upstream and downstream of the FMPC effluent outfall. More recently, Bauer et al. (1978) compared fish populations between Paddy's Run and Dry Fork Creek, a tributary of the Whitewater River. Unfortunately the ecological reports of Pomeroy et al. (1977) and Battelle Laboratories (1981) are deficient in field data. They included extensive lists of flora and fauna which were expected to be on site

because of their occurrence in published county, state, or regional lists. Field work on terrestrial plants and animals were limited to casual or cursory observations. With the exception of Tarzwell (1952), none of these studies used standardized sampling techniques for determining population and community structure. Hence, despite the voluminous reports previously submitted to FMPC, actually very little is known about the flora and fauna on site, particularly with respect to the terrestrial communities.

This report summarizes preliminary field and laboratory studies conducted from mid-June through August, 1986. It includes the identification of 6 major habitats, the establishment of permanent line transects for sampling of terrestrial communities within these habitats, and sampling protocols for fish communities in Paddy's Run. Community structure is characterized for the following: (1) herbaceous vegetation, (2) woody vegetation, (3) terrestrial insects, (4) fishes, (5) birds, (6) small mammals, and (7) game populations. Some plants and animals from the FMPC and from offsite locations were analyzed to determine the possible effects of environmental stress on genetic structure. The results of these analyses are included. For a catalog of species found at the FMPC during the summer, 1986, see Appendix A, Part I.

STUDY SITE AND HABITATS

The study area included the major ecological habitats within the 425 ha of the FMPC site excluding 55 ha covered by the FMPC operations complex, parking lots and associated construction facilities. The six (6) major habitats identified were riparian, coniferous woodlot (pine plantings), deciduous woodlot, reclaimed fly ash piles and grazed and ungrazed pastures. The number of cow paddies intersected by a 600 m transect line determined whether a pasture was grazed or ungrazed.

TRANSECTS

Eleven (11) 600 m permanent transects were established in mid-June, 1986, on the FMPC site. Terrestrial flora and fauna were censused or collected along each transect. The number of transects within each habitat was allocated in proportion to the area of each habitat type (Table 1). The area of each habitat type was determined by the proportion of that habitat type to the total area of the FMPC. A topographical overlay of an aerial photograph of the site was used in making this determination.

The number of transects by habitat type was: grazed pastures (GP) - 2, ungrazed pastures (UGP) - 1, pine plantings (PP) - 2, reclaimed fly ash piles (RFAP) - 1, riparian (RN) - 2, and deciduous woodlots (W) - 3.

A stratified random procedure (Southwood 1966:21) was used to establish the beginning of each transect to assure adequate coverage of each area. Transects were laid out by compass and transit, flagged, and mapped (Fig. 1).

Descriptions and coordinates of each transect are presented in Table 2. The beginning and end of each transect was permanently marked with partially sunken salt-treated posts. The exposed end of each post was sprayed with florescent red paint.

FLORA AND FAUNA

These sections describe the floral and faunal studies conducted at the FMPC. Certain taxa were excluded due to time or seasonal constraints (e.g., amphibians, fungi, spring flowering plants, and some terrestrial invertebrates) or severe drought conditions (e.g., benthos, and aquatic plants).

METHODS

All terrestrial flora and fauna included in this study were censused or collected along or adjacent to the established transects. The location of each species surveyed was mapped by transect and habitat type.

Standard community indices were used to reduce the data. Results for each organismal group are expressed by habitat type in terms of density (number per unit area), or number per unit effort (e.g., number of insects per 1000 sweeps). Additional parameters were also calculated for each community. Species

richness (R) is the number of species found. Relative frequency of occurrence is the proportion of individuals of each species in the sample with respect to the total number of individuals sampled. The latter data were used to assign estimates of abundance in Appendix A, Catalogue of Species of the FMPC.

Species diversity was calculated using the Shannon-Weaver (1949) formula ($H' = -\Sigma p_i \log_2 p_i$) and Simpson's Index, *D*, (Simpson 1949). Species dominance (C) was calculated from the index of Simpson (1949). Evenness of distribution and abundance (J') was calculated using the methods outlined in Pielou (1966). The Jaccard Coefficient (Jaccard 1908) and the Coefficient of Similarity (Whittaker 1975) were used as measures of qualitative community similarity in terms of presence or absence of species. Percent Similarity (Whittaker 1975) and Morisita's Index (Morisita 1959) were used as measures of quantitative community similarity with respect to the number of individuals of each species present. Additional synthesis of the data is treated in each section.

All taxa were catalogued according to frequency of occurrence by habitat type (Appendix A). Representative voucher specimens are housed in the Robert A. Hefner Museum of Zoology or the Willard Sherman Turrell Herbarium, Miami University, Oxford, Ohio 45056.

HERBACEOUS VEGETATION

METHODS

Herbaceous vegetation was censused using a focal-point sampling procedure (Burzlaff 1966). Foot surveys, similar to those used for sampling the herbaceous community in an offsite beech-maple forest (Snyder and Vankat 1984), were conducted to supplement plant species not detected by the focal-point sampling method. The individual plant (or substrate type: soil, litter (dead and decomposing plant parts), or rock) visible through a sighting scope placed at one-meter intervals along each of the eleven 600 m transect lines (see Fig. 1) was scored. The sighting scope, an aluminum tube 22.9 cm long x 10 mm i.d. equipped with cross-hairs, was affixed at a 45° angle to a tripod. The tripod was centered over a metric tape along the transect line. At odd (1, 3, 5, etc.) meter-marks, vegetation to the left of the transect line was scored, and at even meter-marks, vegetation to the right of the transect line was counted. Due to the pattern of mowing and the general discontinuity of habitat, transect lines 40 m in length were laid out perpendicular to the original transects in the pine plantations, woodlots and riparian habitats. Regardless of habitat type, 600 points were scored along each transect with the exception of the RFAP. Only 400 points were scored there due to the shorter than normal transect in that habitat (see Table 2). Relative cover and herbaceous community structure indices were computed from these data.

RESULTS

In all habitats, red fescue (*Festuca rubra*) was the most dominant herb on the basis of percent ground cover (Table 3). In PP1, W1, W2, and W3, however, more of the surface was covered by litter. In several areas a substantial portion of the litter was composed of old fescue culms. In particular, GP2 had recently been mowed and all of the litter at that site was *F. rubra*. The dominant ground covers in RN1 and RN2 were either litter or soil, followed in each case by red fescue.

Based on the relative percent of cover, herbaceous species community structure was most similar among the pastures, followed by riparian and then woodlot habitats (Table 4). RFAP was least similar (32%) when compared to an older woodlot. Although PP1 and PP2 were similar in plant species richness (R=37 and 30, respectively), they showed only 46% similarity (Table 4). This was because PP1 had less fescue and over two times more litter than PP2. The southern-most riparian habitat (RN2) was the richest, containing 43 herbaceous species (Table 5). Herbaceous community diversity (Simpson's Index, *D*) was similar (range=0.926-0.930) over all wooded habitats. Species diversity was intermediate in RFAP. The three pasture habitats were the least diverse (range=0.495-0.654).

DISCUSSION

Pomeroy et al. (1977) listed only 25 herbaceous species on the FMPC; we found 98 species representing 38 families. The difference is due to more rigorous sampling by the Miami

University plant team. Pomeroy and coworkers probably listed only those species most visible (≠most common). In addition, they (Pomeroy et al. 1977) listed several species which were not observed by Miami University personnel, however some of those listed seem to be incorrectly identified. As a result, it is impossible to infer any direct gross changes in the plant community which may have occurred within recent history at the FMPC.

The majority of sites within the FMPC are in various stages of succession from earlier usage as pastures or orchards. Regarding herbaceous vegetation, W3 and the riparian habitats are the only areas which approach a mature southwestern Ohio woodland. All three woodlots are, however, heavily encroached by neighboring pastures and are subject to occasional bush-hogging and to frequent grazing.

Considering the current and historical land use of these areas, the pattern of species diversity within the various habitats are close to expected. Compared to an offsite beech-maple forest (Snyder and Vankat 1982), FMPC woodlots and riparian habitats contained 32-43% fewer herbaceous species. Plant species expected but missing, or present in extremely low abundance, include two ferns (*Botrychium* and *Asplenium*), an orchid (*Lipria*), tick trefoil (*Desmodium* sp.), and bedstraw (*Galium aparine*). More significant is the rarity or absence of several taxa normally common to disturbed or successional communities such as W1, W2, W3, and RFAP (Hickey, Pers. Comm.) These taxa, either missing or found in low numbers, include

honeysuckle (*Lonicera*), dogbane (*Apocynum*), asters (*Aster* spp.), and the fleabanes (*Eriogeron* spp.).

The vegetation survey was conducted during the late summer of 1986. It must, therefore, be considered incomplete as a major portion of the flora was unavailable at that time.

WOODY VEGETATION

METHODS

Trees and shrubs in one reclaimed fly ash pile (RFAP), 3 woodlots (W), and 2 riparian habitats (RN) were sampled from 22 July to 4 September,1986, using the 1/10-acre-circle method (James and Shugart 1970). Woody vegetation in the pastures was extremely sparse and therefore was not sampled. Six tree plots were established at 100 m intervals tangential to the transects (Fig. 1), except in the RFAP, where four tree plots were established. Six 0.04 ha (tree) and six 0.004 ha (shrub) circular plots were used to determine frequency, density, and dominance of trees (diameter at breast height (DBH) ≥ 7.6 cm) and shrubs (DBH < 7.6 cm), respectively. Important percentages were calculated for each species by averaging the sum of the relative frequency, relative density, and relative dominance. Dead standing trees and shrubs were not included in the analyses.

Shrub plots were centered within the tree plots. All woody plants in the plot were identified and their diameters were measured. Saplings and vines (<7.6 cm DBH) were sampled in the

shrub plots and scored as shrubs. Canopy height and percent canopy cover were measured for each tree plot (James and Shugart 1970).

An aerial photograph supplied by WMCO was used to determine the frequency, density, and dominance of trees in the pine plantations (PP1, PP2). Seven stratified random, 0.25 ha rectangular plots were layed out on the photograph in each pine stand. Trees in each plot were identified by color (light trees = white pines; dark trees = Austrian pines) and counted. Selected trees on the photograph were spot-checked in the field to confirm species identification. Dominance was estimated by visually determining the percent area covered by each species. Importance percentages were calculated as described above. Because of high tree density, and inaccessibility, the shrub community was not sampled in the pine stands.

RESULTS

Riparian

Twenty-two species of trees were found in the riparian habitats (Table 6). The dominant species in RN1 were the eastern cottonwood and hackberry whereas in RN2 the dominants were American elms and boxelders (Table 7). Cottonwoods, American elms, hackberries, and boxelders made up two-thirds of the tree community in RN1 (Table 8). In RN2, 60% of the tree community consisted of American elms, boxelders, and Ohio buckeyes.

Tree diversity and richness were greater in RN1 than RN2 (Table 8). Nine species present in RN1 were absent in RN2 including some which were unexpectedly absent; i.e., the black willow, sugar maple, the hickory group, and most of the oaks. RN2 had three species, including the Ohio buckeye which had a density of over 100 trees/ha., which were absent in RN1 (Table 12). Nine species were found in both of the riparian habitats.

Several species unique to the riparian habitats were the black willow, chinquapin oak, swamp white oak, shagbark hickory and a species of hawthorn (*Crategus* sp.). The osage-orange, a typical hedgerow and secondary growth species, was only found in RN1. Typical riparian species (sycamores, willows, cottonwoods, and silver maples) were in low abundance. Additionally, American beeches were expected but not found.

Twenty-three species of shrubs were present in the riparian habitats (Table 9). Boxelders and poison ivy dominated RN1 and RN2. Trumpet creeper and hackberry were abundant in RN1. These 4 species constituted over three-fourths of the shrub community in RN1.

Shrub diversity was greater in RN2 than RN1, although RN1 had a greater number of species (21 vs 14; Table 10). Species in RN2 were apportioned more evenly (Table 10), which contributed to its high diversity. Notably absent shrub species in RN2 that were present in RN1 were the black walnut, sugar maple, multiflora rose, trumpet creeper, and hawthorn. Shrub community similarity was greater among the riparian habitats than among other habitats (Table 11). Shrubs unique to the

riparian habitats included the black maple, swamp white oak, sawbrier, and a species of hawthorn.

Woodlots

Twenty-five species of trees were found in the woodlots. Shellbark hickory and white ash dominated W1 and W2, respectively, whereas sugar maples and boxelders dominated W3. Several other species were common (density ≥ 50 trees/ha). These were the shingle oak, American elm, hackberry, and black locust in W1, American elm, American sycamore, and boxelder in W2, and American elm and Ohio buckeye in W3. The dominants and common species made up 67, 89, and 71% of the tree community of W1, W2, and W3, respectively. Total woodlot tree densities ranged from 400 to 550 trees/ha (Table 12).

American elms, hackberries, black cherries, boxelders, and white ashes were found in each woodlot, yet tree community similarity among the woodlots was less than 40% (Table 13). W1 had 7 species that were not found in the other woodlots, W3 had 4, and W2 had 2. Shellbark hickories, shingle oaks, and black locusts were present in large numbers in W1, but were absent in W2 and W3. Species present in large numbers, including the white ash and sycamore in W2 and the sugar maple and Ohio buckeye in W3, were absent, or nearly so, in the other woodlots. W1 and W3 had the most species in common (9), but were the least quantitatively similar. Tree diversity and richness were greatest in W1 and smallest in W2. W1 had twice as many species as W2 (Table 8).

Several species unique to the woodlots were the eastern red cedar, shellbark hickory, mockernut hickory, chestnut oak, northern red oak, Kentucky coffeetree, red maple, and an unexpected species, the common persimmon. Several very large trees were found in the woodlots, most notably a swamp white oak in W3 and a red oak in W1, both of which measured over 125 cm in diameter. Species expected but absent were the alianthus (*Alianthus alianthus*), American hornbeam, (*Carpinus caroliniana*), hop hornbeam (*Ostrya virginiana*), flowering dogwood (*Cornus florida*), osage-orange (*Maclura pomifera*), redbud (*Ceris canadensis*), mulberries (*Morus rubra* and *M. alba*), American basswood (*Tilia americana*), Tulip tree (*Liriodendron tulipifera*), hawthorns (*Crategus* spp.), and American beech (*Fagus grandifolia*). The eastern red cedar, honey locust, black locust, and sugar maple were expected in greater numbers.

Twenty-two species of shrubs were found in the woodlots (Table 14). Shrubs common to each woodlot were the American elm, black cherry, roughleaf dogwood, grape vine, and Virginia creeper. Roughleaf dogwood, multiflora rose, and honeysuckles were the most abundant shrubs in W1. The former two species and blackberry were most abundant in W2, and sugar maples and Ohio buckeyes in W3. These species constituted from 60 to 70 percent of the total shrub community in each woodlot.

Shrub diversity was greater in W2 and W3, although W1 had a greater species richness. The shrubs in W2 and W3 were apportioned more evenly (Table 10), which contributed to their higher shrub diversity. Woodlot 3 was very different from

either of the other woodlots with a similarity of less than 20% (Table 11). Ten of 14 tree species (71%) found in W3 were also present as shrubs; boxelder, a dominant tree, was not found as a shrub (Tables 6,9).

Several shrubs unique to the woodlots were shellbark hickory, silver maple, chestnut oak, and black raspberry. The dominance of rough-leafed dogwood and low abundance of honeysuckles was unexpected. The pawpaw (*Asimina triloba*) and the spicebush (*Ledera benzoin*) were expected, but were absent.

Reclaimed Fly Ash Pile

Only 5 species of trees and 7 species of shrubs were found in the RFAP (Tables 6,7). The RFAP was dominated by eastern cottonwoods and black locusts although many small American elms were also present (Table 7). These three species constituted over 95% of the tree community in this sparsely wooded habitat. The shrub layer was dominated by poison ivy although honeysuckles and boxelders were present in moderate numbers (Table 14).

The reclaimed fly ash pile had the lowest tree (Table 5) and shrub (Table 13) diversity of any of the deciduous habitats. Two species found in the RFAP that were not found in any other habitat were the redbud and prairie rose. The most notable features of the RFAP were the great abundance of poison ivy, the many scattered small elms, and the relatively large cottonwoods. Species absent but expected include shrubby species such as the black raspberry, blackberry, and multiflora rose.

Pine Plantations

The pine plantations were comprised of only two species, white pines (*Pinus strobus*) and Austrian pines (*P. nigra*). White pines were more abundant in PP1, and Austrian pines were slightly more abundant in PP2 (Table 6). The northern pine plantation (PP1) was more dense than the southern pine stand (Table 12).

SUMMARY

In summary, thirty-four species of trees (15 families), and 28 species of shrubs (15 families) were found on the FMPC. The beech family (Fagaceae) was represented by 5 species of oaks although, unexpectedly, the American beech was not recorded on site. The walnut family (Juglandaceae) and the maples (Aceraceae) were represented by 5 species, and the roses (Rosaceae) by 4. Tree species richness and diversity as well as shrub species richness were greatest in W1 and RN1. Shrub species diversity, was greatest in the riparian habitats. The reclaimed fly ash pile had the least diverse deciduous tree and shrub community. The pine plantations were comprised of 2 species.

Tree densities were greatest in PP1 and RN1, with over 700 trees/ha, and least dense, in the RFAP. Shrub densities were greatest in RN1 and least dense in W3 and RN2. Overall, the wooded habitats of the FMPC are composed of open, patchy, heterogeneous successional communities in addition to disjunct, man-created communities. Analyses of community tree and shrub

similarity indices showed only 2 of 11 comparisons having similarities of greater than 50 percent. Trees seldom averaged over 20 m in height (Table 10).

DISCUSSION

Battelle (1981) gives general descriptions of the woody vegetation in the vicinity of the FMPC, but provides little quantitative information about the FMPC site. They cite Pomeroy, (1977) as having recorded 37 species of trees and shrubs on the FMPC. We recorded 46. Eight species listed by Battelle (1981: Table A-1) were not recorded in our samples. They included the Norway spruce (*Picea excelsa*), gray birch (*Betula populifolia*), Shumard oak (*Quercus shumardii*), rock elm (*Ulmus thomasii*), pawpaw (*Asimina triloba*), ailanthus (*Ailanthus altissima*), sumac (*Rhus* sp.), and gray-stemmed dogwood (*Cornus racemosa*).

The riparian communities lacked the typical large dominant sycamores, silver maples, and cottonwoods of a mature riparian system. Tree species diversities of the riparian plots were most similar to those of the northern woodlot (W3). We found that the northern riparian habitat was more diverse and dense with respect to trees and shrubs as compared to the southern plot. These deviations may be partly explained by the ephemeral nature of Paddy's Run or by the history of the stream. Recently we were informed that the upper portion of Paddy's Run was diverted from its original course, which may explain vegetational differences.

All of the woodlots were in various successional stages. Woodlot 2 was the youngest, W1 intermediate in maturity, and W3 the most mature woody community on site in terms of species composition, dominance, canopy cover, and canopy height (Table 15). The pattern of increased species richness and evenness in Woodlots 1 and 2 are similar to that found for timbered forests (Adams and Barrett 1976). Woodlot 3 more approximated a mature forest than the other woodlots, but its canopy rarely extended above 24 m as compared to the 27-40 m canopy of a mature beech-maple forest (Beissinger and Osborne 1982). American beech and sugar maple co-dominate in mature beech-maple forest ecosystems, and tulip trees are often the third most dominant tree in the forest (Vankat et al. 1975). Yet, tulip trees and American beech were absent from all strata. Other woody vegetation notably absent in our plots were redbuds, American hornbeams, pawpaws, mulberries, and honeysuckles, plants typical of woodlots.

Total tree densities in our woodlot samples ranged from 408 to 550 trees/ha as compared to 267 to 365 trees/ha for a beech-maple forest in southwestern, Ohio (Sperger 1986), which consisted of more trees of larger size. Mean tree diameters for our woodlots were W1: 15.7 cm ± 0.9, N = 115; W2: 19.0 cm ± 0.9, N = 90; W3: 17.4 cm ± 0.8, N = 132, as compared to 28 cm for Hueston Woods. Shrub densities ranged from 2625 (W3) to 7375 (W1) shrubs/ha versus 3896 shrubs/ha for a mature beech-maple site (Sperger 1986). The pattern of woody plant species richness and diversity in our woodlots was similar to that

reported for strip-mined land in east-central Illinois (Karr 1968). Most differences accounting for absences and low abundances of many shrub species may be related to the fact that all woodlots were highly impacted by grazing and bush hogging.

Both the pine plantations and the reclaimed fly ash pile are unique man-created communities and thus are difficult to compare to other natural habitats on site. The northern pine plantation was more dense and dominated by white pine. Austrian pine dominated the less dense southern stand. Norway spruce, which were included in the 131,000 tree seedlings planted on the FMPC in 1972 (Battelle 1981), were noticeably absent from both plantations, and from all samples.

The reclaimed fly ash pile was comprised of 5 species dominated by small cottonwoods, American elms, and black locust. It was the least diverse of the deciduous habitats on the FMPC. Structurally it resembles an early shrub strip-mined area also dominated by black locusts and cottonwoods (Karr 1968). Although the reclaimed fly ash pile is unique, further study of this community may not be feasible because of disturbance by FMPC operations. Portions of this transect were destroyed by bulldozers during the first week of September, 1986. To our knowledge, manipulation of this habitat continues.

TERRESTRIAL ARTHROPODS

METHODS

Arthropods were collected along permanently established transects (Fig. 1) in early July, 1986, using a 40 cm diameter standard sweep-net. The collector walked briskly along the transect sweeping the vegetation using a figure-eight sweep pattern. Each complete figure-eight pattern was counted as two sweeps. The number of sweeps per transect varied from 352 to 549 and was mostly dependent upon vegetation structure and density. Other terrestrial invertebrates (i.e., molluscs) collected by sweep-netting were included in the data analysis.

After collection, the organisms were placed in a kill-jar containing ethyl acetate and then preserved in 70% ethyl alcohol awaiting identification. Identification was made to family except as noted. Nymphs were identified to family for groups with simple metamorphosis (e.g., Orthoptera, Homoptera, Hemiptera, Thysanoptera) and only to order otherwise.

RESULTS AND DISCUSSION

We were unable to complete the identification of all organisms collected in time for inclusion within this report, and thus only 9 of the 11 transects are addressed. From these 9 transects nearly 18,000 individuals representing some 127 families were collected. The number of insects caught per 1000 sweeps and the relative frequency of occurrence of major taxa are presented in Tables 16 and 17, respectively.

The data for the other two transects (GP1 and W1), with a more comprehensive discussion of the insect community on the FMPC, as well as estimates of relative abundance by habitat type (see Addendum to Appendix A, Catalogue of Species of the FMPC), appears in the report covering work performed during October through December, 1986.

Phytophagous (plant-eating) insects were the most prevalent group within the habitats studied. Leafhoppers (Cicadellidae: Homoptera) were present in consistently large numbers. The percentage of total for this family ranged from 13.28% in UGP to 23.38% in PP2 (Table 17), many being nymphs. The most abundant group for any one sample was the short-horned grasshoppers (Acrididae:Orthoptera) which equalled 31.85% of the total in UGP. The large amount of undisturbed vegetation in UGP was probably the reason for their great abundance there. Nearly five times more short-horned grasshoppers were present in UGP than in GP1. Population numbers in GP1 were probably reduced due to heavier grazing in this pasture. Acridids were much reduced in numbers in the other habitats, with none found in W3, as might be expected due to a lack of herbaceous cover. Herbs and grasses in W3 were extremely sparse (see Table 3). Only 38% of the forest floor was covered by vegetation.

Another group found in large numbers were leaf beetles (Chrysomelidae:Coleoptera). They were most abundant in PP1 and PP2 (15.54% and 15.80% of total, respectively). Among the chrysomelids, flea beetles (Alticinae) were most abundant. All three of the above mentioned families are large and common

groups which often become pests to cultivated plants. Springtails (Collembola, especially Entomobryidae), which inhabit soil and leaf litter, were also abundant in UGP (14.31% of total). Almost 8 times more entomobriads were present in UGP than in GP1; again the probable cause was heavier grazing on the latter area.

The largest number of families present (averaging 14.9 families per habitat) from a single order were those within the order Diptera (flies). It is perhaps significant that the extremes were found in RN1 and RN2, with representatives from 24 and 5 families, respectively. Most dipterans were small acalyptrate muscoid flies, the most common being frit flies (Chloropidae), and fruit flies (Tephritidae). Dark-winged fungus gnats (Sciaridae) were also common. An interesting find was the big-headed fly (Pipunculidae), the third most common Dipteran found in PP1 (0.36% of total; 3.6% of all flies in PP1). This fly is not commonly encountered. Their larger numbers in PP1 (Table 16, 17) were probably due to the fact that the larvae are parasitic to homopterans, chiefly cicadellids, which were also very abundant there.

The majority of Hymnenoptera (ants, bees and wasps) found in UGP, GP1, PP1 and RN1 were small chalcid wasps (Chalcidoidea), the larvae of which are parasitic to other insects. Another small hymenopteran similar to the chalcids occasionally found in some of the habitats was the platygasterid wasp (Platygasteridae). Their larvae are parasitic to gall gnats (Cecidomyiidae) which were also present in samples from

these areas. Most hymenopterans in RN2 were vespids (Vespidae; yellowjackets and hornets), comprising 6.30% of the total. Ants (Formicidae) were the most abundant hymenopterans in RFAP (equal in number to Chalcidoidea), W2 and W3. Halictid wasps were the most frequently found hymenopterans in PP2. Several taxa, too numerous to mention, were found only within a single habitat type (see Table 16 or 17).

The greatest number of insects per thousand sweeps (10,682) was collected in UGP and the least (975) in RN2 (Table 16). Some taxa, e.g., Aradidae (Hemiptera) in RFAP, were present in fair numbers in only one habitat type. Others, e.g., Sminthuridae (Collembola) in UGP and Acrididae (Orthoptera) in UGP, while not unique to a single habitat, were observed in much greater (1-2 orders of magnitude) numbers in one area than in others.

Many taxa (Gryllidae and Tettigoniidae: Orthoptera; Miridae: Hemiptera; Cercopidae and Cicadellidae: Homoptera; Chrysomelidae: Coleoptera; Braconidae and Formicidae: Hymenoptera) were found in all 9 habitats. There were also many taxa which were collected along one transect of a habitat type, but not the other. There were 40 taxa found in PP1, but not in PP2, but only 3 in the latter that were not collected in the former. In the woodlots, 25 taxa were unique to W2 and 17 to W3. The two riparian transects were also different: 52 and 11 taxa were unique to RN1 and RN2, respectively. No ground beetles (Carabidae:Coleoptera) were collected and tiger beetles (Cicindelidae:Coleoptera) were found only in RN2. Both beetles

may have been under-represented in our samples due to sampling method as both are ground-dwellers.

A significant difference in community structure between grasshopper communities in UGP was also noted. Two species ubiquitous in southwestern Ohio, the red-legged grasshopper (*Melanoplus femur-rubrum*) and the straight-lanced meadow katydid (*Conocephalus strictus*) were selected for future electrophoretic studies. Each was present in approximately equal numbers at each of 3 offsite locations and 4 experimental (FMPC) sites except in the area between boundary air sampling station 3 (BS3) and the old incinerator located at the eastern site boundary. The ratio of *M. femur-rubrum* to *C. strictus* at this location was 10.5:1 in contrast to a ratio of 1:1.2 near the north end of the UGP transect in the vicinity of BS2. No readily observable differences could be detected in the microhabitat at the two collecting areas. We cannot offer an explanation for this phenomenon at this time.

Lepidopteran families were grossly under-represented in our samples. This was likely due to bias introduced by our sampling method.

Larval Insects

Coleopteran (beetle) and lepidopteran (moth and butterfly) larvae collected ranged from 0% of total in RFAP to 8.78% in RN2. Most were beetle (Coleoptera) larvae, however lepidopteran larvae were more abundant in PP2.

Non-Insect Arthropods

Spiders (Araneida) constituted a large percentage of the total catch in several habitats, but greatly outnumbered all other arthropods in RFAP where they made up 38.91% of the total. Spiders were abundant in the riparian habitats as well: 19.39% and 23.66% of total in RN1 and RN2, respectively. Orbweavers (Araneidae) were dominant in these two areas. Few spiders were found in UGP constituting only 1.85% of the total. Because of the nature of the vegetation there, it is probable that many ground-dwelling spiders were not netted. Mites and ticks (Acarina) were present in 6 of the 9 habitats. The low number of mites and ticks (Table 17) was probably an artifact of the sampling technique. The same is probably true for harvestmen (Phalangida).

Molluscs

Gastropods (snails) were found only in the woodlots and riparian habitat. They were most abundant in RN1 (111/1000 sweeps).

SUMMARY

Short-horned grasshoppers (Acrididae) were by far the largest group found in the ungrazed pasture. Leafhoppers (Cicadellidae) were abundant as were springtails. Many dipteran families were present, including frit flies and dark-winged fungus gnats which were present in UGP and GP1 in larger numbers than in any other area. Chalcid wasps were very common.

Sizeable numbers of thysanopterans were also found. Tephritids (Diptera) were most numerous in UGP.

The RFAP was characterized by sizeable populations of grasshoppers, leafhoppers, chrysomelids, frit flies, chalcid wasps and ants. Psocopteran numbers were higher in RFAP than any other habitat type. Flatbugs (Aradidae:Hemiptera) were found only there. Spiders were present in high numbers (1905/1000 sweeps).

The pines were dominated by the order Homoptera, especially leafhoppers and planthoppers. Flea beetles were abundant as well. Many families of Diptera were represented, mostly small acalyptrate muscoid flies; frit flies being the dominant group. Other common groups were chalcid wasps and jumping spiders (Salticidae).

With the exception of RN2, woodlot relative densities were the lowest of all habitats considered in this report. Phytophagous insects and ants were present in fair numbers. Braconid wasps were greatest in abundance in W2 as were two families of Diptera: Dolichopidae and Drosophilidae. The Chloropidae were the dominant dipteran family in W3. Lycidae (Coleoptera) were unique to W3.

The riparian habitat was characterized by an abundance of spiders, mostly orb-weavers. Leafhoppers were the most abundant insects there. Meadow katydids (Tettigoniidae), crickets (Gryllidae) and vespid wasps were relatively common as were lepidopteran and Coleopteran larvae.

Chi-square analysis of the numbers of individuals in each order by transect indicated that no two habitats were similar to one another. Most similar, if spiders were omitted from the analysis, were W2 and RN1, but even so the chi-square statistic (df=9) was 65.11 ($p<<0.005$). With spiders included, W2 and W3 were most similar ($X^2_{(a=0.05,\ df=8)}=87.15$, $p<<0.005$). When considering most-comparable habitats, the two pastures, UGP and GP1, were least similar ($X^2_{(a=0.05,\ df=11)}=1927.78$, $p<0.005$).

FISH

STUDY SITES

Three sites in Paddy's Run within the boundaries of FMPC were sampled on June 24-25, 1986 (Fig 2). The three sites were located between the northern boundary fence and the section of Paddy's Run lying below the K-65 storage tanks. All sites were identified with marker flags and site numbers spray painted on trees located on the east bank of the stream. Sites 2 and 3 consisted of one pool and one riffle. Site 4 consisted of a single pool. The downstream reach of Paddy's Run south of the K-65 storage tanks was completely dry.

METHODS

Fish were collected using the seine method (Bennet 1970). Each riffle and pool was sampled for 30 minutes. Fish caught at each site were held in collecting buckets until the end of the sampling period. At the end of each sampling period, fish were enumerated, identified, and returned to the stream at their

capture location. Fish were identified with the aid of keys by Pfleiger (1975) and Trautman (1981). At site 4, a large proportion of the catch consisted of larval and juvenile cyprinids under 20 mm in length. Field identification of these individuals was too difficult to attempt. Therefore, three random samples of 36 individuals from this size class were collected and returned to the laboratory. Fish in the three subsamples were enumerated and identified with the aid of a key by Auer (1982). The mean number of individuals of each species was calculated for the three subsamples and used to calculate the proportion of the total subsample represented by each species. These values were multiplied by the total number of larvae and juveniles collected at site 4 to obtain an estimate of the number of fish of each species contained in the sample. One of three fish of each new species collected was preserved in 10% formalin and held as a voucher specimen. Area measurements were taken for each site.

Catch data for each pool and riffle were used to calculate an index of the catch per unit effort (Gulland 1969, Ricker 1975), the proportion of catch, and the density for each fish species. The mean catch per unit effort, proportion of total catch, and mean density were calculated to establish the abundance of each species throughout the stream.

RESULTS

A total of 2590 fish representing 13 species were collected from the three sites in Paddy's Run. The catch per unit effort,

proportion of catch, and density for each species are shown in (Tables 18-23). The mean catch per unit effort, the proportion of total catch and the mean density for each species are presented in Table 24.

DISCUSSION

At the time of this survey, water levels in Paddy's Run were relatively low, although some areas of pools were well over one meter deep; few riffles were present. The stream bed was virtually dry below the K-65 storage tanks. Flow began again below the boundaries of the FMPC, between Willey and New Haven Roads. Substrates of riffles consisted of large rocks and gravel, while that of pools included rocks, gravel and sand with large deposits of silt in some areas. Water was extremely turbid during this study.

Although most of the tributaries into Paddy's Run above our collecting sites are intermittent, Paddy's Run is a third-order stream within the boundaries of the FMPC (based on Geological Survey, Shandon quadrangle 1974). The total of 13 species collected is comparable to some other studies. Kuehne (1962), in an extensive collection of an uninhabited region of the Buckhorn Creek drainage, Kentucky, sampled 4 third-order sites and found 9 to 17 species per site. Similarly, Lotrich (1973) collected 15 species in a third order stretch of Clemons Fork, a tributary of Buckhorn Creek. As in Paddy's Run, both of these collections were dominated by cyprinids and percids (darters). In addition to the species collected in this study, an adult

sunfish (appearing to be a bluegill, *Lepomis macrochirus*) and schools of redbelly dace (*Phoxinus erythrogaster*) were visually spotted during an initial walk through Paddy's Run in May, 1986. At that time, the water was very clear. It is difficult to explain the lack of redbelly dace in our collections, especially since Trautman (1981) notes that this is not a species that normally migrates downstream in the summer. However, he adds that it is important for streams inhabited by redbelly dace to contain an adequate amount of water throughout the year, and further notes that they are sensitive to turbidity. It is possible that the low water levels or high degree of turbidity at the time of this study may have contributed to the absence of this species.

Many of the species taken in this study were described by Trautman (1981) as being reasonably tolerant of silt and turbidity. However, such factors may limit the distribution and abundance of some sensitive species in Paddy's Run, such as the blacknose dace (*Rhinichthys atratulus*). Nevertheless, other species that are sensitive to these factors, such as the rosefin shiner (*Notropis ardens*) and silverjaw minnow (*Ericymba buccata*), were common.

Numerically, bluntnose minnows (*Pimephales notatus*), creek chubs (*Semotilus atromaculatus*), and stoneroller (*Campostoma anomalum*) minnows dominated our collections, although the rosefin shiner, Johnny (*Etheostoma nigrum*), orangethroat (*E. spectabile*), and fantail (*E. flabellare*) darters were also major components of the ichthyofauna. However, the numerical values

are somewhat misleading since a large portion of our collections included specimens under 20mm standard length (SL) that were presumably young of the year. For example, of the 209 creek chubs taken at site 2, only about 10 to 15 were over 25mm SL.

The Shannon-Weaver indices calculated for the two riffles (H' = 0.725) and three pools (H' = 0.769) indicate that the species composition is different (see Tables 1-3). White suckers (*Catostomus commersoni*), silverjaw minnows, rosefin shiners, and Johnny darters were rare or absent from riffle samples, but common in pools. Fantail darters were common only in riffles. Results also demonstrated the importance of sampling several sites. For example, bluntnose minnows were rare in riffle 2, but very abundant in riffle 3, and rosefin shiners were very rare in pool 4, but common in pool 3 and moderately common in pool 2.

After sampling the three sites described above, additional fish were collected from a wide variety of habitats over a stretch of stream approximately 300 meters in length in order to survey for the presence of sunfish (Centrarchidae) or other species listed in Tarzwell's (1952) survey of Paddy's Run, but not found at our sampling stations. Although the very deepest pools (1.5m or more) could not be adequately sampled, no additional fish species were identified. However, one young centrarchid (less than 15mm SL), tentatively identified as a green sunfish (*Lepomis cyanellus*) was collected downstream below Willey Road. While it is possible that centrarchids and other species not found in our study do inhabit the stretch of Paddy's

Run within the FMPC boundaries, they may be restricted to periods of greater flow, as in the spring. Trautman (1981) notes that most Ohio stream fishes demonstrate downstream movement after the spawning season.

Some species listed in Tarzwell's (1952) survey of Paddy's Run are apparently in error. The common shiner (*Notropis cornutus*), listed by Tarzwell, is restricted to northern Ohio, whereas the striped shiner (*N. chrysocephalus*), identified in this study, is found throughout Ohio (Trautman 1981). These two species were considered conspecific at the time of Tarzwell's survey. Similarly, the northern red-fin shiner (*N. umbratilis cyanocephalus*) does not occur in southwestern Ohio (Trautman 1981). It appears likely that Tarzwell confused this species with the rosefin shiner.

Based on this survey, Paddy's Run appears to have a relatively diverse ichthyofauna in the area of stream above the K-65 storage tanks. However, it is regrettable that the stream within the FMPC boundaries was dry below the plant site, making comparisons impossible. Spot collections were made farther downstream, just above New Haven Road on July 8, 1986. These collections, although not nearly as thorough as those described above, indicated that the fish fauna in this offsite region was similar to that at FMPC sites 2-4, although blacknose dace appeared to be more common.

Bauer et al. (1978) found significant reductions in the number of species collected at three sites in Paddy's Run located below FMPC and the Mobil Oil (now Rutgers-Neese

Chemical) Company facility. Three sites sampled above these plants included 10-17 species each, while the three lower sites each contained only 4 or 5 species.

AMPHIBIANS AND REPTILES

Amphibians and reptiles were not censused during the summer of 1986 due to time constraints. Incidental sightings of herpetofauna were noted, however, and a listing of those organisms seen is included in Appendix A, Catalogue of Species of the FMPC.

American toads (*Bufo americanus*) and spring peepers (*Hyla crucifer*) were found in breeding ponds in the spring prior to the beginning of this study. Northern water snakes (*Nerodia sipedon*) seemed to be common in Paddy's Run during a survey in May, again prior to the formal commencement of this study. A queen snake (*Regina septemvittata*) was also observed in the stream during the same period.

We often found Butler's garter snakes (*Thamnophis butleri*) within the environs of the FMPC and a black rat snake (*Elaphe obsoleta*) was seen in Woodlot 3. Box turtles (*Terrapene carolina*) were frequently seen along Paddy's Run and in the wooded areas.

We would expect the herpetofaunal community of the FMPC to be similar to that of southwestern Ohio and southeastern Indiana.

BIRDS

METHODS

Breeding birds were censused from 25 June to 25 July using a fixed-width line transect (Emlen 1971). Each of 11 600 m permanent transects (Fig.1) was censused 12 times in order to obtain accurate and consistent density estimates (Engel-Wilson et al. 1981). Censuses began from 1/2 to 3 hours after sunrise and ended before 1100 hours. The Emlen transect method has been shown to be more feasible and provide similar estimates of bird densities, species diversity, evenness, and species richness when compared to variable circular plot techniques (Anderson and Ohmart 1981).

Results were expressed in terms of percent frequency of occurrence, density (as calculated by Emlen 1971), species diversity (*H'*, Shannon and Weaver 1949; *D*, Simpson 1949), species dominance (*C*, Simpson 1949), community evenness (*J'*, Pielou 1966), and community similarity. Percent frequency of occurrence values were calculated by dividing the number of censuses a species was present (0-12) by the total number of censuses (12) and multiplying by 100. The Jaccard Coefficient (Jaccard 1908) and the Coefficient of Similarity (Whittaker 1975) were used as measures of qualitative community similarity in terms of presence or absence of species. Percent Similarity (Whittaker 1975) and Morisita's Index (Morisita 1959) were used as measures of quantitative community similarity in terms of the number of individuals of each species present.

RESULTS

Eighty-three species of birds were found on the FMPC site (Table 25). More than 1/3 of these (34) were found in a majority (≥6) of the habitats (Table 25). Every habitat contained the mourning dove (*Zenaida macroura*), American robin (*Turdus migratorius*), blue jay (*Cyanocitta cristata*), American crow (*Corvus brachyrhynchos*), American goldfinch (*Carduelis tristis*), northern bobwhite (*Colinus virginianus*), and common grackle (*Quiscalus quiscula*). Goldfinches, song sparrows (*Melospiza melodia*), and robins had the greatest onsite densities - robins had densities of more than 100 birds per 40 ha in five of eleven habitats (Table 26). Avian densities varied substantially between habitats, from less than 250 birds per 40 ha in the pastures to more than 2500 birds per 40 ha in the pine plantings (Table 26). Avian diversity was lowest in the pastures ($H' < 1.75$) and greatest in the riparian habitats ($H' > 3.45$; Table 27). Avian community similarity was greatest between UGP and GP1 and between PP1 and PP2, whereas the RFAP avian community was least similar to that of any other habitat studied (Table 28).

<u>Pastures</u>

Thirty-six species of birds were found in the pastures at the FMPC (Table 25). The most abundant species in the pastures were the eastern meadowlark (*Sturnella magna*) and red-winged blackbird (*Agelaius phoeniceus*; Table 26). These two species, in addition to the European starling (*Sturnus vulgaris*),

constituted over 70% of the total avian community in each pasture (Table 26). Most of the species (70 - 90%) had densities of less than 5 individuals per 40 ha. Dominance by a few species was also evident by the high Simpson dominance values and low species diversity indices (Table 27).

Community similarity indices showed that the pastures were somewhat similar in terms of the species present (Table 28) with fifteen species common to all. UGP and GP1 were the most quantitatively similar (i.e., the number of individuals in each taxa were similar). Several differences were observed, however. The killdeer (*Charadrius vociferus*) and savannah sparrow (*Passerculus sandwichensis*) were frequently found in GP1 but absent or nearly so in the other pastures. The UGP contained two species, the grasshopper sparrow (*Ammodramus savannarum*) and song sparrow, that were absent in the grazed pastures. Additionally, two raptors, the red-tailed hawk (*Buteo jamaicensis*) and American kestrel (*Falco sparverius*), were present in UGP and GP1 but absent in GP2. Overall, species diversity was highest in UGP, intermediate in GP1, and lowest in GP2.

Unexpected species included the red-headed woodpecker (*Melanerpes erythrocephalus*) and grasshopper sparrow in UGP, the hairy woodpecker (*Picoides villosus*) and savannah sparrow in GP1, and the great blue heron (*Ardea herodias*) and the eastern bluebird (*Sialia sialis*) in GP2. The northern harrier (*Circus cyaneus*), northern mockingbird (*Mimus polyglottos*), and savannah sparrow were found only in the pastures. All expected species

were found in at least one of the pastures sampled on the FMPC site.

Reclaimed Fly Ash Pile

Thirty-nine species were found in RFAP (Table 25). The most common species included the mourning dove, American robin, common yellowthroat (*Geothlypis trichas*), northern cardinal (*Cardinalis cardinalis*), field sparrow (*Spizella pusilla*), song sparrow and American goldfinch. The cardinal, field sparrow and goldfinch constituted over half of the total avian community (Table 26), although the overall concentration of dominant species was not as great as many of the other avian communities at the FMPC (Table 27). RFAP species diversity ranked 7th or 8th greatest (depending on the index) out of 11 habitats.

The avian community structure of the RFAP was most similar to W2 and PP2 although similarities were relatively low (Table 28). Field sparrows were more abundant in the RFAP than any other habitat. Many species that would be expected in an old-field habitat (a community with vegetation structure similar to the RFAP) were found in the RFAP. However, several species typical of old-fields such as the catbird (*Dumetella carolinensis*), mockingbird and yellow-breasted chat (*Icteria virens*) were expected but not found. No species were unique to the RFAP, however, hairy woodpeckers, cedar waxwings (*Bombycilla cedrorum*) and grasshopper sparrows were unexpected.

Pine Plantations

Forty-three species were found in PP1 and PP2 (Table 25). The most abundant species (> 250 birds/ha) in both areas, constituting 60 to 70% of the total avian community, were the mourning dove, American robin, song sparrow and American goldfinch. Other abundant species were the willow flycatcher (*Empidonax trailii*), gray catbird, northern cardinal, field sparrow, and red-winged blackbird. Avian densities were extremely high in both areas and densities of the most common species were higher in the pines than any other habitat type.

The avian communities in PP1 and PP2 were more similar than between any other habitat types (Table 28). There were, however, several notable differences. Icterids, except red-winged blackbirds, were more abundant in PP2 than PP1 (Table 26). PP1 supported greater densities of yellow warblers (*Dendroica petechia*) and gray catbirds whereas PP2 supported greater densities of eastern wood-pewees (*Contopus virens*) (Table 26). Pewee density differences may not have been real however, as the separation of pewees from willow flycatchers by visual cues alone was extremely difficult. Overall, species diversity was greater in PP2 than PP1, but was intermediate when compared to other FMPC habitats.

Unexpected species in the pines included the cedar waxwing and willow flycatcher. Willow flycatchers were found in large densities in both areas. No species were unique to the pines although prairie warblers (*Dendroica discolor*) were expected but not found.

Woodlots

Sixty species of birds were found in the woodlots (Table 25). The most common species in the woodlots were the yellow-billed cuckoo (*Coccyzus americanus*), downy woodpecker (*Picoides pubescens*), blue jay, Carolina chickadee (*Parus carolinensis*), American robin and northern cardinal with sizable numbers of northern flickers (*Colaptes auratus*), tufted titmice (*Parus bicolor*), house wrens (*Troglodytes aedon*), wood thrushes (*Hylocichla mustelina*), gray catbirds, common yellowthroats, indigo buntings (*Passerina cyanea*), field sparrows, and song sparrows. Robins were dominant in each woodlot (Table 26). The three species with the greatest densities composed 37, 52 and 59 percent of the avian community in W1, W2 and W3,respectively.

Although dominance concentrations were more similar in W2 and W3, avian community similarity was greater in W1 and W2 (Table 28), both qualitatively and quantitatively. The gray catbird, common yellowthroat, indigo bunting, field sparrow, song sparrow and American goldfinch were most abundant in W1 and W2 and the Carolina chickadee and tufted titmouse were most abundant in W3. Overall, species diversity was highest in W1, intermediate in W2, and lowest in W3 (Table 27).

Several unexpected species were found in the woodlots. These were the Cooper's hawk (*Accipiter cooperii*), black-billed cuckoo (*Coccyzus erythropthalmus*), Philadelphia vireo (*Vireo philadelphicus*) and black-and-white warbler (*Mniotilta varia*) in W1; the cedar waxwing in W2; and the American woodcock (*Scolopax*

minor), pileated woodpecker (*Dryocopus pileatus*) and summer tanager (*Piranga rubra*) in W3. The scarlet tanager (*P. olivacea*) was present in all woodlots. The American woodcock, white-eyed vireo (*V. griseus*), Philadelphia vireo, black-and-white warbler and yellow-breasted chat were all unique to the woodlots. Several species were expected but not found. The blue-gray gnatcatcher (*Polioptila caerulea*), yellow-throated vireo (*V. flavifrons*), ovenbird (*Seiurus aurocapillus*), Kentucky warbler (*Oporornis formosus*), cerulean warbler (*Dendroica cerulea*) and blue-winged warbler (*Vermivora pinus*), normally observed in similar areas (Probst 1979, Bull and Farrand 1977), were absent from FMPC woodlots. Acadian flycatchers (*Empidonax virescens*), white-eyed vireos and red-eyed vireos (*V. olivaceus*), while present, were fewer in number than expected.

Riparian

Sixty-eight species were found in the riparian habitat along Paddy's Run (Table 25). RN1 and RN2 had the greatest species richness and diversity of all habitats at the FMPC. Most abundant were the mourning dove, northern flicker, blue jay, American robin and northern cardinal. Other species, including the yellow-billed cuckoo, downy woodpecker, Carolina wren, European starling, indigo bunting, song sparrow, common grackle and American goldfinch, were frequent.

RN1 and RN2 were somewhat similar in avian community structure (Table 28). The differences in species composition, however, were much more apparent. In RN1 the robin, starling

and red-winged blackbird were dominant whereas in RN2 the dominant species were the robin, cardinal and blue jay. Species diversity was greater in RN1 than RN2 (Table 27). Two wading birds, the great blue heron and green-backed heron (*Butorides striatus*); three shorebirds, the solitary sandpiper (*Tringa solitaria*), spotted sandpiper (*Actitis macularia*) and killdeer; and six songbirds, the wood thrush, red-eyed vireo, yellow warbler, summer tanager, eastern meadowlark and orchard oriole (*Icterus spurius*); all present in RN1, were absent in RN2. Many species common to RN1 were observed infrequently in RN2 (Table 25). Avian density in RN1 was nearly twice that of RN2, however the red-bellied woodpecker (*Melanerpes carolinus*), downy woodpecker, tufted titmouse and white-breasted nuthatch (*Sitta carolinensis*) were greater in abundance in RN2 (Table 26).

Unexpected species in RN1 and RN2 were the pileated woodpecker, cedar waxwing, Louisiana waterthrush (*Seiurus motacilla*), and scarlet tanager, as well as the solitary sandpiper in (RN1 only). Six species were unique to the riparian habitats. These were the green-backed heron, solitary sandpiper, wood duck (*Aix sponsa*), belted kingfisher (*Ceryle alcyon*), and Louisiana waterthrush. The yellow-throated warbler and blue-gray gnatcatcher were expected but absent and the yellow warbler was expected in greater numbers.

DISCUSSION

A diverse avifauna exists at the FMPC. Eighty-three species (including 3 only seen prior to the commencement of censusing) of birds representing 12 orders and 29 families were found on the site (See Appendix A) as compared to 105 species of breeding birds listed by Battelle (1981) and 57 reported by Weston (1986). We do not believe this difference to be significant as Battelle's listing relied to a great extent upon state and regional lists rather than actual sightings (only 50 actually sighted). The high overall avian diversity at the FMPC is probably due to high habitat heterogeneity. Six major habitat types occur on site. The many small discontinuous patches, create a large area of contact between habitats (i.e., edge habitats). An increase in bird species diversity has been associated with these contact zones between habitats (e.g., Strelke and Dickson 1980, Kroodsma 1984) and thus avian diversity at the FMPC is probably increased due to this "edge effect".

Avian species richness and diversity in FMPC habitats were, in some cases, higher and in others, lower than those found in the literature. On site diversities in the woodlots ranged from 2.393 to 2.886 with 28 to 35 species, whereas Temple et al. (1979) reported values from 2.938 to 3.135 and 54 to 58 species for northern deciduous forests. Diversities in Hueston Woods State Park, Oxford, Ohio varied yearly from 2.777 to 3.084 (Beissinger 1984). The RFAP, somewhat similar to Karr's (1968) early shrub habitat on a reclaimed strip mine, had a lower

diversity (2.616 vs. 2.722) but higher richness (30 vs. 18) than Karr's study site. The avian diversities in the riparian habitat ranged from 3.486 to 3.623 with 42 to 54 species which was greater than those found in Karr's (1968) bottomland forest (H'' = 3.315, R =32) and in a floodplain forest (H' = 2.82; Beissenger 1984, recalculated from Tramer 1969). Although comparable diversities in habitats similar to the pastures and pine plantations could not be found in the literature, species diversity and richness in these areas were similar to what we would expect.

Avian densities at the FMPC were slightly less than those reported in the literature. Densities in the woodlots ranged from 439-602 birds/40 ha whereas Karr (1968) reported 329 territorial males (~658 individuals)/40 ha in an upland oak-maple forest and Beissinger (1984) reported 583 territorial males (~1166 individuals)/40 ha. Avian densities in RN1 were similar to those noted by others; 1161 birds/40 ha compared to 978 birds/40 ha in an Illinois bottomland forest (Karr 1968) and 600-1400 individuals/40 ha estimated in a mixed bottomland forest (Udvardy 1957). Density in RN2 (623 birds/40 ha) was less than the above values. The RFAP avian community was less dense than Karr's (1968) early shrub plot (524 vs. 682, respectively).

Twenty-four species of birds that regularly nest within a 20 mile radius of downtown Cincinnati, Ohio (CNC 1978) were not found at the FMPC. Eleven of these were expected but not found on the FMPC. Nine of these 11 missing species are insectivores,

primarily foliage gleaners. Additionally, 9 species, 6 of which are insectivores, were expected in greater densities. Perhaps the most noticeably missing species was the common nighthawk (*Chordeiles minor*). This species, an insectivore which may be found hawking for insects in the early morning or late evening, was not found at the FMPC during the summer of 1986. The absence or low density of these insectivorous birds might be attributed to several factors:

(1) The reduction of the herbaceous and shrub layer due to grazing and bush hogging may have eliminated a preferred strata for nesting or foraging. Willson (1974) reported that the addition of herbaceous and shrub layers resulted in the presence of one and three more insectivorous guilds, respectively. The reduction of these layers, especially in the mature woodlot (W3), may explain the absence of the acadian flycatcher and Kentucky warbler, but does not explain the absence and low densities of several other insectivores.

(2) The small size of the FMPC woodlots may preclude some insectivorous species. Forest fragmentation has been shown to be a factor affecting avian community structure, especially lowering the densities of some insectivores (see Robbins 1979, for a review). Area sensitive insectivores listed in Robbins (1979) included the whip-poor-will (*Caprimulgus vociferus*), yellow-throated vireo, ovenbird and Kentucky warbler: all of which were absent but expected at the FMPC; and the acadian flycatcher and red-eyed vireo, which were expected in greater densities. Additional species found at the FMPC that are

sensitive to forest fragmentation include the great crested flycatcher (*Myiarchus crinitus*), wood thrush, black-and-white warbler, Louisiana waterthrush, scarlet tanager, and summer tanager.

(3) Treehoppers (Membracidae), which may be a major food source for many insectivores, were absent from 3 transects and only represented by 1-7 individuals (1.88-17.43/1000 sweeps; see Terrestrial Arthropod Discussion) in the 5 other transects for which analysis is complete.

(4) The detectability of canopy foragers may have been reduced because the sampling period was late in the breeding season when many of these species had completed nesting and stopped vocalizing.

(5) Normal FMPC operations may be affecting the food supply or the insectivorous species directly.

Several unexpected species were observed. Most notable of these was the savannah sparrow which was present in the ungrazed pasture throughout the breeding season. Previously, the normal breeding range of this species did not include southwestern Ohio. The savannah sparrow has been listed only as an uncommon migrant in the Cincinnati area (CNC 1978). However, Rice (pers. comm.) has noted that the species is expanding southward. The probable ecological equivalent of this species in our area is the grasshopper sparrow which has been noted on the FMPC previously in fairly large numbers (Pomeroy et al. 1977). Rice et al. (1983) reported a general decline in grasshopper sparrow population numbers throughout the state. At present, we cannot

offer an explanation for the apparent replacement of the grasshopper sparrow by the savannah sparrow within the FMPC site boundaries.

SMALL MAMMALS

METHODS

Small mammal populations (rats, mice, shrews, etc.) were sampled by removal. In each habitat type, 120 snap-traps were set, 3 (2 museum specials, 1 Victor rat trap) to a station, at each of 40 stations. Generally, trapping stations were 15 m apart along each of 2 lines 25 m to either side of and parallel to the permanent transect lines; each line consisting of 20 stations. The area covered by this method was arbitrarily set at 3.35 ha with exceptions as noted. Traps were baited and set each evening and morning for three consecutive nights or 360 trap-nights (TN) per transect. Trapping was completed between July 14 and August 22, 1986. Animals were removed from the traps, identified to species (except *Peromyscus;* see DISCUSSION), and retained for further analysis (only to be lost subsequently during freezer failure due to a power outage; no further investigation as to sex or age was possible). Trapping in all habitats was completed between July 14 and August 23, 1986.

Population estimates were derived using a method first described by DeLury (1947) and hence has been termed the DeLury regression method. Using this method the catch per unit effort

(y axis) was plotted against the cumulative catch (x axis). Standard linear regression analysis and the solution for x when y=0 yielded population estimates for each area trapped. Density estimates were calculated by dividing the population estimate by the total area covered by the trap line.

RESULTS

Six small mammal species, including the cottontail rabbit (*Sylvilagus floridanus*), were collected (Table 29). The cottontail will not be addressed under this heading, however, as it is included in the section regarding game animals.

Whereas short-tailed shrews (*Blarina brevicauda*) were the most cosmopolitan (present in 8 of the 11 habitats sampled), white-footed mice (*Peromyscus leucopus*) were the most numerous, comprising over 60% of the total number of animals trapped. *Blarina* (27%) and the meadow vole (*Microtus pennsylvanicus;* slightly > 6%) represented the second and third most frequently occurring small mammals on the FMPC. The eastern chipmunk (*Tamius striatus*), heard or observed in other habitats, was trapped only in WL1, and the meadow jumping mouse (*Zapus hudsonius*) was found only in the two riparian areas.

The pastures (GP1, GP2, UGP) were seemingly the most depauperate. During 360 trap nights (TN) of effort, nothing was caught in GP1, and only a single individual (meadow vole) was caught in each of the other two. With the exception of a cottontail, only shrews were taken in RFAP. Animal densities,

where calculations were possible (see Table 29), were highest in WL2 followed by RN1, WL1, and WL3, in that order.

DISCUSSION

Short-tailed shrew

Three to 10 times more shrews were trapped in RFAP than in any other area on the FMPC. Mumford and Whitaker (1982) reported only 0.23 animals/100TN in a brushy field, a habitat somewhat similar, at least in description, to RFAP. Whereas wooded areas have generally been reported to be optimal habitat for the species, non-wooded areas with heavy ground cover, such as RFAP, have been found to often support higher numbers (Mumford and Whitaker 1982). Gottschang (1981) stated that the short-tailed shrew was possibly present in greater numbers and in a wider variety of habitats than any other wild mammal in Ohio. Fread (1947) noted the species as one of the most common in Butler County. Our data generally support this hypothesis.

This species is of particular importance for two reasons: (1) it is venomous (George et al. 1986, Gottschang 1981), and (2) it is a predator of insects and other mice (Mumford and Whitaker 1982). Due to its food habits, DDT and other pesticide residues have been found to concentrate at levels up to 10 times those reported in *Peromyscus* (Dimond and Sherburne 1969). Heavy metal concentrations have also been noted (Getz et al. 1977).

White-footed mouse

The only sub-species of white-footed mouse known to occur within the state of Ohio is *Peromyscus leucopus noveboracensis*,

the woodland white-footed mouse (Gottschang 1981, Fread 1947). The only other species of *Peromyscus* in the state, *P. maniculatus bairdii*, is nearly identical to the white-footed mouse. Mumford and Whitaker (1982) stated that differentiation of live specimens of Indiana populations of the two species was difficult and reported that they could not distinguish between the two, using skull characteristics, with any degree of certainty. The same is true in other areas and sub-species. Hoffmeister (pers. comm.) has noted similar difficulty in the identification of Arizona populations.

We assigned all *Peromyscus* collected to *P. l. noveboracensis* on the basis of habitat association. Lyon (1936) noted that *P. maniculatus* was never collected in Indiana woodlands and Mumford and Whitaker (1982) stated that the species was not an inhabitant of wooded areas. Fread (1947) reported the white-footed mouse as the most abundant rodent in Butler County woodlots. The latter was the most abundant mouse in county woodlands.

Our capture rates of 2.22 to 3.89 individuals/100TN are higher than that noted by Mumford and Whitaker (1982): 1.60/100TN in upland wooded areas. However, they reported 4.80/100TN in riverbottom woods which is approximately 2.5 to slightly over 4 times the numbers trapped in RN1 and RN2, respectively.

We estimated densities to be 2.4 to 9.2 animals/ha, dependent on habitat. These data compare favorably with home range sizes of 0.09 to 0.68 ha as reported by Gottschang (1981).

Meadow vole

As most microtine rodent populations display periodic cycles, annual catch rates may vary considerably. Densities have been reported to vary from 1 or 2 to over 500 individuals/ha during a 2 to 5 year period (Krebs and Myers 1974, Hamilton 1941). In Ohio, Gottschang (1981) and Bole (1939) believed a 3-year cycle to be normal. But, whereas our catch rates of 0.28 to 0.56/100TN do not seem to indicate high densities, they are well within the range of 0.18 to 0.65/100TN reported by Mumford and Whitaker (1981) in Indiana. The fact that none were caught in GP1 may only be indicative of insufficient cover or of extreme compaction of the soil due to grazing. In addition, local vole populations may be at the low part of the cycle. Further investigation is necessary to verify any or all of these hypotheses.

Eastern chipmunk

An inhabitant of woodlands and woodland borders (Mumford and Whitaker 1981), chipmunk densities have been reported to be highly variable, both temporally and geographically, ranging from 0.3 to 37.6/ha (Snyder 1982). Our efforts yielded only a single animal from WL1 and we do not believe this to be truly indicative of FMPC population distribution and numbers. For example, the author (CFF) has personally observed or heard several animals along Paddy's Run, particularly in the woodland border on the east bank; however, none were captured there

during 720 TN. No explanation can be offered regarding why more animals were not caught.

Snyder (1982) reported a 2- to 5-fold annual variation in numbers and a home range of 0.03-0.4 ha. Our data support the latter.

Meadow jumping mouse

The meadow jumping mouse was found only in riparian habitat during the summer of 1986. Mumford and Whitaker (1982) listed the preferred habitats as old-fields, damp old-fields, floodplains and woodlands (if dense ground cover was present). They believed densities of 5 to 25 animals/ha were probably common and reported a home range of 0.1 to 0.8 ha. In wooded areas, similar to the riparian borders along Paddy's Run, Mumford and Whitaker (1982) reported a catch rate of 1.42/100TN; nearly 5 times that found on the FMPC.

SUMMARY

Those small mammal species found on the FMPC during the summer of 1986 were essentially as expected. Three other species were expected but not found. Most notable was the house mouse, *Mus musculus*. Fread (1947) stated that this species was to be found everywhere in Butler County, even though not abundant in wooded areas. Gottschang (1981) reported house mice to be common in fields with a heavy cover of weeds and grasses. Catch rates of nearly 3/100TN in grassy and weedy fields were reported by Mumford and Whitaker (1982) in Indiana. The species

is highly prolific and during outbreaks, in excess of 80,000 animals/0.4 ha have been reported (Hall 1927).

Mumford and Whitaker (1982) noted the house mouse was a close associate of the white-footed mouse, meadow vole, and meadow jumping mouse, all of which were present on the FMPC. The author (CFF) has trapped extensively in the Chihuahuan desert as well as in Indiana and Ohio, and with the exception of FMPC lands, house mice were a common find in either live or snap traps. At this point in time, we can offer no explanation for their apparent absence in FMPC habitats. In addition, the prairie vole, *Microtus ochrogaster*, and woodland vole, *M. pintorum*, both relatively common in the area surrounding the FMPC (Mumford and Whittaker 1982, Gottschang 1981, Fread 1947), were not found onsite.

GAME WILDLIFE POPULATIONS

Population estimates for white-tailed deer (*Odocoileus virginianus*), bobwhite quail (*Colinus virginianus*), and fox squirrel (*Sciurus niger*) were made at the FMPC during late June through mid-July, 1986.

Bobwhite Quail

Bobwhite quail density was estimated during July, 1986 with a modification of the call-count technique (Brown et al. 1978). Listening stations within the FMPC were established such that

all calling males could be detected by the observer. The locations of the 14 stations used are shown in Figure 3.

During each of 7 separate counts, the number of vocalizing males heard within a single 5 min period was recorded at each station. Counts were made between 0723 and 1153 hrs during 11-17 July. The weather was characterized by hot and humid conditions, and was similar during all counts.

RESULTS

A summary of census results is given in Table 30. Seven counts made on consecutive days averaged 6.1(±0.7SE) calling males. The pronounced variation in frequency among stations (0.0 to 1.3 birds per count) indicated a heterogeneous distribution of calling males on the FMPC. Figure 4 depicts the distribution and relative densities of birds censused during July.

Because males are highly territorial during the breeding season, the best estimate of the calling male population was determined by summing the maximum number observed at each station during the entire study period. At least 18 males were known to use the FMPC for breeding purposes. These data were incorporated into an estimate of the entire FMPC quail population by using the species' life-history characters (Costanzo, unpublished) which follow:

Mean sex ratio	1.00:0.75 (male:female)
Mean nesting success	30%
Mean renesting attempts	3
Mean clutch size	14

Mean juvenile survival after 16 wks	65%

From these data, a predictive equation was derived:

$$\text{Total Population} = 7.89\ (CM)$$

where CM is the number of calling males determined from census, and the total population includes adults and progeny 16 wks after census.

The above equation does not allow for adult mortality, which is minimal following brood-rearing. Accordingly, 142 quail were predicted to use habitat on the FMPC in mid-November, 1986, although some dispersal to adjacent offsite areas is expected. This estimate is probably conservative, as the census was made during the final weeks of the breeding season.

At present, about 57.3% (2.1 km^2) of the vegetated portion of the FMPC potentially serves as summer habitat for bobwhite quail. Habitat quality ranged from fair to excellent during July, 1986. Relative density data obtained from the call-count census generally reflect this variation in quality (Fig. 4).

White-tailed Deer

The trail-count method (McCaffery 1976) was used to estimate white-tailed deer density on the FMPC. Trails were counted from randomly-determined transects in deciduous forest/second growth, riparian and pine plantation habitats (Fig. 5). The technique could not be adapted to pasture and fly ash habitats, which probably received only incidental deer use.

RESULTS

A total of 63 deer trails were located along 3.8 km of transect. Density estimates were obtained for each habitat sampled by using the relationship between mean trails per 400m transect and known deer density ($Y = 2.16X - 2.83$, $r=0.94$; McCaffery 1976). Table 31 presents pertinent census results.

Deer density was similar within deciduous forest/second growth and riparian habitats (7.3 and 9.5 deer/km^2). The calculated estimate of the entire FMPC deer herd in July, 1986 was 18 (11-24, 95% CI). This estimate is probably conservative because the abundance of mowed strips, access roads, cattle paths, and other corridors on the study site reduce the number of trails needed by deer. Consequently, slightly more deer probably utilized FMPC habitat than the census indicated.

For comparative purposes, the fecal pellet-group method (Eberhardt and Van Etten 1956) was used to obtain a second measure of deer density. Censusing was done in the northern (PP1) and southern (PP2) pine plantation habitats only; pellet-group densities in the other habitats were very diffuse which prevented the use of this method. A total of 37 sample plots (19.6 m^2) were temporarily established at 100 m intervals along 3.5 km of transect within mowed strips. Only pellet groups recently deposited on top of the herbaceous stratum were recorded.

The results of this census were based upon a defecation rate of 13.7 groups/deer/day (Neff 1968) and a pellet life of 42d. The value for pellet life is contingent upon the

assumption that mowing destroys or conceals pre-existing pellet groups and that mowing had not occurred for 6 wks prior to the census. Mean deer per habitat was 1.7 times that obtained by the trail count method (Table 31).

About 42.7% (1.6 km^2) of the vegetated portion of the FMPC was characterized as high-quality deer range in July, 1986. The habitats most heavily used by resident and visiting deer were pine plantation, riparian, and deciduous forest/second growth. The large deer herd supported by FMPC landholdings undoubtedly resulted from a high degree of habitat interspersion, and good food quality and availability. Mowed areas, cattle paths, and other disturbed areas also contributed to the quality of the range.

The pine plantations on the FMPC received a great deal of use by deer during the course of this study. Deer densities were 3 times greater in pine than in other habitats studied. PP1 was more important to deer than was PP2, as indicated by a higher density of trails (3.2 vs. 2.3 trails/0.1km transect) and pellet groups (0.35 vs. 0.06 groups/plot); and by more frequent sightings (Appendix A). PP1 is probably used heavily during summer and winter because it provides a relatively stable and buffered thermal microenvironment. Also, the narrow mowed strips within PP1 serves as an important corridor for resident and visiting deer on the FMPC. It is probable that PP2 does not receive equal use because of its relatively wider mowed strips, more diffuse cover, and internal location. Intensive management

for the purpose of increasing the FMPC deer herd is not judged to be practical.

Fox Squirrel

The gray squirrel (*S. carolinensis*) time-area count described by Bouffard and Hein (1978) was adapted for use with fox squirrels on the FMPC. Twelve temporary, semi-circular plots (0.001 km^2) were established in three deciduous woodlots at least one day prior to censusing. All plots were randomly chosen within prime habitat (Fig. 6). Riparian habitat could not be effectively sampled owing to topographical irregularities. Where feasible, two plots were sampled simultaneously.

All squirrels observed inside plot boundaries within a 30-min sample period (following a 10-min habituation period) were recorded.Censusing was done in early July between 0830 and 1030 hr. The weather was characterized by hazy skies and hot, humid conditions, and was similar during all counts.

RESULTS

An average of 0.25 (±0.13SE) squirrels per plot was observed, suggesting that the density in prime FMPC habitat is about 250 squirrels/km^2 (±130SE). Since this area constitutes about 60% of the 0.73 km^2 deciduous forest/second growth vegetation, a total of 109 fox squirrels were estimated to have used the FMPC during July, 1986. This value excludes squirrels which utilized riparian habitat, but this error was expected to

be slight; sightings of squirrels in riparian habitat were infrequent.

About 20% (0.73 km^2) of the vegetated portion of the FMPC was considered to be usable fox squirrel habitat; of this, 60% (0.44km^2) was judged to be of high quality. The majority of FMPC woodlots are too young to support many squirrels. Observations of habitat quality showed that woodlots in the northern 1/3 of the FMPC support the highest squirrel densities.

SUMMARY AND DISCUSSION

A summary of game wildlife census results obtained at the FMPC during the summer of 1986 is presented in Table 32. Deer populations at FMPC were "low" in 1981 (Battelle 1981). The density of deer at the FMPC during summer, 1986, (38/km^2) was similar to that reported for chestnut oak habitat in Pennsylvania and within the range of other estimates (23 to 276/km^2) summarized by Bennett et al. (1940). Deer population density on the FMPC was, however, considerably lower than that (115/km^2) reported for an enclosed NASA facility in northern Ohio, and for winter populations at Hueston Woods State Park (262/30km transect; La Gory and Taylor 1984). Without knowing what "low" represented in the Battelle (1981) study, it is impossible to compare the size of the herd at present with that of 1981.

The FMPC quail density in summer (68/km^2) was within ranges reported from other regions (66 to 200/km^2 in Iowa and 58 to 210/km^2 in Wisconsin, Errington 1934); however, the estimate was

well below quail densities on managed lands (282 to 1591/km^2 in Illinois, Ellis et al. 1969; 191 to 572/km^2 in Wisconsin and 829/km^2 in Iowa, Errington 1934).

Fox squirrel density at the FMPC (250/km^2) was within the range reported for eastern gray squirrels (241 to 542/km^2) by Bouffard and Hein (1978).

Densities of deer and quail appeared to be high owing to the availability of quality cover and food resources. These species were also numerous because outside human perturbation was slight at the FMPC. Fox squirrels were not particularly abundant, however this paucity undoubtedly reflects marginal habitat quality.

Cottontail rabbits (*Sylvilagus floridanus*) were a dominant game species at the FMPC, both in terms of numbers and distribution. This species is important as a valued game animal and as a first-order consumer. Sightings and indications of some game, fur-bearing and important non-game wildlife species were mapped; they are presented in Figure 7.

THREATENED AND ENDANGERED SPECIES

No federally endangered plant or animal species were observed on the FMPC during the summer of 1986. However, two birds were recorded onsite that appear on the "Rare Species of Native Ohio Wild Animals" list (DNAP-ODNR 1982). A northern harrier (*Circus cyaneus*) was sighted flying over the UGP in mid-June,1986. Since the bird was only observed once, it was

presumed to be either a late migrating individual (harrier migration usually occurs in Ohio from late March to late April; Trautman and Trautman 1968), a bird that was nesting offsite, or an unmated individual. The northern harrier is listed as a species which occasionally nests in the Cincinnati area (CNC 1978), as an uncommon summer resident in nearby Hueston Woods State Park (Osborne and Smallwood 1982), and as an endangered breeder in Ohio (DNAP-ODNR 1982).

A Cooper's hawk (*Accipiter cooperii*) was sighted seven times in July at the FMPC. A female observed on four occasions along the southern boundary of PP1 was believed to be using the pines as a hunting area. Along Paddy's Run just north of RN2, a Cooper's hawk was observed diving into a covey of fledgling bobwhite quail. Additional sightings were "flyovers" in RFAP and W1. Thus, the Cooper's hawk may have been breeding onsite, or at least was utilizing habitats within the boundaries of the FMPC. The Cooper's hawk is listed as an uncommon but regular breeder in the Cincinnati area (CNC 1978), a non-breeder in Hueston Woods (Osborne and Smallwood 1982), and a threatened breeder in Ohio (DNAP-ODNR 1982).

ENVIRONMENTAL POPULATION GENETICS

The ability of a species to survive and adapt to changing environmental conditions may be increased by it possessing a greater pool of genetic variability that can respond to varying selection forces. Under natural conditions (e.g, absence of

anthropogenic influence), the allelic frequencies of a population should fluctuate with time according to stochastic and environmental selection pressures while maintaining a certain level of genetic variability. However, severe perturbations, such as pollution, may reduce genetic variability of populations and thereby increase their susceptibility to the effects of further environmental changes. The loss of genetic diversity may, therefore, weaken the stability of the species (Thorpe and Koonce 1981, Allendorf and Leary 1986). The technique most commonly used to quantify genetic structure in populations employs electrophoretic analysis of selected enzymes to determine allele and genotype frequencies for specific gene loci. These data are used to describe the genetic structure of populations and to compare the genetic diversity among populations.

The importance of genetic variation to animal populations for surviving environmental changes is evidenced by several studies. Enzyme polymorphism may allow for adaptation to changes in thermal environments produced by heated discharges. Allozyme frequencies in mummichog minnows (Mitton and Koehn 1975) and in largemouth bass (Smith et al. 1983) varied between populations inhabiting artificially heated waters and those of natural temperatures. Interestingly, the frequencies of allozymes in largemouth bass from heated waters returned to frequencies of reference populations 10 years after the cessation of thermal stress (Smith et al. 1983). Therefore, the plasticity of enzyme formation, maintained by genetic diversity,

may increase the chance of survival for a species by allowing for adaptation to man-induced environmental changes.

Genetic diversity may also be an important mechanism for adaptation to toxic effects of environmental contaminants. Differential tolerance to mercury was linked to varying genotypes of an enzyme in shrimp (Nevo et al. 1981). Similarly, enzyme polymorphism in marine invertebrates may allow for adaptations to the toxic effects of copper and zinc (Lavie and Nevo 1982), as well as detergents and crude oil-surfactant mixtures (Lavie et al. 1984). The genetic diversity of a population may, therefore, moderate the toxic effects of pollutants and provide a mechanism of survival.

Loss of genetic variability has become a major concern to scientists, with many species displaying low levels of diversity. A continuum of vulnerability to loss of genetic resources exists for fishes due in part to human activities such as fishing and pollution (Thorpe and Koonce 1981). Strittholt et al. (1988) have suggested that the reduction in abundance of yellow perch in Lake Erie could be partly due to low genetic variability resulting from the toxic effects of pollutants. A loss of reproductive fitness, slower development rates and decreased resistance to disease might result from genetic uniformity (Allendorf and Leary 1986). Maintaining genetic diversity is, therefore, essential to the survival of fish populations.

To maintain allozyme diversity we need to monitor genetic structure in aquatic populations that are exposed to risks of

environmental stress. Assessments of genetic structure (allozyme diversity) may provide a sensitive end-point for the effects of environmental stressors (e.g. pollutants) on biological systems. Therefore, analyses of genetic structure may act as a sensitive biological indicator of the health of aquatic populations.

Allozyme variation has been linked to several environmental stressors. Studies have shown how allele frequencies in fishes can be influenced by heat stress (Smith et al 1983) and in marine invertebrates by organic contaminants (Lavie et al. 1984, Nevo et al. 1986) and heavy metals (Lavie and Nevo 1982, 1986, Nevo et al. 1986). Genotypes and alleles of malate dehydrogenase (MDH), glucose phosphate isomerase (GPI) and phosphoglucomutase (PGM) in marine invertebrates were sensitive to organic and inorganic pollutants (Lavie and Nevo 1982, 1986, Lavie et al. 1984, Nevo et al. 1981, 1986). Recent studies in our laboratory (Gillespie and Guttman 1989; Chagnon and Guttman 1989) support a relationship between the effects of contaminants and allozyme frequencies of fishes. Although the effects of radiation on allozyme genotypes have not yet been studied, radiation is a mutagen and increased heterozygosity might result from excessive exposure (Anderson and Harrison 1986).

We examined the genetic structure of a diversity of plant and animal populations to determine whether there are stress induced differences among onsite and offsite populations.

STUDY SITES

Taraxacum officinale

Samples of 20 common dandelions (*Taraxacum officinale*) were obtained from July to September 1986 at each of 13 sites (Fig. 8) at the FMPC. Samples 1, 5, 9, and 10 were collected from mowed pastures, samples 2, 3, and 4 from grazed pastures, samples 6, 7, 8, and 13 from mowed, lawn-like areas, and samples 11 and 12 from the waste pit area. Samples 2 and 3 were from the extreme western boundary of the FMPC. Sample 14 was an offsite population collected from a mowed lawn in Peffer Park, Oxford, Ohio.

Dandelions were collected randomly along transects where possible (1, 2, 4, 5, 7, 11, 12). Only undamaged leaves (2/plant) were taken leaving the rest of the plant intact. The leaves were immediately placed in Ziploc bags on ice for transport to Miami University and stored at 5° C for no more than 48 h prior to electrophoresis.

Asclepias syriaca

Samples of 20 milkweed (*Asclepias syriaca*, 2 leaves/plant) were collected from four sites at the FMPC (Fig. 8) in September 1986. Sample A was obtained from a soil-covered fly ash pile, sample B was collected on the southwest edge of an uncovered fly ash pile, sample C was collected on the west side of Paddy's Run Road in an old-field and sample D was collected in the north pine plantation among the pine trees. Sample E, an offsite population, was collected from a young-field in Hueston Woods

near Oxford, Ohio. Collection and storage were as above for the dandelions. In some areas however, the milkweed plants occurred in isolated clumps which made collecting from transects impossible.

Amphibians

In May 1986, 60 spring peeper (*Hyla crucifer*) tadpoles were collected from an ephemeral pond, surrounded by mowed grass, within the Waste Pit Storage Area about 400m southeast of the waste pits (Fig. 8). Fifty American toad (*Bufo americanus*) tadpoles were taken from a small, concrete-lined pool beneath a metal oil tank immediately south of the north pine plantation (Fig. 8). An offsite population of *B. americanus* was sampled from the marsh area at the base of the Acton Lake Dam in Hueston Woods State Park near Oxford, Ohio. All tadpoles were in the same stage of development.

Tadpoles were transported live to Miami University and maintained, individually frozen at -70° C, until electrophoretic processing in November 1986.

ELECTROPHORETIC METHODS

Dandelion and milkweed leaves were homogenized manually in buffer [0.20M Tris HCl (pH 8.0), 0.5% sodium metabisulfite, 0.5% tetrasodium EDTA, 0.01M $MgCl_2$; final pH 7.5] and then frozen at-70° C until electrophoretic processing 12 h later.

Tadpoles were homogenized mechanically with 0.25M sucrose 2% 2-phenoxyethanol buffer, then centrifuged at 20,000 g at 5° C

for 6 min. The supernatant was then stored at -70° C until use. All tadpoles were electrophoresed within 3 weeks of homogenization.

Loci analyzed and buffers used are detailed for each taxon in Table 33. Gels for plant samples were 15% Sigma starch (Karlin and Guttman 1981); tadpoles were examined using the same starch concentration except for the LiOH system which was made with 13% Sigma starch.

Histochemical procedures followed Harris and Hopkinson (1976) and Selander et al. (1971). After the gels were stained, the genotypic composition of each sample at each locus was determined and recorded. Genotypic data (*Asclepias*, *Bufo*, *Hyla*) were analyzed using the BIOSYS-I computer program (Swofford and Selander 1981). Allele frequencies, deviation from expected proportions assuming Hardy-Weinberg equilibrium conditions, amount of genetic variation, similarity matrices and chi-square contingency tests for interpopulation heterogeneity were performed. When expected numbers of alleles in a sample or expected genotypic classes were rare, rare alleles or uncommon genotypic classes were pooled. *Taraxacum* data were analyzed as allele frequency data using BIOSYS-I. Since *Taraxacum* has been reported to reproduce asexually, principal component analyses (SYSTAT; Systat, Inc.) were utilized to determine whether clones exist and to estimate clonal diversity within our population samples.

Throughout our analyses of genetic data we have assumed that the populations studied are in Hardy-Weinberg equilibrium.

The Hardy-Weinberg theorem states that if populations are large, mating is random, and migration, mutation and natural selection do not occur, then gene frequencies and genotype ratios in populations reach an equilibrium in one generation and remain constant thereafter; under this theorem evolution does not occur. However, evolution does occur if these gene frequencies and genotypic ratios are disturbed by new mutations, assortative mating, natural selection or genetic drift. Thus, in population genetic studies, observed gene and genotypic proportions are compared with those proportions expected under conditions of Hardy-Weinberg equilibrium. We compared deviations from values expected under Hardy-Weinberg equilibrium conditions in FMPC and offsite populations and determined whether deviations were significantly different among the sampled populations. Therefore, the genetic structure of FMPC populations sampled is not only compared with a theoretical population but is also compared with actual offsite populations.

Expected genotypic proportions and heterozygosity were calculated from observed allele patterns. (Using the Hardy-Weinberg theorem, let the three alleles a, b, c have gene frequencies p, q, and r where $p + q + r = 1$. Then the expected genotypic frequencies after one generation of random mating are given by the binomial expansion $(p + q + r)^2$. Multiplying the expected genotypic frequencies times the sample size yields the expected genotypic proportions. Individual genotypes with two alleles are heterozygous; summing expected heterozygosity for

each locus and dividing by the number of individuals in the sample yields the expected heterozygosity for the population.)

RESULTS

Asclepias syriaca - milkweed

Three of the nine loci examined (GPI, MDH, NP) were invariant in the five samples analyzed. Number of alleles present at the polymorphic loci ranged from two (GDH) to six (DIA). Allele frequencies are presented in Table 34.

Genetic variability data from milkweed populations provide insight concerning population patterning (Table 35). Allelic diversity (mean number of alleles/locus) is high, ranging between 1.7-2.2, with between 33% and 67% of the loci examined polymorphic within a single population sample. In contrast, mean heterozygosity is considerably lower than expected in all samples. These data indicate that deficiencies of heterozygotes exist in population samples; tests for conformation of genotypic distribution to expected proportions under Hardy-Weinberg equilibrium conditions (Table 36) support genetic variability data.

Contingency chi-square analyses of heterogeneity were performed between each pairwise combination of populations (Table 37), among FMPC populations (Table 38) and between a combined FMPC sample and the Hueston Woods outgroup (Table 38). Significant heterogeneity does not occur among pairwise samples at the 6PGD or SOD loci; GDH and ACP heterogeneity exist in 30% and 50% of the comparisons, respectively (Table 37). In

contrast, homogeneity is the exception at the LAP and DIA loci, occurring in only 10% of the comparisons. Identical loci (ACP, DIA, LAP) confer the same degree of heterogeneity ($p \leq 0.01$) in comparisons among the FMPC samples and between a combined FMPC sample and the offsite sample (Table 38).

Taraxacum officinale - common dandelion

Three (MDH, PGM-1, NP) of the 14 electrophoretic loci analyzed in the 14 dandelion collections were monomorphic. Number of alleles present at the polymorphic loci ranged from two (CAT, DIA-2, G6PD, GPI-2) to six (DIA-1). Allele frequencies are presented in Table 39.

Population patterning in dandelions cannot be directly compared with that in milkweeds because in southwestern Ohio the former taxon is present as a triploid apomict. Actual allelic diversity in the triploid parallels that found in *Asclepias*, the mean number of alleles/locus ranging from 1.6-2.4 (Table 40), with between 35.7% and 78.6% of the 14 loci polymorphic within a single sample. The apomictic nature of *Taraxacum* precludes calculation of expected heterozygosity data as well as conformation of population genotypic proportions to that expected under conditions of Hardy-Weinberg equilibrium since both statistics are based on assumptions of random mating. Direct-count mean heterozygosity is high (Table 40), ranging from 0.08 to 0.29.

Principal component analysis of *Taraxacum* populations (Fig. 9) demonstrates a general lack of clonal population structure.

In two samples, no two individuals were electrophoretically identical (Table 41); other samples each had from one to three instances with two or three individuals sharing genotypes. Sample 10, from the north side of the abandoned incinerator site (located near the sewage treatment plant), was unusual; three groups of electrophoretically identical individuals existed and one of these groups comprised half of the 20 dandelions sampled (Table 42).

Bufo americanus - American toad

Sixty per cent of the 20 loci were variable (Table 43) in the toad populations sampled. The AAT locus, with four alleles, demonstrated the greatest allelic diversity. A major allele frequency shift occurred between populations at the FMPC and Hueston Woods sites at one locus (PGM-1). Contingency chi-square analyses demonstrated significant heterogeneity between the populations at five of the eight variable loci ($p \leq 0.01$: EST-1, GPI, PGM-1; $p \leq 0.05$: ICD-2, LDH-2) examined in both populations. Genetic variability parameters were similar in the two toad samples (Table 44).

Hyla crucifer - spring peeper

Six of the 11 loci sampled in *H. crucifer* were variable (Table 43). Maximal variation was present at the EST and LDH-1 loci, each of which had four alleles. Genotypic proportions at two loci (LDH-1 and 6PGD) deviated significantly ($p \leq 0.01$) from expected under Hardy-Weinberg equilibrium conditions. These

deviations were due to heterozygote deficiencies with all heterozygous genotypes being under-represented at 6PGD and 50% being below expectations at LDH-1. However, the mean number of alleles per locus and mean heterozygosity over all loci were high (2.1 and 19.8%, respectively), with direct-count heterozygosity not significantly different from expected.

DISCUSSION

Asclepias syriaca

Sufficient samples of milkweeds from the FMPC site were analyzed to allow for heterogeneity determinations; these demonstrated that significant heterogeneity exists among population samples of *Asclepias* onsite. The most divergent milkweed population was D, from the northeast mowed area. Pairwise comparisons between D and each of the other four samples were significantly different more often than with any other FMPC milkweed sample. In addition, *Asclepias* collections C and D had the least variability (mean direct-count heterozygosity 4% and 7%, respectively) and their genotypic proportions were significantly different from expected under Hardy-Weinberg equilibrium conditions at all polymorphic loci. Heterozygosities in all FMPC *Asclepias* samples were approximately half that expected and low for plant populations (Nevo 1978, Nevo et al. 1984); actual heterozygosity in population C was about 25% of expected. However, the offsite milkweed sample exhibited the same genetic properties present in most of the FMPC samples: significant deviations from expected

proportions at half (2) the polymorphic loci, actual heterozygosity 50% of expected and not significantly different from FMPC samples. Contingency chi-square analyses demonstrated significant differentiation among the FMPC milkweed populations and between those and the offsite sample. Since only one milkweed population was collected at a sufficient distance from the site to insure that FMPC operations could not affect the sample, heterogeneity could not be measured between offsite samples.

Taraxacum officinale

Solbrig and coworkers (reviewed by Solbrig and Solbrig 1979) electrophoretically analyzed two loci in *Taraxacum officinale* populations in the vicinity of Ann Arbor, Michigan and noted three to four clones per site; clonal dominance varied with the type of habitat. Five enzyme loci were combined with seed color in a study of 22 populations of *T. officinale* from the western U. S. (Lyman and Ellstrand 1984); they found 47 discernible clones among 518 individuals sampled with the number of clones per population ranging from 1-13. Our intent was to examine 14 loci in 13 dandelion populations from the FMPC and one from Oxford to determine whether FMPC operations affect clonal diversity. Our data suggest that diversity in *Taraxacum officinale* from the FMPC is generally high and not different from that in the Oxford sample. With one exception, we did not find evidence for clonal structuring of populations; the general pattern for the FMPC and offsite samples was extreme

intrapopulation heterogeneity. Few individuals within each population were electrophoretically identical; each individual with a unique combination of genotypes represents a distinct clone. Differences between our data and other studies of *Taraxacum officinale* (Lyman and Ellstrand 1984, Solbrig and Solbrig 1979) could be attributable to differences in analysis; we utilized 11 variable loci in contrast to their two loci. This increase in loci sampled resulted in a large change in the potential number of genotypic combinations that could be found in individual *Taraxacum* and other studies, by utilizing fewer loci may have grossly underestimated clonal diversity (Ellstrand and Roose 1987). However, Silander (1979, 1984) found extensive heterogeneity in the distribution of clones among subpopulations of salt marsh cord grass (*Spartina patens*). Some subpopulations were dominated by a small number of large clones while other subpopulations were characterized by a large number of small clones with little overlap in genotypic composition. The latter *Spartina* pattern describes that found in almost all *Taraxacum* populations that we studied. Silander (1984) noted greater genetic similarity within habitat types than between habitat types. Chi-square contingency tests within and between subpopulation groups from dandelion habitat types yield similar data.

Population 10, from the north side of the abandoned incinerator, was composed of one large clone including 50% of the individuals sampled and two smaller clones; the remaining 30% of the individuals were each electrophoretically unique.

This is the only sample showing reduced clonal diversity; mean direct-count heterozygosity for population 10 is lowest of all samples. Larger and more successful clones were less heterozygous than smaller ones (Silander 1984). Selection has been shown to result in decreased genetic (Nevo et al. 1978, 1984, Strittholt et al. 1988) and clonal diversity (Silander 1984). Conditions at the location of sample 10 may be acting to negatively influence dandelion clonal diversity with the dominant clone being the hardiest. Future investigations should determine whether the reductions found in *Taraxacum* genetic variability at the abandoned incinerator site extend to other plant and animal taxa in the area and the cause(s) for the reduction(s).

Since this genetic survey began in July, samples of both plant taxa were collected in the middle to late portions of the growing season; therefore, the genetic composition of samples may not be representative of that present early in the spring. Seasonal and annual changes have been shown to occur in allelic and genotypic frequencies.

All sites sampled at the FMPC were disturbed either by a variety of land management procedures (e.g., mowing, grazing) and/or FMPC operations. Different management procedures select for altered genotypic combinations (Solbrig and Solbrig 1979); byproducts from manufacturing processes (heavy metals, organics) also differentially eliminate certain alleles and alter genetic variation (Strittholt et al. 1988). Contingency chi-square analyses documented significant frequency differences

between *Asclepias* or *Taraxacum* populations from different habitats as well as among populations within a habitat type. Offsite samples for each taxon differed significantly from the FMPC samples but the former populations were also from managed sites.

Bufo americanus

Marked differences in allele frequency existed between the two toad populations; 62.5% of the variable loci examined in both samples were significantly different. The habitats occupied by the two *Bufo* populations were also extremely different. The marsh at the base of Acton Lake Dam in Hueston Woods State Park is occasionally ephemeral but usually contains water until at least mid-summer. The concrete-lined pool at the FMPC is ephemeral and probably dries up during any xeric interval. In addition, the water in the FMPC pool was rusty-brown in color and metal flakes were on the pool bottom. The water also had an oily film on the surface.

Anurans, especially toads (Christein and Taylor 1978, Christein et al. 1979), have been shown to exhibit fidelity to their natal site when they mature and commence reproduction. Selection for both early oviposition and rapid development must be intense in the FMPC pool. Studies (Place and Powers 1979, Allendorf et al. 1983) have demonstrated that different alleles at certain enzyme loci (LDH and PGM, respectively) differ in their effect on growth of fish. Some of the allelic changes between the two sites may be due to this selection. Heavy

metals have been shown to inhibit certain alleles of glycolytic enzyme loci (recently reviewed by Strittholt et al. 1988). Nevo et al. (1978) demonstrated organic pollution selection of allozyme polymorphisms. Tadpoles can be raised under controlled laboratory or field conditions and exposed to heavy metals, organics, xeric conditions or other variables; the effects of these variables on genotypic composition can readily be determined.

Heterozygosity was equal and high in the two samples. *Bufo americanus* is genetically one of the most variable diploid vertebrate taxa (Guttman 1975; Guttman 1985) and the populations examined possessed greater than average variability for the species.

Toads were observed calling from, and depositing eggs at, the *Hyla crucifer* sample site (see Fig. 1) but *Bufo* tadpoles could not be found at this site.

Hyla crucifer

Only one spring peeper sample was obtained. Genetically this sample is unusual for several reasons. First, direct-count mean heterozygosity and mean number of alleles per locus are extremely high; the only *Hyla* with a higher reported heterozygosity is a tetraploid (Guttman 1985). Second, GPI is unusual in that one of the alleles (GPI^C) is a null (inactive under assay conditions). Null alleles have been identified at glycolytic enzyme loci (e.g., G6PD deficiencies) in human populations (Spiess 1977) and these are often associated with

disease. Guttman (1985) recently reviewed the literature on biochemical systematics and population genetics of frogs and toads and did not find any instance of a null allele at a glycolytic enzyme locus. Until offsite samples of spring peepers can be examined it is not possible to determine whether the null allele originated in treefrogs from the waste pit area and/or is restricted to that population.

Amphibian tadpoles were collected in May after they were observed during a tour of the FMPC. Since the study did not formally commence until July and frogs and toads frequenting ephemeral bodies of water metamorphose by June, we were unable to obtain additional populations to compare to the sparse number onsite and offsite. The late starting date of the study precluded determining possible reasons for the lack of *Bufo* tadpoles in the waste pit ephemeral pond and whether there was selective elimination of certain genotypes during the development of a toad or spring peeper cohort.

SUMMARY AND CONCLUSIONS

The terrestrial biota is described, quantified, and mapped for 6 major habitat types representing 364.5 ha within the confines of the FMPC. The habitat types sampled, and the percentage of the total FMPC area represented by each, were ungrazed pastures (30%), grazed pastures (25%), woodlots (20%), riparian (12%), pine plantings (11%) and reclaimed fly ash piles (2%). Eleven permanent line transects were established and all

terrestrial flora and fauna were sampled in relation to these transects. Three fish sampling sites in Paddy's Run, which courses north to south near the western border of the facility, were established, marked, and mapped. Biota of the production area was not sampled. Populations of American toads, spring peepers, milkweed and dandelions were sampled from onsite and offsite locations to evaluate possible differences in genetic structure. Appendix A, Catalogue of Species of the FMPC (under separate cover), includes estimates of relative abundance for 98 species of herbaceous plants, 46 species of trees and shrubs, 127 families of terrestrial insects and arthropods, 13 species of fish, 10 species of amphibians and reptiles, 83 species of birds and 8 mammalian species in each habitat type. Thus, a total of 385 taxa (more than 41,000 organisms) were identified and recorded during summer, 1986. Forty-four percent of these were terrestrial arthropods. The FMPC facility did not support any federally listed rare or endangered species; however, a northern harrier and a Cooper's hawk were recorded onsite. Both appear on the list of rare species in Ohio.

The 3 pasture habitats (55% of the study area), were the simplest in terms of biotic richness and diversity and were most similar to each other with respect to herbaceous vegetation. The 2 discontinuous pine plantations also had similar herbaceous and avian species composition despite their being dominated by different tree species. The northern pine stands were predominantly white pine while Austrian pine was dominant in the southern stand. These stands were least diverse with respect to

woody vegetation (H' = 0.975 and 0.998, respectively), and were also the most dense of the habitats studied. They supported the highest number of deer of any habitat type.

Vegetation

We found 98 herbaceous species representing 38 families on the FMPC. The majority of sites within FMPC boundaries are in various stages of succession from pasturage and orchard use. Regarding herbaceous vegetation, woodlot 3 and the riparian habitats are most like mature woodlands common to southwestern Ohio.

Compared to an offsite reference area, FMPC woodlots contained 32-43% fewer herbaceous species. Several plant species were expected but missing (or present in extremely low abundance) from FMPC habitats. In addition, several taxa common to disturbed and successional habitats were absent or rare from obviously successional FMPC habitats. Of all herbaceous species present, 50% were considered rare in occurrence in our sample.

Thirty-four species of trees were found on the FMPC, but less than half this number (16) were found to be present as saplings. Only along the northern section of Paddy's Run and in woodlot 3 was this ratio exceeded. The absence of common dominant species such as the tulip tree and American beech is notable.

Terrestrial Arthropods

Treehoppers were present in only half of the areas sampled, and low in number (1.9-17.4/1000 sweeps) where present. We also

found low numbers of Lepidoptera and some Coleoptera. Carabids were absent from all areas and cicindellids were present only in the southern riparian area. Low numbers of jumping spiders, crab spiders, and orb weavers were found in the pasture habitats. Similar patterns were not observed in the pine and riparian communities. In addition, while collecting grasshoppers for biochemical analysis, one of the authors (CFF) noted a significant difference in community structure between grasshopper communities found near boundary air sampling stations 2 and 3.

Fish

As Paddy's Run was dry from the K-65 storage area to a point below the Willey Road bridge, only 3 sites upstream of the waste pit area could be sampled. A total of 2590 fish representing 13 species were collected. Ten species were collected at the two most upstream sites (sites 1 and 2) whereas only 8 were found at site 3. The number of species present at site 1 was enhanced by sampling both pool and riffle. Dominant species at the 3 sites were the stoneroller, creek chub, and bluntnose minnow (sites 1,2,and 3, respectively), but creek chub density was greatest ($1.43/m^2$) when considering the total catch. Densities at each site were probably inflated by the large number of juveniles (<20 mm total length) collected. Based on this survey, the ichthyofauna in Paddy's Run appears to be fairly diverse, but a more extensive survey is required before the piscine community in the stream may be fully characterized.

Amphibians and Reptiles

A systematic method of censusing this faunal group was not employed during the summer of 1986. Only anecdotal sightings were recorded and presented in Appendix A, Catalogue of Species of the FMPC.

Avifauna

We found 83 species of birds on site. Eleven species, normally present in similar habitat types, were absent from the FMPC. Perhaps the most notable of these was the common nighthawk. Nine of the species actually present on site were expected in higher numbers. Nine of the 11 missing species, and 6 of those which were expected in higher numbers, were insectivores, predominantly foliage gleaners.

Several unusual or unexpected species were observed including the savannah sparrow which has been listed only as an uncommon migrant in the southwestern corner of the state. This species appears to be replacing the grasshopper sparrow in some FMPC habitats.

Small Mammals

Small mammal populations on FMPC pasture lands seemed to be extremely low in numbers. During 360 trap-nights, none were caught in the southeast pasture and only one meadow vole was captured in each of the other pastures sampled. The most ubiquitous small mammal on the FMPC, present in 8 of the 11 sampling areas, was an insectivore, the short-tailed shrew. Other than an immature cottontail, shrews were the only

mammalian species caught in the reclaimed fly ash pile habitat. Overall, the woodland white-footed mouse was the most numerous small mammal on the FMPC. In those areas where present (6 of 11 sampling areas), 47 individuals were caught; an average of nearly 2.18 animals per 100 trap nights (range=1.11/100TN in RN2 to 3.89/100TN in W1). The meadow jumping mouse (1 individual in each riparian area) and the eastern chipmunk (a single individual in W1) were least numerous. No house mice were captured on the FMPC.

Game Animals

Quail, white-tailed deer and squirrel populations onsite were censused using a variety of methods. Generally, such populations appeared to be healthy and present in good numbers. One hundred forty-two quail and 18 deer were estimated to have been present on the FMPC in November, 1986. Approximately 109 squirrels were present in July, 1986; a density of 250/km^2. Cottontail rabbits were not censused due to time constraints.

Threatened and Endangered Species

No federally listed threatened or endangered species were found on the FMPC.

Environmental Population Genetics

Four organisms were chosen for study: common dandelions, milkweed, spring peepers and American toads. With the exception of spring peepers, which were collected from an onsite location only, both onsite and offsite samples were collected for

comparison. The number of enzyme systems analyzed ranged from 9 for milkweed to 12 for the toad. Genotypic data for milkweed, toads and peepers were analyzed to determine allele frequencies, deviation from Hardy-Weinberg equilibrium conditions, amount of genetic variation and interpopulation heterogeneity. Since dandelions have been reported to reproduce asexually, dandelion data were analyzed as allele frequency data only and principal component analysis was used to detect the number of clones within each sub-population.

Thirty-three to 67% of milkweed loci examined were polymorphic with 1.7-2.2 alleles per locus, depending on the population. Heterozygosity was lower than expected in all populations. This may have been due to late season sampling after selection had already occurred.

Only 3 of 14 loci examined in dandelions were monomorphic, and 2 to 6 alleles were present at the polymorphic loci. Clonal diversity was much greater than expected. Of 20 plants examined from a population located in the northwest corner of the site, none were identical. From a site near the old incinerator, however, 10 of 20 plants were identical. We may have found greater clonal diversity than has previously been reported due to the fact that we examined 11 variable loci compared to only 2-6 examined by earlier workers. The plants from near the incinerator also showed reduced heterozygosity. Conditions at that location may be acting as a selective agent, the dominant clone being the most hardy.

Whereas the 2 toad populations were significantly different at over 62% of the loci examined, there were major site differences as well. The relative uncertainty of the presence of water in the FMPC pool where the tadpoles were collected may have acted to select for early oviposition and development in the offspring of toads which breed there. There was no difference in heterozygosity of the 2 samples, and both possessed greater than average variability for the species.

Spring peepers collected from the FMPC had extremely high mean heterozygosity (0.20 by direct-count). Only one other species of *Hyla*, a tetraploid, is known to be higher. The mean number of alleles per locus detected (2.1) was also higher than expected. A null allele was found at the GPI locus. Although sometimes found in human populations (usually associated with diseases), this is the first reported instance of a null allele at a glycolytic enzyme locus in amphibians. The pool from which the spring peeper tadpoles were collected contained several breeding pairs of American toads prior to our sampling effort. Eggs of this species were seen as well, but when we sampled spring peeper tadpoles we were unable to find *Bufo* tadpoles. This may be indicative of differential mortality between the two species due to some unknown environmental factor associated with that location (near the waste pits).

GENERAL CONCLUSIONS

Many of the phenomena observed during summer, 1986, are indicative of environmental stress, but the cause(s) cannot be

determined with the information presently available. As noted in the sections of this report which deal with FMPC avifauna, habitat manipulation may have been the major cause of the deviations observed. The summer of 1986 was dryer than usual and probably stressed some populations. Drought conditions were particularly stressful on aquatic biota.

Several groups of organisms were sampled relatively late in the year after natural selective forces had an opportunity to work, thus some of our samples may not have been truly representative of the populations from whence they came. In addition, without adequate controls for comparison, it was, and will continue to be, impossible to assign probable cause. Even when reference populations were available, as in the case of the population genetics studies, results were not totally clear, and may have been influenced by natural factors (e.g., the predictability of water in toad breeding ponds).

ACKNOWLEDGEMENTS

Sincere appreciation is expressed to Chris Aas and Dr. Suellen A. van Ooteghem, Environmental Compliance, WMCO, for their continued encouragement in all phases of this project, and to Security for their cooperation, including watching over our field base camp and reporting sightings of deer and other mammals. Special appreciation is extended to Mr. Ronald Mehrley, grounds supervisor, WMCO, for rearranging mowing schedules to meet our sampling needs, and to Mr. Byron Knollman

for allowing us to maintain flagging in his pastures for extended periods of time. Finally, we wish to thank students Kara Koprowski, Christina Osborne, and Brenda Sinclair for their long hours spent in preparing data sheets, drafts, and the final copy of this report.

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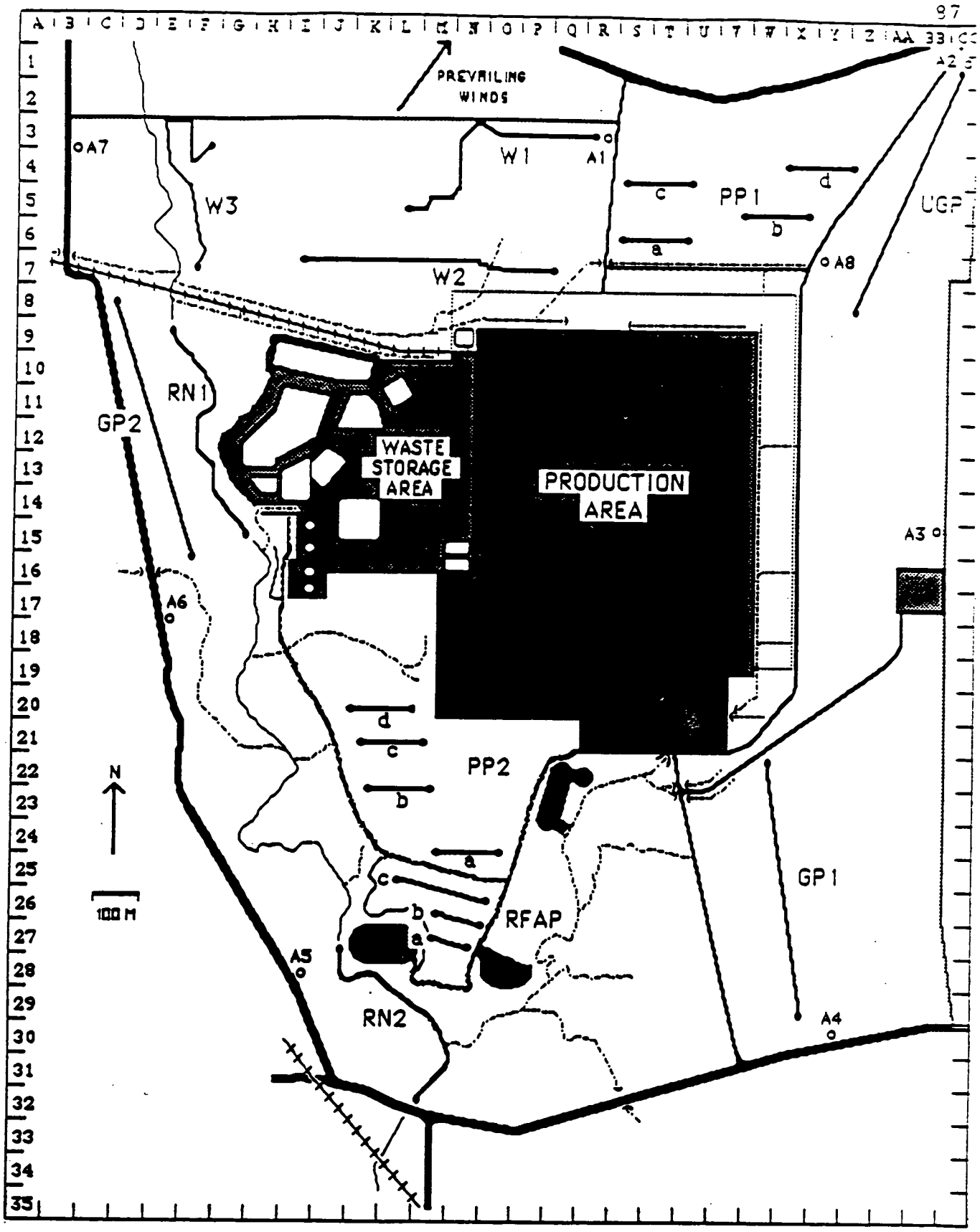

Figure 1. Locations of the permanent transects established and air monitoring stations(A) at the FMPC. UGP=ungrazed pasture; GP=grazed pasture; PP=pine plantation; RFAP=reclaimed fly ash pile; W=woodlot; RN=riparian.

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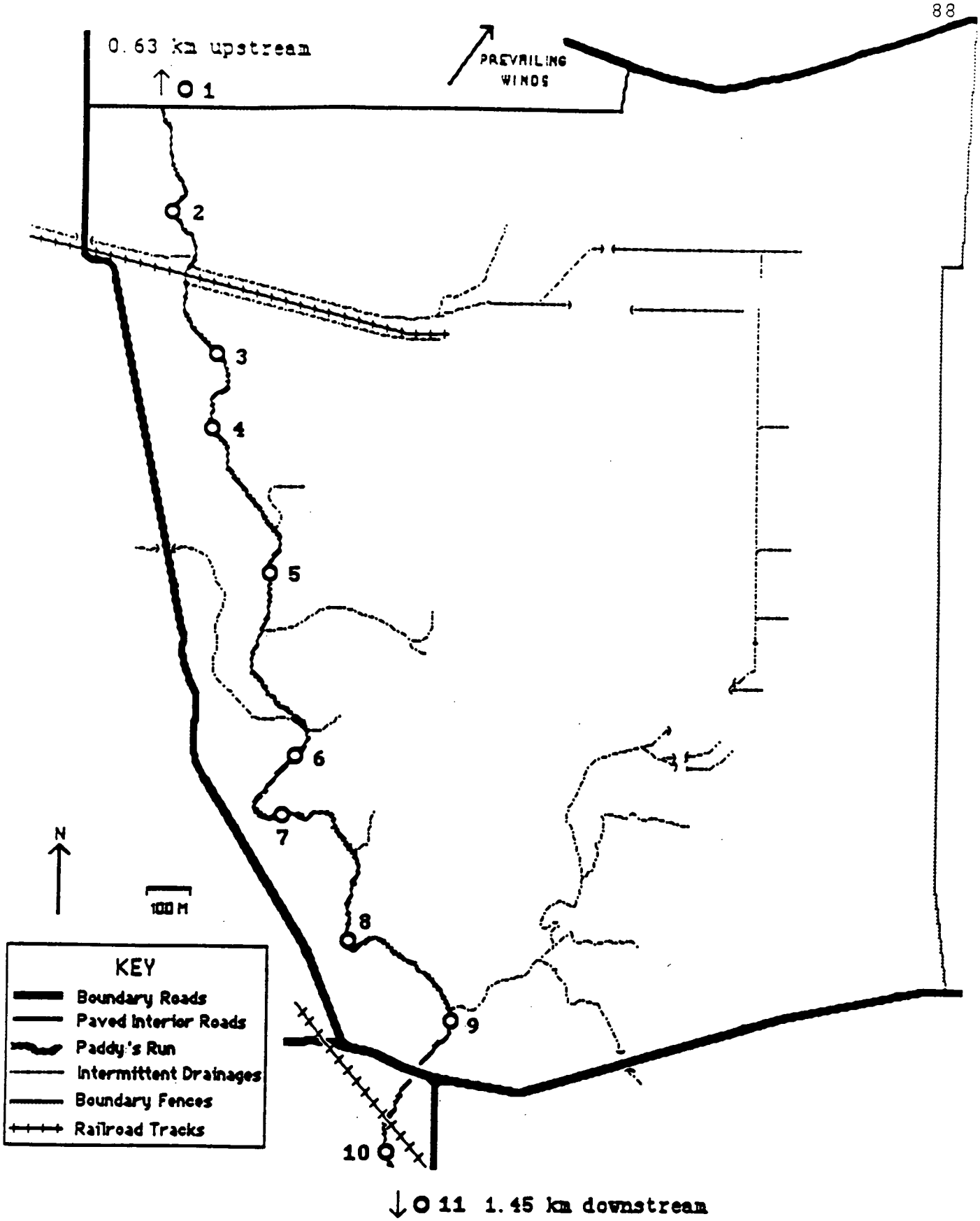

Figure 2. Fish sampling sites on Paddy's Run.

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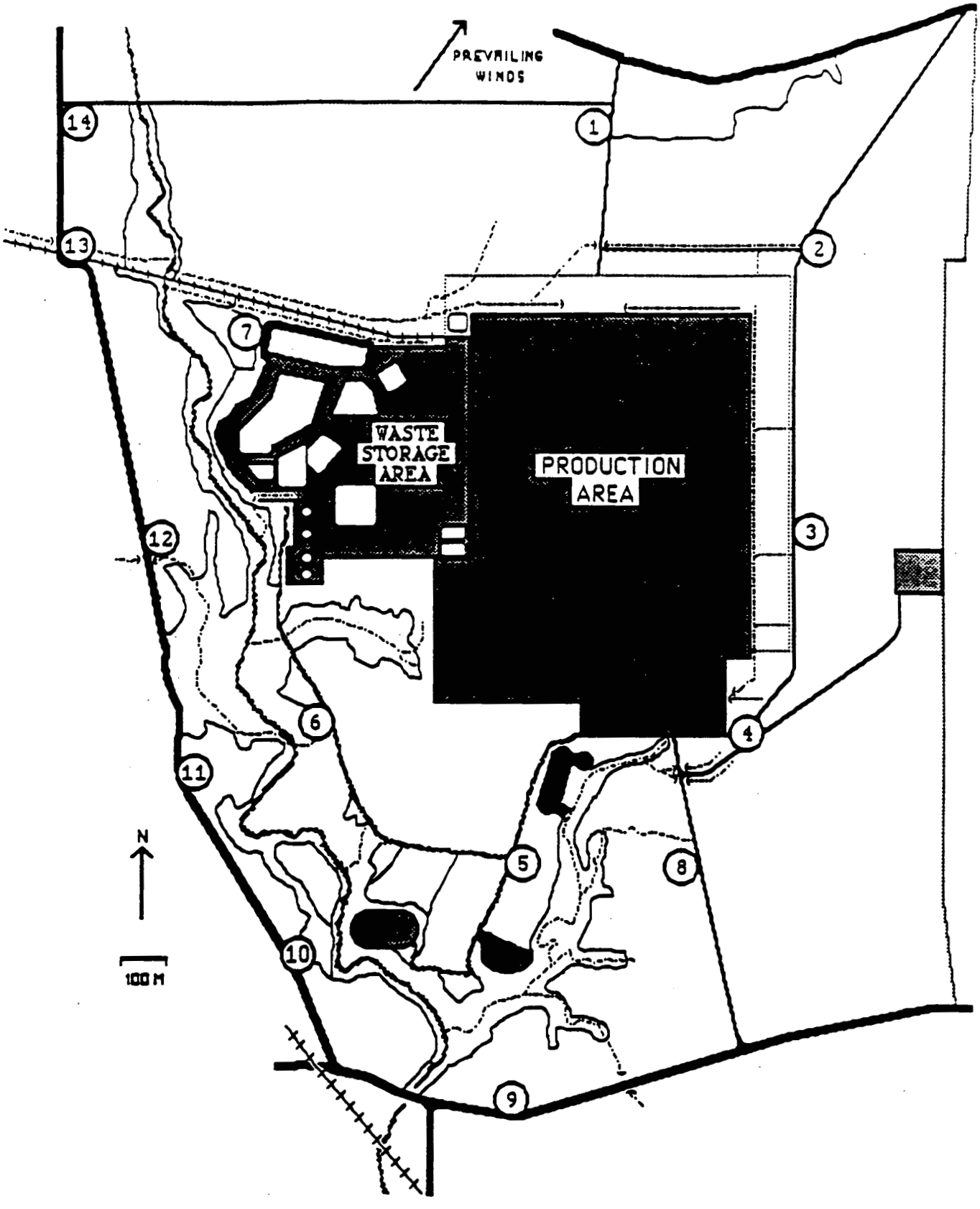

Figure 3. Location of the 14 call-count stations used in bobwhite quail censuses at the FMPC during July, 1986.

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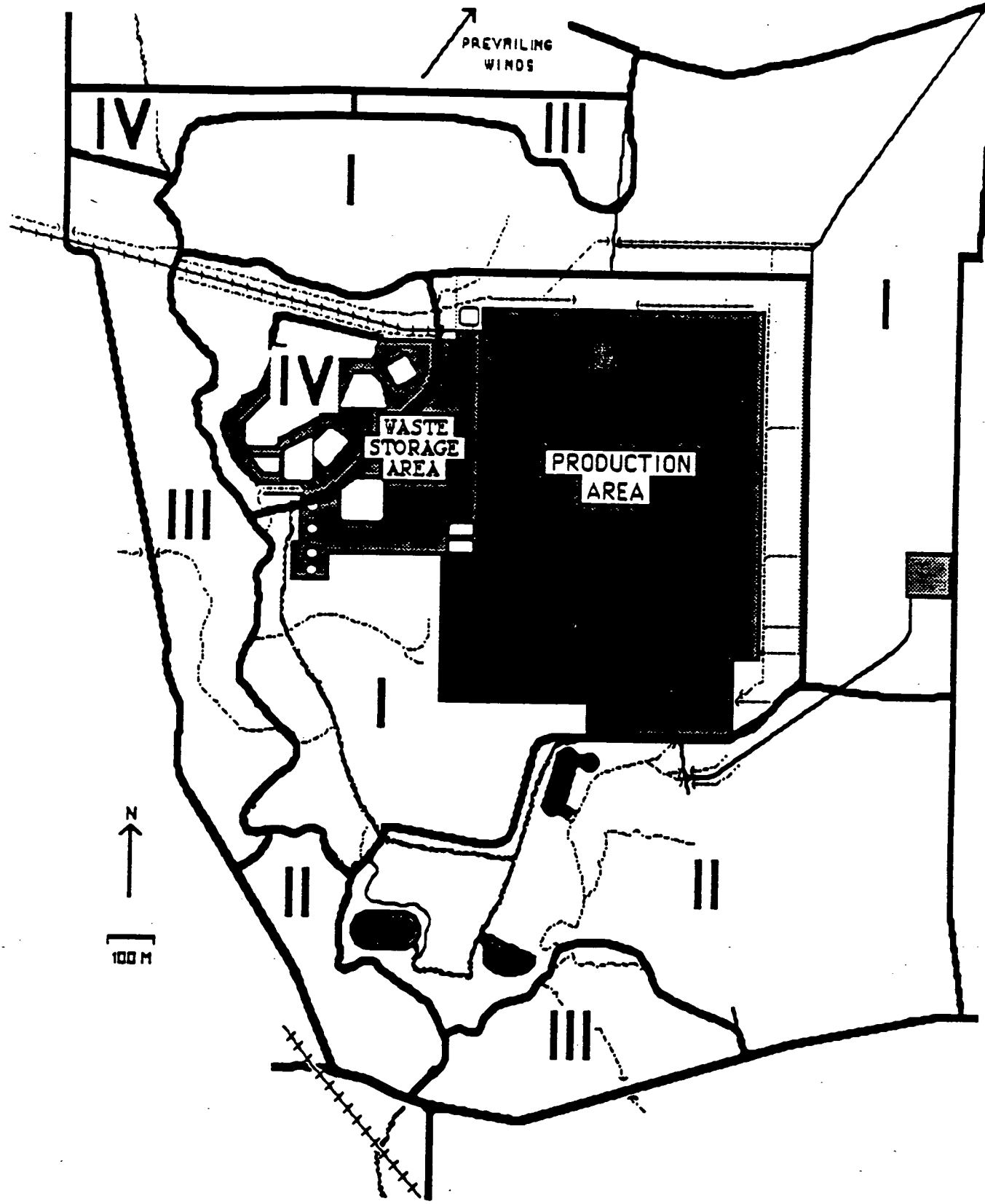

Figure 4. Distribution and quality of breeding bobwhite quail habitat at the FMPC during July, 1986. Quality codes are: l=poor; ll=fair; lll=good; lV=excellent.

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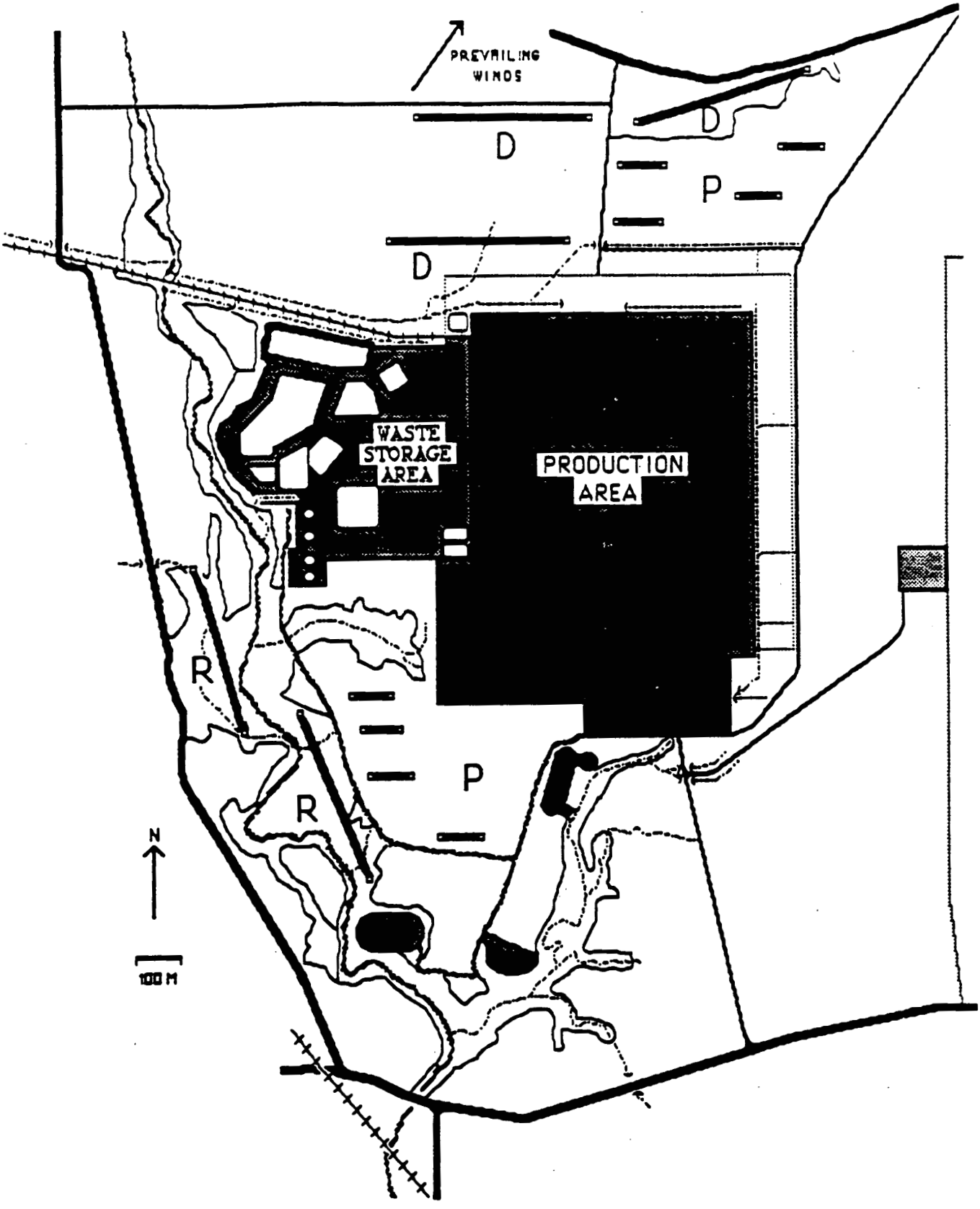

Figure 5. Locations of 13 temporary transects used in the trail count method for censusing white-tailed deer at the FMPC during June, 1986.

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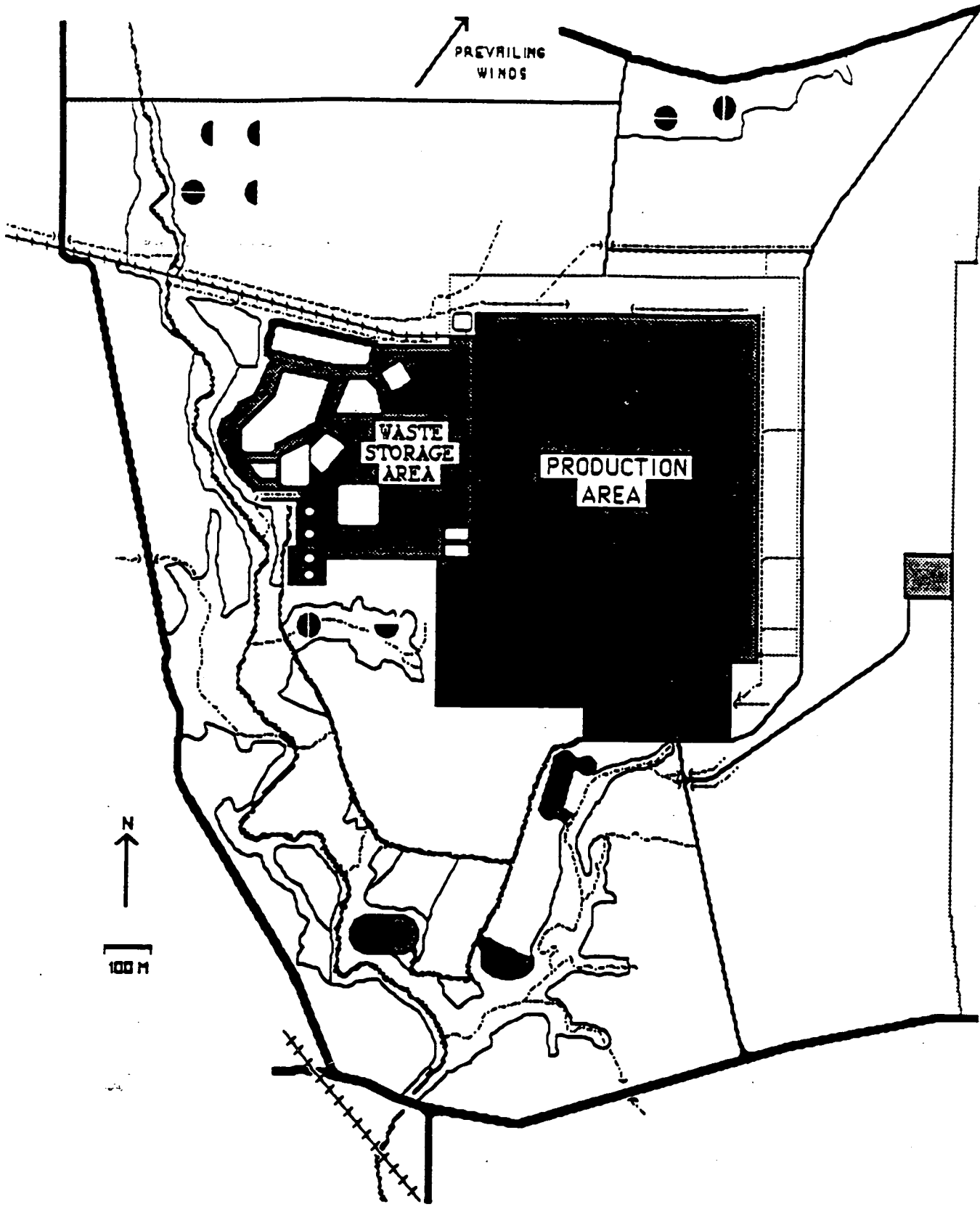

Figure 6. Locations of 12 semi-circular, temporary plots used in the time-area count technique for censusing fox squirrels at the FMPC during July, 1986.

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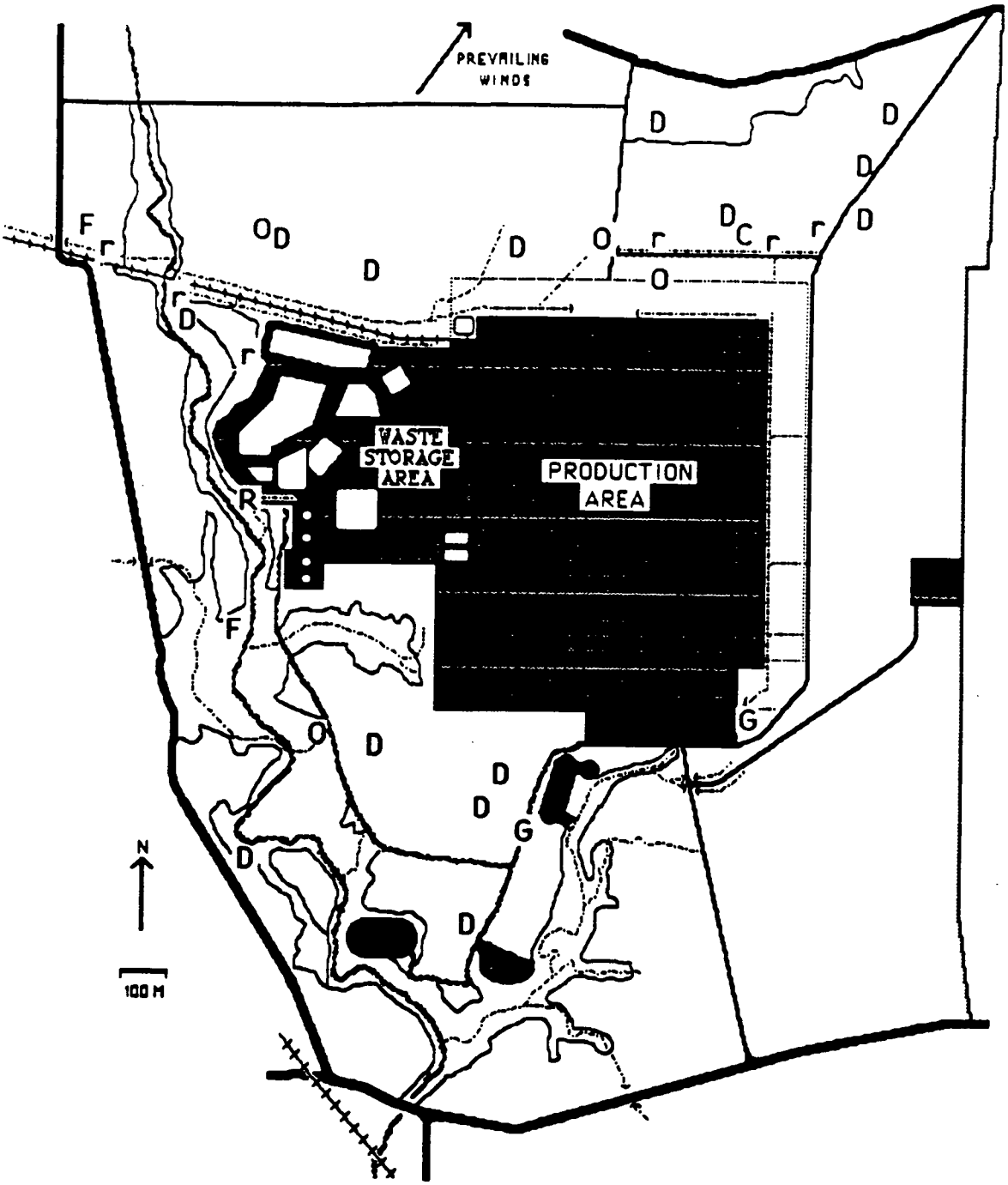

Figure 7. Game furbearing and important non-game species observed or identified by indirect evidence (tracks, feces, etc.) during summer, 1986, at the FMPC. Codes: C = coyote, identified by scat; D = white-tailed deer individual sightings (although not indicated, group sightings were frequent); F = red fox with dens identified; G = groundhog; O = great horned owl; R = raccoon; r = cottontail rabbit (indicates area of frequent sightings.

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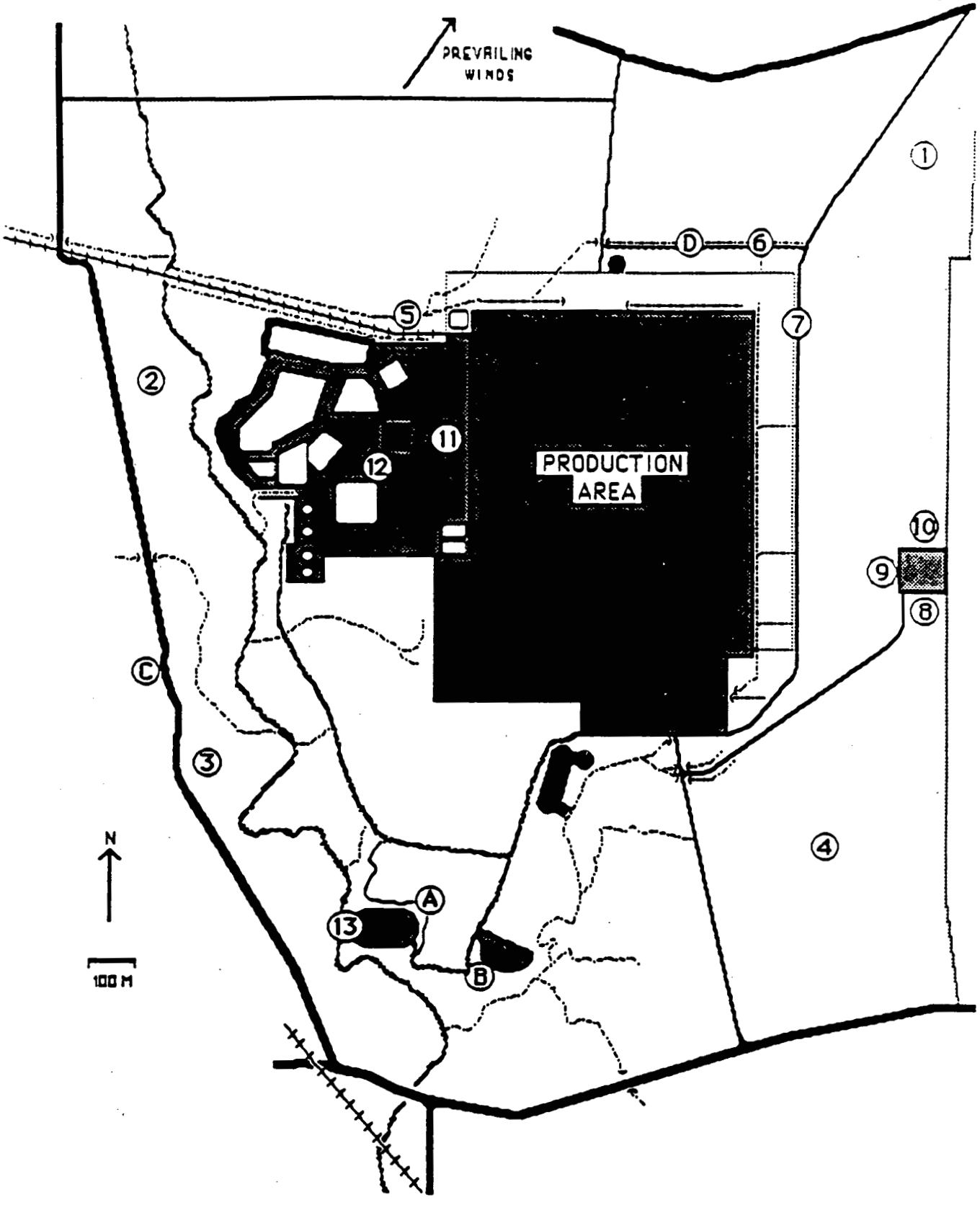

Figure 8. Locations of FMPC sample sites for dandelions (1-13), milkweeds (A-D), toad tadpoles (solid circle), and spring peeper tadpoles (solid square).

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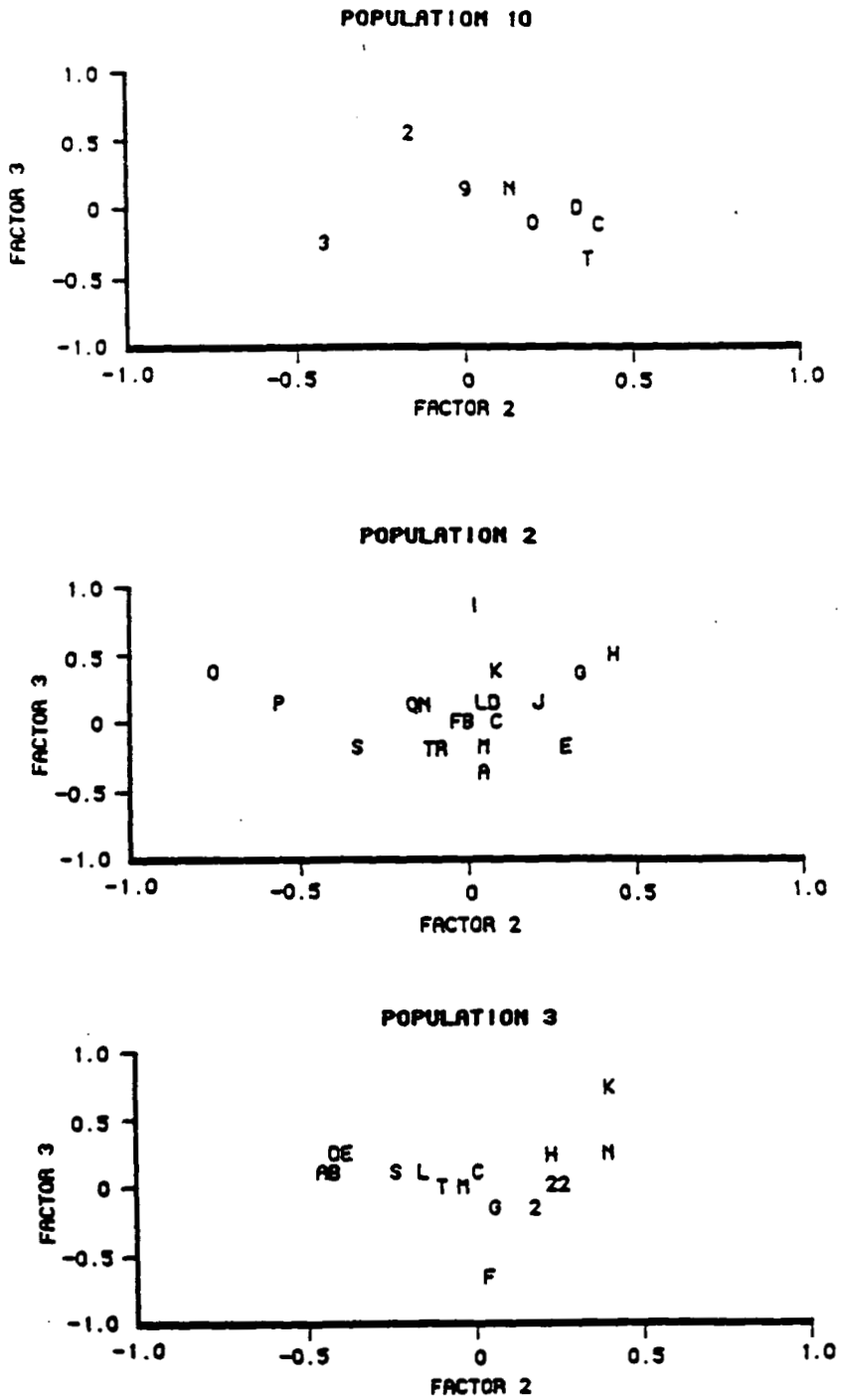

Figure 9. Patterns from principal component analysis of selected dandelion populations demonstrating atypical reduction in clonal diversity (population 10), all unique individuals (population 2) and three multi-individual clones, each composed of three individuals (population 3). Letters represent individual dandelion plants (clones); numbers (to a maximum of 9 representing 9 or more) indicate the frequency of occurrence of dandelion plants with identical genotypes in a population.

Table 1. Distribution of the permanent transects and area of the habitats sampled at FMPC.

HABITAT TYPE	NO. OF TRANSECTS	AREA (ha)	% OF TOTAL
Ungrazed Pasture	1	108.7	29.8
Grazed Pasture	2	93.0	25.5
Woodlots / Sec. Growth	3	72.5	19.9
Riparian	2	42.9	11.8
Pine Plantations	2	40.1	11.0
Reclaimed Fly Ash Pile	1	7.3	2.0
TOTALS	11	364.5	100.0

Table 2. Descriptions of the transects established at the FMPC.

TRANSECT	CODE NAME	MAP COORDINATES[1]	STARTING POINT AND DESCRIPTION
Ungrazed Pasture	UGP	CC01/Z08	190° S and 22 m from air sampler 2. 200° SSW for 600 m.
Grazed Pasture 1	GP-1	Z29/X22	307° NW from air sampler 4 for 93 m. 343° NW for 600 m.
Grazed Pasture 2	GP-2	C08/F16	148° SE and 82 m from fence post next to "Official Business" sign north of RR tracks. 161° SSE for 600 m.
Woodlot 1	W-1	R03/L05	243° WSW and 28 m from air sampler 1. Westerly for 600 m.
Woodlot 2	W-2	Q07/I07	360° N and 52.6 m from sprayed corner fencepost. 270° for 600 m.
Woodlot 3	W-3	F07/F03	44° NE and 70.5 m from sprayed cement slab below RR bridge on Paddy's Run to large oak on east bank, then 78° ENE for 47.2 m. North for 400 m, east for 55 m, south for 85 m, and east for 50 m.
Riparian 1	RN-1	E09/H15	203° SSW and 61 m from west foundation of RR tracks, Paddy's Run. South (downstream) for 600 m.
Riparian 2	RN-2	M32/J27	33 m from beneath center of Willey Road bridge near large elm on east bank of Paddy's Run. North (upstream) for 600 m.

TRANSECT	CODE NAME	MAP COORDINATES[1]	STARTING POINT AND DESCRIPTION
Pine Plantation No. 1	PP-1		
Strip a		S06/U06	First mowed strip from S border, 61 m from western border road. 93° E for 150 m.
Strip b		X05/V05	Third mowed strip from south border, 55 m from eastern border road. 270° W for 150 m.
Strip c		S04/U04	Fifth mowed strip from south border, 55 m from western border road. 94° for 150 m.
Strip d		Z04/X04	Sixth mowed strip from south border, 41 m from eastern border road. 270° W for 150 m.
Pine Plantation No. 2	PP-2		
Strip a		O24/M24	Second mowed strip from south border, 30 m from eastern border road. 270° W for 150 m.
Strip b		K23/M23	Sixth mowed strip from south border, 29 m from western border road. 90° E for 150 m.
Strip c		K21/M21	Ninth mowed strip from south border, 50 m from western border road. 96° E for 150 m.
Strip d		K20/M20	Eleventh mowed strip from south border, 57 m from western border road. 90° E for 150 m.

TRANSECT	CODE NAME	MAP COORDINATES[1]	STARTING POINT AND DESCRIPTION
Reclaimed Fly Ash Pile	RFAP		
Strip a		N27/M27	154 m SW from intersection of fly ash road and road to K-65 tanks. 13 m at 290° from west edge of fly ash road. 290° NNW for 78 m.
Strip b		O27/M26	104 m from same intersection, 9 m at 290° from west edge of fly ash road. 290° NNW for 110 m.
Strip c		O26/L25	54 m from same intersection, 17 m at 290° from west edge of fly ash road. 290° NNW for 212 m.

[1] Starting coordinate followed by ending coordinate (see Fig. 1).

Table 3. Relative (%) cover of herbaceous vegetation at the FMPC.

SPECIES	TRANSECTS										
	UGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RM1	RM2
Equisetaceae											
Equisetum arvense Common horsetail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.2
Poaceae											
Phleum pratense Timothy-grass	1.2	3.5	0.9	2.8	0.5	1.5	1.2	1.7	0.9	0.0	0.0
Agrostis alba Redtop	0.5	0.3	0.2	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0
Poa pratensis Kentucky bluegrass	3.3	12.7	4.2	0.0	1.9	3.5	0.0	5.2	0.0	0.0	0.9
Festuca rubra Red fescue-grass	65.8	53.7	53.0	32.3	21.2	30.8	13.0	9.4	5.0	7.8	8.0
Festuca elatior Meadow-fescue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Echinocloa crusgalli Barnyard grass	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	1.3	0.0
Setaria sp. Bristly foxtail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.2
Digitaria filiformis Slender crabgrass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Poaceae sp.	0.2	0.0	0.0	21.8	0.0	1.3	0.0	0.0	0.9	1.8	0.7
Cyperaceae											
Carex sp. Sedge	0.0	0.0	0.0	0.3	0.0	0.5	0.0	4.5	1.5	0.0	0.0
Commelinaceae											
Commelina communis Dayflower	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Juncaceae											
Juncus tenuis Slender rush	0.3	0.2	0.5	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Liliaceae											
Smilax sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Allium canadense Wild garlic	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Urticaceae											
Urtica procera Nettle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
Pilea pumila Clearweed	0.0	0.0	0.0	0.0	0.0	1.2	1.5	3.7	6.5	1.3	1.3
Aristolochiaceae											
Asarum canadense Wild ginger	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.3	0.0
Polygonaceae											
Polygonum hydropiperoides Mild water-pepper	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	1.0
Polygonum persicaria Lady-thumb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.9
Polygonum cilinode Climbing buckwheat	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.3
Polygonum sp. Smartweed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Rumex obtusifolius Blunt-leaved dock	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Rumex sp. Dock	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.9	0.0	0.0
Tovara virginiana Jumpseed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Caryophyllaceae											
Saponaria officinalis Soapwort	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.9
Brassicaceae											
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0

SPECIES	TRANSECTS										
	OGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
Saxifragaceae											
Heuchera americana Rock-geranium	0.0	0.0	0.0	0.0	0.0	0.0	0.2	3.0	0.5	0.2	0.0
Platanaceae											
Platanus occidentalis Sycamore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Rosaceae											
Geum canadense Guens	0.0	0.0	0.0	0.3	0.0	0.2	2.2	1.8	3.3	0.2	0.2
Agrimonia parviflora Small flowered agrimony	0.0	0.0	0.0	0.0	0.0	0.0	0.5	3.7	0.2	0.0	0.0
Rubus allegheniensis Blackberry	0.0	0.0	0.0	6.0	0.9	4.3	1.7	7.5	1.3	1.3	0.0
Rosa multiflora Multiflowered rose	0.0	0.0	0.2	0.0	0.0	0.2	3.3	0.7	0.3	0.0	0.0
Leguminosae											
Trifolium repens White clover	1.2	11.5	3.8	0.0	0.3	0.0	0.0	0.5	0.0	0.0	0.2
Medicago lupulina Black medick	0.3	0.0	0.7	1.0	0.2	0.6	0.2	0.5	0.5	0.2	0.0
Apios americana Ground-nut	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.9
Trifolium pratense Red clover	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Melilotus alba White sweet clover	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Robinia pseudoacacia Black locust	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oxalidaceae											
Oxalis sp.	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.3	0.0	0.0	1.3
Oxalis europea Wood-sorrel	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0
Euphorbiaceae											
Acalyphe rhomboidea Copperleaf	1.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0
Balsaminaceae											
Impatiens sp. Touch-me-not	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.9	0.2	0.5
Vitaceae											
Parthenocissus quinquefolia Virginia creeper	0.0	0.0	0.0	1.3	0.3	0.3	6.2	4.8	1.7	1.9	2.3
Vitis sp. Grape	0.0	0.0	0.0	1.0	0.2	0.3	0.5	0.0	1.7	1.2	0.3
Hypericaceae											
Hypericum sp. St. Johnswort	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Violaceae											
Viola sp. Violet	0.0	0.0	0.0	0.0	0.2	0.0	1.8	0.2	0.9	0.3	0.9
Umbelliferae											
Sanicula canadensis Black snakeroot	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.3	0.0	0.0
Daucus carota Wild carrot	0.0	0.0	0.0	1.5	0.5	0.7	0.0	0.5	0.2	0.2	0.0
Pastinaca sativa Parsnips	0.0	0.0	0.0	0.8	0.0	1.2	0.0	0.0	0.0	0.0	0.0
Carum carvi Caraway	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0
Primulaceae											
Lysimachia nummularia Moneywort	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.5	0.0	0.2
Oleaceae											
Fraxinus sp. Ash	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0

SPECIES	TRANSECTS										
	DGP	GP1	GP2	REAP	PP1	PP2	W1	W2	W3	RN1	RN2
Apocynaceae											
Apocynum sp. Dogbane	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0
Asclepiadaceae											
Asclepias sp. Milkweed	0.0	0.0	0.0	2.2	1.5	0.2	0.0	0.2	0.0	0.2	0.0
Convolvulaceae											
Convolvulus sepium Hedge-bindweed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Convolvulus arvensis Field-bindweed	0.3	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.2	0.2
Convolvulus sp. Bindweed	0.0	0.0	0.0	4.3	0.3	11.0	0.0	0.0	0.0	0.0	0.0
Ipomoea sp. Morning-glory	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Ipomoea pandurata Wild potato-vine	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0
Verbenaceae											
Verbena urticifolia White vervain	0.0	0.0	0.0	0.0	0.3	0.2	4.8	0.3	0.0	0.3	0.0
Labiatae											
Prunella vulgaris Heal-all	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Leonurus cardiaca Common motherwort	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Glechoma hederacea Ground-ivy	0.0	0.0	0.7	0.0	0.2	1.8	5.3	1.3	4.5	1.7	1.8
Solanaceae											
Physalis heterophylla Ground cherry	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solanum carolinense Horse-nettle	0.5	0.9	0.3	0.0	1.0	0.0	0.0	0.5	0.0	0.0	0.0
Datura stramonium Jimsonweed	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
Scrophulariaceae											
Verbascum blattaria Moth-mullein	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bignoniaceae											
Campsis radicans Trumpet-flower	0.0	0.0	0.0	0.3	0.0	1.7	0.0	0.0	0.0	0.0	0.0
Plantaginaceae											
Plantago major Common plantain	0.2	0.2	0.0	0.0	0.0	0.0	0.2	0.9	0.0	0.0	0.0
Plantago lanceolata English plantain	2.2	5.5	4.7	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Rubiaceae											
Galium aparine cleavers	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Caprifoliaceae											
Lonicera sp. Honeysuckle	0.0	0.0	0.0	0.5	0.0	0.4	5.7	0.2	0.2	0.2	0.0
Lonicera japonica Japanese honeysuckle	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Sambucus canadensis Common elder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Dipsacaceae											
Dipsacus sylvestris Teasel	0.0	0.0	0.0	1.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Campanulaceae											
Campanula americana Tall Bellflower	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Compositae											
Vernonia altissima Ironweed	5.0	0.3	2.3	0.5	1.3	1.7	0.7	2.7	0.0	0.2	1.3
Eupatorium rugosum White snakeroot	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	1.5

SPECIES	TRANSECTS										
	OGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
Eupatorium sp. Thoroughwort	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Aster sp. Aster	0.0	0.0	0.2	0.0	0.2	0.0	0.2	1.2	0.0	0.3	0.7
Solidago sp. Goldenrod	0.5	0.0	0.0	11.0	10.8	11.7	6.0	12.0	2.2	8.7	8.8
Erigeron annuus Daisy fleabane	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.0	0.0	0.0
Helianthus tuberosus Sunflower	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6
Actinomeris alternifolia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.5
Bidens vulgata Beggar-ticks	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	1.5	0.5
Silphium trifoliatum Rosinweed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3
Achillea millefolium Yarrow	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.5	0.2	0.0	0.0
Cirsium arvense Canada thistle	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cirsium sp. Thistle	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cirsium altissimum fall thistle	0.0	0.0	0.0	0.0	3.2	3.5	0.0	0.0	0.0	0.0	0.0
Arctium sp. Burdock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Cichorium intybus Chicory	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale Common dandelion	0.0	2.0	3.0	0.3	0.3	0.0	0.3	1.0	0.3	0.0	0.0
Ambrosia artemisiifolia Ragweed	10.5	6.7	0.0	0.0	4.7	0.5	0.2	0.0	0.0	0.2	0.7
Ambrosia sp. Ragweed	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ambrosia trifida Ragweed	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.2	0.3
Xanthium echinatum Cocklebur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
SUBTOTALS	95.7	97.5	75.5	94.7	64.5	83.6	72.8	75.0	37.8	39.0	47.8
Litter	4.0	2.0	24.2	3.8	35.5	16.2	18.5	22.2	46.2	25.8	17.2
Soil	0.3	0.5	0.3	1.5	0.0	0.2	10.5	2.8	16.0	24.5	26.8
Rock	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	10.7	8.2
TOTALS	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 4. Community similarity indices for herbaceous vegetation of the FMPC, summer, 1986.

Similarity Index*	UGP vs GP1	UGP vs GP2	GP1 vs GP2	PP1 vs PP2	RFAP vs W1	W1 vs W2	W1 vs W3	W2 vs W3	RN1 vs RN2
Jaccard Coefficient	0.545	0.526	0.423	0.312	0.234	0.511	0.476	0.418	0.384
Coefficient of Similarity	0.705	0.689	0.594	0.476	0.379	0.676	0.645	0.590	0.555
Percent Similarity	70.8	75.4	81.2	46.5	32.0	49.3	51.1	44.5	53.7
Morisita's Index	0.956	0.968	0.992	0.820	0.524	0.828	0.863	0.714	1.062

* Indices calculated from percent relative cover (Table 3).

Table 5. Community parameters for herbaceous vegetation of the FMPC, summer, 1986.

HABITAT	Species Richness (R)	Simpson Diversity (D)	Simpson Dominance (C)	Shannon Diversity* (H')	Pielou Evenness (J')
UGP	22	0.510	0.490	1.918	0.430
GP1	13	0.654	0.346	2.149	0.581
GP2	16	0.495	0.505	1.822	0.455
RFAP	29	0.836	0.164	3.198	0.658
PP1	37	0.904	0.096	4.008	0.769
PP2	30	0.819	0.181	3.309	0.674
W1	38	0.930	0.070	4.256	0.811
W2	39	0.931	0.068	4.349	0.823
W3	33	0.926	0.074	4.225	0.830
RN1	37	0.897	0.103	3.981	0.764
RN2	43	0.920	0.072	4.441	0.818

Table 6. Percent frequency of occurrence of trees in the wooded habitats at the FMPC.

	TRANSECT							
SPECIES	PP1	PP2	RFAP	W1	W2	W3	RN1	RN2
white pine	71	43	0	0	0	0	0	0
Austrian pine	43	57	0	0	0	0	0	0
eastern red cedar	0	0	0	33	0	0	0	0
black willow	0	0	0	0	0	0	17	0
eastern cottonwood	0	0	50	17	0	0	83	17
black walnut	0	0	0	17	0	50	50	67
shellbark hickory	0	0	0	83	0	0	0	0
shagbark hickory	0	0	0	0	0	0	17	0
bitternut hickory	0	0	0	0	0	17	33	0
mockernut hickory	0	0	0	0	0	17	0	0
chestnut oak	0	0	0	33	0	17	0	0
chinquapin oak	0	0	0	0	0	0	17	0
northern red oak	0	0	0	50	0	17	0	0
shingle oak	0	0	0	50	0	0	17	0
swamp white oak	0	0	0	0	0	0	0	17
American elm	0	0	75	83	83	100	50	100
slippery elm	0	0	0	17	0	67	50	50
hackberry	0	0	0	67	17	33	67	67
osage-orange	0	0	0	0	0	0	33	0
American sycamore	0	0	0	0	33	0	50	33
black cherry	0	0	0	67	33	17	17	0
hawthorn sp.	0	0	0	0	0	0	33	0
redbud	0	0	25	0	0	0	0	0
Kentucky coffeetree	0	0	0	0	0	17	0	0
honey locust	0	0	0	17	0	0	50	17
black locust	0	0	25	17	0	0	0	17
sugar maple	0	0	0	0	17	67	17	0
red maple	0	0	0	0	17	0	0	0
silver maple	0	0	0	17	17	0	0	17
boxelder	0	0	25	17	50	50	67	100
Ohio buckeye	0	0	0	0	0	50	0	33
common persimmon	0	0	0	17	0	0	0	0
white ash	0	0	0	33	100	33	17	17
honeysuckle sp.	0	0	0	17	0	0	0	0

Table 7. Importance percentages of trees in the wooded habitats at the FMPC.*

	TRANSECT							
SPECIES	PP1	PP2	RFAP	W1	W2	W3	RN1	RN2
white pine	58.9	49.9	0.0	0.0	0.0	0.0	0.0	0.0
Austrian pine	41.1	50.1	0.0	0.0	0.0	0.0	0.0	0.0
eastern red cedar	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0
black willow	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0
eastern cottonwood	0.0	0.0	35.6	3.6	0.0	0.0	20.4	3.8
black walnut	0.0	0.0	0.0	1.4	0.0	11.2	6.6	11.3
shellbark hickory	0.0	0.0	0.0	16.3	0.0	0.0	0.0	0.0
shagbark hickory	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
bitternut hickory	0.0	0.0	0.0	0.0	0.0	3.6	3.3	0.0
mockernut hickory	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
chestnut oak	0.0	0.0	0.0	6.1	0.0	2.5	0.0	0.0
chinquapin oak	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0
northern red oak	0.0	0.0	0.0	11.9	0.0	1.8	0.0	0.0
shingle oak	0.0	0.0	0.0	8.5	0.0	0.0	2.1	0.0
swamp white oak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
American elm	0.0	0.0	19.0	10.3	18.1	10.9	8.2	16.8
slippery elm	0.0	0.0	0.0	1.2	0.0	6.6	5.0	6.6
hackberry	0.0	0.0	0.0	9.0	3.4	3.7	16.5	8.9
osage-orange	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0
American sycamore	0.0	0.0	0.0	0.0	19.2	0.0	4.4	9.8
black cherry	0.0	0.0	0.0	6.2	4.7	2.0	1.1	0.0
hawthorn sp.	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
redbud	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.0
Kentucky coffeetree	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
honey locust	0.0	0.0	0.0	1.3	0.0	0.0	3.6	1.4
black locust	0.0	0.0	34.0	6.9	0.0	0.0	0.0	4.4
sugar maple	0.0	0.0	0.0	0.0	2.4	19.4	2.7	0.0
red maple	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0
silver maple	0.0	0.0	0.0	4.0	4.4	0.0	0.0	1.4
boxelder	0.0	0.0	5.4	1.8	14.0	20.7	9.4	21.9
Ohio buckeye	0.0	0.0	0.0	0.0	0.0	11.2	0.0	9.7
common persimmon	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0
white ash	0.0	0.0	0.0	5.4	31.8	3.6	4.6	1.3
honeysuckle sp.	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0
TOTAL	99.9	100.0	99.9	100.0	99.9	100.0	100.3	99.9

*Values are based on relative frequency, relative density, and relative dominance.

Table 8. Tree species richness, diversity, and dominance in each habitat.*

HABITAT	Species Richness (R)	Simpson Diversity (D)	Simpson Dominance (C)	Shannon Diversity (H')	Pielou Evenness (J')
PP1	2	0.483	0.517	0.975	0.975
PP2	2	0.499	0.501	0.998	0.988
RFAP	5	0.671	0.329	1.869	0.723
W1	18	0.897	0.103	3.533	0.847
W2	9	0.789	0.211	2.474	0.781
W3	14	0.844	0.156	3.054	0.802
RN1	18	0.871	0.129	3.401	0.816
RN2	13	0.853	0.147	3.025	0.818

*Diversity values were calculated using log base 2.

Table 9. Percent frequency of occurrence of shrubs in the deciduous habitats at the FMPC.

	TRANSECTS					
SPECIES	RFAP	W1	W2	W3	RN1	RN2
sawbrier	0	0	0	0	17	17
black walnut	0	17	0	17	50	0
bitternut hickory	0	0	0	33	17	17
shellbark hickory	0	50	0	0	0	0
chestnut oak	0	0	0	17	0	0
swamp white oak	0	0	0	0	17	17
american elm	0	17	50	17	33	33
slippery elm	0	17	0	17	17	0
hackberry	17	17	0	17	50	17
black cherry	17	17	33	17	17	0
hawthorn sp.	0	0	0	0	17	0
multiflora rose	0	83	67	0	17	0
prairie rose	17	0	0	0	0	0
blackberry	0	50	17	0	17	0
black raspberry	0	17	17	0	0	0
burning bush	17	0	0	0	17	17
poison ivy	50	33	17	0	50	17
sugar maple	0	17	0	67	17	0
silver maple	0	0	17	0	0	0
black maple	0	0	0	0	0	17
boxelder	33	17	50	0	50	50
Ohio buckeye	0	0	0	50	0	17
grape vine	0	33	50	33	33	33
Virginia creeper	0	17	17	33	17	17
roughleaf dogwood	0	67	50	17	17	0
white ash	0	50	0	17	33	33
trumpet creeper	0	50	0	0	17	0
honeysuckle sp.	17	83	17	0	17	17

Table 10. Shrub species richness, diversity and dominance in each deciduous habitat at the FMPC.

HABITAT	Species Richness (R)	Simpson Diversity (D)	Simpson Dominance (C)	Shannon Diversity* (H')	Pielou Evenness (J')
RFAP	6	0.570	0.430	1.615	0.575
W1	18	0.729	0.272	2.687	0.645
W2	12	0.833	0.167	2.858	0.797
W3	13	0.804	0.169	2.885	0.758
RN1	21	0.822	0.178	3.100	0.705
RN2	14	0.838	0.162	3.160	0.809

*Diversity values were calculated using the log base 2.

Table 11. Shrub community similarity between habitats with similar vegetative structure.

SIMILARITY INDEX	RFAP vs. W2	W1 vs. W2	W2 vs. W3	W1 vs. W3	RN1 vs. RN2
QUALITATIVE INDICES					
Jaccard Coefficient	0.266	0.578	0.250	0.476	0.521
Coefficient of Similarity	0.421	0.733	0.400	0.645	0.685
QUANTITATIVE INDICES					
Percent Similarity	10.1	58.7	13.6	13.2	66.4
Morisita's Index	0.057	0.780	0.082	0.090	0.895

Table 12. Tree densities (number per ha) in each of the wooded habitats at the FMPC.

	TRANSECT							
SPECIES	PP1	PP2	RFAP	W1	W2	W3	RN1	RN2
white pine	442.9	233.1	0.0	0.0	0.0	0.0	0.0	0.0
Austrian pine	305.7	256.0	0.0	0.0	0.0	0.0	0.0	0.0
eastern red cedar	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0
black willow	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0
eastern cottonwood	0.0	0.0	45.8	8.3	0.0	0.0	104.2	16.7
black walnut	0.0	0.0	0.0	4.2	0.0	33.3	20.8	58.3
shellbark hickory	0.0	0.0	0.0	104.2	0.0	0.0	0.0	0.0
shagbark hickory	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0
bitternut hickory	0.0	0.0	0.0	0.0	0.0	29.2	12.5	0.0
mockernut hickory	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
chestnut oak	0.0	0.0	0.0	16.7	0.0	12.5	0.0	0.0
chinquapin oak	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
northern red oak	0.0	0.0	0.0	20.8	0.0	4.2	0.0	0.0
shingle oak	0.0	0.0	0.0	50.0	0.0	0.0	8.3	0.0
swamp white oak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3
American elm	0.0	0.0	80.8	54.2	83.3	50.0	87.5	112.5
slippery elm	0.0	0.0	0.0	4.2	0.0	25.0	29.2	37.5
hackberry	0.0	0.0	0.0	62.5	12.5	20.8	183.3	58.3
osage-orange	0.0	0.0	0.0	0.0	0.0	0.0	29.2	0.0
American sycamore	0.0	0.0	0.0	0.0	79.2	0.0	25.0	20.8
black cherry	0.0	0.0	0.0	29.2	12.5	8.3	4.2	0.0
hawthorn sp.	0.0	0.0	0.0	0.0	0.0	0.0	20.8	0.0
redbud	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0
Kentucky coffeetree	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
honey locust	0.0	0.0	0.0	4.2	0.0	0.0	16.7	4.2
black locust	0.0	0.0	83.3	54.2	0.0	0.0	0.0	25.0
sugar maple	0.0	0.0	0.0	0.0	8.3	133.3	20.8	0.0
red maple	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0
silver maple	0.0	0.0	0.0	20.8	8.3	0.0	0.0	4.2
boxelder	0.0	0.0	4.2	4.2	62.5	145.8	100.0	150.0
Ohio buckeye	0.0	0.0	0.0	0.0	0.0	62.5	0.0	100.0
common persimmon	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0
white ash	0.0	0.0	0.0	29.2	137.5	16.7	20.8	4.2
honeysuckle sp.	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0
TOTAL	748.6	489.1	218.3	487.7	408.3	550.0	708.3	600.0

Table 13. Tree community similarity between habitats with similar vegetative structure.

SIMILARITY INDEX	PP1 vs. PP2	RFAP vs. W2	W1 vs. W2	W2 vs. W3	W1 vs. W3	RN1 vs. RN2
QUALITATIVE INDICES						
Jaccard Coefficient	1.000	0.166	0.285	0.352	0.391	0.409
Coefficient of Similarity	1.000	0.285	0.444	0.521	0.562	0.580
QUANTITATIVE INDICES						
Percent Similarity	91.0	23.5	29.6	36.3	28.2	48.9
Morisita's Index	0.933	0.180	0.345	0.436	0.279	0.695

Table 14. Shrub density (number per ha) in each of the deciduous habitats at the FMPC.

	TRANSECTS					
SPECIES	RFAP	W1	W2	W3	RN1	RN2
sawbrier	0.0	0.0	0.0	0.0	41.7	208.3
black walnut	0.0	41.7	0.0	83.3	250.0	0.0
bitternut hickory	0.0	0.0	0.0	208.3	41.7	41.7
shellbark hickory	0.0	208.3	0.0	0.0	0.0	0.0
chestnut oak	0.0	0.0	0.0	41.7	0.0	0.0
swamp white oak	0.0	0.0	0.0	0.0	41.7	83.3
american elm	0.0	41.7	208.3	83.3	250.0	83.3
slippery elm	0.0	41.7	0.0	83.3	83.3	0.0
hackberry	41.7	41.7	0.0	41.7	875.0	125.0
black cherry	41.7	83.3	291.7	41.7	83.3	0.0
hawthorn sp.	0.0	0.0	0.0	0.0	125.0	0.0
multiflora rose	0.0	1166.7	625.0	0.0	125.0	0.0
prairie rose	125.0	0.0	0.0	0.0	0.0	0.0
blackberry	0.0	291.7	833.3	0.0	41.7	0.0
black raspberry	0.0	83.3	41.7	0.0	0.0	0.0
burning bush	250.0	0.0	0.0	0.0	166.7	83.3
poison ivy	3375.0	416.7	41.7	0.0	2875.0	916.7
sugar maple	0.0	41.7	0.0	1000.0	416.7	0.0
silver maple	0.0	0.0	41.7	0.0	0.0	0.0
black maple	0.0	0.0	0.0	0.0	0.0	41.7
boxelder	333.3	41.7	250.0	0.0	1583.3	416.7
Ohio buckeye	0.0	0.0	0.0	583.3	0.0	83.3
grape vine	0.0	291.7	166.7	208.3	125.0	125.0
Virginia creeper	0.0	41.7	41.7	125.0	41.7	41.7
roughleaf dogwood	0.0	3583.3	1000.0	83.3	41.7	0.0
white ash	0.0	166.7	0.0	41.7	83.3	166.7
trumpet creeper	0.0	291.7	0.0	0.0	1125.0	0.0
honeysuckle sp.	1458.3	500.0	83.3	0.0	125.0	41.7
TOTAL	5625.0	7375.3	3625.1	2624.9	8541.8	2458.4

Table 15. Average canopy height and percent canopy cover of the deciduous habitats at the FMPC.*

HABITAT	CANOPY HEIGHT (m)	CANOPY COVER (%)
RFAP	12.5 ± 10.1(4)	16 ± 12 (4)
W1	19.1 ± 2.5 (6)	68 ± 8 (6)
W2	17.9 ± 1.7 (6)	57 ± 15 (6)
W3	24.1 ± 1.9 (6)	84 ± 3 (6)
RN1	20.8 ± 3.2 (6)	56 ± 12 (6)
RN2	23.3 ± 2.3 (6)	61 ± 8 (6)

* Values are expressed as means ± 1 SE; (N) = sample size.

Table 16. Number of insects, spiders, mites, ticks and molluscs collected per 1000 sweeps along FMPC transects.

TAXON	TRANSECT								
	UGP	GP2	RFAP	PP1	PP2	W2	W3	RN1	RN2
INSECTS									
Collembola									
Entomobryidae	1602	235	0	338	0	27	3	0	0
Poduridae	0	0	0	6	0	0	0	0	0
Sminthuridae	145	2	23	32	0	2	0	0	0
Odonata									
Coenagrionidae	0	0	0	0	0	0	0	3	0
Libellulidae	0	0	3	0	0	0	0	0	2
Orthoptera									
Acrididae	3566	631	128	474	175	86	0	28	10
Dictidae	0	0	0	0	0	2	0	0	0
Gryllidae	48	119	40	122	130	53	20	68	70
Mantidae	0	0	15	0	0	2	0	3	2
Phasmidae	0	0	5	0	0	2	0	0	0
Tetrididae	0	0	0	0	0	0	0	3	0
Tettigonidae	265	233	40	105	77	48	3	38	77
Psocoptera	0	0	83	0	0	0	3	15	0
Thysanoptera	255	348	88	122	0	2	6	25	0
Hemipters									
Anthocoridae	12	0	0	8	0	0	0	15	0
Aradidae	0	0	63	0	0	0	0	0	0
Berytidae	2	11	3	15	4	6	0	0	0
Coreidae	0	0	0	0	0	0	0	0	5
Corimelaenidae	2	0	0	19	0	0	0	5	0
Lygaeidae	19	4	0	6	0	8	0	5	0
Miridae	378	89	23	122	4	29	34	25	37
Nabidae	10	4	0	4	6	2	0	5	5
Pentatomidae	2	9	5	4	4	2	0	0	10
Phymatidae	2	0	0	0	0	0	0	0	2
Reduviidae	0	15	10	6	4	65	0	35	2
Rhopalidae	0	6	0	0	0	0	0	0	0
Saldidae	0	0	0	0	0	0	0	3	0
Tingididae	0	0	30	0	0	0	6	93	0
Unidentified	0	19	0	0	0	0	0	3	0
Homoptera									
Acanaloniidae	0	0	75	521	92	151	0	3	15
Actiopheridae	0	0	0	0	2	0	0	0	0
Aleyrodidae	0	0	0	0	0	0	0	65	0
Aphididae	36	26	196	113	0	29	3	121	0
Cercopidae	39	19	60	346	207	139	37	141	45
Cicadellidae	1822	940	756	1874	691	429	270	602	206
Cicadidae	0	0	0	0	0	0	0	3	2
Cixiidae	0	0	0	0	0	0	0	18	0
Coccidae	0	0	0	9	0	0	0	0	0
Delphacidae	0	22	0	21	0	0	0	43	0
Dictyopharidae	0	11	0	13	0	2	0	0	0
Flatidae	0	0	83	0	0	67	9	5	7
Issidae	0	0	0	0	0	0	0	3	0
Membracidae	0	0	5	6	2	15	0	18	17
Psyllidae	0	0	0	0	0	0	0	23	0
Unidentified									
Planthopper nymphs	0	0	0	86	0	0	0	0	0
Neuroptera									
Chrysopidae	0	0	5	0	0	0	0	0	0
Hemerobiidae	0	0	0	0	0	0	0	0	5
Coleoptera									
Anthribidae	0	0	0	4	0	0	0	5	0
Chrysomelidae	320	518	209	1391	467	95	14	144	32
Cicindelidae	0	0	5	0	0	0	0	0	2
Coccinellidae	10	0	0	9	0	0	0	15	7
Cucujidae	0	0	0	6	0	0	0	0	0
Curculionidae	10	114	70	4	28	6	3	13	0
Elateridae	0	0	3	0	0	0	0	0	0
Histeridae	0	0	0	0	0	0	0	3	0
Lampyridae	5	0	0	2	0	6	0	0	0
Lycidae	0	0	0	0	0	0	3	0	0
Meloidae	0	0	0	6	0	0	0	0	0
Mordellidae	27	2	3	13	4	13	0	3	0
Nitidulidae	0	4	0	0	0	0	3	43	0
Scarabaeidae	0	2	3	4	9	6	0	3	45
Staphylinidae	5	0	0	17	0	0	6	0	0
Strepsiptera	0	0	0	0	0	0	0	3	0
Mecoptera									
Panorpidae	0	0	0	0	0	2	6	10	22

TAXON	TRANSECT								
	UGP	GP2	RFAP	PP1	PP2	W2	W3	RM1	RM2
Lepidoptera									
Ctenuchidae	0	0	0	0	0	0	0	3	0
Danaidae	0	0	3	0	0	2	0	3	2
Lycaenidae	0	0	3	0	0	0	0	0	0
Noctuidae	0	0	3	0	6	2	0	0	0
Nymphalidae	0	0	5	0	0	4	0	0	2
Pieridae	0	4	0	0	0	0	0	0	0
Unidentified	19	13	0	21	0	0	6	25	5
Diptera									
Agromyzidae	43	0	0	0	0	0	3	5	0
Anthomyzidae	0	0	0	6	0	0	0	0	0
Asilidae	2	2	8	2	0	17	0	25	0
Calliphoridae	14	2	3	4	0	19	9	5	15
Cecidomyiidae	0	78	0	11	0	27	3	146	0
Chamaemyiidae	0	0	0	17	0	0	0	0	0
Chironomidae	0	0	0	0	0	0	0	68	0
Chloropidae	386	235	490	626	41	90	364	327	0
Culicidae	0	2	0	2	0	8	14	3	0
Curtonotidae	0	6	0	0	0	0	0	0	0
Dolichopodidae	0	0	0	2	2	128	45	18	0
Drosophilidae	0	0	0	13	0	263	0	10	0
Empididae	0	0	0	6	0	0	0	5	0
Ephydridae	0	0	0	0	0	0	0	10	0
Heleomyzidae	2	0	0	8	0	0	0	0	0
Lauxaniidae	0	0	0	0	0	0	9	8	0
Lonchopteridae	7	2	0	0	0	0	0	0	0
Micropezidae	0	2	0	0	0	0	0	0	0
Muscidae	17	0	18	9	6	6	0	0	12
Mycetophilidae	0	13	0	0	0	0	20	23	0
Otitidae	0	0	0	0	0	0	0	5	0
Phoridae	2	15	0	0	0	0	14	30	0
Piophilidae	0	0	0	0	0	0	6	0	20
Pipunculidae	10	6	8	32	0	0	0	3	0
Platystomatidae	0	2	0	0	0	0	6	0	0
Psychodidae	0	0	0	0	0	0	0	3	0
Rhagionidae	7	0	0	0	0	0	0	0	27
Sarcophagidae	120	0	8	13	0	0	0	3	0
Sciaridae	224	207	0	19	9	67	9	38	0
Sciomyzidae	14	0	3	88	15	0	0	8	0
Sepsidae	12	4	0	4	0	0	57	3	0
Stratiomyidae	5	2	0	0	0	0	0	0	0
Syrphidae	2	89	3	9	55	13	0	5	2
Tabanidae	0	2	0	2	0	0	0	0	0
Tachinidae	2	2	0	15	9	34	0	0	0
Tephritidae	202	4	25	9	9	8	0	3	0
Therevidae	34	15	0	2	0	0	0	0	0
Tipulidae	0	0	0	0	0	23	11	5	0
Unidentified Diptera	36	48	0	68	0	0	0	65	0
Hymenoptera									
Apidae	2	0	3	0	0	0	0	0	7
Bethylidae	2	0	0	0	0	0	0	3	0
Braconidae	70	24	28	90	21	147	20	63	32
Cephidae	0	0	0	0	2	0	0	0	0
Chalcidoidea	549	322	146	367	0	80	51	411	2
Colletidae	2	0	0	2	0	0	0	0	0
Cynipidae	60	17	0	36	4	0	11	20	0
Diapriidae	0	0	0	19	0	0	0	5	0
Diprionidae	0	0	0	2	0	0	0	0	0
Formicidae	157	263	146	128	209	193	105	345	7
Halictidae	0	69	28	9	217	69	31	33	0
Ichneumonidae	7	0	0	9	9	15	40	15	5
Megachilidae	0	0	0	0	0	0	0	3	0
Platygasteridae	46	13	28	115	0	0	14	65	0
Pompilidae	0	0	0	0	0	0	0	3	0
Proctotrupidae	0	0	0	2	0	0	3	0	0
Scelionidae	0	9	0	0	0	4	3	5	0
Sphecidae	2	2	3	6	4	0	20	5	5
Tenthredinidae	0	0	0	2	0	0	0	0	0
Vespidae	0	0	3	2	28	11	3	5	82
Larvae									
Coleoptera	17	0	0	246	51	0	0	0	0
Lepidoptera	19	0	0	56	64	0	0	0	0
Strepsiptera	0	0	0	0	0	0	0	0	0
Trichoptera	0	0	0	0	0	0	0	3	0
Unidentified	0	13	0	0	0	38	28	50	114
Subtotal (Insects)	10682	4875	2987	7902	2667	2567	1330	3537	975
Non-insect species									
Acarina	308	37	3	90	0	4	0	8	0
Araneida	207	251	1905	959	288	408	148	879	308
Phalangida	0	0	0	2	0	0	3	0	0
Mollusca									
Gastropoda	0	0	0	0	0	40	3	111	20
Subtotal (Non-insects)	516	287	1907	1051	288	452	153	997	328
Total Organisms	11198	5162	4894	8953	2955	3019	1483	4534	1303

Table 17. Relative frequency of occurrence (%) of insects, spiders, mites, ticks and molluscs collected at the FMPC.

TAXON	TRANSECT								
	UGP	GP2	RFAP	PP1	PP2	W2	W3	RN1	RN2
INSECTS									
Collembola									
Entomobryidae	14.31	4.56	.00	3.78	.00	.90	.19	.00	.00
Poduridae	.00	.00	.00	.06	.00	.00	.00	.00	.00
Sminthuridae	1.29	.04	.46	.36	.00	.07	.00	.00	.00
Odonata									
Coenagrionidae	.00	.00	.00	.00	.00	.00	.00	.06	.00
Libellulidae	.00	.00	.05	.00	.00	.00	.00	.00	.19
Orthoptera									
Acrididae	31.85	12.22	2.62	5.29	5.92	2.85	.00	.61	.76
Dictidae	.00	.00	.00	.00	.00	.07	.00	.00	.00
Gryllidae	.43	2.30	.82	1.36	4.40	1.74	1.34	1.50	5.34
Mantidae	.00	.00	.31	.00	.00	.07	.00	.06	.19
Phasmidae	.00	.00	.10	.00	.00	.07	.00	.00	.00
Tetrididae	.00	.00	.00	.00	.00	.00	.00	.06	.00
Tettigonidae	2.37	4.52	.82	1.18	2.60	1.60	.19	.83	5.92
Psocoptera	.00	.00	1.69	.00	.00	.00	.19	.33	.00
Thysanoptera	2.28	6.74	1.80	1.36	.00	.07	.38	.56	.00
Hemiptera									
Anthocoridae	.11	.00	.00	.08	.00	.00	.00	.33	.00
Aradidae	.00	.00	1.28	.00	.00	.00	.00	.00	.00
Berytidae	.02	.21	.05	.17	.14	.21	.00	.00	.00
Coreidae	.00	.00	.00	.00	.00	.00	.00	.00	.38
Corimelaenidae	.02	.00	.00	.21	.00	.00	.00	.11	.00
Lygaeidae	.17	.08	.00	.06	.00	.28	.00	.11	.00
Miridae	3.38	1.72	.46	1.36	.14	.97	2.30	.56	2.86
Nabidae	.09	.08	.00	.04	.22	.07	.00	.11	.38
Pentatomidae	.02	.17	.10	.04	.14	.07	.00	.00	.76
Phymatidae	.02	.00	.00	.00	.00	.00	.00	.00	.19
Reduviidae	.00	.29	.21	.06	.14	2.16	.00	.78	.19
Rhopalidae	.00	.13	.00	.00	.00	.00	.00	.00	.00
Saldidae	.00	.00	.00	.00	.00	.00	.00	.06	.00
Tingididae	.00	.00	.62	.00	.00	.00	.38	2.06	.00
Unidentified	.00	.38	.00	.00	.00	.00	.00	.06	.00
Homoptera									
Acanaloniidae	.00	.00	1.54	5.82	3.10	5.01	.00	.06	1.15
Actiopheridae	.00	.00	.00	.00	.07	.00	.00	.00	.00
Aleyrodidae	.00	.00	.00	.00	.00	.00	.00	1.44	.00
Aphididae	.32	.50	4.00	1.26	.00	.97	.19	2.67	.00
Cercopidae	.34	.38	1.23	3.86	7.00	4.59	2.49	3.11	3.44
Cicadellidae	16.27	18.20	15.45	20.93	23.38	14.20	18.20	13.28	15.84
Cicadidae	.00	.00	.00	.00	.00	.00	.00	.06	.19
Cixiidae	.00	.00	.00	.00	.00	.00	.00	.39	.00
Coccidae	.00	.00	.00	.10	.00	.00	.00	.00	.00
Delphacidae	.00	.42	.00	.23	.00	.00	.00	.94	.00
Dictyopharidae	.00	.21	.00	.15	.00	.07	.00	.00	.00
Flatidae	.00	.00	1.69	.00	.00	2.23	.57	.11	.57
Issidae	.00	.00	.00	.00	.00	.00	.00	.06	.00
Membracidae	.00	.00	.10	.06	.07	.49	.00	.39	1.34
Psyllidae	.00	.00	.00	.00	.00	.00	.00	.50	.00
Unidentified									
Planthopper nymphs	.00	.00	.00	.97	.00	.00	.00	.00	.00
Neuroptera									
Chrysopidae	.00	.00	.10	.00	.00	.00	.00	.00	.00
Hemerobiidae	.00	.00	.00	.00	.00	.00	.00	.00	.38
Coleoptera									
Anthribidae	.00	.00	.00	.04	.00	.00	.00	.11	.00
Chrysomelidae	2.86	10.04	4.26	15.54	15.80	3.13	.96	3.17	2.48
Cicindelidae	.00	.00	.10	.00	.00	.00	.00	.00	.19
Coccinellidae	.09	.00	.00	.10	.00	.00	.00	.33	.57
Cucujidae	.00	.00	.00	.06	.00	.00	.00	.00	.00
Curculionidae	.09	2.22	1.44	.04	.94	.21	.19	.28	.00
Elateridae	.00	.00	.05	.00	.00	.00	.00	.00	.00
Histeridae	.00	.00	.00	.00	.00	.00	.00	.06	.00
Lampyridae	.04	.00	.00	.02	.00	.21	.00	.00	.00
Lycidae	.00	.00	.00	.00	.00	.00	.19	.00	.00
Meloidae	.00	.00	.00	.06	.00	.00	.00	.00	.00
Mordellidae	.24	.04	.05	.15	.14	.42	.00	.06	.00
Nitidulidae	.00	.08	.00	.00	.00	.00	.19	.94	.00
Scarabaeidae	.00	.04	.05	.04	.29	.21	.00	.06	3.44
Staphylinidae	.04	.00	.00	.19	.00	.00	.38	.00	.00
Strepsiptera	.00	.00	.00	.00	.00	.00	.00	.06	.00
Mecoptera									
Panorpidae	.00	.00	.00	.00	.00	.07	.38	.22	1.72

TAXON	TRANSECT								
	DGP	GP2	RFAP	PP1	PP2	W2	W3	RN1	RN2
Lepidoptera									
Ctenuchidae	.00	.00	.00	.00	.00	.00	.00	.06	.00
Danaidae	.00	.00	.05	.00	.00	.07	.00	.06	.19
Lycaenidae	.00	.00	.05	.00	.00	.00	.00	.00	.00
Noctuidae	.00	.00	.05	.00	.22	.07	.00	.00	.00
Nymphalidae	.00	.00	.10	.00	.00	.14	.00	.00	.19
Pieridae	.00	.08	.00	.00	.00	.00	.00	.00	.00
Unidentified	.17	.25	.00	.23	.00	.00	.38	.56	.38
Diptera									
Agromyzidae	.39	.00	.00	.00	.00	.00	.19	.11	.00
Anthomyzidae	.00	.00	.00	.06	.00	.00	.00	.00	.00
Asilidae	.02	.04	.15	.02	.00	.56	.00	.56	.00
Calliphoridae	.13	.04	.05	.04	.00	.63	.57	.11	1.15
Cecidomyiidae	.00	1.51	.00	.13	.00	.90	.19	3.22	.00
Chamaemyiidae	.00	.00	.00	.19	.00	.00	.00	.00	.00
Chironomidae	.00	.00	.00	.00	.00	.00	.00	1.50	.00
Chloropidae	3.44	4.56	10.01	6.99	1.37	2.99	24.52	7.22	.00
Culicidae	.00	.04	.00	.02	.00	.28	.96	.06	.00
Curtonotidae	.00	.13	.00	.00	.00	.00	.00	.00	.00
Dolichopodidae	.00	.00	.00	.02	.07	4.24	3.07	.39	.00
Drosophilidae	.00	.00	.00	.15	.00	8.70	.00	.22	.00
Empididae	.00	.00	.00	.06	.00	.00	.00	.11	.00
Ephydridae	.00	.00	.00	.00	.00	.00	.00	.22	.00
Heleomyzidae	.02	.00	.00	.08	.00	.00	.00	.00	.00
Lauxaniidae	.00	.00	.00	.00	.00	.00	.57	.17	.00
Lonchopteridae	.06	.04	.00	.00	.00	.00	.00	.00	.00
Micropezidae	.00	.04	.00	.00	.00	.00	.00	.00	.00
Muscidae	.15	.00	.36	.10	.22	.21	.00	.00	.95
Mycetophilidae	.00	.25	.00	.00	.00	.00	1.34	.50	.00
Otitidae	.00	.00	.00	.00	.00	.00	.00	.11	.00
Phoridae	.02	.29	.00	.00	.00	.00	.96	.67	.00
Piophilidae	.00	.00	.00	.00	.00	.00	.38	.00	1.53
Pipunculidae	.09	.13	.15	.36	.00	.00	.00	.06	.00
Platystomatidae	.00	.04	.00	.00	.00	.00	.38	.00	.00
Psychodidae	.00	.00	.00	.00	.00	.00	.00	.06	.00
Rhagionidae	.06	.00	.00	.00	.00	.00	.00	.00	2.10
Sarcophagidae	1.08	.00	.15	.15	.00	.00	.00	.06	.00
Sciaridae	2.00	4.02	.00	.21	.29	2.23	.57	.83	.00
Sciomyzidae	.13	.00	.05	.99	.51	.00	.00	.17	.00
Sepsidae	.11	.08	.00	.04	.00	.00	3.83	.06	.00
Stratiomyidae	.04	.04	.00	.00	.00	.00	.00	.00	.00
Syrphidae	.02	1.72	.05	.10	1.88	.42	.00	.11	.19
Tabanidae	.00	.04	.00	.02	.00	.00	.00	.00	.00
Tachinidae	.02	.04	.00	.17	.29	1.11	.00	.00	.00
Tephritidae	1.81	.08	.51	.10	.29	.28	.00	.06	.00
Therevidae	.30	.29	.00	.02	.00	.00	.00	.00	.00
Tipulidae	.00	.00	.00	.00	.00	.77	.77	.11	.00
Unidentified Diptera	.32	.92	.00	.76	.00	.00	.00	1.44	.00
Hymenoptera									
Apidae	.02	.00	.05	.00	.00	.00	.00	.00	.57
Bethylidae	.02	.00	.00	.00	.00	.00	.00	.06	.00
Braconidae	.62	.46	.56	1.01	.72	4.87	1.34	1.39	2.48
Cephidae	.00	.00	.00	.00	.07	.00	.00	.00	.00
Chalcidoidea	4.91	6.23	2.98	4.09	.00	2.64	3.45	9.06	.19
Colletidae	.02	.00	.00	.02	.00	.00	.00	.00	.00
Cynipidae	.54	.33	.00	.40	.14	.00	.77	.44	.00
Diapriidae	.00	.00	.00	.21	.00	.00	.00	.11	.00
Diprionidae	.00	.00	.00	.02	.00	.00	.00	.00	.00
Formicidae	1.40	5.10	2.98	1.43	7.07	6.40	7.09	7.61	.57
Halictidae	.00	1.34	.56	.10	7.36	2.30	2.11	.72	.00
Ichneumonidae	.06	.00	.00	.10	.29	.49	2.68	.33	.38
Megachilidae	.00	.00	.00	.00	.00	.00	.00	.06	.00
Platygasteridae	.41	.25	.56	1.28	.00	.00	.96	1.44	.00
Pompilidae	.00	.00	.00	.00	.00	.00	.00	.06	.00
Proctotrupidae	.00	.00	.00	.02	.00	.00	.19	.00	.00
Scelionidae	.00	.17	.00	.00	.00	.14	.19	.11	.00
Sphecidae	.02	.04	.05	.06	.14	.00	1.34	.11	.38
Tenthredinidae	.00	.00	.00	.02	.00	.00	.00	.00	.00
Vespidae	.00	.00	.05	.02	.94	.35	.19	.11	6.30
Larvae									
Coleoptera	.15	.00	.00	2.75	1.73	.00	.00	.00	.00
Lepidoptera	.17	.00	.00	.63	2.16	.00	.00	.00	.00
Strepsiptera	.00	.00	.00	.00	.00	.00	.00	.00	.00
Trichoptera	.00	.00	.00	.00	.00	.00	.00	.06	.00
Unidentified	.00	.25	.00	.00	.00	1.25	1.92	1.11	8.78
Subtotal (Insects)	95.39	94.44	61.04	88.26	90.26	85.04	89.66	78.00	74.81
Non-insects									
Acarina	2.75	.71	.05	1.01	.00	.14	.00	.17	.00
Araneida	1.85	4.85	38.91	10.71	9.74	13.50	9.96	19.39	23.66
Phalangida	.00	.00	.00	.02	.00	.00	.19	.00	.00
Mollusca									
Gastropoda	.00	.00	.00	.00	.00	1.32	.19	2.44	1.53
Subtotal (Non-insects)	4.61	5.56	38.96	11.74	9.74	14.96	10.34	22.00	25.19
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 18. Catch data for fish collected from Paddy's run, Site 2, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/30 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	123	86	0.190	0.251
White sucker *Catostomys commersoni*	29	0	0.045	0.000
Silverjaw minnow *Ericymba buccata*	26	0	0.040	0.000
Stoneroller minnow *Campostoma anomalum*	180	94	0.279	0.274
Bluntnose minnow *Pimephales notatus*	108	16	0.167	0.047
Rosefin shiner *Notropis ardens*	48	1	0.074	0.003
Blacknose dace *Rhinichthyes atratulus*	0	12	0.000	0.035
Johnny darter *Etheostoma nigrum*	87	2	0.135	0.006
Orangethroat darter *Etheostoma spectabile*	34	67	0.053	0.195
Fantail darter *Etheostoma flabellare*	11	65	0.017	0.190
Totals =	646	343	1.000	1.000

Table 19. Catch data for fish collected from Paddy's Run, Site 3, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/30 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	103	134	0.208	0.360
White sucker *Catostomus commersoni*	2	0	0.004	0.000
Silverjaw minnow *Ericymba buccata*	15	0	0.030	0.000
Stoneroller minnow *Campostoma anomalum*	110	48	0.222	0.129
Bluntnose minnow *Pimephales notatus*	77	128	0.156	0.344
Rosefin shiner *Notropis ardens*	107	1	0.216	0.003
Striped shiner *Notropis chrysocephalus*	7	1	0.014	0.003
Johnny darter *Etheostoma nigrum*	68	4	0.137	0.011
Orangethroat darter *Etheostoma spectabile*	4	18	0.008	0.048
Fantail darter *Etheostoma flabellare*	2	38	0.004	0.102
Totals =	495	372	1.000	1.000

Table 20. Catch data for fish collected from Paddy's Run, Site 4, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/30 min)	Proportion of catch
	Pool	Pool
Creek chub *Semotilus atromaculatus*	235	0.321
White sucker *Catostomys commersoni*	12	0.016
Silverjaw minnow *Ericymba buccata*	20	0.027
Stoneroller minnow *Campostoma anomalum*	4	0.005
Bluntnose minnow *Pimephales notatus*	450	0.614
Rosefin shiner *Notropis ardens*	1	0.001
Steelcolor shiner *Notropis whipplei*	2	0.003
Johnny darter *Etheostoma nigrum*	9	0.012
Totals =	733	1.000

Table 21. Density of fish in Paddy's Run, Site 2.
(Pool area = 81.1 square meters, riffle area = 38.6 square meters).

Species	Density (fish/square meter)	
	Pool	Riffle
Creek chub *Semotilus atromaculatus*	1.52	2.23
White sucker *Catostomus commersoni*	0.36	0.00
Silverjaw minnow *Ericymba buccata*	0.32	0.00
Stoneroller minnow *Campostoma anomalum*	2.22	2.44
Bluntnose minnow *Pimephales notatus*	1.33	0.42
Rosefin shiner *Notropis ardens*	0.59	0.03
Blacknose dace *Rhinichthyes atratulus*	0.00	0.31
Johnny darter *Etheostoma nigrum*	1.07	0.05
Orangethroat darter *Etheostoma spectabile*	0.42	1.74
Fantail darter *Etheostoma flabellare*	0.14	1.68
Total =	7.97	8.90

Table 22. Density of fish in Paddy's Run, Site 3. (Pool area = 103.7 square meters, riffle area = 80.0 square meters).

Species	Density (fish/square meter) Pool	Riffle
Creek chub *Semotilus atromaculatus*	0.99	1.68
White sucker *Catostomus commersoni*	0.02	0.00
Silverjaw minnow *Ericymba buccata*	0.15	0.00
Stoneroller minnow *Campostoma anomalum*	1.06	0.60
Bluntnose minnow *Pimpephales notatus*	0.74	1.60
Rosefin shiner *Notropis ardens*	1.03	0.13
Striped shiner *Notropis ardens*	0.07	0.01
Johnny darter *Etheostoma nigrum*	0.66	0.05
Orangethroat darter *Etheostoma spectabile*	0.04	0.23
Fantail darter *Etheostoma flabellare*	0.02	0.48
Total =	4.78	4.78

Table 23. Density of fish in Paddy's run, Site 4. (Pool 326.3 area = square meters).

Species	Density (fish/square meter) Pool
Creek chub *Semotilus atromaculatus*	0.720
White sucker *Catostomus commersoni*	0.370
Silverjaw minnow *Ericymba buccata*	0.060
Stoneroller minnow *Campostoma anomalum*	0.010
Bluntnose minnow *Pimpephales notatus*	1.380
Rosefin shiner *Notropis ardens*	0.003
Steelcolor shiner *Notropis whipplei*	0.006
Johnny darter *Etheostoma nigrum*	0.030
Carp *Cyprinus carpio*	0.003
Total =	2.582

Table 24. Total fish catch data for Paddy's Run. Mean catch per unit effort (CPUE) and mean density calculated for 3 pools and 2 riffles.

Species	N	Proportion of total catch	Mean (+ S.E.) CPUE (no./30 min)	Mean (+ S.E.) Density (no./square meter)
Creek chub *Semotilus atromaculatus*	681	0.260	136.2(26.0)	1.43 (0.26)
White sucker *Catastoma commersoni*	43	0.020	8.6 (1.3)	0.08 (0.07)
Silverjaw minnow *Ericymba commersoni*	61	0.020	12.2 (5.3)	0.11 (0.06)
Stoneroller minnow *Campostoma anomalum*	436	0.170	87.2(29.7)	1.27 (0.47)
Bluntnose minnow *Pimpephelas notatus*	779	0.300	155.8(75.9)	1.09 (0.22)
Rosefin shiner *Notropis ardens*	158	0.060	31.6(20.9)	0.33 (0.21)
Striped shiner *Notropis chrysocephalus*	8	0.003	1.6 (3.0)	0.02 (0.01)
Spotfin shiner *Notropis spilopterus*	2	0.001	0.4 (0.4)	0.001(0.001)
Blacknose dace *Rhinichthys atratulus*	12	0.005	2.4 (2.4)	0.06 (0.06)
Johnny darter *Etheostoma nigrum*	170	0.070	34.0(18.0)	0.46 (0.19)
Orangethroat darter *Etheostoma spectabile*	123	0.050	24.6(12.2)	0.48 (0.32)
Fantail darter *Etheostoma flabellare*	116	0.040	23.2(12.5)	0.46 (0.32)
Carp *Cyprinus carpio*	1	0.001	0.2 (0.2)	0.001(0.01)
Total =	2590	1.000	518.0	5.792

Table 25. Percent frequency of occurrence of birds in each habitat on the FMPC site.*

SPECIES	TRANSECT										
	OGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
great blue heron	0	0	8	0	0	0	0	0	0	8	0
green-backed heron	0	0	0	0	0	0	0	0	0	33	0
wood duck(a)	0	0	0	0	0	0	0	0	0	+	0
mallard	0	0	0	0	0	0	0	0	0	+	+
turkey vulture	+	0	0	0	0	+	+	0	0	0	0
northern harrier	+	0	0	0	0	0	0	0	0	0	0
Cooper's hawk	0	0	0	+	+	0	+	0	0	0	+
red-tailed hawk	8	42	0	+	+	+	+	+	+	+	0
American kestrel	25	17	0	8	8	0	+	33	0	25	0
northern bobwhite	8	42	8	8	8	+	8	+	+	8	+
killdeer	+	92	8	+	+	0	0	0	0	42	0
solitary sandpiper	0	0	0	0	0	0	0	0	0	8	0
spotted sandpiper	0	0	0	0	0	0	0	0	0	42	0
American woodcock	0	0	0	0	0	0	0	0	+	0	0
rock dove	0	+	0	0	0	0	0	0	0	0	0
mourning dove	100	58	17	92	100	100	50	8	42	83	92
black-billed cuckoo	0	0	0	+	0	8	+	0	0	0	+
yellow-billed cuckoo	0	0	0	42	25	+	67	58	42	58	58
eastern screech-owl	0	0	0	0	0	0	0	0	0	0	+
great horned owl	0	0	0	0	+	+	8	+	8	33	8
chimney swift	+	+	+	+	+	+	+	+	+	+	+
ruby-thr. hummingbird	0	0	0	0	33	17	17	0	0	8	8
belted kingfisher	0	0	0	0	0	0	0	0	+	92	8
red-headed woodpecker	8	0	0	0	0	0	0	0	0	+	8
red-bellied woodpecker	8	0	8	+	0	0	33	0	67	17	58
downy woodpecker	0	0	8	42	33	8	67	67	42	67	67
hairy woodpecker	0	8	0	8	0	0	+	0	33	8	17
northern flicker	17	8	25	42	0	8	17	42	83	83	92
pileated woodpecker	0	0	0	+	0	0	0	0	+	+	8
eastern wood-pewee	0	0	0	42	+	83	+	17	58	50	67
acadian flycatcher	0	0	0	0	0	0	0	0	+	0	0
willow flycatcher	+	0	0	0	83	50	8	8	0	0	0
eastern phoebe	0	0	0	25	0	0	0	0	+	33	42
great cr. flycatcher	0	0	0	0	0	8	0	8	33	25	8
eastern kingbird	58	25	33	0	+	0	8	8	0	25	25
purple martin	0	0	0	0	0	+	0	0	0	0	+
n. rough-winged swallow	+	0	+	0	+	0	0	0	0	+	+
barn swallow	+	+	+	+	+	+	+	+	0	+	+
blue jay	8	17	33	33	8	+	83	42	83	92	100
American crow	8	50	17	+	+	+	+	+	+	8	8
Carolina chickadee	0	0	0	25	+	0	58	67	83	92	75
tufted titmouse	0	0	0	0	0	+	33	33	100	25	75
white-breasted nuthatch	0	0	0	0	0	0	17	8	67	17	50
Carolina wren	0	0	0	0	0	0	17	25	+	83	75
house wren	0	0	+	0	0	0	93	42	25	50	50
blue-gray gnatcatcher	0	0	0	8	0	8	0	0	0	0	0
eastern bluebird	0	0	0	8	0	0	0	42	0	8	+
wood thrush	0	0	0	0	0	0	33	8	92	17	0
American robin	100	33	50	75	100	100	100	100	100	100	100
gray catbird	0	0	0	0	83	58	100	92	8	75	8
northern mockingbird	0	+	+	0	0	0	0	0	0	0	0
brown thrasher	0	0	0	8	0	0	25	33	42	0	+
cedar waxwing	0	0	0	17	25	42	0	8	0	33	8
European starling	67	25	50	0	8	+	0	0	0	75	58
white-eyed vireo	0	0	0	0	0	0	8	0	0	0	0
warbling vireo	0	0	0	0	0	0	0	0	8	75	33
Piladelphia vireo	0	0	0	0	0	0	8	0	0	0	0
red-eyed vireo	0	0	0	0	0	0	0	0	+	17	0
Tennessee warbler(a)	0	0	0	0	0	0	0	0	0	+	0
yellow warbler	0	0	0	0	17	8	8	0	0	8	0
black-and-white warbler	0	0	0	0	0	0	8	0	0	0	0
Louisiana waterthrush	0	0	0	0	0	0	0	0	0	+	8
common yellowthroat	+	0	+	58	33	50	58	67	+	75	+
yellow-breasted chat	0	0	0	0	0	0	33	8	0	0	0
summer tanager	0	0	0	0	0	0	0	0	+	8	0
scarlet tanager	0	0	0	0	0	0	33	8	8	8	8
northern cardinal	8	0	8	100	100	100	100	100	83	92	100
rose-br. grosbeak(a)	0	0	0	0	0	0	0	0	0	+	+
indigo bunting	+	0	0	50	33	42	100	92	0	75	83
rufous-sided towhee	0	0	0	17	17	50	33	42	25	75	8
chipping sparrow	0	0	0	0	17	50	0	8	0	0	0
field sparrow	+	0	0	100	50	92	100	92	25	33	67
savannah sparrow	0	100	0	0	0	0	0	0	0	0	0
grasshopper sparrow	25	0	0	8	0	0	0	0	0	0	0
song sparrow	25	0	+	83	100	100	83	100	8	92	67
red-winged blackbird	100	75	100	42	92	75	0	8	0	83	+
eastern meadowlark	100	100	100	8	+	17	0	0	0	17	+
common grackle	+	+	+	+	+	67	+	8	17	83	58
brown-headed cowbird	0	0	0	50	+	25	33	42	8	42	33
orchard oriole	0	0	0	50	0	0	+	0	0	50	0
northern oriole	0	0	0	8	0	0	17	8	17	92	8
American goldfinch	25	8	33	100	100	100	42	33	8	75	75
house sparrow	0	0	+	0	0	0	0	0	0	0	42

*A plus (+) represents a species that was detected outside the census plot or

Table 26. Avian densities (number per 40 ha) in each habitat at the FMPC.

SPECIES	TRANSECT										
	OGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RM1	RM2
great blue heron	0	0	1	0	0	0	0	0	0	1	0
green-backed heron	0	0	0	0	0	0	0	0	0	4	0
wood duck	0	0	0	0	0	0	0	0	0	+	+
mallard	0	0	0	0	0	0	0	0	0	+	+
turkey vulture	+	0	0	0	0	+	+	0	0	0	+
northern harrier	+	0	0	0	0	0	0	0	0	0	0
Cooper's hawk	0	0	0	+	+	0	+	0	0	0	+
red-tailed hawk	1	2	0	+	+	+	+	+	+	+	0
American kestrel	1	2	0	0	1	0	+	6	0	4	0
northern bobwhite	1	1	1	1	1	+	1	+	+	6	+
killdeer	+	20	1	+	+	0	0	0	0	3	0
solitary sandpiper	0	0	0	0	0	0	0	0	0	1	0
spotted sandpiper	0	0	0	0	0	0	0	0	0	3	0
American woodcock	0	0	0	0	0	0	0	0	+	0	0
rock dove	0	+	0	0	0	0	0	0	0	0	0
mourning dove	17	7	1	34	411	287	8	2	11	28	24
black-billed cuckoo	0	0	0	+	0	1	+	0	0	0	+
yellow-billed cuckoo	0	0	0	6	8	+	12	7	5	20	9
eastern screech-owl	0	0	0	0	0	0	0	0	0	0	+
great horned owl	0	0	0	0	+	+	1	+	1	3	1
chimney swift	+	+	+	+	+	+	+	+	+	+	+
ruby-throated hummingbird	0	0	0	0	11	2	2	0	0	2	3
belted kingfisher	0	0	0	0	0	0	0	0	+	14	1
red-headed woodpecker	1	0	0	0	0	0	0	0	0	+	2
red-bellied woodpecker	1	0	1	+	0	0	6	0	9	2	14
downy woodpecker	0	0	1	9	18	8	9	31	8	12	23
hairy woodpecker	0	1	0	1	0	0	+	0	6	2	3
northern flicker	1	2	1	7	0	1	3	11	16	41	35
pileated woodpecker	0	0	0	+	0	0	0	0	+	+	4
eastern wood-pewee	0	0	0	12	+	114	+	2	8	10	13
acadian flycatcher	0	0	0	0	0	0	0	0	+	0	0
willow flycatcher	+	0	0	0	112	140	1	2	0	0	0
eastern phoebe	0	0	0	4	0	0	0	0	+	5	5
great crested flycatcher	0	0	0	0	0	8	0	2	6	4	2
eastern kingbird	5	2	2	0	+	0	1	2	0	9	11
purple martin	0	0	0	0	0	+	0	0	0	0	+
n. rough-winged swallow	+	0	+	0	+	0	0	0	0	+	+
barn swallow	+	+	+	+	+	+	+	+	0	+	+
blue jay	1	2	2	7	8	+	25	7	28	69	47
American crow	1	1	1	+	8	+	+	+	+	5	14
Carolina chickadee	0	0	0	18	+	0	15	20	58	72	39
tufted titmouse	0	0	0	0	0	+	13	7	32	13	42
white-breasted nuthatch	0	0	0	0	0	0	6	1	9	6	14
Carolina wren	0	0	0	0	0	0	4	4	+	25	20
house wren	0	0	0	0	0	0	22	6	3	20	8
blue-gray gnatcatcher	0	0	0	1	0	8	0	0	0	0	0
eastern bluebird	0	0	+	1	0	0	0	6	0	2	+
wood thrush	0	0	0	0	0	0	6	1	26	3	0
American robin	13	2	4	27	310	274	76	150	176	107	55
gray catbird	0	0	0	0	160	64	32	41	2	37	1
northern mockingbird	0	+	+	0	0	0	0	0	0	0	0
brown thrasher	0	0	0	1	0	0	4	7	6	0	+
cedar waxwing	0	0	0	5	17	23	0	1	0	6	6
European starling	76	61	14	0	1	+	0	0	0	87	36
white-eyed vireo	0	0	0	0	0	0	2	0	0	0	0
warbling vireo	0	0	0	0	0	0	0	0	1	21	10
Philadelphia vireo	0	0	0	0	0	0	2	0	0	0	0
red-eyed vireo	0	0	0	0	0	0	0	0	+	7	0
Tennessee warbler	0	0	0	0	0	0	0	0	0	+	+
yellow warbler	0	0	0	0	23	2	2	0	0	4	0
black-and-white warbler	0	0	0	0	0	0	2	0	0	0	0
Louisiana waterthrush	0	0	0	0	0	0	0	0	0	+	3
common yellowthroat	+	0	+	15	33	46	9	20	+	11	+
yellow-breasted chat	0	0	0	0	0	0	4	1	0	0	0
summer tanager	0	0	0	0	0	0	0	0	+	3	0
scarlet tanager	0	0	0	0	0	0	6	2	2	5	2
northern cardinal	1	0	1	49	74	90	44	50	14	63	70
rose-breasted grosbeak	0	0	0	0	0	0	0	0	0	+	+
indigo bunting	+	0	0	17	15	10	29	17	0	20	20
rufous-sided towhee	0	0	0	4	9	64	5	11	3	23	1
chipping sparrow	0	0	0	0	2	143	0	1	0	0	0
field sparrow	+	0	0	121	33	67	42	70	8	10	7
savannah sparrow	0	12	0	0	0	0	0	0	0	0	0
grasshopper sparrow	2	0	0	1	0	0	0	0	0	0	0
song sparrow	2	0	+	33	527	411	28	91	2	76	17
red-winged blackbird	31	15	35	10	205	83	0	2	0	108	+
eastern meadowlark	65	77	90	1	+	2	0	0	0	4	0
common grackle	+	+	+	+	+	166	+	2	3	50	15
brown-headed cowbird	0	0	0	20	+	30	5	7	4	6	11
orchard oriole	0	0	0	20	0	0	+	0	0	42	0
northern oriole	0	0	0	4	0	0	6	6	4	28	8
American goldfinch	4	1	1	95	576	676	6	6	1	54	14
house sparrow	0	0	+	0	0	0	0	0	0	0	13
TOTAL	224	208	157	524	2563	2720	439	602	452	1161	623

*A plus (+) represents a species that was detected outside the census plot or identified during casual observation.

Table 27. Avian species richness, diversity, and dominance in each habitat on the FMPC site.*

HABITAT	Species Richness** (R)	Simpson Diversity (D)	Simpson Dominance (C)	Shannon Diversity (H')	Pielou Evenness (J')
UGP	20 (29)	0.788	0.212	1.715	0.572
GP1	18 (21)	0.719	0.281	1.652	0.571
GP2	19 (25)	0.698	0.302	1.584	0.538
RFAP	30 (38)	0.892	0.108	2.616	0.769
PP1	23 (37)	0.845	0.155	2.156	0.688
PP2	26 (37)	0.886	0.114	2.494	0.765
W1	35 (47)	0.920	0.080	2.886	0.812
W2	35 (41)	0.880	0.120	2.619	0.737
W3	28 (41)	0.827	0.173	2.393	0.718
RN1	54 (62)	0.952	0.048	3.623	0.908
RN2	42 (64)	0.948	0.052	3.486	0.933

*Diversity values were based on sightings within the census plots and calculated using the natural log.
**Richness values in ( ) include species that were detected outside the census plot or identified during casual observation.

Table 28. Avian community similarity between areas with similar vegetation structure.

SIMILARITY INDEX	UGP vs. GP1	UGP vs. GP2	GP1 vs. GP2	RFAP vs. W2	RFAP vs. PP2	PP1 vs. PP2	W1 vs. W2	W1 vs. W3	W2 vs. W3	RN1 vs. RN2
QUALITATIVE INDICES:										
Jaccard Coefficient	0.619	0.619	0.600	0.500	0.427	0.548	0.627	0.574	0.615	0.636
Quotient of Similarity	0.764	0.764	0.750	0.666	0.641	0.708	0.771	0.730	0.761	0.778
QUANTITATIVE INDICES:										
Percent Similarity	74.0	59.5	59.3	50.9	51.4	75.3	71.2	49.5	47.4	63.8
Morisita's Index	0.950	0.755	0.821	0.563	0.672	0.927	0.900	0.673	0.739	0.771

Table 29. Number of small mammals trapped per 100 trap nights along FMPC transects. Numbers in () are estimated density in individuals/ha.

Species	W1	W2	W3	PP1	PP2	RN1	RN2	UGP	GP1	GP2	RFAP
Short-tailed shrew *Blarina brevicauda*	0.83 (1.1)	0.83 (3.1)	0.28 (0.3)	0.28 (*)	0.28 (*)	0.56 (1.6)	0.56 (*)	-	-	-	2.22 (*)
White-footed mouse *Peromyscus leucopus*	3.89 (5.2)	2.5 (9.2)	2.22 (2.4)	1.39 (*)	-	1.94 (5.6)	1.11 (*)	-	-	-	-
Meadow vole *Microtus pennsylvanicus*	-	-	-	0.56 (*)	0.28 (*)	-	-	0.28 (*)	-	0.28 (*)	-
Meadow jumping mouse *Zapus hudsonius*	-	-	-	-	-	0.28 (0.8)	0.28 (*)	-	-	-	-
Eastern chipmunk *Tamius striatus*	0.28 (0.4)	-	-	-	-	-	-	-	-	-	-
Cottontail rabbit *Sylvilagus floridanus*	-	-	-	0.28 (*)	-	-	-	-	-	-	0.28 (*)

(*)unable to calculate density due to number of animals caught or to a positive slope. A dash indicates the species was not caught in the particular habitat sampled. Species expected but not found in any of the habitats on the FMPC, (e.g., the house mouse, *Mus musculus*), are treated in the text.

Table 30. Summary of modified call-count quail census data obtained from 7 separate counts during July, 1986, at FMPC.

Station	Total Birds Counted	Mean Birds Per Count	Maximum Birds Counted	Habitat Rating
1	3	0.43	1	III
2	0	0	0	I
3	0	0	0	I
4	2	0.29	2	II
5	2	0.29	2	II
6	0	0	0	I
7	9	1.29	2	IV
8	2	0.29	1	II
9	3	0.43	1	III
10	2	0.29	1	II
11	3	0.43	1	III
12	5	0.71	2	III
13	5	0.71	2	III
14	8	1.14	3	IV
TOTALS	44	6.3	18	

Note: Habitat rating based upon total number of birds observed at each station during 7 counts. Rating system used was 0 = I, 1-2 = II, 3-5 = III, 6+ = IV.

Table 31. Results of the FMPC deer herd census obtained during July, 1986, with trail-count and pellet-group count methods.

TRAIL COUNT METHOD

Habitat	Transect Surveyed(m)	No. Trails Counted	Mean No. Deer/sq km	Mean No. Deer/ Habitat
Deciduous	1800	19	4.67 (1.02)	5.26 (1.60)
Riparian	800	11	5.50 (0.50)	3.98 (0.36)
Pine	1200	33	11.00 (1.67)	8.40 (1.45)
TOTALS	3800	63	21.17 (3.20)	17.64 (3.41)

PELLET-GROUP COUNT

Habitat	Plots Sampled	No. Groups Counted	Mean No. Groups/Plot	Mean No. Deer/sq km	Deer/ Habitat
PP1	20	7	0.350	30.99	12.43
PP2	17	1	0.059	5.22	2.09
TOTALS	37	8	0.409	36.21	14.52

Table 32. Summary of game-wildlife habitats and population estimates determined during summer, 1986, at FMPC. Parenthetic values are 1 SE of the estimate.

Species	Area of FMPC Game Habitat		N using FMPC
	km^2	%*	
White-tailed deer	1.6	42.7	17.6 (3.4)
Bobwhite quail	2.1	57.3	142.2
Fox squirrel	0.4	12.1	108.7 (56.5)

*Percent of all FMPC vegetated area.

Table 33. Buffers utilized and enzyme systems analyzed in each species examined. Number of loci examined are listed in parentheses.

LOCUS	TAXON			
	Asclepias	*Taraxacum*	*Hyla*	*Bufo*
Acid phosphatase (ACP)	TC(1)			
Aspartate amino transferase (AAT)				TC(1)
Catalase (CAT)	RW(1)	RW(1)		
Diaphorase (DIA)		RW(2)		
Esterase (EST)		TC(1)	LiOH(1)	LiOH(3)
Glucose 6-phosphate dehydrogenase (G6PD)		RW(1)		
Glucose phosphate isomerase (GPI)	RW(1)	RW(2)	C&T(1)	C&T(1)
Glutamate dehydrogenase (GDH)	RW(1)	RW(1)	TC(1)	
Isocitrate dehydrogenase (ICD)			TC(2)	TC(2)
Lactate dehydrogenase (LDH)			TC(2)	TC(2)
Leucine amino peptidase (LAP)	TC(1)		LiOH(1)	TC(1)
Malate dehydrogenase (MDH)	RW(1)	RW(1)	C&T(1)	C&T(2)
Malic enzyme (ME)				TC(2)
Mannose phosphate isomerase (MPI)				C&T(1)
Non-specific protein (NP)	TC(1)	TC(1)		
Peptidase (PEP)		TC(1)	LiOH(1)	LiOH(1)
6-Phosphogluconate dehydrogenase (6PGD)	TC(1)	TC(1)	TC(1)	TC(1)
Phosphoglucomutase (PGM)		RW(2)	TC(1)	TC(3)
Superoxide dismutase (SOD)	RW(1)			

TC = Tris-citrate, pH 8.0 (Selander, et al. 1971)
RW = Gel: Tris citrate; electrode: Lithium borate; pH 8.5 (Ridgway, et al. 1970)
LiOH = Lithium hydroxide, pH 8.1/8.4 (Selander, et al. 1971)
CT = Citric acid, 4-(3-aminopropyl)morpholine, pH 6.1 (Clayton and Tretiak 1972)

Table 34. Allele frequencies at polymorphic loci in milkweed samples.

LOCUS		POPULATION A	B	C	D	E
	N	20	20	20	17	20
6PGD	A	0.02	0.02			
	B	0.05				
	C	0.93	0.98	1.00	1.00	1.00
LAP	A	0.02				
	B	0.23	0.38		0.14	0.20
	C	0.33	0.22	0.13		0.13
	D	0.42	0.40	0.79	0.86	
	E			0.08		
DIA	A		0.20			
	B		0.55			0.95
	C		0.25			
	D				0.94	0.05
	E	0.95		1.00	0.06	
	F	0.05				
GDH	A	0.90	0.98	0.90	1.00	1.00
	B	0.10	0.02	0.10		
ACP	A				0.13	
	B	0.95	1.00	1.00	0.81	0.71
	C	0.05			0.06	0.29
SOD	A	0.15	0.14	0.24	0.18	0.09
	B	0.15	0.28	0.28	0.32	0.31
	C	0.39	0.29	0.29	0.36	0.19
	D	0.31	0.29	0.29	0.14	0.41

Table 35. Genetic variability at 9 loci in all populations of *Asclepias*.

	MEAN NO. OF ALLELES PER LOCUS	PERCENTAGE OF LOCI POLYMORPHIC	MEAN HETEROZYGOSITY	
			DIRECT-COUNT	HARDY-WEINBERG EXPECTED
POPULATION				
A	2.2	66.7	0.11	0.22
B	2.0	55.6	0.12	0.24
C	1.7	33.3	0.04	0.15
D	1.8	44.4	0.07	0.16
E	1.8	44.4	0.10	0.20

Table 36. Tests for conformation of genotypic distribution in milkweed populations to expected under Hardy-Weinberg equilibrium. Levene's (1949) correction factor for small samples has been utilized.

POPULATION	LOCUS					
	6PGD	LAP	DIA	GDH	ACP	SOD
A	NS	NS	**	•	**	**
B	NS	*	**	NS		**
C		**		•		**
D		**	**		**	**
E		NS	NS		**	**

*p ≤ 0.05, **p ≤ 0.01, NS = not significant, blank = invariant.

Table 37. Pairwise heterogeneity chi-square between milkweed populations.

			Population A			
	6PGD	LAP	DIA	GDH	ACP	SOD2
Population B	NS	NS	**	NS	NS	NS
Population C	NS	**	NS	NS	NS	NS
Population D	NS	**	**	NS	NS	NS
Population E	NS	*	**	*	**	NS
			Population B			
	6PGD	LAP	DIA	GDH	ACP	SOD
Population C	NS	**	**	NS		NS
Population D	NS	**	**	NS	*	NS
Population E		**	**	*		NS
			Population C			
	6PGD	LAP	DIA	GDH	ACP	SOD
Population D		*	**	NS	*	NS
Population E		**	**	*	**	NS
			Population D			
	6PGD	LAP	DIA	GDH	ACP	SOD
Population E	NS	**	**	NS	**	NS

*p ≤ 0.05, **p ≤ 0.01, NS = not significant, blank = invariant.

Table 38. Contingency chi-square analyses for heterogeneity (A) among FMPC samples of milkweeds and (B) between combined FMPC sample and offsite control.

LOCUS	A	B
6PGD	NS	NS
LAP	**	**
DIA	**	**
GDH	NS	NS
ACP	**	**
SOD	NS	NS

**$p \leq 0.01$, NS = not significant.

Table 39. Allele frequencies at polymorphic loci in dandelion samples.

LOCUS		POPULATION 1	2	3	4	5	6	7	8	9	10	11	12	13	14
	N	20	20	20	20	20	20	20	20	20	20	20	20	20	20
CAT	A	0.50	0.33	0.50	0.48	0.53	0.50	0.57	0.50	0.50	0.50	0.28	0.50	0.50	0.50
	B	0.50	0.67	0.50	0.52	0.46	0.50	0.43	0.50	0.50	0.50	0.72	0.50	0.50	0.50
DIA-1	A												0.03		
	B			0.10					0.10				0.03		
	C	0.33	0.44	0.85	0.33	0.40	0.37	0.38	0.17	0.33	0.28	0.74	0.34	0.45	0.45
	D	0.33	0.56		0.33	0.60	0.63	0.58	0.33	0.33	0.17	0.11	0.44	0.24	0.04
	E	0.34			0.34			0.06	0.20	0.34	0.50	0.15	0.13	0.30	0.51
	F			0.05					0.20		0.06		0.03		
EST	A			0.07											
	B	0.10	0.03	0.28	0.09	0.08	0.42	0.28	0.07	0.15	0.15				
	C	0.45	0.84	0.33	0.74	0.92	0.42	0.65	0.93	0.70	0.70	1.00	0.93	1.00	0.91
	D	0.45	0.03	0.20	0.17	0.03	0.16	0.07		0.15	0.15		0.07		0.09
	E			0.12											
G6PD	A	0.75	0.85	0.15	0.73	1.00	1.00	0.90	1.00	1.00	1.00	0.10	1.00	0.98	0.83
	B	0.25	0.15	0.85	0.27			0.10				0.90		0.02	0.17
GPI-1	A	0.92	1.00	0.95	1.00	1.00	1.00	1.00	0.83	0.97	0.97	1.00	1.00	1.00	0.93
	B	0.08							0.07	0.03	0.03				0.07
	C			0.05											
	D								0.10						
GPI-2	A	1.00	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.90	1.00
	B			0.06								0.02		0.10	
GDH	A	1.00	0.90	0.10	0.65	1.00	1.00	1.00	0.85	1.00	1.00	1.00	1.00	0.98	1.00
	B		0.10	0.90	0.35				0.05					0.02	
	C								0.10						
PEP	A								0.17						
	B	0.18	0.12	0.08	0.08	0.12	0.02	0.15	0.07	0.15	0.25	0.25	0.31	0.33	0.15
	C	0.72	0.72	0.61	0.80	0.82	0.85	0.75	0.67	0.69	0.50	0.50	0.57	0.48	0.73
	D	0.10	0.16	0.31	0.12	0.06	0.13	0.10	0.09	0.17	0.25	0.25	0.12	0.19	0.12
6PGD	A	0.28	0.08	0.02	0.07	0.12	0.27	0.18	0.13	0.20	0.25	0.10	0.22	0.08	0.15
	B	0.27	0.33	0.25	0.48	0.67	0.43	0.28	0.63	0.50	0.25	0.58	0.32	0.17	0.45
	C	0.30	0.20	0.30	0.22	0.21	0.20	0.35	0.18	0.25	0.25	0.27	0.42	0.60	0.25
	D	0.15	0.28	0.43	0.23		0.10	0.18	0.05	0.05	0.25	0.05	0.04	0.15	0.15
	E		0.10												
PGM-2	A								0.07				0.02		
	B			0.08					0.08				0.03		
	C										0.02		0.92		
	D	0.97	0.97	0.92	1.00	1.00	1.00	0.93	0.75	1.00	0.07	1.00	0.03	1.00	1.00
	E	0.03	0.03					0.07	0.10		0.92				

Table 40. Genetic variability at 9 loci in all populations of *Taraxacum*.

POPULATION	MEAN NO. OF ALLELES PER LOCUS	PERCENTAGE OF LOCI POLYMORPHIC	MEAN HETEROZYGOSITY DIRECT-COUNT
1	1.9	57.1	0.12
2	2.0	64.3	0.29
3	2.3	78.6	0.15
4	1.9	50.0	0.19
5	1.6	35.7	0.12
6	1.6	35.7	0.10
7	1.9	50.0	0.17
8	2.4	57.1	0.09
9	1.8	42.9	0.09
10	2.0	50.0	0.08
11	1.7	42.9	0.17
12	2.2	50.0	0.13
13	1.8	50.0	0.13
14	1.9	57.1	0.12

Table 41. Contingency chi-square analyses for genetic heterogeneity among dandelion populations. Comparisons are within and among habitat types.

LOCUS	ABANDONED INCINERATOR SITE	WASTE PIT	MOWED PASTURES	GRAZED PASTURES	MOWED LAWNS	MOWED LAWNS AND PEFFER PARK
CAT	NS	NS	NS	NS	NS	NS
DIA-1	NS	NS	*	**	**	**
DIA-2		NS	**	NS	NS	NS
EST	NS	NS	NS	**	**	**
GPI-1	*		NS	NS	*	**
GPI-2		NS		NS	**	**
GDH	**		**	**	**	**
PEP	NS	NS	NS	NS	**	**
6PGD	NS	NS	*	NS	**	**
PGM-2	**	**	**	NS	**	**

* $p \leq 0.05$, **$p \leq 0.01$, NS = not significant, blank = invariant.

Table 42. Principal component determination of the number of dandelion clones composed of more than one individual and the number of individuals in each of these clones.

Population Number	Number of Multi-individual Clones	Number of Individuals per Clone
1	2	3-2
2	0	
3	3	2-2-2
4	2	3-2
5	2	2-2
6	2	3-2
7	0	
8	3	2-2-2
9	2	3-2
10	3	10-3-2
11	1	3
12	3	2-2-2
13	1	2
14	1	3

Table 43. Allele frequencies at polymorphic loci in toad and treefrog samples.

LOCUS		POPULATION		
		Bufo americanus FMPC	*Bufo americanus* Hueston Woods Park	*Hyla crucifer* FMPC
	N	60	60	60
AAT	A		0.06	*
	B	0.45	0.55	
	C	0.40	0.33	
	D	0.15	0.06	
EST-1	A		0.13	0.01
	B	1.00	0.78	0.70
	C		0.09	0.23
	D			0.06
EST-2	A	*	0.56	*
	B		0.28	
	C		0.16	
EST-3	A	0.64	*	*
	B	0.36		
GPI	A	0.10		0.07
	B	0.76	1.00	0.75
	C	0.14		0.18
GDH	A	*	*	0.05
	B			0.95
ICD-2	A		0.04	*
	B	1.00	0.96	
LDH-1	A	*	*	0.28
	B			0.40
	C			0.15
	D			0.17
LDH-2	A	0.04		0.65
	B	0.96	1.00	0.35
MPI	A	0.79	*	*
	B	0.21		
6PGD	A	0.32	*	0.24
	B	0.47		0.49
	C	0.21		0.27
PGM-1	A	0.37	0.79	*
	B	0.63	0.21	
PGM-2	A	0.40	0.28	*
	B	0.47	0.49	
	C	0.13	0.23	
PGM-3	A	0.35	0.26	*
	B	0.65	0.74	

* = locus not scored in that population

Table 44. Genetic variability in populations of toads and treefrogs.

POPULATION	MEAN NO. OF ALLELES PER LOCUS	PERCENTAGE OF LOCI POLYMORPHIC	HETEROZYGOSITY MEAN DIRECT-COUNT	HETEROZYGOSITY HARDY-WEINBERG EXPECTED
FMPC toads	1.8	50	0.17	0.24
Hueston Woods toads	1.8	50	0.18	0.23
FMPC treefrogs	2.1	55	0.20	0.25

SECTION II

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER

October-December, 1986*

*Includes bird data through March 1987.

290

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189

TABLE OF CONTENTS

INTRODUCTION	1
STUDY SITE AND METHODS	2
FAUNA	
Benthic Macroinvertebrates	4
Terrestrial Invertebrates	11
Winter Birds	14
Owls	27
Rabbits	35
Threatened and Endangered Species	40
ENVIRONMENTAL POPULATION GENETICS	
Fish	40
Grasshoppers	51
SUMMARY AND CONCLUSIONS	52
ACKNOWLEDGEMENTS	55
FIGURES	56
TABLES	63

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INTRODUCTION

The purpose of this study, under WMCO Subcontract No. E-75969, was to survey, inventory and characterize additional terrestrial and aquatic fauna inhabiting the FMPC during fall and winter, 1986/87. In addition, several fish species from the FMPC were analyzed for the possible effects of environmental stress on genetic structure. The results of these analyses are included in the current report. Results of the electrophoretic analysis of grasshoppers will be included in the next report (Section III). Appendix A, Part II includes a catalog of species found at the FMPC during the period from October through December, 1986.

The most comprehensive study on the biota of the FMPC to date is that reported in Section I. This study, conducted from mid-June through August, 1986, included the identification of six major habitats and the establishment of permanent transects and stations for sampling of terrestrial communities and fish communities in Paddy's Run. They described community structure for the summer herbaceous vegetation, woody vegetation, terrestrial arthropods, fishes, birds, small mammals, and several game species on the FMPC. They also analyzed selected plants and animals from the FMPC and from offsite populations to determine the possible effects of environmental stress on genetic structure. In addition, their Catalogue of Species included estimates of the relative abundance for 98 species of herbaceous plants, 46 species of trees and shrubs, 127 families of terrestrial invertebrates, 13 species of fish, 10 species of

amphibians and reptiles, 83 species of birds and 8 mammalian species. They recorded a total of 385 taxa during the summer of 1986 on the FMPC.

Results of the current study are discussed with respect to seasonal changes in population or community structure and to other on or offsite studies.

STUDY SITES AND METHODS

The study area included six (6) major terrestrial habitats and Paddy's Run within the 425 ha of the FMPC site excluding 55 ha covered by the FMPC operations complex, parking lots and associated construction facilities. The six (6) major habitat types (transect identification codes are included in parentheses after the habitat identification), were riparian (RN1 and RN2), coniferous woodlots (pine plantings, PP1 and PP2), deciduous woodlots (W1, W2 and W3), the reclaimed fly ash pile (RFAP) and grazed (GP1 and GP2) and ungrazed (UGP) pastures.

All terrestrial fauna were censused along previously established permanent transects (Fig. 1). Descriptions of the habitats and the methods for laying out the transects are reported elsewhere (Section I).

This report includes the relative abundance, frequency of occurrence and/or density of nocturnal raptors (owls), winter resident birds, and benthic fauna on the FMPC. Each faunal group is inventoried, and mapped by habitat, or by sampling site on Paddy's Run. All endangered species are listed and included

in the Addendum to the Catalogue of Species of the FMPC. The report also includes the results for terrestrial insects, collected during the summer, 1986, and summer population estimates for cottontail rabbits (*Sylvilagus floridanus*). Prior to commencing the study, sampling and electrophoretic protocols were submitted to WMCO for approval.

Standard community indices were used to reduce the data. Results for each organismal group are expressed by habitat type in terms of density (number per unit area), or number per unit effort (e.g., number of insects per 1000 sweeps). Additional parameters were also calculated for each community. Species richness (R) is the number of species found. Relative frequency of occurrence is the proportion of individuals of each species in the sample with respect to the total number of individuals sampled. The latter data were used to assign estimates of abundance in Appendix A, Catalogue of Species of the FMPC.

Species diversity was calculated using the Shannon-Weaver (1949) formula ($H' = -\Sigma p_i \ln p_i$) and Simpson's Index, D, (Simpson 1949). Species dominance (C) was calculated from the index of Simpson (1949). Evenness of distribution and abundance (J') was calculated using the methods outlined in Pielou (1966). The Jaccard Coefficient (Jaccard 1908) and the Coefficient of Similarity (Whittaker 1975) were used as measures of qualitative community similarity in terms of presence or absence of species. Percent Similarity (Whittaker 1975) and Morisita's Index (Morisita 1959) were used as measures of quantitative community

similarity with respect to the number of individuals of each species present. Additional synthesis of the data is treated in each section.

All taxa were catalogued according to frequency of occurrence by habitat type (Appendix A). Representative voucher specimens are housed in the Robert A. Hefner Museum of Zoology, Miami University, Oxford, Ohio 45056.

BENTHIC MACROINVERTEBRATES

METHODS

Benthic macroinvertebrates were collected from ten riffle/pool sites on Paddy's Run (Fig. 2) during the period 20 November - 18 December 1986 (sites 1-4 on 20 Nov., 5-7 on 11 Dec., 8-10 on 18 Dec.). Eight of the sites (2-9) lay within the boundaries of the FMPC. Physical characteristics of riffles and pools are summarized in Table 1. Most of the stream bed downstream from site 4 was dry from late-June through October 1986 during an extended dry period that had a similar effect on many other area streams (Mundahl, personal observation).

At each collection site, three quantitative samples of each macroinvertebrate community were taken from a riffle with a Surber sampler (sample area = 0.09 m^2; mesh size = 571 µm; Merritt et al. 1984). A single qualitative sample was collected from a pool at each site with a U.S. Standard No. 30 soil sieve (mesh size = 590 µm; Merritt et al. 1984). Organisms in each sample were separated from most sediments and organic debris by

washing the sample in a 4-liter pail of water and screening it through a U.S. Standard No. 30 soil sieve. Samples were preserved in the field in 70% ethanol.

In the laboratory, macroinvertebrates in each riffle sample were identified and counted. Organisms in the pool sample were identified but not counted. Identification was accomplished with the aid of taxonomic keys by Flowers and Hilsenhoff (1975), Hilsenhoff (1975), Pennak (1978), and Merritt and Cummins (1984). Densities (number/m^2) were calculated for organisms in each riffle sample, and mean densities were used to establish the abundance of each invertebrate taxon throughout the stream reach. A Shannon-Weaver diversity index (Weber 1973) was calculated for each riffle sample as a measure of community structure. The Spearman rank correlation coefficient (Zar 1974) was used to quantify faunal similarity between riffles at all adjacent collecting sites, and Sorensen's index (Wolda 1981) was used to quantify similarity of pools at adjacent sampling locations with respect to presence-absence of taxa.

RESULTS

Forty-one taxa of benthic macroinvertebrates were collected from riffles and pools on Paddy's Run (Fig. 2) between 20 November and 18 December 1986 (Tables 2 and 3). Six of these taxa were collected only from sites 1 and/or 10 which lay outside FMPC boundaries (Tables 2 and 3). Thirty-nine taxa (33 within FMPC boundaries) were collected in riffles, and 12 taxa (9 within FMPC boundaries) were found in pools.

Four taxa of macroinvertebrates were present at each of the ten riffles sampled: the non-biting midges, Chironomidae; the riffle beetle, *Stenelmis* sp.; the mayfly, *Caenis* sp.; and the stonefly, *Allocapnia* sp. (Table 2). An additional seven taxa (the mayfly, *Stenonema femoratum*; the isopod, *Lirceus fontinalis*; the caddisflies, *Cheumatopsyche* sp. and *Hydropsyche* sp.; the segmented worms, Oligochaeta; the blackfly *Simulium* sp.; and the stonefly, Nemouridae) were collected at seven or more sites. These 11 taxa generally comprised more than 90% of the organisms found in each riffle sample (Table 2).

Only three taxa (Chironomidae, *Caenis* sp., *Allocapnia* sp.) were found in four or more of the pools sampled (Table 3). The Chironomidae were present at all ten sites, and most of these individuals belonged to the genus *Chironomus*.

Riffles and pools at sites 1-4 generally contained more taxa of benthic macroinvertebrates than did their counterparts at sites 5-10 (Tables 2 and 3). Riffles at sites 1-4 averaged greater than 21 taxa, whereas those at sites 5-10 averaged less than 11 taxa. Pools at sites 1-4 contained an average of 5 taxa, but those at sites 5-10 averaged only 2 taxa.

Macroinvertebrate communities in riffles exhibited consistently high similarity between adjacent sites. All site pairs had statistically significant Spearman rank correlation coefficients (Table 4). Pools displayed good similarity in presence-absence of taxa between adjacent sites, with five site pairs having Sorensen's index of similarity greater than or equal to 0.5 (Table 4). Lower values were generally correlated

with a large difference in the number of taxa collected between the sites of a site pair (Table 3).

Mean densities of macroinvertebrates in riffles differed significantly (ANOVA $F=12.71$, $P<0.001$) among sample sites. Densities were significantly higher at upstream sites 1-4 than at most downstream sites (Table 5). Only site 8 had a high macroinvertebrate density similar to those at the upstream sites.

Macroinvertebrate community diversity in riffles also differed significantly (ANOVA $F=6.60$, $P<0.001$) among collection sites. Shannon-Weaver diversity values ranged from a mean of 0.79 at site 5 to 3.03 at site 1 (Table 5). There was no apparent pattern in diversity values among the sample sites.

Benthic macroinvertebrate samples collected from the ten riffles differed significantly (ANOVA $F=11.23$, $P<0.001$) with respect to the percentage of each sample comprised of Chironomidae. The average percentage of Chironomidae per sample increased gradually from site 1 through site 4, decreased significantly at site 5, and remained at low levels at most of the downstream sites (Table 5). As with density, site 8 had a significantly higher percentage of Chironomidae per sample than any of the six sites below the railroad trestle south of site 2.

DISCUSSION

The 41 taxa of benthic macroinvertebrates collected from Paddy's Run represent a substantial increase over the 19 taxa reported previously for this stream (Pomeroy et al. 1977). Most

of this increase is probably attributable to sampling at ten sites, compared to only one site in the previous study. Site 2 in the present study was in the near vicinity of the single site of Pomeroy et al. (1977), and contained 21 taxa.

Three taxa found previously in Paddy's Run (Pomeroy et al. 1977) were not collected in the present study: the caddisfly, *Agraylea* sp.; the true bug, *Microvelia* sp.; and the fingernail clam, *Sphaerium* sp. *Agraylea* and *Microvelia* are summer forms, and are generally not collected in winter (Merritt and Cummins 1984). *Sphaerium* is apparently rare in Paddy's Run (only a single specimen was collected by Pomeroy et al. 1977), and may have been missed by the collections.

The type and number of macroinvertebrate taxa collected from Paddy's Run are typical of streams in southwestern Ohio. Lenoble (1982) reported a total of 53 taxa of macroinvertebrates (excluding Chironomidae) from seven sites on Four Mile Creek in Butler County. Samples were dominated by the caddisflies, Chironomidae, and riffle beetles. Wynes and Wissing (1981) collected more than 20 taxa of macroinvertebrates from each of six sites on the Little Miami River in Greene County. Chironomidae, caddisflies (*Cheumatopsyche* and *Hydropsyche* spp.), mayflies (*Caenis*, *Stenonema*, and *Baetis* sp.), riffle beetles (*Stenelmis* sp.), stoneflies (Plecoptera), blackflies (*Simulium* sp.), oligochaetes, and the limpet (*Ferrissia* sp.), were seasonally dominant. Pomeroy et al. (1977) reported 13-18 taxa per site at three sites on the Great Miami River just upstream

from its confluence with Paddy's Run. The dominant organisms in all collections were caddisflies and the Chironomidae.

Shannon-Weaver diversity values (H' = 0.79-3.03) calculated for each of the ten sites on Paddy's Run also are typical of macroinvertebrate community values for area streams. Pomeroy et al. (1977) reported diversity values of 1.80-2.21 and 2.23-3.06 for macroinvertebrate samples collected from Paddy's Run and the Great Miami River, respectively. Shannon-Weaver diversity values for the Little Miami River communities ranged from 1.02-2.47 (Wynes and Wissing 1981). In Four Mile Creek, macroinvertebrate community diversities ranged from 1.01-2.45 (Lydy, Miami University, unpublished data). These diversity values are similar to those reported for streams receiving moderate amounts of pollution (Wilhm 1967, Wilhm and Dorris 1968, Sheehan and Winner 1984). It is possible that runoff from nearby homesteads, agricultural lands, and the FMPC may have reduced water quality in Paddy's Run and lowered macroinvertebrate community diversity. However, by not identifying the Chironomidae below the family level, diversity calculations may have been artificially depressed (Hughes 1978). Chironomidae comprised up to 75% of the total number of organisms collected at any given site. Winner et al. (1980) collected 15-39 species of Chironomidae at five sites on Elam's Run in Butler County, Lewis (1986) reported 12 genera of Chironomidae at two sites on the Little Miami River in Greene County, and Lenoble (1982) collected 27 total taxa (subfamily, genera, species) of Chironomidae at seven sites on Four Mile

Creek. If similar numbers of Chironomidae taxa were present and identified in Paddy's Run, diversity values may have been significantly higher.

The number of taxa in pools and riffles, macroinvertebrate density, and the percent Chironomidae per sample were reduced significantly between sites 4 and 5, and remained at low levels at the majority of the sites downstream. There are two possible explanations for these changes: runoff from the FMPC into the stream (Dames and Moore 1985), and the prolonged period preceding collections during which the stream bed was dry.

The most probable cause of the observed changes in macroinvertebrate communities downstream from site 4 was the dry period preceding sampling. The stream bed of Paddy's Run was mostly dry below site 4 between late-June and October. Some macroinvertebrates can move down into the hyporheic habitat below the streambed and find sufficient moisture to survive (Hynes 1958). However, the majority of macroinvertebrates, either in an active or egg stage, are killed by extended dry periods (Hynes 1970). The dry period during summer and autumn probably eliminated the organisms that had been present in Paddy's Run below site 4. When the stream again contained water in late autumn, macroinvertebrates began to recolonize the portion of the stream downstream from site 4. Most of the colonizers probably drifted in from upstream areas, hence the strong community similarities between sampling sites. However, as it generally requires several months for a barren area of stream bed to be completely recolonized by drifting organisms

(Hynes 1970), macroinvertebrate densities and the numbers of taxa remained low when collections were made in November and December.

Sites 5-10 on Paddy's Run were located downstream from the waste storage facilities at the FMPC. It may be possible that some of these materials entered the stream system and reduced macroinvertebrate taxa and densities downstream (Hocutt 1975; Swift 1985). However, Winner et al. (1980) have shown in two southwestern Ohio streams that a chemical stress tends to increase the fraction of a macroinvertebrate community comprised of Chironomidae. In Paddy's Run, the percent Chironomidae per sample decreased significantly below site 4, suggesting that macroinvertebrate communities in these areas may have been affected by something other than a chemical stress.

TERRESTRIAL INVERTEBRATES

METHODS

The methods employed were presented in detail in Section I. Only those data previously unreported and the conclusions drawn therefrom will be presented hereafter. Refer to Figure 1 for transect locations.

RESULTS AND DISCUSSION

A total of 21,316 organisms were collected and identified. Of these, 18,573 were either insects or insect larvae and 2,469 were spiders. Seventy-two gastropods were also found in the samples. Over 130 insect families in 15 orders were

represented. Spiders were not identified to family nor were the other non-insect taxa. Most groups were represented by only a few individuals and were considered rare. Only leaf hoppers (Cicadellidae) were abundant in all habitats and several taxa were restricted to a single transect or habitat type (see Appendix). Nineteen species were unique to the two riparian transects in contrast to 8, 5, 4 and 3 in the pine plantations, grazed pastures, reclaimed fly ash pile and woodlots, respectively. No species were unique to the ungrazed pasture.

The number of individuals caught per 1,000 sweeps and the relative abundance of each within the habitat are reported in Tables 6 and 7, respectively. All possible pair-wise combinations were compared using Spearman's rank correlation analysis. The results of the analyses are presented in Table 8. UGP and GP2 were most similar and UGP and RN2 were least similar.

Some interesting trends are evident. The data seem to indicate that, for the most part, only one family of Collembola (springtails) may be present in any given habitat; either entomobryiads or sminthurids. Sminthurids were the only springtail present in GP1, RFAP and W1. Where entomobryiads were present (UGP, GP2, W2, W3, PP1), they outnumbered sminthurids by 1-2 orders of magnitude (Table 6). No springtails were present in PP2, RN1, or RN2.

Orthopterans were present in all habitats. In the pastures, acridids were dominant followed by lesser numbers of tettigonids and gryllids in that order. The patterns of

dominance were variable in the other areas. In PP1 and PP2, acridids, while still dominant, were less so in relation to the other two families, but tettigonids were sub-dominant to gryllids here. A yet different order was observed in the riparian habitat. Here Gryllidae was the dominant family, followed by Tettigonidae and Acrididae (RN2 had slightly greater numbers of Tettigonidae than Gryllidae, however). The woodlots, as a whole, were similar to the riparian habitat. RFAP was the only habitat containing sizeable numbers of mantids.

Psocopterans were present only in RFAP, RN1 and W3. Miridae was the dominant hemipteran family in most habitats, however aradids were the dominant group in RFAP and assassin bugs (Reduviidae) were dominant in W1 and W2. Tingids were dominant in RN1.

As previously reported (Section I), cicadellids were the major homopteran in all habitats, followed by the families Cercopidae, Acanaloniidae and Aphidae, respectively. With the exception of RN2, where scarabaeids dominated, chrysomelids were the most numerous coleopteran in all habitats. Lepidopterans were most broadly represented in RFAP where individuals from four families were present.

The most diverse group were the dipterans (flies). There were no clear patterns between habitats. GP1 and RFAP were most similar in terms of dipterans (Spearman's rho=0.615) and GP1 and W3 were least similar (Spearman's rho=-0.273). RN1 and RN2 were very dissimilar (Spearman's rho=-0.216), but, due to the large number of flies, these statistics may not be entirely reliable.

Chloropidae were generally present in largest numbers in most habitats. For some reason, few dipterans of any kind were found in RN2. Among the hymenopterans, the Chalcidoidea were most prevalent, but ants (Formicidae), braconids and halictids were present in most habitats in fair numbers.

Large numbers of spiders were present in all habitats, but twice as many were found in RFAP as in PP1 (1905 vs. 959/1,000 sweeps), the habitat with the second largest number of individuals. As far as other non-insect species are concerned, there were no changes from the previous report (Section I).

Considering the individual transects, UGP held the highest numbers (in terms of number/1,000 sweeps) of Collembola, Orthoptera, Hemiptera, Diptera and Acarina. The greatest numbers of Thysanoptera were captured in GP2. RFAP led in the number of Odonata (tied with RN1), Psocoptera, Neuroptera (tied with RN2), and as noted previously, Araneida. The greatest numbers of Homoptera, Coleoptera and insect larvae were present in PP1. RN1 held the largest numbers of Hymenoptera, Lepidoptera, Strepsiptera and Gastropoda.

WINTER BIRDS

METHODS

Wintering birds were censused from 5 February to 6 March using a fixed-width line transect (Emlen 1971). Ten 600m permanent transects and one 225m transect in the RFAP (Fig.1) was censused 8 times in order to obtain accurate and consistent

density estimates (Engel-Wilson et al. 1981). Generally, censuses began from 1/2 to 3 hours after sunrise and ended before 1200 hours because late morning censuses during winter yield more species and individuals (Verner and Ritter 1986). Several afternoon censuses were also conducted. The Emlen transect method has been shown to be more feasible and provide similar estimates of bird densities, species diversity, evenness, and species richness when compared to variable circular plot techniques (Anderson and Ohmart 1981).

Results were expressed in terms of percent frequency of occurrence, density, species diversity, species dominance, community evenness, and community similarity as described above (see Introduction). Percent frequency of occurrence values were calculated by dividing the number of censuses a species was present (0-8) by the total number of censuses (8) and multiplying by 100.

RESULTS

Thirty-seven species of wintering birds were found on the FMPC site (Table 9). More than 1/3 (14) of these were found in a majority (≥6) of the eleven habitats (Table 9). Every habitat contained the mourning dove (*Zenaida macroura*), downy woodpecker (*Picoides pubescens*), blue jay (*Cyanocitta cristata*), northern cardinal (*Cardinalis cardinalis*), and song sparrow (*Melospiza melodia*). American robins (*Turdus migratorius*) and American goldfinches (*Carduelis tristis*) were found in 10 of 11 habitats. Song sparrows, Carolina chickadees (*Parus carolinensis*),and

mourning doves, in that order, had the greatest onsite densities (Table 10). Avian densities varied from less than 50 birds per 40 ha in the pastures to more than 300 birds per 40 ha in the pine plantings and W1. Avian diversity (Table 11) was lowest in the pastures ($H' < 2.1$) and the pines ($H' < 2.2$) and greatest in the woodlots ($H' > 2.45$). Species richness was the highest and similar (20-21 species) in the riparian and woodlot communities. Avian community similarity was greatest between PP1 and PP2, W1 and W2, and RN1 and RN2, whereas the UGP when compared to the grazed pastures (GP1 and GP2) was the least similar (Table 12).

Pastures

Twenty-four species of wintering birds were found in the pastures at the FMPC (Table 9). Unexpectedly, eastern meadowlarks (*Sturnella magna*) were common in each pasture. American kestrels (*Falco sparverius*), mourning doves, downy woodpeckers, blue jays, northern cardinals, and song sparrows were found in each pasture. However, many of these species were present in very low numbers (Table 10). Overall avian densities in the pastures were much lower (< 50 birds/40 ha; Table 10) than in the other habitats. Mourning doves, song sparrows, and house sparrows in the UGP were present with densities greater than 5 individuals/40ha and constituted approximately 65% of the avian community. In GP1, over 83% of those individuals present were eastern meadowlarks. Since only one large flock of house sparrows was recorded once in the UGP, their population density was probably over estimated. Avian diversity was thus extremely

low in GP1 (H' = 0.293 compared to H'_{max} = 1.609; Table 11) where meadowlarks and kestrels were the only commonly found species. Avian diversity in GP2 and UGP were substantially greater, although GP1 and GP2 had more similar avian communities (Table 12).

Unexpected species included the Cooper's hawk, eastern bluebird, rufous-sided towhee, American tree sparrow, and house sparrow in the UGP; the Carolina chickadee in GP1, and the red-bellied woodpecker, Carolina chickadee, and eastern bluebird in GP2. These species were all associated with trees within the plots or along edges of the pastures. No species were unique to pastures, although horned larks were expected.

Reclaimed Fly Ash Pile

Fourteen species of wintering birds were found in the RFAP at the FMPC (Table 9). The most abundant species were the mourning dove, Carolina chickadee, eastern bluebird, American robin, and the song sparrow, while northern cardinals and blue jays were found in smaller numbers (Table 10). The RFAP bird community was more similar to the avifauna in W2 than to any other avian community (Table 12). All of the species found in the RFAP, except the golden-crowned kinglet, were also seen in W2 (Table 9). The RFAP was also quite similar to PP2.

Avian diversity was lower in the RFAP (H' = 2.139; Table 11) than in any other deciduous habitat, but was slightly higher than the pines or the pastures. More species of ground foraging seedeaters, such as American tree sparrows (*Spizella arborea*),

white-throated sparrows (*Zonotrichia albicollis*), and dark-eyed juncos (*Junco hyemalis*), were expected. No unique species were found although golden-crowned kinglets were somewhat unexpected. The absence of nuthatches and most woodpecker species was also unexpected.

Pine Plantations

Eighteen species of wintering birds were found in PP1 and PP2 (Table 9). The most abundant species in both areas, constituting 70% to 80% of the total avian community, were mourning doves, Carolina chickadees, northern cardinals, and song sparrows (Table 10). The relatively high avian community similarity of the PP1 and PP2 is shown in Table 12. The abundance of kinglets in PP1 and their virtual absence in PP2 was the most notable difference (Table 10). As in the summer, avian densities were greater than most other habitats although diversities (H' = 2.001 and 1.797 for PP1 and PP2, respectively) were quite low (Table 11). Species richness, however, dropped dramatically (60% to 65%) from summer to winter, more than in any other habitat type. No species were unique to the pines although abundance of kinglets in PP1 and the numerous sighting of Cooper's hawks in both pines was unexpected. The nearly complete absence of woodpeckers (Table 9) as well as the absence of pine siskins (*Carduelis pinus*) and other finches (Fringillidae) was unexpected.

Woodlots

The woodlots had the most diverse winter avifauna of any habitat type (Table 11), with a total of 32 species (Table 9) and Shannon-Weaver diversities (*H'*) that ranged from 2.58 to 2.65. Avian density was substantially greater in W1 than the other woodlots and it was second only to PP1 in overall avian abundance (Table 10). The woodlots were similar in terms of species richness, diversity, dominance, and evenness (Table 11), although W1 and W2 had the most similar avian community structure (Table 12). Percent similarity was greater between W1 and W2 than any other avian communities compared.

Although these community indices indicate many similarities, each of the woodlots had a different group of dominant species. Eastern bluebirds (*Sialia sialis*), dark-eyed juncos, and American goldfinches were the most abundant species in W1 whereas northern cardinals, American tree sparrows, and song sparrows were most abundant in W2 (Table 10). These species are mainly ground foraging seedeaters. Although cardinals were also an abundant species in W3, the other abundant species were bark foraging species that consume both insects and seeds. These include the downy woodpecker, Carolina chickadee, tufted titmouse (*Parus bicolor*), and white-breasted nuthatch (*Sitta carolinensis*). Mourning doves, blue jays, and Carolina wrens (*Thryothorus ludovicianus*) were common in each woodlot (Table 10). The woodlots had 13 species in common. Although the white-throated sparrow was unique to the woodlots, this and many other ground foraging sparrows as well as finches

were absent or in low abundance in the woodlots and the FMPC in general.

Riparian

The riparian habitats along Paddy's Run were the second most diverse habitat (Table 11), with 28 species of wintering birds (Table 9). They were quite similar to each other (Table 12), with an abundance of mourning doves and Carolina chickadees along both transects (Table 10). Tufted titmice were frequently found in both habitats. Species richness was similar. RN2 was slightly more diverse with greater community evenness. However, RN1 had greater total avian abundance (Table 10) and fewer species making up the bulk of the community (see Simpson dominance, Table 11). Belted kingfishers (*Megaceryle alcyon*) and a single sighting of a red-winged blackbird (*Agelaius phoeniceus*) represent the only species found exclusively in the riparian habitats. More finches and sparrows were expected as well as greater numbers of killdeer (*Charadrius vociferus*).

DISCUSSION

Although the summer avifauna of the FMPC has been studied by Battelle (1981), Weston (1986), and as reported in Section I, the winter avifauna of the FMPC has never been documented. Thus, this represents the second step in characterizing this important faunal group.

Thirty-six species, including permanent and winter residents, were found at the FMPC during the winter of 1987. An additional eight species were observed flying over the FMPC

but were not observed using the habitats within the site boundaries. Common permanent residents were the mourning dove, downy woodpecker, blue jay, Carolina chickadee, American robin, northern cardinal, song sparrow, and American goldfinch. The most common winter residents were the American tree sparrow, white-throated sparrow, and dark-eyed junco. Permanent residents were more ubiquitous, abundant, and represented a greater number of species than winter residents.

Abundance and diversity of winter residents was lower than expected. Most of the flocking winter Emberizids including American tree sparrows, white-throated sparrows, and dark-eyed juncos were in low abundance. In an analysis of Christmas Bird Count (CBC) data from 1938-1981 in Oxford, Ohio, (Peterson 1981) showed that dark-eyed juncos and American tree sparrows were the 4th and 7th most abundant species recorded with an average of 247.6 and 155.5 individuals, respectively. At the FMPC tree sparrows were only abundant in W2 with an overall relative abundance ranking of 13th out of 36 species. Although juncos ranked 5th in relative abundance at the FMPC, they were only abundant in W1 with depressed densities in both of the riparian habitats. Peterson (1981) found that white-throated sparrows ranked 16th out of 63 passerines recorded on Oxford CBC's; we found that white-throated sparrows ranked 18th out of 36 species.

Additionally, fourteen species that regularly winter within a 20 mile radius of downtown Cincinnati, Ohio (CNC 1978) were expected but not found at the FMPC. Most of these "missing"

species are only found in small numbers in southwestern Ohio (Peterson 1981). Three of the more common species, the horned lark (*Eremophila alpestris*), common grackle (*Quiscalus quisculus*), and house finch (*Carpodacus mexicanus*) were seen on several occasions flying over the site and were probably wintering nearby. The most notable absences were the white-crowned sparrow (*Zonotrichia leucophrys*), swamp sparrow (*Melospiza georgiana*), fox sparrow (*Passerella iliaca*), field sparrow (*Spizella pusilla*), and cedar waxwing (*Bombycilla cedrorum*). Since the latter two species were present in good numbers on site during the summer (Section I), at least a few individuals were expected to overwinter especially due to the mild seasonal conditions. Peterson's (1981) analysis showed that white-crowned sparrows were recorded in 34 of 44 CBC's, swamp sparrows in 21, fox sparrows in 11, field sparrows in 29, and cedar waxwings in 20.

The absence and low abundance of many winter residents might be attributed to three factors:

(1) The food supply, especially weed seeds and berries, as well as shelter was reduced in the woodlots due to the removal of herbaceous and shrubby vegetation caused by grazing and bushhogging (see also Discussion, page 79, Section I). The reclaimed fly ash pile was impacted similarly by FMPC operations, including the removal of these vegetative layers by bulldozing and the compaction of the herbaceous layer by vehicles. Meents et al. (1982) concluded that the abundance of wintering sage sparrows (*Amphispiza belli*) were associated with

an inkweed shrub (*Suaeda torreyama*). Similarly, Townsend's solitaires' (*Myadestes townsendi*) winter abundance pattern was highly correlated with its preferred plant food, the juniper (*Juniperus* sp.) berry (Bock 1982). The cedar waxwing, an absent FMPC species, feeds almost entirely on berries (97%) during the winter, especially red cedar (*Juniperus virginiana;* Martin et al. 1951) which was in low abundance at the FMPC (Section I). However, the eastern bluebird, a related species, only depends on berries for 39% of its winter food (Martin et al. 1951) and was abundant in W1 and W2. Lewke (1982) found that invading winter residents in eastern Washington usually foraged in the shrub-tree physiognomic type (similar to FMPC woodlots) at the height of 1-9m. These studies suggest that the winter residents would be most affected by FMPC land management practices that remove low weedy and shrubby vegetation.

(2) Warm temperatures and little snow cover throughout the Midwest may have reduced the usual number of northern breeders forced to winter in southern Ohio.

(3) Northern breeders may have had a poor reproductive season.

Lower than normal populations of winter residents were noted during local 1986 CBC's (personal observations of RHS and DRO) which may support hypotheses 2 and 3. We feel that a combination of FMPC management practices (hypothesis 1) and weather conditions (hypothesis 2) were probably responsible for the absence and low abundance of many winter residents.

Habitat fragmentation is probably another factor affecting winter avian community structure at the FMPC (see Section I for summer effects). The abundance of bark gleaners was low in the RFAP, W1 and W2 when compared to W3 (Table 10) and may be related to the smaller size of the the wooded areas in RFAP, W1, and W2. Blake (1983) also found greater abundance of bark foragers in larger deciduous forest patches than in smaller ones. Yahner (1985), however, suggested that winter bird communities, especially permanent residents (this would include bark foragers), may be less sensitive to forest fragmentation than breeding bird communities in northern latitudes. The avian community in the RFAP may also be affected by the small total area occupied by the habitat, thus reducing the chance of a species occurring there.

The pastures (especially UGP and GP2) were the only habitats with higher than expected avian species richness (19 and 10, respectively) and diversity (2.096 and 1.940, respectively). Winter avian species richness reported for pastured, cultivated, or successional grasslands of the south-central U.S. ranged from one to six (Grzybowski 1982), similar to that of the most highly grazed, open pasture, GP1. High richness and diversity were attributed to the presence of trees in the pastures in combination with adjacent wooded habitats. All species in each pasture used available trees as song posts (e.g., eastern meadowlarks), hunting perches (e.g., American kestrels), foraging sites (e.g., downy and red-bellied woodpeckers, northern flickers, Carolina chickadees) or shelter

(e.g., song sparrows by fallen trees). Trees were serving as narrow corridors for resting (e.g., mourning doves, American robins, northern cardinals) and foraging as birds moved from one wooded habitat to another.

Eastern meadowlarks in GP1 and golden-crowned kinglets in PP1 had unusually high population densities onsite, both of which were in greater abundance as compared to Peterson's (1981) analysis of CBC data. Abundance of meadowlarks may be attributed to warm weather conditions and the open character and short grass in GP1. Few pastures of this nature are found in southwestern Ohio (personal observation). Abundance of kinglets may be explained by the mere existence of relatively large tracts of coniferous trees, which is a preferred winter foraging habitat. No explanation can be offered for the high abundance of kinglets in PP1 and virtual absence in PP2.

Seasonal changes in avian community structure were evident by reductions in species richness, species diversity, and avian density from summer to winter at the FMPC. Avian species richness ranged from 18-54 species during the summer (Section I) as compared to 9-21 species in this study. All habitats showed reduced richness in wintering birds. The bird community decreased from 52-72% in 6 of the 11 habitats sampled. Percentage decreases were similar across habitat type: 52 and 63% for the 2 riparian, 25-40% for the 3 woodlot, and 61 and 65% for the 2 pine habitats. GP1 showed the highest seasonal decrease in species richness (72%).

Summer avian diversities (H') ranged from 1.6 to 3.5 and winter diversities from 1.7-2.6. All 8 of the wooded habitats showed a winter reduction in avian species diversity whereas diversity in 2 of the 3 pasture habitats increased. Greatest seasonal declines were found in the riparian communities (H' = 3.6 - summer vs. H' = 2.3 - winter).

Avian densities in the summer ranged from 157-2720 birds per 40 ha (Section I) and winter densities from 11-380 birds per 40 ha. All habitats showed a winter reduction in avian density with an average decline of almost 70%. The greatest reduction in numbers occurred in the pines and pastures with average declines of 87 and 85%, respectively. Patterns of decreased avian species richness, diversity, and density have also been shown by Anderson and Ohmart (1983) in many of the habitats of the lower Colorado River valley.

Winter species richness reported by Anderson and Ohmart (1983) ranged from 8 to 28 species compared to 5 to 21 in this study. Their avian diversities (1.55-2.64) were comparable to this study (1.797-2.646), except for the low diversity in GP1 (0.293). However, they did not sample any avian communities in pastures. The range of winter densities were also similar to this study (28-529 vs. 11-380 birds/40 ha).

Although avian community structure parameters differed seasonally, generally, the most common species found in the summer (see Section I) were also quite abundant in the winter. Mourning doves, Carolina chickadees, song sparrows, northern cardinals increased in relative abundance whereas American

robins and American goldfinches decreased in relative abundance. Mourning doves showed an increased relative abundance in 10 of 11 habitats, averaging a 6% increase. Chickadees, song sparrows, and cardinals increased in 9, 7, and 6 of 11 habitats averaging 10, 13, and 5% increases, respectively. Although goldfinches increased in relative abundance in 6 habitats, they showed larger decreases in 5 habitats for an overall decrease in relative abundance. Robins averaged an 11% decline in relative abundance for 10 of the 11 habitats.

OWLS

METHODS

Eastern screech owls (*Otus asio*), great horned owls (*Bubo virginianus*), and barred owls (*Strix varia*) were censused by standard playback techniques (Fuller and Mosher 1981; Johnson et al. 1981). Censuses were conducted from 5 December, 1986 to 4 February, 1987. Eight 600m transects in the wooded habitats (Fig. 1) were censused 6 times for screech owls and twice for great horned and barred owls. Because breeding territories were unlikely in pastures, these habitats were censused only once. Censusing began shortly after sunset and ended by 2300 hrs. Pre-recorded tapes of each species were played on separate nights at 100 m intervals along each transect. The stimulus consisted of a series of three calls followed by a one minute pause. Up to 12 calls were played at each station. Habituation was minimized by alternating species, using vocal mimicry, or

using taped recordings of captive birds (Fuller and Mosher 1981). Responding individuals were spot-mapped for each census period. Clustering of the mapped responses were used to delineate territories and optimal screech owl habitat.

Visual sightings during our summer and winter bird censuses, counts at dusk, and reports of owls by security (WMCO) were also used to substantiate breeding territories and the presence of migrant species.

RESULTS

Censusing of the transects in the wooded habitats disclosed 15 screech owl territories on the FMPC (Fig. 3). The riparian transects supported 6 breeding pairs, each of the woodlots two, and the pine plantations three. The pastures and the reclaimed fly ash pile did not support any breeding owls. One territory was recorded offsite near the western boundary. Riparian habitats are optimal screech owl habitats on the FMPC followed by woodlots and then pine plantations (Fig. 4). However, because screech owl territories in the pines were adjacent to woodlots we believe that the pine communities are only marginal breeding habitats and the owl territories were probably centered off our transects in the woodlots.

Based upon the area (155.5 ha) of the woodlot,pine and riparian habitats (Section I), we estimate the FMPC sustains a total of 29 territorial pairs, including 3 pairs along the storm sewer outfall. Computed screech owl densities are 14 pairs/40 ha for the riparian habitats and 6 pairs/40 ha for the woodlots.

No barred owls were recorded on the FMPC during the winter owl census nor during our summer and winter bird censuses. One individual was recorded calling on three separate occasions from an offsite woodlot west of Paddy's Run Road.

Only one great horned owl responded during our playback censuses. The individual was recorded at the northern end of W3. Analysis of summer breeding bird censuses (Section I) and winter bird censuses (this section) revealed numerous sightings of great horned owls (Fig. 5). Except for the pastured and fly ash habitats, great horned owls were widely distributed throughout the FMPC. Clustering of sightings suggests an activity center in the riparian habitat west of pit 3, and one in the woodlot northwest of the southern pine plantation (PP2). Another activity center (probably feeding and roosting) was in the northern pine plantation (PP1). However, this pair probably nested in the woodlot north of PP1. Unfortunately the small size of this woodlot prohibited the establishment of a 600m transect. A fourth activity center appears to be in W3 in the NW corner of the FMPC. Thus, there were about 2 pairs of great horned owls on the 364.5 ha site during the summer, and 2 pairs during the winter. Great horned owls occupied only the wooded habitats, 162.8 ha (44.4%) of the 364.5 ha site. This represents a density of 1 pair/1.82 km^2 for the FMPC or 1 pair/0.81 km^2 of usable habitat.

DISCUSSION

Only two species of owls were found on the FMPC. They included the eastern screech owl and the great horned owl. Absent from our surveys were barred owls, short-eared owls (*Asio flammeus*), long-eared owls (*A. otus*), northern saw-whet owls (*Aegolius acadicus*), common barn-owls (*Tyto alba*), and snowy owls (*Nyctea scandiaca*).

The barred owl is an uncommon winter resident in southwestern, Ohio (Trautman and Trautman 1968) and prefers large woods and require stands that are sufficiently mature to provide numerous nesting and roosting hollows. Such climax stands of timber are absent on the FMPC (Section I).

The migrant short-eared owl and long-eared owl are most frequently observed in winter in the northern and western half of Ohio (Trautman and Trautman 1968). Craighead and Craighead (1969) report short-eared owls roost communally in fields of dense timothy (*Phleum pratense*), fox-tail grass (*Setaria* sp.) or brome-grass (*Bromus* sp.) which support high populations of meadow voles (*Microtus pennsylvanicus*). These vegetative covers and prey species were not abundant throughout the FMPC during fall-winter 1986 (Appendix A, Part I). The uncommon long-eared owl is a winter resident which roosts communally in coniferous woods. Roosts in Michigan averaged 7 owls per roost; one spruce stand in Ann Arbor township averaged 12 individuals (Craighead and Craighead 1969).

The northern saw-whet owl is an accidental to rare winter resident in southwestern Ohio (Trautman and Trautman 1968) and

rarely detected on Christmas Bird Counts in southwestern Ohio. It prefers to roost in dense young evergreens or thickets. Sizeable, but erratic overwintering populations have been reported in Winton Woods and in Miami Whitewater Forest, Hamilton County, Ohio (Randle and Austing 1952; Austing and Imbrogno 1976).

The common barn-owl is a rare to uncommon breeder in Ohio (Trautman and Trautman 1968) and was not expected to be on site. It is listed as a threatened species in Ohio (DNAP-ODNR 1982). Recent nestings have been reported for Ross County, Ohio and nesting programs have been developed in barns and old buildings adjacent to good grassland habitat (Gray 1986).

Snowy owls are accidental to rare winter migrants in Ohio (Trautman and Trautman 1968) and are not recorded annually. They have been reported every two or three years in the Cincinnati area (Osborne, Sperger, personal observations). Thus, the lack of an influx of wintering owls on the FMPC seems related to suboptimal habitats for cover or for supporting adequate densities of prey.

Screech owls were the most abundant nocturnal avian predator on the FMPC. Riparian habitats supported 14 pairs/40 ha and the woodlots 6 pairs/40 ha. Our density values for the riparian habitats on site are much lower than have been reported for screech owls in other riparian systems. Johnson et al. (1981) recorded 90 pairs/40 ha in a cottonwood-mesquite (*Populus fremontii-Prosopis velutina*) habitat on the Salt River near Phoenix, Arizona. In a similar community, Phillips et al.

(1964) reported territorial pairs occurring "100 yards" apart. Johnson et al. (1981), in a census of mesquite bosques along the Salt River, had screech owls spaced as closely as 50m apart, the highest breeding density recorded for screech owls in North America. Distances between adjacent screech owl pairs in our riparian habitats averaged 130m (N=4), whereas pairs in woodlots averaged 217m (N=4) apart. Phillips et al. (1964) report that screech owls are generally widely spaced at approximately 100 meters between pairs in woodlands. Thus, screech owl densities on the FMPC appear to be normal for riparian and woodlot systems.

We estimated 2 pairs of great horned owls utilizing the FMPC. Centers of activity included the northern pine plantation, borders of woodlots, and riparian habitats. We have no evidence of great horns nesting in the pines. They probably used this habitat for roosting or feeding. Most of the sightings in PP1 were of birds flushed while conducting early morning foot surveys on summer and winter avian populations. Preferred nesting sites for great horned owls in Ohio are former red-tailed hawk (*Buteo jamaicensis*) nests, tree hollows, and arboreal squirrel nests (Kirkley and Springer 1980). Such sites are not available in the pine plantations.

Our density value of 1 pair/0.81 km^2 of usable habitat was considerably higher than densities previously reported for Ohio. Kirkley and Springer (1980) reported an owl density of one nesting pair per 8.2 km^2 for a 483.6 km^2 site near Delaware, Ohio. Cornmann (1973) and Misztal (1974) reported densities of

82.9 and 171.7 km^2 per nesting pair, respectively, for other Ohio sites. Counts of responses to taped calls revealed densities of 1 pair/10 km^2 in a 293 km^2 area in Wood County, Ohio (Siminiski 1976).

Our higher densities may be related to the clumped populations of cottontail rabbits (*Sylvilagus floridanus*) on site (this section). Great horned owl population densities have been shown to cycle with snowshoe hare (*Lepus americanus*) densities in central Alberta (McInvaille and Keith 1974). Hares consistently ranked first over a six year period as the most important prey (% biomass) of nestlings. Similar prey preferences were reported by Marti (1974) who found cottontail rabbits constituted over 60% of the prey biomass of great horned owls in north-central Colorado. Other preferred mammalian prey include *Peromyscus* sp. and meadow voles (Marti 1974; McInvaille and Keith 1974). White-footed mice (*Peromyscus leucopus noveboracensis*) were common in 3 of the 6 habitats censused at the FMPC, whereas meadow voles were quite rare; the prairie deer mouse (*P. maniculatus bairdii*) was not found (Appendix A, Part I).

A common avian prey of great horned owls are mourning doves (*Zenaida macroura*). Birds comprised 34% of the diet of great horned owls in central Ohio (Springer and Kirkley 1978). Of 17 species, 21% were doves. Dove densities (411 birds/40 ha) were the highest in the northern pine plantation during summer, 1986 (Section I) and winter 1986 (this section) and probably represents another important food resource for great horned owls

on site. We observed many dove kills (10-15/600 m transect) during our censuses of the northern pines (PP1), although their cause of death cannot positively be attributed to great horned owl predation. An analysis of pellets from roost sites is needed to further substantiate these hypotheses.

SUMMARY

The FMPC supported relatively high densities of screech owls and great horned owls. Screech owl densities (14 pairs/40 ha) were highest in the riparian habitats along Paddy's Run. Great horned owl densities (1 pair/0.81 km^2) of usable habitat are higher than previously reported for Ohio and may be related to the densities of rabbits and doves on site. Habitats on the FMPC are not suitable for breeding barred owls and barn-owls, or for over-wintering short-eared, long-eared, saw-whet, and snowy owls.

Screech owls readily responded to playbacks of taped calls in mid-December, but ceased responding by the end of January. Only one great horned owl responded, yet numerous individuals were detected on our summer and winter bird censuses. Siminski (1976) found that it took 26 calls to elicit responses from great horned owls in Wood County, Ohio; we played only 12 at each station. However, Springer (1978) reported the relative effectiveness of foot surveys (95 and 95.8%) for great horned owl populations in central Ohio was higher than with playback recording surveys (72 and 87.5%) in locating 66 known pairs of owls.

RABBITS

METHODS

Eastern cottontail rabbits (*Sylvilagus floridanus*) were censused from 25 June to 25 July, 1986 using a fixed-width line transect. Each of the 11 permanent terrestrial transects (Fig. 1) was censused 12 times. Censuses began from 1/2 to 3 hrs after sunrise and ended before 1100 hours. Effective detection width of the strips was 13 m for the pines, 20 m for the riparian, 30 m for the woodlots, 50 m for the fly ash pile, and 100 m for the pastures. We also recorded the total time it took to complete each census. Abundance was calculated for each transect in terms of the average number of rabbits per census and the average number per sampling effort. Density estimates were calculated for each habitat based upon areas reported earlier (Section I) and compared to densities previously reported for onsite and offsite populations.

RESULTS

Eighty-two rabbits were recorded on our 132 censuses of the transects. The distribution and abundance of cottontails on the FMPC was highly variable (Table 13). Only one rabbit was encountered in the three pastured habitats; they comprised 55.3% (201.7 ha) of the vegetated area on site. Thus, over 55% of the habitat on the FMPC was not conducive to cottontail use.

The most productive cottontail habitats were the pine plantations. The northern pines (PP1) and southern pines (PP2)

averaged 3.08 and 1.08 rabbits per census, respectively. Of the 82 rabbits scored during our censuses, 50 (61⅔) were from the pine plantings. Average cottontail densities ranged from 1.37-3.95 rabbits per ha in these communities.

Similar patterns of abundance exist when the data is analyzed per unit effort of time spent censusing (Table 13). In 10 hours of censusing we would expect to encounter 30 rabbits in PP1 and 14 in PP2.

The woodlots, reclaimed fly ash pile and riparian habitats supported low to moderate numbers of cottontails. Intra- and interhabitat differences in cottontail abundance and density of these communities were highly variable. Because of the high degree of variation of population abundance within habitats it is difficult to determine the total density of rabbits on the FMPC. Together the pine plantations supported 106 cottontails per 40.1 ha of evergreen habitat on site. Total estimated density is about 142 rabbits for the 364.5 ha site (0.39/ha), or 142 cottontails/164 ha (0.87/ha) of occupied habitat.

DISCUSSION

Intra- and interhabitat differences in rabbit distribution, abundance and density on site are probably related to the degree of habitat fragmentation by browsing cattle, mowing and bushhogging in the woodlots affecting the herbaceous cover important to rabbit usage. However, the relationships are not clearcut. RN1 had 10 rabbits per 12 censuses and RN2 had 2; shrub density was 8542 and 2458 per ha, respectively (Section

I). Conversely, W3 had the highest number of rabbits of the woodlots sampled, but the lowest density of shrubs (W1-7375, W2-3624, W3-2625 shrubs/ha). All woodlots were presumed to be subjected to similar land management practices, although our field surveys suggested less bushhogging occurred in W3. The pine plantations offer the greatest protection to cottontails on site. Rabbit densities in the northern pines were 3 times higher than in the southern stand (3.95 vs 1.37/ha, respectively). Intrahabitat rabbit population differences may be related to the fact that PP1 is much more dense than PP2. Litter (mostly pine needles) accounted for 35% of the ground cover in PP1 and only 16% in PP2; tree densities were 749/ha in PP1 as compared to 489/ha in PP2 (Section I).

Pomeroy et al. (1977) and Battelle (1981) lists the eastern cottontail as one of the most common species of native mammals on site. Battelle (1981) suggests their average onsite densities of less than 2/ha are lower than to be expected in surrounding areas because of extensive mowing and grazing over much of the FMPC. We found a density of 142 rabbits for the 364.5 ha site (0.39/ha), or about 0.87/ha of occupied habitat.

Except for the pine stands cottontail densities are much lower than reported elsewhere. The fall density of a confined population of *S. floridanus* on the 210 ha Urbana (Ohio) Wildlife Area in 1964 was 14.9/ha (Leite 1965). The peak density of eastern cottontails for St. Clements Island, Maryland, was 10.2/ha (Bittner and Chapman 1982). Based upon hunter harvest data over 9 years, cottontail density ranged from 1.23-1.85/ha

on a site near Delaware, Ohio (Chapman et al. 1982). Population estimates derived from live trapping over 23 years on a 48 ha site in Piatt County, Illinois ranged from 88 to 358 (Edwards et al. 1981).

Several factors may account for the low overall abundance of cottontails on the FMPC. Numerous papers on food habits stress the importance of grasses in adult cottontail diets. Kentucky bluegrass (*Poa pratensis*), Canadian bluegrass (*P. compressa*), Timothy (*Phleum pratense*), quack grass (*Agropyron repens*) and orchard grass (*Dactylis glomerata*) are the most important (Dalke and Sime 1941; Smith 1950; Klimstra and Corder 1957; Bailey and Siglin 1966). Red fescue (*Festuca rubra*) is the dominant herbaceous ground cover on the FMPC (Section I), but it is not mentioned as being an important food in the literature. Other herbaceous plants, including red clover (*Trifolium pratense*), wild carrot (*Daucus carota*), and ragweed (*Ambrosia* spp.), important in the diet of young rabbits (Bailey and Siglin 1966) are not particularly abundant on site. The most important woody food plants, apple (*Malus pumla*), staghorn sumac (*Rhus typhina*), red maple (*Acer rubrum*), blackberry (*Rubus allegheniensis*), and red raspberry (*R. strigosus*) occur sporadically in low numbers throughout the FMPC.

Cottontails are found in a variety of disturbed, successional, and transitional habitats. In New England, Jackson (1973) found no relationship between cottontail declines and any forest region or any major land use pattern and concluded that population declines were related to declines in

the abundance of cover. Statewide reductions of more than 70% were closely associated with changes in agricultural land use in Illinois (Edwards et al. 1981). Overgrazing is known to reduce cottontail habitat for protective cover and for nesting (Chapman et al. 1982).

Thus, mowing of pastures, bushhogging of woodlots, and extensive grazing by cattle seem to be major factors at the FMPC which account for cottontail abundances and densities to be below those reported offsite. But one also needs to consider that great horned owl density on the FMPC during the fall and winter of 1986/87 was higher than in other somewhat similar areas as reported in the literature. As rabbits are a major food item of great horned owls, low numbers of cottontails may also be due to this factor.

Although cottontail abundance and density are lower than reported elsewhere, they may represent a high in the FMPC population. Ten year peaks have been reported for years ending in 6 (Sadler 1981), but highs at 8-9 year intervals have also been found (Bailey 1968; Edwards et al. 1981).

SUMMARY

The summer density of cottontail rabbits on site was 0.39/ha or 0.87/ha of occupied habitat. The pastured habitats, 55.3% (201.7 ha) of the vegetated area, were not conducive to rabbit use. Rabbit abundance and density varied considerably within and between habitat type, and showed clumped densities in the pine plantings (3.95 and 1.37/ha). FMPC cottontail

densities were considerably lower than reported for offsite populations and could be related to current land management practices and/or owl predation.

THREATENED AND ENDANGERED SPECIES

No federally endangered animal species were observed on the FMPC during fall-winter 1986. Two birds were recorded onsite that appear on the "Rare Species of Nature Ohio Wild Animals" list (DNAP-ODNR 1982). A red-shouldered hawk (*Buteo lineatus*) was seen over W1. Cooper's hawks (*Accipiter cooperii*) were frequently sighted in the pines and over the ungrazed pasture. This species is listed as an uncommon, but regular, breeder in the Cincinnati area (CNC 1978), a non-breeder in Hueston Woods (Osborne and Smallwood 1982), and a threatened breeder in Ohio (DNAP-ODNR 1982). Cooper's hawks have been reported during summer on the FMPC (Section I). They are considered an uncommon to common fall migrant and winter resident in Ohio (Trautman and Trautman 1968).

ENVIRONMENTAL POPULATION GENETICS

FISH

STUDY SITES

Fish were collected using the seine method (Bennet 1970) from three sites in Paddy's Run within the boundaries of FMPC on June 24-25, 1986 (Fig. 6); individuals collected from sites 2

and 3 were pooled (**U**), site 4 is represented by the symbol **D**. Sites 2 and 3 were resampled on October 29, 1986 and fish were separated by site. Four hundred thirty-five fish representing 14 species and 10 genera were collected and analyzed using electrophoresis (Table 14).

ELECTROPHORETIC METHODS

Fish were homogenized mechanically in a 0.25M sucrose, 2% 2-phenoxyethanol extraction solution, centrifuged at 20,000 g at 5° C for 6 min and the supernatant was stored at -70° C until used. All fish were electrophoresed within 3 weeks of homogenization.

Loci analyzed and buffers used are detailed in Table 15. Gels were 15% Sigma starch (Karlin and Guttman 1981) except for the LiOH system which was made with 13% Sigma starch.

Histochemical procedures followed Harris and Hopkinson (1976) and Selander et al. (1971). After the gels were stained, the genotypic composition of each sample at each locus was determined and recorded. Genotypic data were analyzed using the BIOSYS-I computer program (Swofford and Selander 1981). Allele frequencies, deviation from expected genotypic proportions assuming Hardy-Weinberg equilibrium conditions, amount of genetic variation, similarity matrices and chi-square contingency tests for interpopulation heterogeneity were performed. See Section I for a discussion of Hardy-Weinberg equilibrium and methods for determination of expected genotypic proportions and heterozygosity.

RESULTS

Sample sizes were small for two of the species collected (*Notropis chrysocephalus, Semotilus atromaculatus*); since few individuals were collected, the data will not be considered here.

Rhinichthys atratulus - blacknose dace (RA)

Three loci examined (EST-2, GPI-2, PGM-1) were variable in the blacknose dace sample (U; Table 16). The major allele was present in high frequency (> 0.80) for all loci. All genotypic proportions conformed to those expected under conditions of Hardy-Weinberg equilibrium (Table 18).

Pimephales notatus - bluntnose minnow (PN)

Polymorphism was maximal in the June sample from site U (pooled 2 and 3), occurring at five of the loci examined (Table 16). Concomitant with this variation was high allelic diversity; the mean number of alleles per locus in this sample was 1.8. Four alleles were present at the EST-2 locus while three were found at GPI-1; the major allele occurred at a frequency < 0.65 at these loci.

The remaining samples of this species did not exhibit variation of the magnitude found in the sample from site U. The June downstream site (D), and October samples from sites 2 and 3 were either invariant for a locus polymorphic in sample U or had less allelic diversity at these loci (Table 16). While estimated heterozygosity was highest in sample U (20%; Table 17) direct-count heterozygosity was greatest in sample D. Both

samples U and D had significant heterozygote deficiencies when compared to expected proportions under Hardy-Weinberg equilibrium conditions; the deficiencies in the former sample were more marked (Table 18). Contingency chi-square tests (Table 19) indicated significant heterogeneity among the bluntnose minnow samples at three of the five variable loci.

Campostoma anomalum - stoneroller minnow (CA)

Sixty percent of the loci were variable (Table 17) in the stoneroller minnow populations. Allelic diversity was high in all samples except for CA-2 which possessed an average of approximately 67% of the alleles per locus found in conspecific collections. Tests for conformation of genotypic distribution to expected under Hardy-Weinberg equilibrium conditions demonstrated that the EST-2, EST-3 and PGM-2 loci were significantly different from expected. This was most evident in the CA-D and CA-3 samples where 50 and 60% of the polymorphic loci, respectively, were significantly different from expected proportions (Table 18). Contingency analysis using a chi-square test (Table 19) indicates that significant heterogeneity exists among samples at the EST-2, EST-3 and GPI-2 loci.

Ericymba buccata - silverjaw minnow (EB)

Although four samples of the silverjaw minnow were collected, two (EB-1 and EB-3) were represented by only two individuals each and were, therefore, excluded from further analysis. Twenty to 30% of the loci were variable in this species; no more than two alleles were found at any variable

locus. Two of the loci in EB-D and one in EB-2 were significantly different ($p \leq 0.05$) from expected under conditions of Hardy-Weinberg equilibrium (Table 18); direct-count heterozygosity was less than expected in each sample (Table 17). The populations exhibited homogeneity at all variable loci (Table 19).

Notropis spilopterus - spotfin shiner (NS)

Although three populations were studied, only two individuals were collected from site 2 and, therefore, this sample was excluded from further study. With the exception of EST-2, allele frequencies at the polymorphic loci were similar for samples from the offsite sample and site 3 (Table 16). These similarities were also present for genetic variability parameters as well (Table 17); direct-count heterozygosities approximated values expected under conditions of Hardy-Weinberg equilibrium; genotypic distributions were not significantly different from expected (Table 18). Homogeneity between samples occurred at all variable loci (Table 19).

Notropis ardens - rosefin shiner (NA)

Fish were collected from four sites; however, at two of the sites (2 and 3) few rosefin shiners were obtained and these fish were eliminated from further consideration. Variation existed at four of the loci (Table 16) with one locus (PGM-2) being monomorphic in the NA-1 sample and one heterozygote being present at that locus in the NA-D fish. Although EST-3 was monomorphic in NA-D fish, those from NA-1 possessed both A and B

alleles (Table 16). Rosefin shiners from both sites exhibited fewer mean heterozygotes than expected (Table 17). However, genotypic distribution was significantly ($p \leq 0.05$) different from expected under conditions of Hardy-Weinberg equilibrium at only the GPI-2 locus in each sample (Table 18). Fish from the two sites exhibited significant heterogeneity at both the EST-3 ($p \leq 0.01$) and MDH-2 ($p \leq 0.05$) loci (Table 19).

Catostomus commersoni - white sucker (CC)

Sufficient numbers of white suckers for statistical analysis were collected from the U and D sites. While excellent electrophoretic profiles were obtained for these fish, patterns for several loci are difficult to interpret (see Discussion). Although three variable loci were scored (Table 16), only one population (CC-U) was polymorphic at PGM-2. Since not all loci were interpreted, genetic variability parameters were not calculated. Tests for conformation of genotypic proportions to expectations under conditions of Hardy-Weinberg equilibrium indicated that significant differences existed (CC-U: EST-2, EST-3; CC-D: EST-3; Table 18). The two white sucker samples shared significant heterogeneity ($p \leq 0.05$) at the EST-2 locus.

Etheostoma nigrum - johnny darter (EN)

Only two of the loci studied in johnny darters were variable (GPI-1, GPI-2; Table 16), with only the D sample exhibiting polymorphism at the latter locus. Variation in this species was low (Table 17), with all but one locus in one population (EN-D: GPI-1) exhibiting genotypic distributions

conforming to values expected under conditions of Hardy-Weinberg equilibrium (Table 18). Homogeneity existed among the samples at both variable loci (Table 19).

Etheostoma spectabile - orangethroat darter (ES)

Two loci (GPI-1, GPI-2) were variable in orangethroat darters, with the latter locus being polymorphic only in ES-D (Table 16). Genetic variability values were low for *E. spectabile* (Table 17) and mean direct-count heterozygosity paralleled expected values. However, a significant heterozygote deficiency was found (ES-D: GPI-2, $p \leq 0.01$; Table 18) when genotypic distributions were compared to expected under conditions of Hardy-Weinberg equilibrium. Homogeneity existed among all orangethroat samples at the variable loci (Table 19).

Etheostoma flabellare - fantail darter (EF)

Fantail darters from sites U and D were polymorphic at three of the loci examined (Table 16). Mean direct-count heterozygosity values approximated those expected (Table 17). The MDH-2 locus in sample EF-D exhibited significantly ($p \leq 0.01$) different genotypic proportions from expected under conditions of Hardy-Weinberg equilibrium (Table 18). Significant heterogeneity ($p \leq 0.01$) occurred between the two fantail darter samples at GPI-2 (Table 19).

DISCUSSION

When fish samples were first collected (June, 1986) sites 2 and 3 were believed to represent control sites with only site 4

potentially subject to FMPC stormwater runoff; therefore, site 4 fish were to be compared to those from upstream sites. After collecting and storing fish from sites 2 and 3 together, we were made aware of the possibility that animals from site 3 could have been subjected to FMPC waste materials at some point between the two locations. Thus new samples had to be collected. These were obtained from Paddy's Run in late October from pools south of the Ohio SR 126 bridge over the creek (Site 1). On that day we also resampled sites 2 and 3. While few juveniles were collected during the October sampling period, mortality since June had reduced populations such that fewer fish were available. We obtained more than 10 individuals of only the johnny darter at the control site. Bluntnose and stoneroller minnows as well as johnny darters were adequately represented from site 2; more than 10 stonerollers and spotfin shiners were collected from site 3.

Contingency chi-square analyses for genetic heterogeneity between conspecifics indicate that some heterogeneity was due to date of sampling rather than differences among sites (Table 20). When bluntnose minnow samples were examined by date of collection, two-thirds of the heterogeneity was eliminated (Tables 19 and 20); heterogeneity at only the EST-3 locus remained. In contrast, elimination of the June sample of stoneroller minnows increased the heterogeneity evident among populations of this species. When all stoneroller minnow samples were included, three of the polymorphic loci exhibited heterogeneity; however, when only the October sites were

analyzed, an additional locus (PGM-2) became significantly heterogeneous ($p \leq 0.05$).

Calculations from Hardy-Weinberg equilibrium data (Table 18) document a higher percent non-conformation (the summation of the number of loci that deviate significantly from expected genotypic proportions in samples from a site divided by the number of variable loci in samples from that site) occurred at sites U (41%), D (52%) and 3 (31%), than at Sites 1 (13%) or 2 (12%) when all fish species were considered. Site U is a composite of June's collection from sites 2 and 3; when we combined data from sites 2 and 3 in the October collection and calculated percent non-conformation (21%), it became evident that seasonal differences occur in genotypic proportions at a site. Non-conformation in the June sample (U) is approximately twice that of the October samples from the same sites. Allochronic samples of a given species from a single site usually represent individuals exposed to differences in environmental selection. Photoperiod, water temperature, water quality as well as biotic factors are all changing with the seasons; the age structure of the fish community in Paddy's Run also changes with time. The majority of the fish collected during the June sampling were young of the year; mortality in fish of this age is high. As the community ages, fewer fish are found; these fish have survived the months between sampling periods presumably by being better adapted to their environment. Recently, investigators have found that allele frequencies and genotypic proportions change dramatically in populations as a

cohort matures (Diehl and Koehn 1985, Ledig et al. 1983, Pierce and Mitton 1982). If seasonal changes in genetic structure of the fish community represent the result of natural selection, then the differences among sites collected at one point in time should also reflect this phenomenon. The percent of non-conformation to expected genotypic distribution, both for the entire fish community sampled and for only species collected at sites 1 and/or 2 and 3, was greater in populations of site 3 than sites 1 and 2. In the June sample percent non-conformation for all fish from Site D is 27% greater than fish from site U; however, when only species common to both sites are compared percent non-conformation is approximately equal (U=50%, D=58%). Most fish taxa are r-selected; this reproductive strategy is to produce many more offspring than will probably survive. Selection in an r-strategist is most intense during early juvenile stages; population size decreases greatly at first and mortality rate decreases throughout the lifespan of the cohort. The differences between observed and expected genotypic distribution under Hardy-Weinberg equilibrium conditions were a result of reduction in the number of individuals heterozygous at enzyme loci. This is most marked in June where the U site showed almost twice the percent non-conformation as sites 2 and 3 combined from October (41% vs 21%, respectively). The genetic data and life history phenomena suggest that selection, common to fish from sites on and off the FMPC boundaries, occurs early in the life of a cohort. Selection later in the life of the cohort, as it approaches sexual maturity, may differ. Evidence

suggests that homozygous excesses (= heterozygote deficiencies) were reduced in October accounting for increased conformity to expectation. However, populations from the furthest downstream site sampled in Paddy's Run in October (site 3; south of the drainage ditch) have a significantly ($p \leq 0.01$) greater proportion of heterozygote deficiencies than were found in synchronic samples from sites north of the drainage ditch.

An alternative explanation for the significantly higher non-conformation in the June vs October samples is that the young of the year fish sampled in June may have consisted of pooled offspring from a few successful parents. If this occurred and heterogeneous sibling groups were pooled in single collections, the data would result in excessive heterozygote deficiencies compared to those expected. This phenomenon, known as the Wahlund effect, would disappear as the young fish disperse and leave their natal area.

Data presented and discussed above indicate that biochemical genetic analysis of the populations in Paddy's Run could serve as a sensitive monitor of both environmental impact and remediation. Five of the 14 fish species studied (bluntnose minnow, stoneroller minnow, spotfin shiner, rosefin shiner and white sucker) possess sufficient variation to serve as indicator species. The white sucker has the potential to be particularly useful because it is a member of a tetraploid fish family that has undergone partial genic diploidization (Ferris and Whitt 1980). Therefore, many more metabolically important loci are present in an individual sucker.

Further studies with increased sample sizes and of increased duration are needed before we can draw any major conclusions as to the specific environmental conditions at the FMPC which may be directly affecting the genetic structure of fish populations in Paddy's Run. What this study has demonstrated is that a pattern seems to be emerging with respect to the genetic structure of most of the FMPC populations studied as compared to offsite populations.

GRASSHOPPERS

STUDY SITES

Grasshoppers were collected by hand and sweep net from four sites within the boundaries of the FMPC and three offsite locations (Figure 7, Table 21); 152 individual *Melanoplus femur-rubrum* and 137 *Conocephalus strictus* were electrophoretically examined (Table 21).

ELECTROPHORETIC METHODS

Grasshopper homogenates were prepared and treated as for fish (above). Loci analyzed and buffers used are detailed in Table 22. Gels were 15% Sigma starch (Karlin and Guttman 1981) except for the LiOH system which was made with 13% Sigma starch. Histochemical procedures and methods of data analysis followed those used for fish (above).

RESULTS

Analysis of grasshopper data is still in progress and will be documented in the next report.

SUMMARY AND CONCLUSIONS

Forty-one taxa of benthic macroinvertebrates were collected from eight onsite and from two offsite riffle/pool sampling stations on Paddy's Run during November and December 1986. Only 19 taxa were found onsite in a previous study. Upstream stations contained more taxa and had significantly higher faunal densities than did downstream stations. Station 5 had the lowest macroinvertebrate density and diversity ($55/m^2$, H' = 0.79, respectively). The lowest percentages of chironomids/sample were recorded at sites 5 and 10 (3.3% and 0.9%, respectively). The faunal diversities, and type and number of macroinvertebrate taxa collected from Paddy's Run were typical of those reported for streams in southwestern Ohio. The observed changes in macroinvertebrate communities downstream from site 4 seem primarily related to drought conditions preceding sampling.

The identification of over 21,000 total terrestrial arthropods was completed during the quarter, October 1-December 31, 1986. Data for GP1 and W1 were added to the applicable tables, and an Appendix listing the relative abundance of more than 130 taxonomic groups is hereby submitted.

Perhaps the most notable observation gained as a result of the completion of this phase of the project deals with springtails (Collembola). Our results indicate that entomobryiads and sminthurids generally do not co-exist on the FMPC.

Spearman rank correlation analysis indicated UGP and GP2 to be the most and UGP and RN2 least similar. This is contradictory to the results obtained using Chi-square analysis as previously reported (Section I). Overall, most taxa were rare in abundance with only a few (e.g., Cicadellidae, Acrididae, Chrysomelidae, and Araneidae) abundant in most habitats.

The winter avifauna of the FMPC was relatively diverse with 36 species occurring onsite. The most abundant species were permanent residents such as the mourning dove, Carolina chickadee, and the song sparrow. Eastern meadowlarks in the grazed pasture southeast of the plant (GP1) and golden-crowned kinglets in the northern pine plantation (PP1) had unusually high densities (30.8 and 57.7 birds/40 ha, respectively). Many winter residents were absent or in low abundance which may be attributed to land management practices and warm seasonal conditions. Fourteen species that regularly winter in the Cincinnati area were absent from the FMPC. Habitat fragmentation may have reduced the number of bark foragers in the reclaimed fly ash pile and two woodlots. Seasonal changes in avian community structure from summer to winter were evident by reductions in species richness (25-72%), species diversity (avg.=14%), and avian density (avg.=70%).

The FMPC supported relatively high densities of screech and great horned owls. Screech owl densities (14 pairs/40 ha) were highest in the riparian habitats along Paddy's Run. Great horned owl densities (1 pair/0.9 km^2 of usable habitat) are

higher than previously reported for Ohio and may be related to the clumped densities of rabbits and doves on site. Habitats on the FMPC are not suitable for breeding barred owls and barn owls, or for overwintering short-eared, long-eared, and saw-whet owls.

The summer density of cottontail rabbits on site was 0.39/ha (0.87/ha of occupied habitat). The pastured habitats, 55.3% of the vegetated area, were not conducive to rabbit use. Rabbit abundance and density varied considerably within and between habitat type, and showed clumped densities in the pine plantings (3.95 and 1.37/ha). FMPC cottontails densities were considerably lower than reported for offsite populations and are possibly related to current land management practices and/or owl predation.

No federally endangered animal species were recorded on site. A red-shouldered hawk was recorded once and a Cooper's hawk was recorded frequently on the FMPC. Cooper's hawks have been previously reported during the summer on site. Both species are listed as "threatened" in Ohio.

Four hundred and thirty-five fish, representing 14 species and 10 genera, were collected from four sites on Paddy's Run and examined using starch gel electrophoresis. At least two loci were found to be polymorphic loci in each species. A comparison between samples collected in June and October indicates that some heterogeneity among genotypic distributions is due to seasonal changes in the genetic structure of the fish populations. Additional significant heterogeneity is

attributable to differences between genotypic proportions at sites studied; these differences occur on either side of a drainage ditch entering Paddy's Run at the northwest corner of the FMPC. The data indicate that monitoring of the genetic structure of fish from Paddy's Run should continue. Five species of fish (bluntnose minnow, stoneroller minnow, spotfin shiner, rosefin shiner, and white sucker) could serve as indicator species.

ACKNOWLEDGEMENTS

Appreciation is expressed to security and to Dr. Suellen A. van Ooteghem, Impact Assessment, WMCO, for their cooperation in all phases of this project. Special thanks are extended to Dave Might and Mark Sparks for their long hours spent in sorting and identifying the insect taxa. Dr. Neal Mundahl identified the benthic fauna and wrote that section included in this document. Dr. Robert Gillespie supervised the fish electrophoretic analysis. We are exceedingly grateful to the numerous Miami University students who helped conduct the diurnal and nocturnal field surveys, or worked as laboratory technicians. They include: Rhonda Beyke, Joe Bonnell, Amy Cogan, Christine Hutchinson, Gwen Keller, Ann Kelly, Vince LaPolla, Cathy Lerch, Connie McBride, Sandy Navaro, Bob Opper, Mike Osborne, Sean Rush, Sonya Serafin, David Uzzel, Mark Vekasy, and Lee Weigt.

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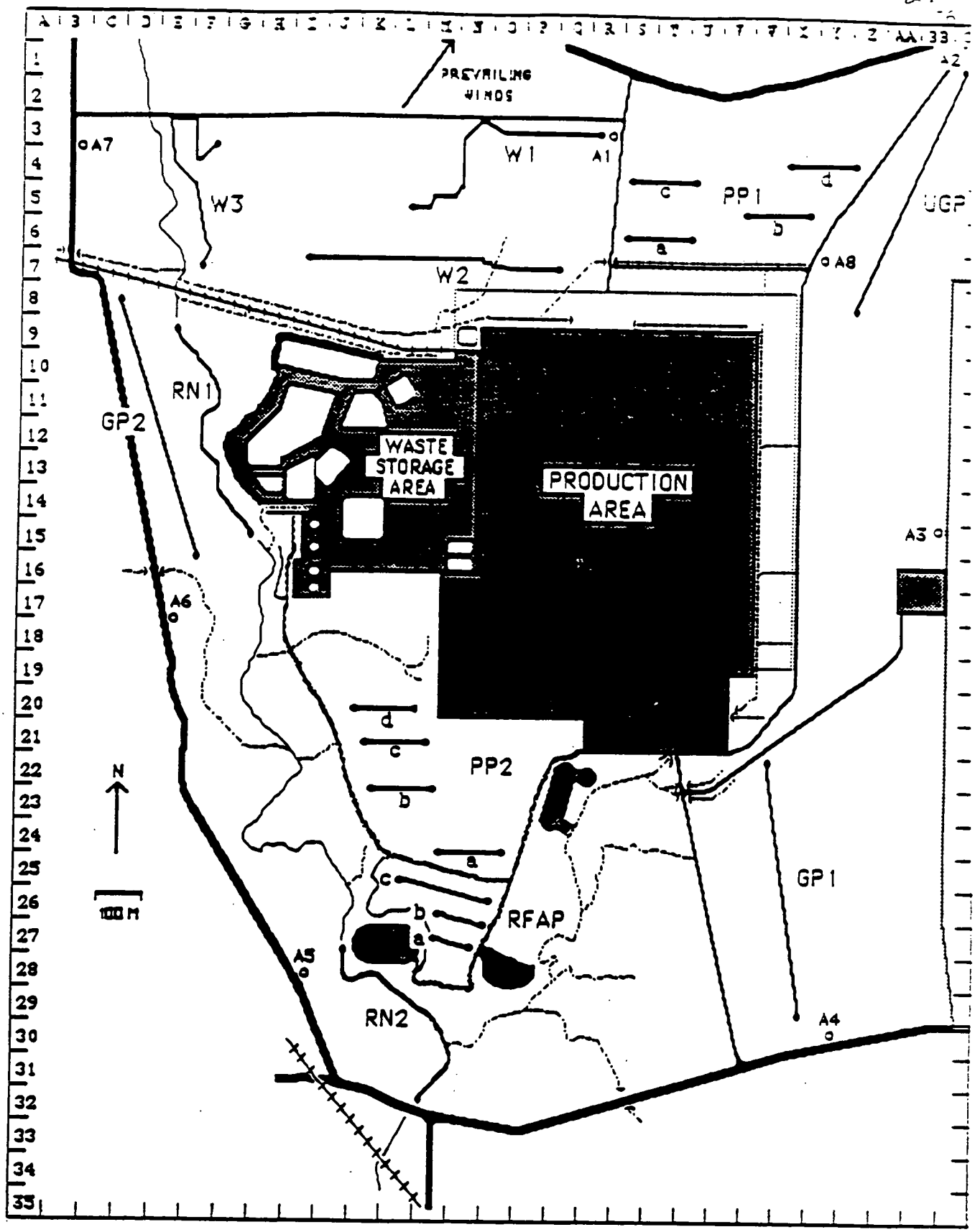

Figure 1. Locations of the permanent transects established and air monitoring stations(A) at the FMPC. UGP=ungrazed pasture; GP=grazed pasture; PP=pine plantation; RFAP=reclaimed fly ash pile; W=woodlot; RN=riparian.

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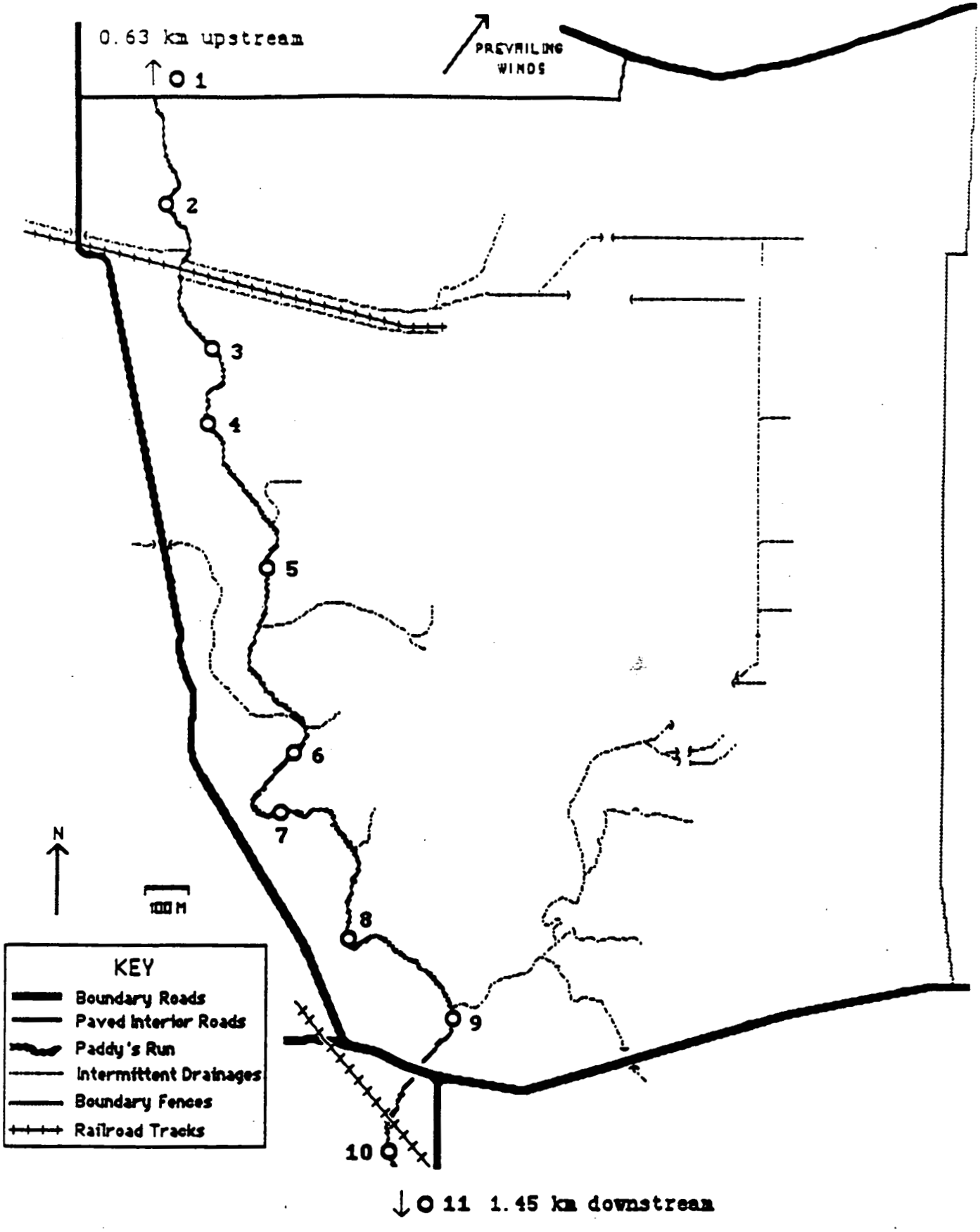

Figure 2. Benthic sampling sites on Paddy's Run.

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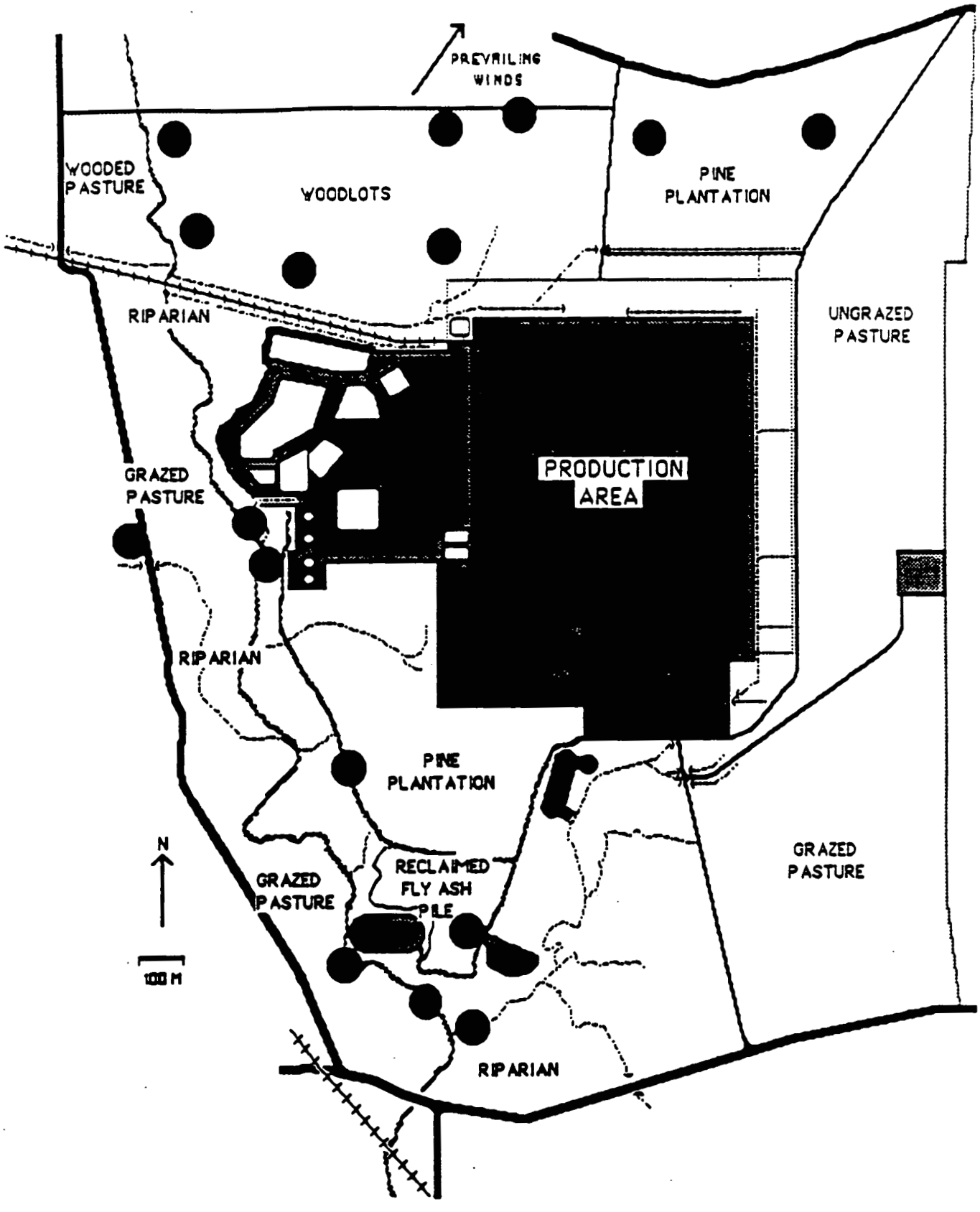

Figure 3. Distribution of eastern screech owl (Otus asio) territories on the FMPC during the winter, 1986-87.

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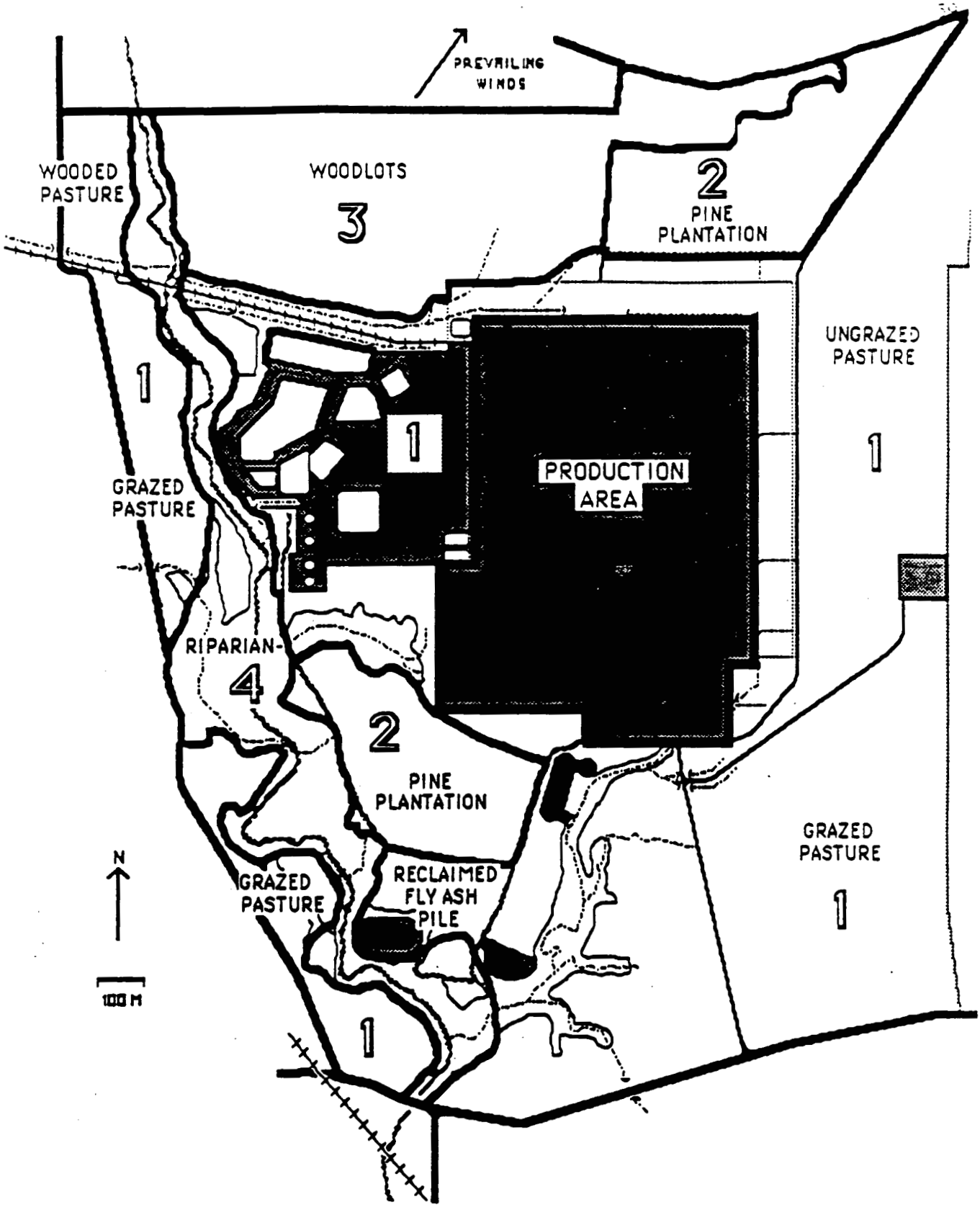

Figure 4. Distribution of quality habitats of the eastern screech owl on the FMPC, winter, 1986-87.

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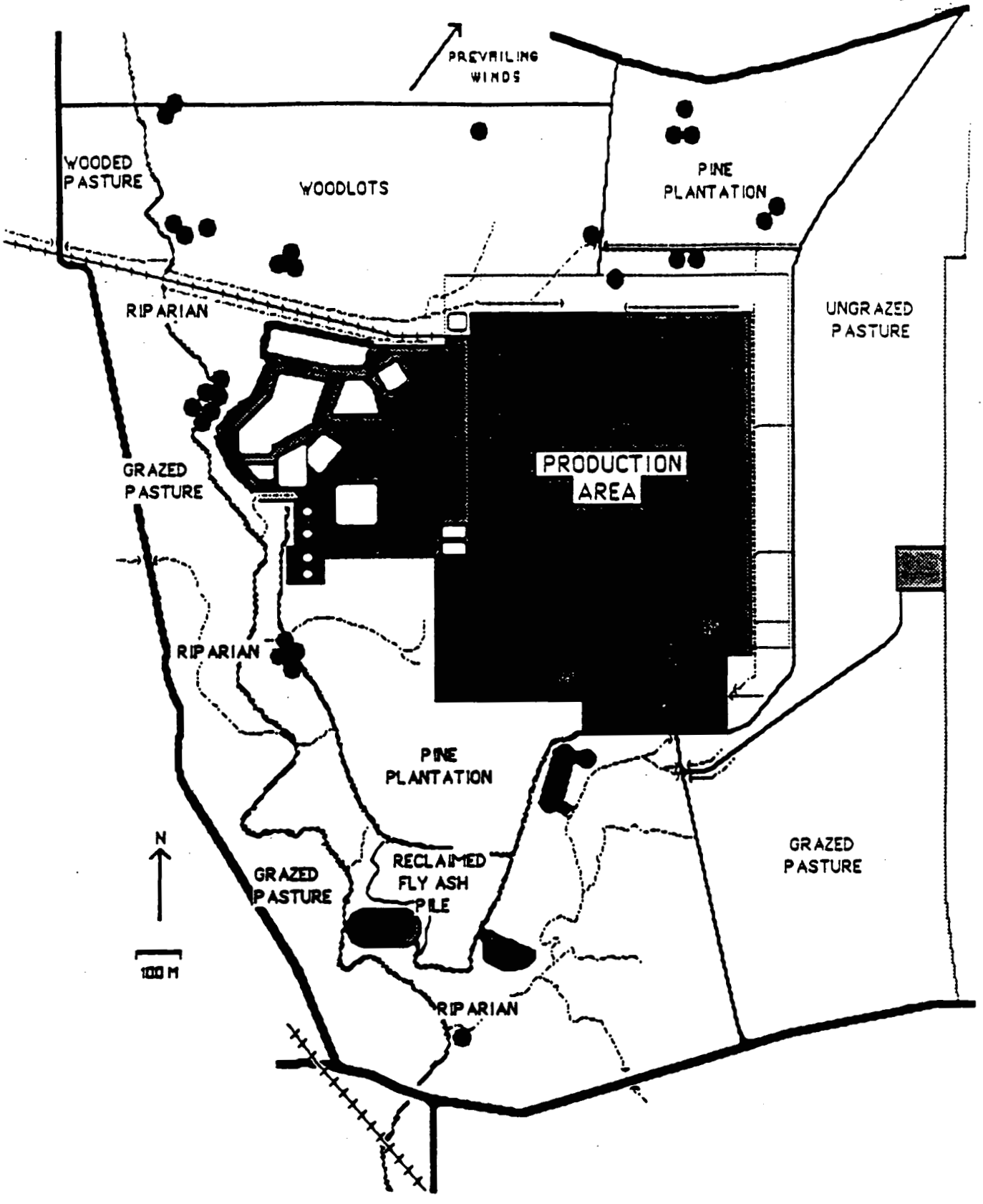

Figure 5. Distribution of great horned owl (Bubo virginianus) territories on the FMPC during the summer, 1986, and winter, 1986-87.

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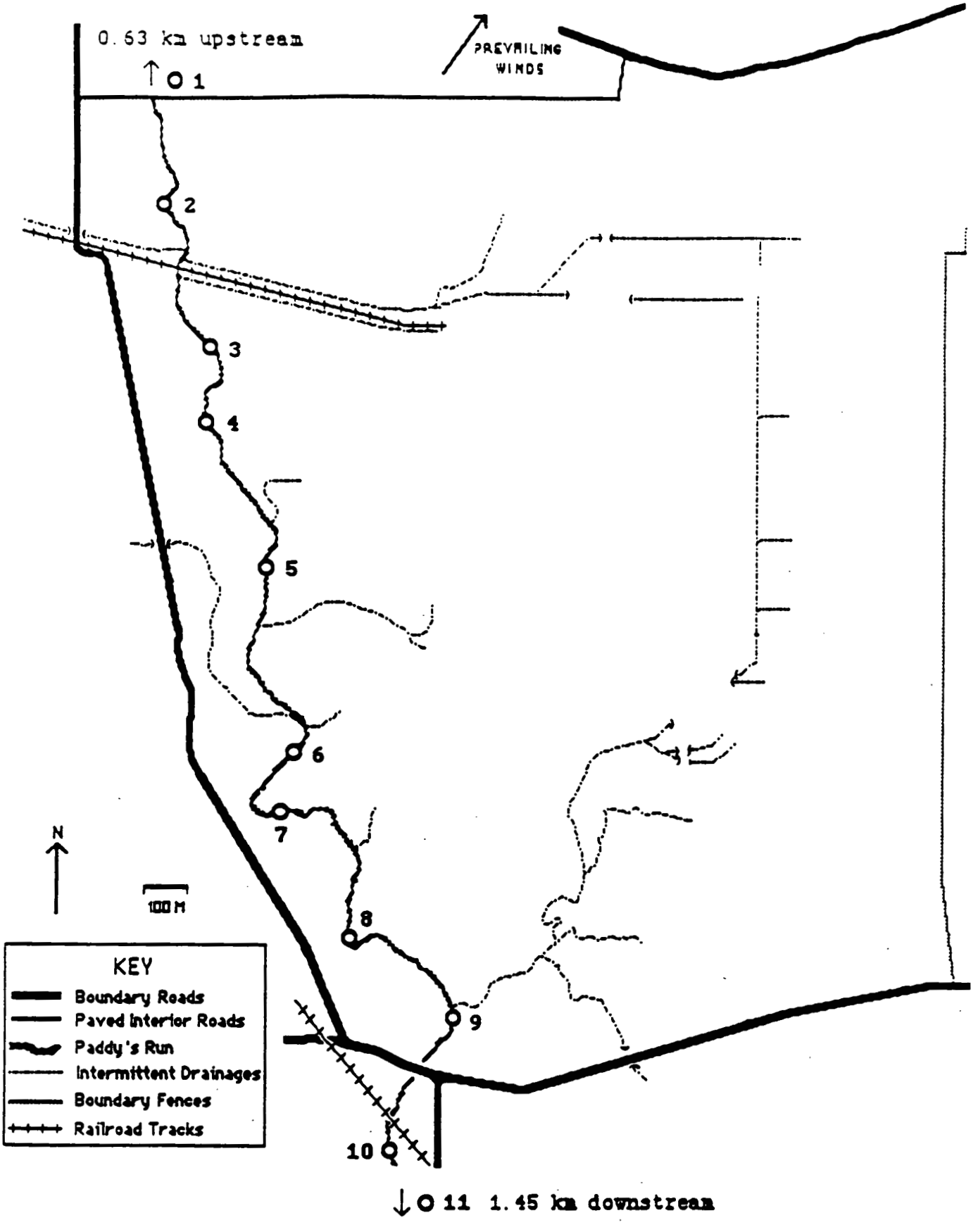

Figure 6. Locations of fish sampling sites on Paddy's Run, summer and fall, 1986. For the summer sample, collections 2 and 3 were combined as U; fish from site 4 were labled as D.

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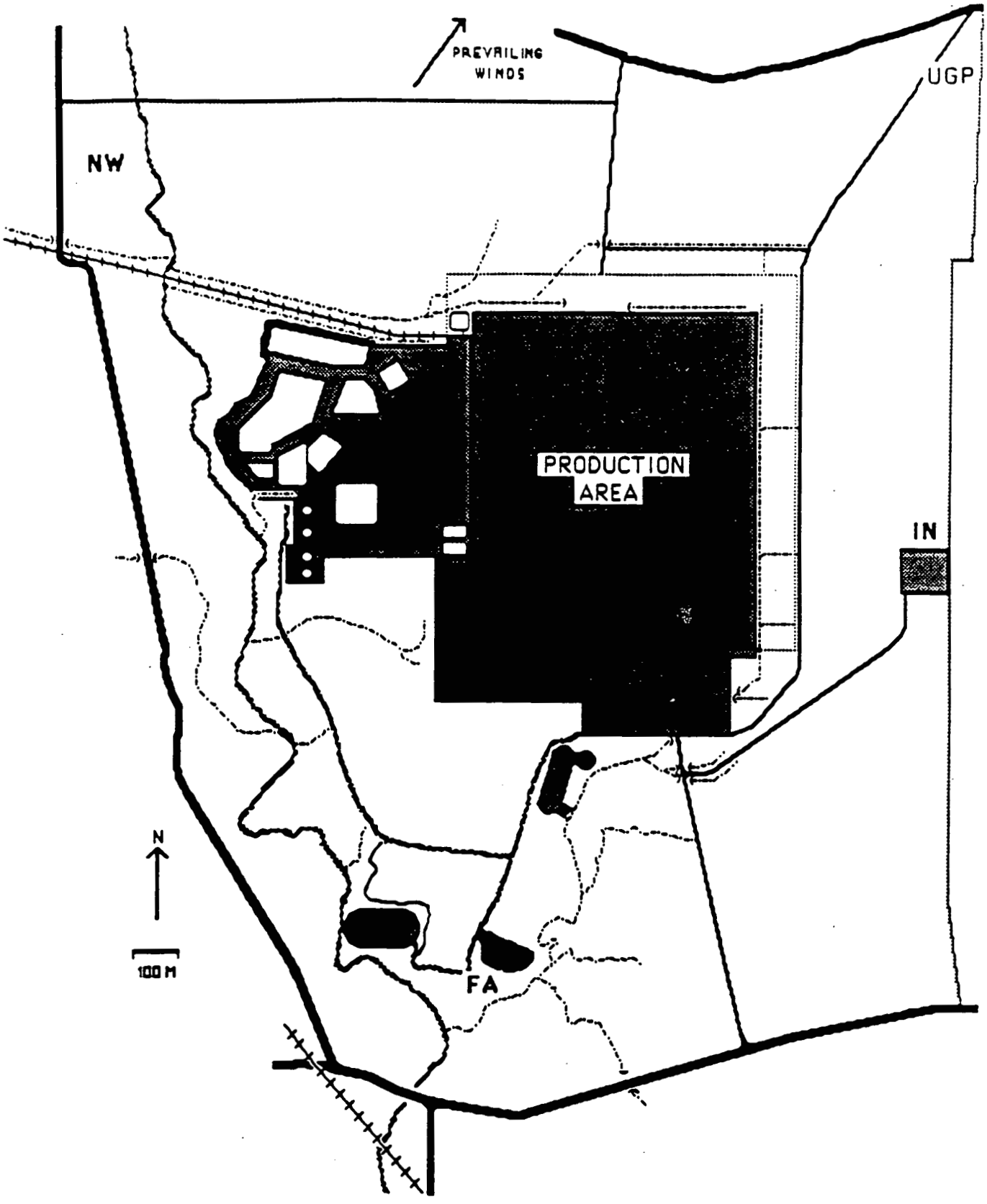

Figure 7. Locations of grasshopper sampling sites on the FMPC during the fall, 1986.

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Table 1. Physical characteristics of riffles and pools on Paddy's Run (Fig. 2) from which benthic macroinvertebrates were collected.

Habitat	Water depth (mean ± SD)	Water movement	Substrate
Riffles	15.9 ± 5.5 cm[1]	rapid to slow[2]	cobble, pebbles, gravel
Pools	37.0 ± 8.5 cm	very slow	fine gravel, sand, silt

[1] gradual increase in downstream direction

[2] general decrease in downstream direction

Table 2. Density (number/square meter) of benthic macroinvertebrates collected from riffles at ten sites on Paddy's Run, 20 November to 10 December 1986. * indicates taxa not collected within FMPC boundaries

	Site									
Taxon	PR1	PR2	PR3	PR4	PR5	PR6	PR7	PR8	PR9	PR10
DIPTERA										
Chironomidae	883.7	1950.7	2772.0	2031.3	3.7	110.0	44.0	2988.3	69.7	3.7
Simuliidae			198.0	25.7		11.0	11.0	80.7		
Simulium sp.	28.3	139.3	7.3							
Tipulidae										
Hexatoma sp.	51.3	7.3								3.7
*Dicranota sp.**	11.0									
Tipula sp.	7.3	3.7								
Limonia sp.		3.7								
Unidentified sp.						7.3				
Tabanidae										
Tabanus sp.	14.7	11.0	7.3							3.7
Empididae										
Hemerodromia sp.		14.7	29.3							
COLEOPTERA										
Psephenidae										
Psephenus herricki	66.0	18.3	25.7			3.7				
Elmidae										
Stenelmis sp.	249.3	80.7	80.7	110.0	3.7	73.3	29.3	106.3	7.3	22.0
Dubiraphia sp.								3.7		
Unidentified sp. 1				7.3						
Unidentified sp. 2				3.7						
TRICHOPTERA										
Hydropsychidae										
Cheumatopsyche sp.	524.3	198.0	638.0	33.0		47.7	3.7	69.7	11.0	
Hydropsyche sp.	7.3	3.7	25.7	7.3	3.7	3.7			3.7	
Helicopsychidae										
Helicopsyche sp.	110.0	11.0	7.3							
Philopotamidae										
Chimarra obscura	29.3		7.3							
Rhyacophilidae										
Rhyacophila sp.							7.3	18.3	3.7	
EPHEMEROPTERA										
Caenidae										
Caenis sp.	146.7	102.7	201.7	3.7	11.0	62.3	11.0	242.0	102.7	51.3
Heptageniidae										
Stenonema bipunctatum	106.3	73.3	99.0	14.7		14.7	3.7	18.3	18.3	40.3
Stenacron sp. *	40.3									
Baetidae										
Psuedocloeon sp.		3.7								
Oligoneuriidae										
Isonychia sp.			11.0	11.0						
PLECOPTERA										
Capniidae										
Allocapnia sp.	209.0	2203.7	630.7	704.0	33.0	249.3	187.0	110.0	95.3	190.7
Nemouridae		95.3	11.0	22.0		18.3	3.7	3.7		
Perlodidae										
Isoperla sp.		7.3	14.7					11.0		
Chloroperlidae										
Alloperla sp.	3.7									
Taeniopterygidae										
Taeniopteryx sp.	3.7									
COLLEMBOLA			3.7	3.7						
MEGALOPTERA										
Sialidae										
Sialis sp.								3.7		
ISOPODA										
Asellidae										
Lirceus fontinalis	84.3	69.7	216.3	14.7		11.0	3.7	7.3	22.0	11.0
AMPHIPODA										
Talitridae										
Hyalella azteca *	11.0									
DECOPODA										
Astacidae										
Orconectes rusticus						3.7			3.7	
GASTROPODA										
Physidae										
Physa sp.	7.3	3.7	73.3	7.3			3.7		3.7	
Ancylidae										
*Ferrissia sp.**	322.7									
TURBELLARIA										
Planariidae										
Dugesia sp.	11.0									
OLIGOCHAETA	11.0	22.0	121.0	66.0		7.3		36.7	11.0	3.7
NEMATOMORPHA			3.7	3.7						
TOTAL TAXA	25	21	22	17	5	14	11	14	11	10

Table 3. Benthic macroinvertebrates collected from pools at ten sites Paddy's Run, 20 November to 10 December 1986. * indicates taxa not collected within FMPC boundaries.

	Site									
	1	2	3	4	5	6	7	8	9	11
DIPTERA										
Chironomidae	X	X	X	X	X	X	X	X	X	X
Ceratopogonidae				X						
COLEOPTERA										
Elmidae										
Stenelmis sp.							X			X
EPHEMEROPTERA										
Caenidae										
Caenis sp	X	X	X			X				
Heptageniidae										
Stenonema bipunctatum	X									
Baetidae										
Baetis sp.			X							
PLECOPTERA										
Capniidae										
Allocapnia sp.	X			X		X	X			X
ISOPODA										
Asellidae										
Lirceus fontinalis	X			X						
AMPHIPODA										
Talitridae										
Hyalella azteca *										X
GASTROPODA										
Physidae										
Physa sp.	X				X					
Ancylidae										
Ferrissia sp.	X									
OLIGOCHAETA		X	X	X						
TOTAL TAXA	7	3	4	6	1	3	3	1	1	4

Table 4. Similarity of benthic macroinvertebrate communities at adjacent sites on Paddy's Run. Similarity between riffles is based upon numerical abundance of all taxa collected (Spearman rank correlation coefficient, r_s), whereas similarity between pools is based upon presence-absence of taxa (Sorensen's index of similarity, QS).

Site pair	Riffle (r_s)	Pool (QS)
1&2	0.413*	0.40
2&3	0.808***	0.86
3&4	0.631***	0.40
4&5	0.499*	0.29
5&6	0.648*	0.50
6&7	0.831***	0.67
7&8	0.752**	0.50
8&9	0.615*	1.00
9&10	0.635*	0.40

*P<0.05 **P<0.01 ***P<0.001

Table 5. Mean (+ SD) density, diversity, and % Chironomidae per sample of macroinvertebrate collections from riffles at ten sites on Paddy's Run. Within each column only, means followed by a common letter are not significantly (P>0.05) different from one another (Newman-Keuls multiple range test).

Site	Density (no./square meter)	Diversity	% Chironomidae/sample
1	2908 (805)a	3.03 (0.12)a	29.5 (9.1)cde
2	5023 (2106)a	1.97 (0.09)ab	42.9 (14.7)bcd
3	5023 (283)a	2.19 (0.53)ab	53.5 (7.3)abc
4	3073 (1420)a	1.52 (0.38)bc	66.1 (14.0)ab
5	55 (50)b	0.79 (0.70)c	3.3 (5.8)e
6	627 (249)b	2.47 (0.08)ab	15.4 (14.2)de
7	308 (175)b	1.85 (0.14)b	18.1 (12.7)de
8	3700 (1632)a	1.34 (0.87)bc	75.6 (19.2)a
9	348 (46)b	2.34 (0.07)ab	21.1 (14.1)de
10	334 (206)b	1.86 (0.19)b	0.9 (1.5)e

Table 6. Number of insects, spiders, mites, ticks and millipedes collected per 100 sweeps along FWPI transects (Fig.).

TAXON	TRANSECT										
	JGP	SP1	SP2	PFAP	PP1	PP2	W1	W2	W3	RN1	RN2
INSECTS											
Collembola											
Entomobryidae	1632	0	235	0	338	0	0	27	3	0	0
Poduridae	0	0	0	0	6	0	0	0	0	0	0
Sminthuridae	145	135	2	23	32	0	11	2	0	0	0
Odonata											
Coenagrionidae	0	0	0	0	0	0	0	0	0	3	0
Libellulidae	0	0	0	3	0	0	0	0	0	0	2
Orthoptera											
Acrididae	3566	349	631	128	474	175	26	86	0	28	10
Gryllidae	48	58	119	40	122	130	46	53	20	68	70
Mantidae	0	0	0	15	0	0	0	2	0	3	2
Phasmidae	0	0	0	5	0	0	0	2	0	0	0
Tettrididae	0	0	0	0	0	0	0	0	0	3	0
Tettigoniidae	265	275	233	40	105	77	44	48	3	38	77
Psocoptera	0	0	0	83	0	0	0	0	3	15	0
Thysanoptera	255	14	348	88	122	0	0	2	6	25	0
Hemiptera											
Anthocoridae	12	7	0	0	8	0	0	0	0	15	0
Aradidae	0	0	0	63	0	0	0	0	0	0	0
Berytidae	2	19	11	3	15	4	4	6	0	0	0
Coreidae	0	0	0	0	0	0	0	0	0	0	5
Corimelaenidae	2	7	0	0	19	0	0	0	0	5	0
Lygaeidae	19	12	4	0	6	0	6	8	0	5	0
Miridae	378	43	89	23	122	4	6	29	34	25	37
Nabidae	10	0	4	0	4	6	0	2	0	5	5
Pentatomidae	2	0	9	5	4	4	7	2	0	0	10
Phymatidae	2	0	0	0	0	0	0	0	0	0	2
Reduviidae	0	0	15	10	6	4	72	65	0	35	2
Rhopalidae	0	0	6	0	0	0	0	0	0	0	0
Saldidae	0	0	0	0	0	0	0	0	0	3	0
Scutteleridae	0	0	0	0	0	0	2	0	0	0	0
Tingididae	0	0	0	30	0	0	0	0	6	93	0
Unidentified	0	0	19	0	0	0	0	0	0	3	0
Homoptera											
Acanaloniidae	0	0	0	75	521	92	20	151	0	3	15
Actiopheridae	0	0	0	0	0	2	0	0	0	0	0
Aleyrodidae	0	0	0	0	0	0	0	0	0	65	0
Aphididae	36	0	26	196	113	0	0	29	3	121	0
Cercopidae	39	12	19	60	346	207	116	139	37	141	45
Cicadellidae	1822	528	940	756	1874	691	170	429	270	602	206
Cicadidae	0	0	0	0	0	0	0	0	0	3	2
Cixiidae	0	0	0	0	0	0	0	0	0	18	0
Coccidae	0	0	0	0	9	0	0	0	0	0	0
Delphacidae	0	0	22	0	21	0	0	0	0	43	0
Dictyopharidae	0	17	11	0	13	0	6	2	0	0	0
Flatidae	0	0	0	83	0	0	18	67	9	5	7
Fulgoridae	0	5	0	0	0	0	0	0	0	0	0
Issidae	0	0	0	0	0	0	0	0	0	3	0
Membracidae	0	5	0	5	6	2	0	15	0	18	17
Psyllidae	0	0	0	0	0	0	0	0	0	23	0
Unidentified											
Planthopper nymphs	0	0	0	0	86	0	0	0	0	0	0
Neuroptera											
Chrysopidae	0	0	0	5	0	0	0	0	0	0	0
Hemerobiidae	0	0	0	0	0	0	0	0	0	0	5
Coleoptera											
Anthribidae	0	0	0	0	4	0	0	0	0	5	0
Cerambycidae	0	2	0	0	0	0	2	0	0	0	0
Chrysomelidae	320	248	518	209	1391	467	91	95	14	144	32
Cicindelidae	0	0	0	5	0	0	0	0	0	0	2
Coccinellidae	10	0	0	0	9	0	0	0	0	15	7
Cucujidae	0	0	0	0	6	0	0	0	0	0	0
Curculionidae	10	14	114	70	4	28	11	6	3	13	0
Elateridae	0	0	0	3	0	0	0	0	0	0	0
Histeridae	0	0	0	0	0	0	0	0	0	3	0
Lampyridae	5	0	0	0	2	0	4	6	0	0	0
Lycidae	0	0	0	0	0	0	0	0	3	0	0
Meloidae	0	24	0	0	6	0	0	0	0	0	0
Mordellidae	27	0	2	3	13	4	4	13	0	3	0
Nitidulidae	0	0	4	0	0	0	0	0	3	43	0
Scarabaeidae	0	5	2	3	4	9	0	6	0	3	45
Staphylinidae	5	0	0	0	17	0	2	0	6	0	0
Strepsiptera	0	0	0	0	0	0	0	0	0	3	0
Mecoptera											
Panorpidae	0	0	0	0	0	0	0	2	6	10	22

TAXON	TRANSECT										
	SP	SP1	SP2	PPAP	PP1	PP2	W1	W2	W3	PN1	PN2
Coleoptera											
Cleridae	0	0	0	0	0	0	0	0	0	0	0
Cerambycidae	0	0	0	0	0	0	0	0	0	0	0
Lycaenidae	0	0	0	0	0	0	0	0	0	0	0
Noctuidae	0	0	0	0	0	0	0	0	0	0	0
Nymphalidae	0	0	0	0	0	0	0	0	0	0	0
Pieridae	0	0	0	0	0	0	0	0	0	0	0
Unidentified	19	0	13	0	21	0	0	0	6	25	0
Diptera											
Agromyzidae	43	0	0	0	0	0	0	0	0	0	0
Anthomyzidae	0	5	0	0	6	0	0	0	0	0	0
Asilidae	2	29	2	8	2	0	26	17	0	25	0
Calliphoridae	14	72	2	3	4	0	17	19	9	5	15
Cecidomyiidae	0	0	78	0	11	0	0	27	3	146	0
Chamaemyiidae	0	0	0	0	17	0	0	0	0	0	0
Chironomidae	0	0	0	0	0	0	0	0	0	68	0
Chloropidae	386	0	235	490	626	41	0	90	364	327	0
Culicidae	0	0	2	0	2	0	0	8	14	3	0
Curtonotidae	0	0	6	0	0	0	0	0	0	0	0
Dolichopodidae	0	2	0	0	2	2	85	128	45	18	0
Drosophilidae	0	10	0	0	13	0	39	263	0	10	0
Empididae	0	0	0	0	6	0	0	0	0	5	0
Ephydridae	0	0	0	0	0	0	0	0	0	10	0
Heleomyzidae	2	0	0	0	8	0	0	0	0	0	0
Lauxaniidae	0	0	0	0	0	0	0	0	9	8	0
Lonchopteridae	7	0	2	0	0	0	0	0	0	0	0
Micropezidae	0	0	2	0	0	0	0	0	0	0	0
Muscidae	17	227	0	18	9	6	18	6	0	0	12
Mycetophilidae	0	0	13	0	0	0	0	0	20	23	0
Otitidae	0	0	0	0	0	0	0	0	0	5	0
Phoridae	2	0	15	0	0	0	0	0	14	30	0
Piophilidae	0	0	0	0	0	0	0	0	6	0	20
Pipunculidae	10	7	6	8	32	0	7	0	0	3	0
Platystomatidae	0	0	2	0	0	0	0	0	6	0	0
Psychodidae	0	0	0	0	0	0	0	0	0	3	0
Rhagionidae	7	0	0	0	0	0	0	0	0	0	27
Sarcophagidae	120	5	0	8	13	0	0	0	0	3	0
Sciaridae	224	0	207	0	19	9	0	67	9	38	0
Sciomyzidae	14	0	0	3	88	15	0	0	0	8	0
Sepsidae	12	0	4	0	4	0	0	0	57	3	0
Stratiomyidae	5	0	2	0	0	0	0	0	0	0	0
Syrphidae	2	289	89	3	9	55	22	13	0	5	2
Tabanidae	0	10	2	0	2	0	4	0	0	0	0
Tachinidae	2	0	2	0	15	9	0	34	0	0	0
Tephritidae	202	80	4	25	9	9	4	8	0	3	0
Therevidae	34	2	15	0	2	0	0	0	0	0	0
Tipulidae	0	0	0	0	0	0	6	23	11	5	0
Unidentified Diptera	36	0	48	0	68	0	0	0	0	65	0
Hymenoptera											
Apidae	2	7	0	3	0	0	2	0	0	0	7
Bethylidae	2	0	0	0	0	0	0	0	0	3	0
Braconidae	70	65	24	28	90	21	70	147	20	63	32
Cephidae	0	0	0	0	0	2	0	0	0	0	0
Chalcidoidea	549	41	322	146	367	0	0	80	51	411	2
Colletidae	2	0	0	0	2	0	0	0	0	0	0
Cynipidae	60	0	17	0	36	4	0	0	11	20	0
Diapriidae	0	0	0	0	19	0	0	0	0	5	0
Diprionidae	0	0	0	0	2	0	0	0	0	0	0
Formicidae	157	113	263	146	128	209	59	193	105	345	7
Halictidae	0	22	69	28	9	217	20	69	31	33	0
Ichneumonidae	7	5	0	0	9	9	2	15	40	15	5
Megachilidae	0	0	0	0	0	0	0	0	0	3	0
Platygasteridae	46	0	13	28	115	0	0	0	14	65	0
Pompilidae	0	0	0	0	0	0	0	0	0	3	0
Proctotrupidae	0	0	0	0	2	0	0	0	3	0	0
Scelionidae	0	0	9	0	0	0	0	4	3	5	0
Siricidae	0	0	0	0	0	0	2	0	0	0	0
Sphecidae	2	0	2	3	6	4	4	0	20	5	5
Tenthredinidae	0	0	0	0	2	0	0	0	0	0	0
Vespidae	0	7	0	3	2	28	4	11	3	5	82
Larvae											
Coleoptera	17	0	0	0	246	51	0	0	0	0	0
Lepidoptera	19	0	0	0	56	64	0	0	0	0	0
Strepsiptera	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	0	0	0	0	0	0	0	0	0	3	0
Unidentified	0	27	13	0	0	0	41	38	28	50	114
Subtotal (Insects)	10682	2805	4875	2987	7902	2667	1098	2567	1330	3537	975
Non-insect species											
Acarina	308	0	37	3	90	0	4	4	0	8	0
Araneida	207	152	251	1905	959	288	150	408	148	879	308
Phalangida	0	0	0	0	2	0	0	0	3	0	0
Mollusca											
Gastropoda	0	0	0	0	0	0	0	40	3	111	20
Subtotal (Non-insects)	516	152	287	1907	1051	288	153	452	153	997	328
Total Organisms	11198	2957	5162	4894	8953	2955	1251	3019	1483	4534	1303

Table 7. Relative frequency of occurrence (%) of insects, spiders, mites, ticks, [illegible] collected at the [illegible]

TAXON	TRANSECT										
	DGP	DP1	DP2	PFAP	PP1	PP2	W1	W2	W3	PN1	PN2
INSECTS											
Collembola											
Entomobryidae	14.31	0.00	4.56	0.00	3.78	0.00	0.00	0.90	0.19	0.00	0.00
Poduridae	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Sminthuridae	1.29	4.56	0.04	0.46	0.36	0.00	0.89	0.07	0.00	0.00	0.00
Odonata											
Coenagrionidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Libellulidae	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Orthoptera											
Acrididae	31.85	11.82	12.22	2.62	5.29	5.92	2.07	2.85	0.00	0.61	0.76
Gryllidae	0.43	1.96	2.30	0.82	1.36	4.40	3.69	1.74	1.34	1.50	5.34
Mantidae	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.07	0.00	0.06	0.19
Phasmidae	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.07	0.00	0.00	0.00
Tetrigidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Tettigoniidae	2.37	9.29	4.52	0.82	1.18	2.60	3.55	1.60	0.19	0.83	5.92
Psocoptera	0.00	0.00	0.00	1.69	0.00	0.00	0.00	0.00	0.19	0.33	0.00
Thysanoptera	2.28	0.49	6.74	1.80	1.36	0.00	0.00	0.07	0.38	0.56	0.00
Hemiptera											
Anthocoridae	0.11	0.24	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.33	0.00
Aradidae	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Berytidae	0.02	0.65	0.21	0.05	0.17	0.14	0.30	0.21	0.00	0.00	0.00
Coreidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38
Corimelaenidae	0.02	0.24	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.11	0.00
Lygaeidae	0.17	0.41	0.08	0.00	0.06	0.00	0.44	0.28	0.00	0.11	0.00
Miridae	3.38	1.47	1.72	0.46	1.36	0.14	0.44	0.97	2.30	0.56	2.86
Nabidae	0.09	0.00	0.08	0.00	0.04	0.22	0.00	0.07	0.00	0.11	0.38
Pentatomidae	0.02	0.00	0.17	0.10	0.04	0.14	0.59	0.07	0.00	0.00	0.76
Phymatidae	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Reduviidae	0.00	0.00	0.29	0.21	0.06	0.14	5.76	2.16	0.00	0.78	0.19
Rhopalidae	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Saldidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Scutteleridae	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Tingididae	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.38	2.06	0.00
Unidentified	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Homoptera											
Acanaloniidae	0.00	0.00	0.00	1.54	5.82	3.10	1.62	5.01	0.00	0.06	1.15
Actiopheridae	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00
Aleyrodidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.44	0.00
Aphididae	0.32	0.00	0.50	4.00	1.26	0.00	0.00	0.97	0.19	2.67	0.00
Cercopidae	0.34	0.41	0.38	1.23	3.86	7.00	9.31	4.59	2.49	3.11	3.44
Cicadellidae	16.27	17.85	18.20	15.45	20.93	23.38	13.59	14.20	18.20	13.28	15.84
Cicadidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.19
Cixiidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00
Coccidae	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Delphacidae	0.00	0.00	0.42	0.00	0.23	0.00	0.00	0.00	0.00	0.94	0.00
Dictyopharidae	0.00	0.57	0.21	0.00	0.15	0.00	0.44	0.07	0.00	0.00	0.00
Flatidae	0.00	0.00	0.00	1.69	0.00	0.00	1.48	2.23	0.57	0.11	0.57
Fulgoridae	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Issidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Membracidae	0.00	0.16	0.00	0.10	0.06	0.07	0.00	0.49	0.00	0.39	1.34
Psyllidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00
Unidentified											
Planthopper nymphs	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00
Neuroptera											
Chrysopidae	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemerobiidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38
Coleoptera											
Anthribidae	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.11	0.00
Cerambycidae	0.00	0.08	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Chrysomelidae	2.86	8.39	10.04	4.26	15.54	15.80	7.24	3.13	0.96	3.17	2.48
Cicindelidae	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Coccinellidae	0.09	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.33	0.57
Cucujidae	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Curculionidae	0.09	0.49	2.22	1.44	0.04	0.94	0.89	0.21	0.19	0.28	0.00
Elateridae	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Histeridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Lampyridae	0.04	0.00	0.00	0.00	0.02	0.00	0.30	0.21	0.00	0.00	0.00
Lycidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00
Meloidae	0.00	0.81	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Mordellidae	0.24	0.00	0.04	0.05	0.15	0.14	0.30	0.42	0.00	0.06	0.00
Nitidulidae	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.19	0.94	0.00
Scarabaeidae	0.00	0.16	0.04	0.05	0.04	0.29	0.00	0.21	0.00	0.06	3.44
Staphylinidae	0.04	0.00	0.00	0.00	0.19	0.00	0.15	0.00	0.38	0.00	0.00
Strepsiptera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Mecoptera											
Panorpidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.38	0.22	1.72

TRANSECT

TAXON	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lepidoptera											
Pieridae	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Danaidae	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lycaenidae	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Noctuidae	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nymphalidae	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pieridae	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Unidentified	[illegible]	[illegible]	0.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diptera											
Agromyzidae	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.11	0.00
Anthomyzidae	0.00	0.16	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Asilidae	0.02	0.98	0.04	0.15	0.02	0.00	2.07	0.56	0.00	0.56	0.00
Calliphoridae	0.13	2.44	0.04	0.05	0.04	0.00	1.33	0.63	0.57	0.11	0.15
Cecidomyiidae	0.00	0.00	1.51	0.00	0.13	0.00	0.00	0.90	0.19	3.22	0.00
Chamaemyiidae	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Chironomidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00
Chloropidae	3.44	0.00	4.56	10.31	6.99	1.37	0.00	2.99	24.52	7.22	0.00
Culicidae	0.00	0.00	0.04	0.00	0.02	0.00	0.00	0.28	0.96	0.06	0.00
Curtonotidae	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dolichopodidae	0.00	0.08	0.00	0.00	0.02	0.07	6.79	4.24	3.07	0.39	0.00
Drosophilidae	0.00	0.33	0.00	0.00	0.15	0.00	3.10	8.70	0.00	0.22	0.00
Empididae	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.11	0.00
Ephydridae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00
Heleomyzidae	0.02	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Lauxaniidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.17	0.00
Lonchopteridae	0.06	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Microperidae	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Muscidae	0.15	7.66	0.00	0.36	0.10	0.22	1.48	0.21	0.00	0.00	0.95
Mycetophilidae	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	1.34	0.50	0.00
Otitidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00
Phoridae	0.02	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.96	0.67	0.00
Piophilidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	1.53
Pipunculidae	0.09	0.24	0.13	0.15	0.36	0.00	0.59	0.00	0.00	0.06	0.00
Platystomatidae	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00
Psychodidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Rhaqionidae	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.10
Sarcophagidae	1.08	0.16	0.00	0.15	0.15	0.00	0.00	0.00	0.00	0.06	0.00
Sciaridae	2.00	0.00	4.02	0.00	0.21	0.29	0.00	2.23	0.57	0.83	0.00
Sciomyzidae	0.13	0.00	0.00	0.05	0.99	0.51	0.00	0.00	0.00	0.17	0.00
Sepsidae	0.11	0.00	0.08	0.00	0.04	0.00	0.00	0.00	3.83	0.06	0.00
Stratiomyidae	0.04	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Syrphidae	0.02	9.78	1.72	0.05	0.10	1.88	1.77	0.42	0.00	0.11	0.19
Tabanidae	0.00	0.33	0.04	0.00	0.02	0.00	0.30	0.00	0.00	0.00	0.00
Tachinidae	0.02	0.00	0.04	0.00	0.17	0.29	0.00	1.11	0.00	0.00	0.00
Tephritidae	1.81	2.69	0.08	0.51	0.10	0.29	0.30	0.28	0.00	0.06	0.00
Therevidae	0.30	0.08	0.29	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Tipulidae	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.77	0.77	0.11	0.00
Unidentified Diptera	0.32	0.00	0.92	0.00	0.76	0.00	0.00	0.00	0.00	1.44	0.00
Hymenoptera											
Apidae	0.02	0.24	0.00	0.05	0.00	0.00	0.15	0.00	0.00	0.00	0.57
Bethylidae	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Braconidae	0.62	2.20	0.46	0.56	1.01	0.72	5.61	4.87	1.34	1.39	2.48
Cephidae	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00
Chalcidoidea	4.91	1.39	6.23	2.98	4.09	0.00	0.00	2.64	3.45	9.06	0.19
Colletidae	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Cynipidae	0.54	0.00	0.33	0.00	0.40	0.14	0.00	0.00	0.77	0.44	0.00
Diapriidae	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.11	0.00
Diprionidae	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Formicidae	1.40	3.83	5.10	2.98	1.43	7.07	4.73	6.40	7.09	7.61	0.57
Halictidae	0.00	0.73	1.34	0.56	0.10	7.36	1.62	2.30	2.11	0.72	0.00
Ichneumonidae	0.06	0.16	0.00	0.00	0.10	0.29	0.15	0.49	2.68	0.33	0.38
Megachilidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Platygasteridae	0.41	0.00	0.25	0.56	1.28	0.00	0.00	0.00	0.96	1.44	0.00
Pompilidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Proctotrupidae	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.19	0.00	0.00
Scelionidae	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.14	0.19	0.11	0.00
Siricidae	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Sphecidae	0.02	0.00	0.04	0.05	0.06	0.14	0.30	0.00	1.34	0.11	0.38
Tenthredinidae	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Vespidae	0.00	0.24	0.00	0.05	0.02	0.94	0.30	0.35	0.19	0.11	6.30
Larvae											
Coleoptera	0.15	0.00	0.00	0.00	2.75	1.73	0.00	0.00	0.00	0.00	0.00
Lepidoptera	0.17	0.00	0.00	0.00	0.63	2.16	0.00	0.00	0.00	0.00	0.00
Strepsiptera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trichoptera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Unidentified	0.00	0.90	0.25	0.00	0.00	0.00	3.25	1.25	1.92	1.11	8.78
Subtotal (Insects)	95.39	94.87	94.44	61.04	88.26	90.26	87.74	85.04	89.66	78.00	74.81
Non-insects											
Acarina	2.75	0.00	0.71	0.05	1.01	0.00	0.30	0.14	0.00	0.17	0.00
Araneida	1.85	5.13	4.85	38.91	10.71	9.74	11.96	13.50	9.96	19.39	23.66
Phalangida	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.19	0.00	0.00
Mollusca											
Gastropoda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.19	2.44	1.53
Subtotal (Non-insects)	4.61	5.13	5.56	38.96	11.74	9.74	12.26	14.96	10.34	22.00	25.19
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 8. Spearman correlation values obtained from all possible pair comparisons of the numbers of insects per 1000 sweeps. Insects were grouped according to order prior to analysis.

	UGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
UGP	--	0.881	0.939	0.723	0.870	0.693	0.844	0.793	0.649	0.577	0.490
GP1		--	0.919	0.807	0.929	0.839	0.920	0.866	0.822	0.732	0.704
GP2			--	0.839	0.926	0.800	0.862	0.843	0.760	0.727	0.598
RFAP				--	0.795	0.743	0.780	0.727	0.724	0.734	0.582
PP1					--	0.863	0.923	0.866	0.817	0.732	0.666
PP1						--	0.875	0.864	0.855	0.872	0.880
W1							--	0.912	0.819	0.786	0.768
W2								--	0.870	0.894	0.825
W3									--	0.888	0.803
RN1										--	0.839
RN2											--

Table 9. Percent frequency of occurrence of birds in each habitat at the FMPC, winter, 1987.*

	TRANSECT										
SPECIES	UGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
red-shouldered hawk	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0	0.0	0.0	0.0
Cooper's hawk	25.0	0.0	0.0	0.0	+	37.5	0.0	0.0	0.0	0.0	0.0
red-tailed hawk	+	+	0.0	0.0	+	0.0	12.5	12.5	+	+	+
American kestrel	25.0	62.5	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
northern bobwhite	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0
killdeer	12.5	0.0	0.0	12.5	0.0	0.0	0.0	+	0.0	12.5	0.0
mourning dove	62.5	25.0	+	75.0	75.0	50.0	62.5	62.5	50.0	50.0	37.5
great horned owl	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	25.0	0.0	0.0
belted kingfisher	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	+	50.0	12.5
red-bellied woodpecker	0.0	0.0	25.0	0.0	0.0	0.0	50.0	0.0	50.0	+	12.5
downy woodpecker	25.0	12.5	12.5	12.5	+	0.0	50.0	75.0	100.0	12.5	62.5
hairy woodpecker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	37.5	12.5	0.0
northern flicker	+	0.0	12.5	0.0	0.0	0.0	37.5	25.0	12.5	0.0	12.5
pileated woodpecker	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0	25.0	12.5	0.0
blue jay	+	+	25.0	37.5	+	+	75.0	37.5	75.0	12.5	12.5
American crow	0.0	0.0	+	0.0	+	0.0	+	12.5	0.0	0.0	+
Carolina chickadee	0.0	+	12.5	62.5	37.5	12.5	75.0	50.0	100.0	50.0	87.5
tufted titmouse	0.0	0.0	+	12.5	+	+	50.0	37.5	87.5	37.5	62.5
white-breasted nuthatch	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	87.5	0.0	25.0
brown creeper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	12.5	25.0
Carolina wren	0.0	0.0	0.0	25.0	0.0	0.0	37.5	62.5	50.0	62.5	87.5
golden-crowned kinglet	0.0	0.0	0.0	12.5	37.5	+	12.5	0.0	37.5	12.5	37.5
eastern bluebird	12.5	0.0	25.0	37.5	0.0	+	75.0	62.5	12.5	25.0	12.5
American robin	+	+	0.0	12.5	12.5	25.0	62.5	37.5	12.5	12.5	12.5
northern mockingbird	0.0	0.0	25.0	0.0	0.0	0.0	25.0	0.0	12.5	12.5	0.0
European starling	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	+	12.5
northern cardinal	12.5	+	+	25.0	37.5	37.5	87.5	75.0	75.0	12.5	50.0
rufous-sided towhee	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
American tree sparrow	12.5	0.0	0.0	0.0	0.0	12.5	+	50.0	0.0	0.0	0.0
song sparrow	62.5	+	12.5	87.5	87.5	62.5	100.0	75.0	+	100.0	62.5
white-throated sparrow	0.0	0.0	0.0	0.0	0.0	0.0	12.5	25.0	0.0	0.0	0.0
dark-eyed junco	12.5	0.0	0.0	0.0	37.5	25.0	87.5	25.0	12.5	25.0	12.5
red-winged blackbird	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5
eastern meadowlark	50.0	100.0	50.0	12.5	0.0	0.0	0.0	12.5	0.0	12.5	+
American goldfinch	37.5	0.0	12.5	25.0	25.0	25.0	75.0	37.5	12.5	12.5	25.0
house sparrow	12.5	0.0	0.0	0.0	+	0.0	12.5	12.5	0.0	0.0	+

*A plus (+) represents a species that was detected outside the census plot or identified during casual observation.

Table 10. Avian densities (number per 40 ha) in each habitat at the FMPC, winter, 1987.*

SPECIES	TRANSECT										
	UGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
red-shouldered hawk	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0	0.0	0.0	0.0
Cooper's hawk	0.8	0.0	0.0	0.0	+	2.0	0.0	0.0	0.0	0.0	0.0
red-tailed hawk	+	+	0.0	0.0	+	0.0	1.4	1.4	0.0	+	+
American kestrel	0.8	3.8	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
northern bobwhite	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0
killdeer	0.8	0.0	0.0	3.0	0.0	0.0	0.0	+	0.0	2.1	0.0
mourning dove	9.2	1.7	+	50.4	89.7	38.5	26.4	13.9	9.7	25.0	25.0
great horned owl	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	2.8	0.0	0.0
belted kingfisher	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	+	10.4	2.1
red-bellied woodpecker	0.0	0.0	0.8	0.0	0.0	0.0	6.9	0.0	11.1	+	2.1
downy woodpecker	0.8	0.4	0.8	3.0	+	0.0	5.6	11.1	26.4	2.1	14.6
hairy woodpecker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	5.6	2.1	0.0
northern flicker	+	0.4	0.4	0.0	0.0	0.0	4.2	4.2	2.8	0.0	2.1
pileated woodpecker	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0	5.6	2.1	0.0
blue jay	+	+	0.8	11.9	+	+	23.6	13.9	13.9	4.2	2.1
American crow	0.0	0.0	0.0	0.0	+	0.0	+	1.4	0.0	0.0	+
Carolina chickadee	0.0	+	0.4	35.6	76.9	32.1	29.2	12.5	44.4	27.1	60.4
tufted titmouse	0.0	0.0	0.0	3.0	+	+	11.1	5.5	25.0	12.5	22.9
white-breasted nuthatch	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	19.4	0.0	4.2
brown creeper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.1	4.2
Carolina wren	0.0	0.0	0.0	6.0	0.0	0.0	5.6	11.1	8.3	14.6	31.3
golden-crowned kinglet	0.0	0.0	0.0	3.0	57.7	+	2.8	0.0	5.6	2.1	8.3
eastern bluebird	0.8	0.0	1.3	41.5	0.0	+	41.7	16.7	1.4	4.2	2.1
American robin	0.4	+	0.0	68.1	12.8	12.8	19.4	6.9	1.4	2.1	6.2
northern mockingbird	0.0	0.0	0.8	0.0	0.0	0.0	2.8	0.0	1.4	2.1	0.0
European starling	4.2	+	0.0	0.0	0.0	0.0	0.0	0.0	1.4	+	8.3
northern cardinal	0.4	+	0.0	11.9	38.5	38.5	25.0	29.2	27.8	2.1	22.9
rufous-sided towhee	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
American tree sparrow	0.4	0.0	0.0	0.0	0.0	6.4	+	36.1	0.0	0.0	0.0
song sparrow	6.3	+	0.8	47.4	57.7	147.4	25.0	34.7	+	60.4	18.8
white-throated sparrow	0.0	0.0	0.0	0.0	0.0	0.0	4.2	2.8	0.0	0.0	0.0
dark-eyed junco	0.4	0.0	0.0	0.0	19.2	25.6	62.5	12.5	15.3	4.2	6.2
red-winged blackbird	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1
eastern meadowlark	3.8	30.8	4.6	6.0	0.0	0.0	0.0	1.4	0.0	2.1	+
American goldfinch	1.3	0.0	0.4	6.0	25.6	19.2	38.9	12.5	2.8	2.1	4.2
house sparrow	12.5	0.0	0.0	0.0	+	0.0	5.6	1.4	0.0	0.0	+
TOTAL	42.9	37.1	11.1	296.8	380.1	322.5	346.1	232.0	233.5	250.1	185.7

*A plus (+) represents a species that was detected outside the census plot or identified during casual observation.

Table 11. Avian species richness, diversity, and dominance in each habitat at the FMPC, winter, 1987.*

HABITAT	Species Richness** (R)	Simpson Diversity (D)	Simpson Dominance (C)	Shannon Diversity (H')	Pielou Evenness (J')
UGP	15(19)	0.839	0.161	2.096	0.774
GP1	5(12)	0.299	0.701	0.293	0.182
GP2	10(12)	0.820	0.180	1.940	0.843
RFAP	14(14)	0.862	0.138	2.139	0.810
PP1	9(16)	0.860	0.140	2.001	0.911
PP2	9(13)	0.777	0.223	1.797	0.818
W1	21(25)	0.909	0.091	2.646	0.869
W2	20(21)	0.915	0.085	2.620	0.874
W3	21(23)	0.908	0.092	2.583	0.848
RN1	20(23)	0.847	0.153	2.271	0.758
RN2	20(24)	0.891	0.109	2.487	0.830

*Diversity values were based on sightings within the census plots and calculated using the natural log.
**Richness values in ( ) include species that were detected outside the census plot or identified during casual observation.

Table 12. Avian community similarity between areas with similar vegetation [illegible] in the FMPC, winter, 1987.

SIMILARITY INDEX	UGP vs. GP1	UGP vs. GP2	GP1 vs. GP2	RFAP vs. W2	RFAP vs. PP2	PP1 vs. PP2	W1 vs. W2	W1 vs. W3	W2 vs. W3	PN1 vs. PN2
QUALITATIVE INDICES:										
Jaccard Coefficient	0.250	0.250	0.250	0.545	0.352	0.636	0.639	0.615	0.464	0.625
Quotient of Similarity	0.400	0.400	0.400	0.705	0.521	0.777	0.780	0.761	0.634	0.769
QUANTITATIVE INDICES:										
Percent Similarity	16.1	23.6	42.9	51.1	47.8	59.2	61.7	46.5	48.3	59.7
Morisita's Index	0.194	0.353	0.772	0.591	0.601	0.710	0.709	0.593	0.524	0.728

Table 13. Abundance and density of eastern cottontail rabbits on the FMPC, Summer, 1986.

Transect	Strip Length (m)	Strip Width (m)	Tot. No. Rabbits (12 censuses)	Aver. per Census	Aver. per 10 hr.	Aver. No. per ha
UGP	600	100	0	0	0	0
GP1	600	100	0	0	0	0
GP2	600	100	1	0.08	1.5	0.02
RFAP	400	50	8	0.66	8.9	0.32
PP1	600	13	37	3.08	29.6	3.95
PP2	600	13	13	1.08	13.6	1.37
W1	600	30	2	0.16	1.5	0.10
W2	600	30	1	0.08	1.1	0.05
W3	600	30	8	0.66	11.1	0.37
RN1	600	20	10	0.83	9.3	0.67
RN2	600	20	2	0.16	2.2	0.12

Table 14. Fish analyzed with electrophoresis from Paddy's Run. Fish collected June 24 - 25, 1986 from sites 2 and 3 were pooled (U) while site 4 = D. Fish collected October 29, 1986 were separated by site (1, 2 and 3).

Species	U	D	Site 1	2	3
Blacknose dace (RA) *Rhinichthys atratulus*	19				
Bluntnose minnow (PN) *Pimephales notatus*	18	20	4	13	5
Stoneroller minnow (CA) *Campostoma anomalum*		16	8	10	32
Silverjaw minnow (EB) *Ericymba buccata*		14	2	7	2
Spotfin shiner (NS) *Notropis spilopterus*			5	2	19
Rosefin shiner (NA) *Notropis ardens*		25	9	3	6
Creek chub (SA) *Semotilus atromaculatus*			7	2	
Striped shiner (NC) *Notropis chrysocephalus*					8
White sucker (CC) *Catostomus commersoni*	13	15		3	
Johnny darter (EN) *Etheostoma nigrum*	18	18	14	18	9
Orangethroat darter (ES) *Etheostoma spectabile*	9	22	3	2	6
Fantail darter (EF) *Etheostoma flabellare*	13	13	3		

Table 15. Buffers utilized and enzyme systems analyzed. Number of loci examined are listed in parentheses.

ENZYME SYSTEM	BUFFER
Esterase (EST)	LiOH(3)
Glucose 6-phosphate dehydrogenase (G6PD)	TC(1)
Glucose phosphate isomerase (GPI)	LiOH(2)
Isocitrate dehydrogenase (ICD)	TC(2)
Lactate dehydrogenase (LDH)	TC(2)
Malate dehydrogenase (MDH)	TC(2)
Non-specific protein (NP)	LiOH(4)
6-Phosphogluconate dehydrogenase (6PGD)	TC(1)
Phosphoglucomutase (PGM)	TC(2)

LiOH = Lithium hydroxide, pH 8.1/8.4 (Selander, et al. 1971)
TC = Tris-citrate, pH 8.0 (Selander, et al. 1971)

Table 16. Allele frequencies at polymorphic loci in fish samples.

LOCUS		POPULATION																													
		RA-U 1	PN-D 2	PN-U 3	PN-1 4	PN-2 6	PN-3 5	CA-D 7	CA-1 8	CA-2 10	CA-3 9	EB-D 11	EB-2 12	NS-1 13	NS-3 14	NA-D 15	NA-1 16	NC-3 17	CC-U 18	CC-D 19	CC-2 20	EN-U 21	EN-D 22	EN-1 23	EN-2 24	EN-3 25	ES-U 26	ES-D 27	ES-3 28	EF-U 29	EF-D 30
EST-2	A	0.95	0.18	0.23				0.69	0.25		0.09			1.00	0.53				0.19	0.50	0.67										
	B	0.05	0.05	0.31				0.12	0.44	1.00	0.64				0.45				0.73	0.50	0.33										
	C		0.41	0.31	0.75	0.81	0.70	0.13	0.19		0.11				0.02				0.08												
	D		0.36	0.15	0.25	0.19	0.30	0.06	0.11		0.16																				
EST-3	A		1.00	0.81	1.00	0.92	1.00	0.44	0.19	1.00	0.66	0.64	0.29				0.50		0.23	0.27	0.67										
	B			0.19		0.08		0.56	0.81		0.34	0.36	0.71			1.00	0.50		0.69	0.73	0.33										
	C																		0.08												
GPI-1	A							0.03				0.71	0.50	0.10		0.82	0.94	0.44				0.04	0.09	0.11	0.08	0.19				0.92	0.92
	B		0.68	0.83	1.00	1.00	0.90	0.97	1.00	1.00	1.00	0.29	0.50	0.90	0.89	0.18	0.06	0.56				0.96	0.91	0.89	0.92	0.81	0.25	0.41	0.17	0.08	0.08
	C		0.32	0.14			0.10								0.11												0.75	0.59	0.83		
	D			0.03																											
GPI-2	A	0.87	0.74	0.94	0.64	1.00	0.87	0.92	0.12	0.10	0.38			0.40	0.54			0.38					0.03					0.09		0.77	0.65
	B	0.13	0.16	0.06	0.36		0.13	0.08	0.88	0.90	0.62			0.60	0.46			0.62				1.00	0.97	1.00	1.00	1.00	1.00	0.91	1.00	0.23	0.35
	C																														
MDH-1	A							0.28	0.44	0.50	0.48			0.80	0.95			0.63													
	B							0.72	0.56	0.50	0.52			0.20	0.05			0.37													
MDH-2	A													0.10	0.17	0.50	0.22	1.00												0.38	0.19
	B													0.90	0.83	0.50	0.78													0.62	0.81
	C																														
PGM-1	A	0.13																													
	B	0.82																													
	C	0.05																													
PGM-2	A		1.00	0.95	1.00	0.92	1.00	0.34	0.38	0.55	0.25		0.07			0.02		1.00	0.93	1.00	1.00										
	B			0.05		0.08		0.66	0.62	0.45	0.75	1.00	0.93			0.98	1.00		0.07												

Table 17. Genetic variability in populations of fish sampled.

POPULATION	MEAN NO. OF ALLELES PER LOCUS	PERCENTAGE OF LOCI POLYMORPHIC	MEAN HETEROZYGOSITY	
			DIRECT-COUNT	HARDY-WEINBERG EXPECTED
RA-U	1.4	30.0	0.07	0.07
PN-D	1.5	30.0	0.13	0.16
PN-U	1.8	50.0	0.07	0.20
PN-1	1.2	20.0	0.08	0.08
PN-2	1.4	40.0	0.07	0.08
PN-3	1.3	30.0	0.08	0.10
CA-D	1.8	60.0	0.14	0.22
CA-1	1.7	50.0	0.19	0.23
CA-2	1.3	30.0	0.13	0.12
CA-3	1.7	50.0	0.13	0.24
EB-D	1.3	30.0	0.06	0.16
EB-2	1.4	40.0	0.11	0.18
NS-1	1.4	40.0	0.12	0.13
NS-3	1.6	50.0	0.15	0.16
NA-D	1.4	40.0	0.10	0.15
NA-1	1.4	40.0	0.06	0.17
NC-3	1.4	40.0	0.14	0.21
EN-U	1.1	10.0	0.01	0.02
EN-D	1.2	20.0	0.01	0.01
EN-1	1.1	10.0	0.02	0.02
EN-2	1.1	10.0	0.02	0.02
EN-3	1.1	10.0	0.04	0.03
ES-U	1.1	10.0	0.05	0.04
ES-D	1.2	20.0	0.05	0.05
ES-3	1.1	10.0	0.03	0.03
EF-U	1.3	30.0	0.11	0.10
EF-D	1.3	30.0	0.06	0.09

Table 18. Tests for conformation of genotypic distribution in fish samples to expected under Hardy-Weinberg equilibrium. Levene's (1949) correction factor for small samples has been utilized.

	POPULATION																													
LOCUS	RA-U 1	PN-D 2	PN-U 3	PN-1 4	PN-2 6	PN-3 5	CA-D 7	CA-1 8	CA-2 10	CA-3 9	EB-D 11	EB-2 12	NS-1 13	NS-3 14	NA-D 15	NA-1 16	NC-3 17	CC-U 18	CC-D 19	CC-2 20	EN-U 21	EN-D 22	EN-1 23	EN-2 24	EN-3 25	ES-U 26	ES-D 27	ES-3 28	EF-U 29	EF-D 30
EST-2	NS	**	**	NS	NS	NS	*	NS		**				NS				**	NS	NS										
EST-3			**		**		**	*		**	*	NS				NS		**	**	NS										
GPI-1		*	**			NS	NS				NS	NS	NS	NS	NS	NS	NS				NS	**	NS	NS	NS	NS	NS	NS	NS	NS
GPI-2	NS	*	**	NS	NS		NS	NS	NS	NS	*	*	NS	NS	*	*	NS					NS					**		NS	NS
MDH-1							NS	NS	NS	NS			NS	NS			**													
MDH-2													NS	NS	NS	NS	*												NS	**
PGM-1	NS																													
PGM-2			NS		NS		**	NS	NS	**		NS			NS			NS												

*p ≤ 0.05, **p ≤ 0.01, NS = not significant, blank = invariant.

Table 19. Contingency chi-square analyses for genetic heterogeneity among samples of fish. populations from different sites/dates. Comparisons are within species and cannot include species with only one sample.

LOCUS	Bluntnose minnow *Pimephales notatus* (PN)	Stoneroller minnow *Campostoma anomalum* (CA)	Silverjaw minnow *Ericymba buccata* (EB)	Spotfin shiner *Notropis spilopterus* (NS)	Rosefin shiner *Notropis ardens* (NA)	White sucker *Catostomus commersoni* (CC)	Johnny darter *Etheostoma nigrum* (EN)	Orangethroat darter *Etheostoma spectabile* (ES)	Fantail darter *Etheostoma flabellare* (EF)
EST-2	**	**		NS		*			
EST-3	NS	**	NS		**	NS			
GPI-1	*	NS	NS	NS	NS		NS	NS	NS
GPI-2	*	**	NS	NS	NS		NS	NS	**
MDH-1		NS		NS					
MDH-2				NS	*				NS
PGM-1									
PGM-2	NS	NS	NS		NS	NS			

* $p \leq 0.05$, **$p \leq 0.01$, NS = not significant, blank = invariant.

Table 20. Contingency chi-square analyses for genetic heterogeneity among samples of fish populations. Comparisons are within species and do not include species with only one sample.

LOCUS	Bluntnose minnow *Pimephales notatus* (PN) JUNE	Bluntnose minnow *Pimephales notatus* (PN) OCTOBER	Stoneroller minnow *Campostoma anomalum* (CA) OCTOBER
EST-2	NS	NS	**
EST-3	**	NS	**
GPI-1	NS	NS	NS
GPI-2	NS	NS	*
MDH-1			NS
MDH-2			
PGM-1			
PGM-2	NS	NS	*

* $p \leq 0.05$, ** $p \leq 0.01$, NS = not significant, blank = invariant.

Table 21. Number of grasshoppers subjected to electrophoresis by species and collection site.

SPECIES	SITE						
	CS1	CS2	CS3	FA	NW	IN	UGP
Melanoplus femur-rubrum	20	20	20	20	20	32	20
Conocephalus strictus	13	12	34	19	20	13	26

SITE IDENTIFICATIONS

CS1: Old-field located on C. Facemire farm, 2.0 mi E Bennington, Switzerland Co., IN

CS2: Pasture (ungrazed) located on G. Libby farm, 2.25 mi E Bennington, Switzerland Co., IN

CS3: Near weather station, around edge of old-field, Ecology Research Center, Miami University, 1 mi N Oxford, Butler Co., OH

FA: South of base of active fly-ash pile, FMPC

NW: Control area of grazed pasture in NW corner of FMPC

IN: Area lying between sewage disposal/old incinerator site and boundary air station 3, FMPC

UGP: Area lying south of fence by boundary air station 2, FMPC

Table 22. Buffers utilized and enzyme systems studied in electrophoretic analysis of grasshoppers.

Melanoplus femur-rubrum (M)
Conocephalus strictus (C)

ENZYME SYSTEM	BUFFER SYSTEM			
	C&T	LiOH	TC	RW
Aspartate Amino Transferase (AAT)		C	M	
Esterase (alpha napthyl acetate; A-EST)				C,M
Esterase (phenyl acetate; PA-EST)				M
Benzaldehyde dehydrogenase (BDH)				C,M
Diaphorase (DIA)		C,M		
Glucose phosphate isomerase (GPI)	M			
Isocitrate dehydrogenase (ICD)			C,M	
Lactate dehydrogenase (LDH)			M	
Leucine Amino Peptidase (LAP)		M		
Malate dehydrogenase (MDH)	C,M			
Malic enzyme (ME)			C,M	M
Non-specific protein (NP)				M
Peptidase (PEP)				C,M
6-Phosphogluconate dehydrogenase (6PGD)			C,M	
Phosphoglucomutase (PGM)			C,M	
Superoxide dismutase (SOD)	M			
Xanthine dehydrogenase (XDH)				C

LiOH = Lithium hydroxide, pH 8.1/8.4 (Selander, et al. 1971)
TC = Tris-citrate, pH 8.0 (Selander, et al. 1971)
C&T = Citric acid, 4-(3-aminopropyl)morpholine, pH 6.1 (Clayton and Tretiak 1972)
RW = Gel: Tris-citrate; electrode: Lithium borate; pH 8.5 (Ridgway et al. 1970)

SECTION III

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER

January-March, 1987

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TABLE OF CONTENTS

INTRODUCTION 1

STUDY SITE AND METHODS 2

FLORA

Spring Flora 4

FAUNA

Benthic Macroinvertebrates 12

Fish: March 17

Fish: June 23

Spring Migrant Birds 26

Growth and Reproductive Success in Doves and Robins 30

Threatened and Endangered Species 34

ENVIRONMENTAL POPULATION GENETICS

Benthic Macroinvertebrates 35

Rabbits 43

SUMMARY AND CONCLUSIONS 45

ACKNOWLEDGEMENTS 50

FIGURES 52

TABLES 55

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INTRODUCTION

Previous baseline and ecological studies conducted by Miami University at the Feed Materials Production Center (FMPC) have been reported in Sections I and II. The present study, under WMCO Subcontract No. E-75969, continues our survey, inventory and characterization of the terrestrial flora and fauna, and aquatic fauna inhabiting the FMPC. This report includes results of spring flora sampling, spring migrant bird counts, and fish and benthic community studies conducted in Paddy's Run and Harker's Run, an offsite stream of similar size and age. Results of a study concerning growth and reproductive success of onsite and offsite populations of mourning doves (*Zenaida macroura*) and American robins (*Turdus migratorius*) are also included. Winter resident bird and owl population studies at the FMPC were reported previously (Section II).

In addition, mayfly, isopod, chironomid, and Eastern cottontail rabbit (*Sylvilagus floridanus*) populations from the FMPC and from offsite areas were collected and analyzed for the possible effects of environmental stress on genetic structure. Results of a similar study on bobwhite quail (*Colinus virginianus*) are not included. Although bobwhite frequented our trapping areas, our efforts with caged calling birds (92 trap days) were not successful in live-trapping a single bird onsite or offsite. Part III of Appendix A includes a catalog of species found at the FMPC during spring, 1987.

Results of this study are discussed with respect to

seasonal changes in population or community structure and to other onsite or offsite studies of biotic community structure or environmental stress.

STUDY SITES AND METHODS

The study area included six (6) major terrestrial habitats (see Section I) and Paddy's Run within the 425 ha of the FMPC site excluding the 55 ha occupied by the FMPC operations complex, parking lots and associated construction facilities.

Except for spring migrant birds, all terrestrial flora and fauna were censused along previously established permanent transects (Fig. 1). Descriptions of the habitats and the methods for laying out the transects are reported elsewhere as are transect identification codes (see Addendum I). Aquatic fauna were censused at sites along Paddy's Run (Fig. 2) and Harker's Run (Fig. 3). Harker's Run was used as an offsite reference stream (see Fish: March, Study Sites, for a description).

Each floral or faunal group was censused, mapped, and listed by habitat type, or by sampling site on Paddy's Run or Harker's Run. All endangered species found are listed and included in Addendum II to the Catalogue of Species of the FMPC. Prior to commencing the study, sampling and electrophoretic protocols were submitted to WMCO for approval.

Standard community indices were used to reduce the data. Results for each organismal group (excluding spring migrant

birds) are expressed by habitat type in terms of density (number per unit area), or number per unit effort (e.g., number of fish per 15 minutes of sampling). Additional parameters were also calculated for each community. Species richness (R) is the number of species found. Relative frequency of occurrence is the proportion of individuals of each species in the sample with respect to the total number of individuals sampled. The latter data were used to assign estimates of abundance in Part II of Appendix A, Catalogue of Species of the FMPC.

Species diversity was calculated using the Shannon-Weaver (1949) formula (*H'*) and Simpson's Index, (*D* ; Simpson 1949). Dominance concentration of species (*C*) was calculated from the index of Simpson (1949). Evenness of abundance (*J'*) was calculated using the methods outlined in Pielou (1966). The Jaccard Coefficient (Jaccard 1908) and the Coefficient of Similarity (Whittaker 1975) were used as measures of qualitative community similarity in terms of presence or absence of species. Percent Similarity (Whittaker 1975) and Morisita's Index (Morisita 1959) were used as measures of quantitative community similarity with respect to the number of individuals of each species present. Additional synthesis of the data is treated in each section.

All taxa were catalogued according to frequency of occurrence by habitat type (Appendix A, Part II). Representative specimens are housed in the Robert A. Hefner Museum of Zoology or the Willard Sherman Turrell Herbarium, Miami University, Oxford, Ohio 45056.

SPRING FLORA

METHODS

Spring herbaceous vegetation was sampled using the focal-point sampling procedure of Burzlaff (1966). The procedures and data analyses followed those outlined in Section I for sampling the summer herbaceous flora on the FMPC. Sampling was conducted from 26 April-23 May, 1987, because Snyder (1984) reported this seasonal period as a major peak in the number of herbaceous species in flower and percent herbaceous cover for forested areas in southwestern Ohio. Each individual plant or substrate (i.e., soil, litter (dead or decomposing plant material), or rock) visible through a sighting scope placed at one-meter intervals along each of the 11 permanent transect lines (Fig. 1) was scored. The sighting scope, an aluminum tube 22.9 cm long x 10 mm i.d. equipped with cross-hairs, was affixed at a 45° angle to a tripod. The tripod was centered over a metric tape along the transect line. At odd meter-marks, vegetation to the left of the transect line was scored, and at even meter-marks, vegetation to the right of the transect line was counted.

Due to the pattern of mowing and the general discontinuity of habitat, transect lines 40 m in length were laid out perpendicular to the original transects in the pine plantations, woodlots and riparian habitats. From 400 to 600 points were scored along each transect, except in UGP, GP1, and RFAP. Because of the uniform nature of pastures (Section I), fewer

points were scored in UGP and GP1 (every 5 m, total = 120). Only 225 points were scored in the RFAP due to the shorter than normal transect and the fact that approximately 1/3 of the RFAP was bulldozed in early September, 1986. Relative cover and herbaceous community structure indices were computed from these data.

RESULTS

Vegetative cover constituted more than 60% of the total ground cover in 10 of 11 habitats studied on the FMPC during the spring, 1987 (Table 1). Only in W3 did the combined ground cover of litter and soil exceed that of vegetative cover. Vegetative cover was greatest in the pastures and least in the woodlots. In the woodlots and pine plantations, however, litter was more dominant than any given species of vegetation.

The vegetative cover on the FMPC was made up of 143 species of herbaceous plants representing 3948 individuals and 48 families (Table 1). Only 18 species (12.6%) were found in the majority (6 of 11) of the habitats (Table 1). The most ubiquitous species were Kentucky bluegrass (*Poa pratense*), fescue (*Festuca* sp.), common chickweed (*Stellaria media*), cleavers (*Galium aparine*), and goldenrod (*Solidago* sp.). Almost two-thirds (62.2%) of the species found at the FMPC were present in only one or two habitats.

Generally, the most ubiquitous species were also the most abundant species (Table 1). Fescue and Kentucky bluegrass (along with orchard grass, *Dactylis glomerata*, in UGP) were the

dominant species in the pastures and the RFAP. Fescue, brome grass (*Bromus* sp.), and Kentucky bluegrass were the dominant species in PP1. Goldenrod and the three grasses listed for PP1 dominated the herbaceous cover of PP2. The most abundant species in the deciduous woodlands were as follows: W1 - meadow fescue (*Festuca elatior*) and Kentucky bluegrass; W2 - common chickweed and goldenrod; W3 - common chickweed and Kentucky bluegrass; RN1 - garlic mustard (*Allaria officinalis*); RN2 - common chickweed and brome grass. In summary, grasses constituted 60% or greater of the ground cover and dominated the herbaceous layer in the pastures and the reclaimed fly ash pile. However, forbs in combination with grasses generally dominated the herbaceous layer of the woodland communities.

Large differences in species richness and diversity existed between the spring flora of similar habitat types (Table 2). The northern pines had 14 more species than the southern pines and a 22% higher species diversity (H') value. Woodlot 2 had greater floral diversity than either of the more mature woodlots (W1 and W3). The discontinuous nature of W2 (small stands of trees interspersed with grassy and shrubby openings) probably accounts for its high species diversity. The high diversities in both PP1 and W2 were related to the even apportionment of species (J' = 0.813 and 0.826, respectively; Table 2) with no species having relative cover percentages of greater than 10 (Table 1). Twenty-five more species were found and diversities were 32% higher in RN1 than RN2. High floral diversity in GP1 may be an artifact of sampling; five times as many points were

sampled in GP1 as compared to the other pastures.

Percent similarity of herbaceous plant communities ranged from 83% between the grazed pastures to 26% between W2 and W3 (Table 3). The high similarities among pastures were mainly due to the dominance of fescue and bluegrass in each pasture. The high similarity between the RFAP and UGP can also be attributed to the abundance of these grasses in both communities (Table 1). As expected, the grazed pastures were more similar to each other than to the ungrazed pasture. The mature, more continuous woodlots, W1 and W3, were more similar to each other than to W2 (Table 3). The riparian floral communities were not very similar, either qualitatively or quantitatively .

DISCUSSION

Pomeroy et al. (1977) listed only 25 herbaceous species on the FMPC. Summer sampling yielded 98 species representing 38 families (Section I) whereas in spring we found 143 species representing 48 families, including 70 species not previously recorded in Section I. Three to 47 species were added to those previously recorded in any given habitat, with the largest number of additions in the riparian habitats (Table 4). The addition of spring species increased richness by habitat from 19 to 127% (Table 4). Many of these "new" species were grasses (Poaceae=12) and mustards (Brassicaceae=8). Seventeen additional families were documented and seven families previously reported (Section I) were not found. Additionally, 47 species found in the summer, 1986 (Section I), were not found

during spring.

Even though 70 new species were documented in spring, herbaceous species diversity declined from summer to spring in seven of the 11 habitats studied, with an average decline of 15.7%. Species diversity (H') in the RFAP and RN2 was reduced by more than 20% from summer to spring. Woodlot 2, RN1, and both pine plantations were the only communities where species diversity increased from summer to spring.

Community similarities paralleled the patterns observed for the summer (Section I). In both summer and spring, the pastures had the most similar community structures and the RFAP was least similar to that of any other habitat studied.

The total number of herbaceous species at the FMPC, including the summer (Section I) and spring, was 190, three times lower than found for similar physiognomic habitats at Hueston Woods (Werth et al. 1982), a state park located approximately twenty miles north of the FMPC. Werth et al. (1982) reported 578 species representing 99 families. Species reduction on the FMPC does not appear to be related to area size. The number of species in an area of given size may be calculated by $S = CA^z$ (MacArthur and Wilson 1967) where C is a taxon-dependent constant, A is the area, and z a value generally between 0.17 and 0.35. Thus the number of species found at the FMPC is lower than expected for a natural area of equal size.

Six important families (those with 4 or more species; Werth et al. 1982) missing from the spring flora were the rushes (Juncaceae), bluebells (Campanulaceae), spurges (Euphorbiaceae),

saxifrages (Saxifragaceae), nightshades (Solanaceae) and orchids (Orchidaceae). However, rushes, bluebells, and spurges were all represented by one species and nightshades by three species in summer sampling (Section I). The rock-geranium (*Heuchera americana*), a saxifrage, was found occasionally in the woodlots in the summer (Section I), but was absent in spring. Due to patchy distribution of many saxifrages, our sampling transects may have missed this species. Orchids (Orchidaceae), represented by six species in Hueston Woods (Werth et al. 1982), were not found in either the summer (Section I) or spring. Even though orchids are normally in low abundance (Hickey, personal communication), some species such as *Lipris liliifolia* were expected but not found. Orchids, bluebells, and saxifrages are adversely affected by grazing cattle (Hickey, personal communication) which may have caused their absence or low abundance at the FMPC.

Although no families were present at the FMPC that were not represented at Hueston Woods (Werth et al. 1982), twelve species were found at the FMPC and not at Hueston Woods. Most notable of these were fringed brome grass (*Bromus ciliatus*), dwarf cinquefoil (*Potentilla canadensis*), blue lettuce (*Lactuca biennis*), broom sedge (*Carex scoparia*), and beggar-ticks (*Bidens vulgata*). All were present in low abundance and most are characteristic of disturbed communities (Fernald 1950). The former three species were found in W2, a highly grazed, fragmented, and disturbed woodlot whereas the latter two occurred in the northern pines. No similar habitats can be

found at Hueston Woods.

Additional species absent from the FMPC were squirrel-corn (*Dicentra canadensis*), Dutchman's breeches (*D. cucullaria*), clearweed (*Pilea pumila*), lobelia (*Lobelia* sp.), and tick trefoil (*Desmodium* sp.). Squirrel-corn and Dutchman's breeches are quite common in wooded habitats throughout southwestern Ohio (Moore 1984, Snyder 1984). During the same season as this study, relative cover values of squirrel-corn ranged from nine to 22% in Hueston Woods (Moore 1984, Snyder 1984). In a successional woodland on the Bachelor Estate, Oxford, Butler Co., Ohio, similar to that of FMPC woodlots, Snyder (1984) reported a relative cover of 15% for Dutchman's breeches. Clearweed was found in six of eight wooded habitats in the summer (Section I), but was absent in the spring. Snyder (1984) found this species to be a late summer plant which probably explains its absence in the spring on the FMPC. Tick trefoil and lobelia were found in two and four of Snyder's (1984) six successional habitats, respectively, but were not found at the FMPC.

Cleavers, which was absent in the summer (Section I), was found in moderate abundance in the spring. Although the ephemeral nature of this species was unexpected, our findings are supported by Moore's (1984) and Snyder's (1984) data which showed that cleavers die by mid-June.

Several species were in low abundance on the FMPC. The spring beauty (*Claytonia virginica*), May apple (*Podophyllum peltatum*), fleabanes (*Erigeron* spp.), touch-me-not (*Impatiens*

sp.), and cut-leafed toothwort (*Dentaria laniciata*) had substantially lower cover values on the FMPC than those reported by Snyder (1984) in Hueston Woods. Fleabanes were also in low abundance during the summer (Section I).

The herbaceous communities are impacted by mowing (e.g., pastures), bush-hogging (e.g.,woodlots, especially W1 and W2), and grazing (e.g., pastures and woodlots). Grazing, especially in the woodlots, probably represents the greatest stress because of its nature and longer duration. In pastures, mowing and grazing may be considered normal perturbations which maintain these communities in an early successional stage. Bush-hogging occurs only once a year after most of the spring ephemerals have flowered and died, and is used to keep the fields located in W1 and W2 in an early successional stage. Cattle, however, are present in the FMPC woodlots 9-12 months of the year. The presence of cattle and their associated impacts, including disturbance and compaction of soils and trampling and consumption of vegetation, affected the herbaceous community structure in two ways:

(1) Herbaceous cover was reduced as shown by the smaller total vegetative cover in the woodlots where cattle graze compared to the riparian woodlands where cattle are generally excluded (Table 1).

(2) Herbaceous community structure was altered as shown by the many species absent or in low abundance as compared to offsite studies (Werth et al. 1982, Moore 1984, Snyder 1984). Onsite, the number of species found in each of the grazed

woodlots was less than the species richness in the ungrazed riparian habitats (Table 2).

BENTHIC MACROINVERTEBRATES

METHODS

Benthic macroinvertebrates were collected 26-27 February 1987 at sites 1, 3, 5 and 11 (Fig. 2) on Paddy's Run (PR) and sites 1 and 2 (Fig. 3) on Harker's Run (HR). Paddy's Run was dry downstream of PR5, thus PR9 could not be sampled as planned. The physical characteristics of the riffles and pools (PR) have been characterized elsewhere (Section II).

At each sampling location, 3 samples were collected from the riffle immediately above (PR1, HR1, HR2) or below (PR3, PR5, PR11) the pool using a Surber stream bottom sampler (total sample area = 0.28 m^2; mesh size = 508 µm; Merritt et al. 1984). Larger rocks were removed from the area enclosed by the sampler frame and were carefully scrubbed clean. The organisms so removed were collected in a bucket. The remaining substrate was disturbed to a depth of 3-5 cm. The contents of the bucket and the sampler were placed into a labeled collection bottle, preserved with either 10% formalin or 70% ethyl alcohol, and stored in our laboratory awaiting sorting.

Two samples, one from near the shore and one from the deeper mid-channel area, were collected from each pool. In each case, the top 5 cm of substrate (gravel, sand, sediment, detritus, etc.) was removed with a stainless-steel sampler

(total sample area = 0.063 m^2). Sub-samples were then washed using a No. 35 standard testing sieve (mesh size = 500 µm). Organisms were floated to the surface, placed in collection jars, and preserved as noted above.

In the laboratory, all benthic organisms were sorted by family, counted, and stored for future reference. Identification was accomplished using taxonomic keys by Wiggins (1977), Pennak (1978), Borrer et al. (1981) and Merritt and Cummins (1984). Densities (no./m^2) were calculated for all organisms in both riffle and pool areas of the streams. Standard community and similarity indices (see Introduction) were used for analysis of the data. A modification of Student's *t* test was used to test for significant differences in Shannon-Weaver diversity between sites (Zar 1974). As the identification of organisms from PR3, PR5 and HR2 is not yet complete, only those data relating to PR1, PR11 and HR1 are presented herein. The complete analysis will be included in Section IV of this report. The taxa identified in PR1 and PR2 are included in Appendix A, Catalog of Species.

RESULTS

Twenty-six, 21 and 20 taxa were collected at PR1, PR11, and HR1, respectively (Tables 5a and 5b). In every case, larval or pupal forms of the non-biting midges (Chironomidae) were most numerous (84 to 92% of all organisms, depending on site); usually present in numbers 10-20 times greater than the next most dominant taxa. Chironomidae were present at every sampling

location with the exception of the pool at HR1. The two pool samples from HR1 contained only a single organism, a stone fly (Capniidae).

Representatives from 9 families were present at all three sampling locations: earthworms (Annelida); isopods (Asellidae: Isopoda); mayflies (Caenidae: Ephemeroptera); stoneflies (Capniidae: Plecoptera); water pennies (Psephenidae: Coleoptera); two groups of caddis flies (Hydropsychidae and Psychomyiidae: Trichoptera); and crane flies and non-biting midges (Tipulidae and Chironomidae, respectively: Diptera).

Several taxa were unique to each site. Tubificids (Annelida); ephemerids (Ephemeroptera); leuctrids, nemourids, and taeniopterigids (Plecoptera); hydraenids (Coleoptera); limnephilids (Trichoptera); and lymnaeids (Lepidoptera) were found only at PR1. At PR11, representatives of the following families were unique: Heptegeniidae and Siphlonuridae (Ephemeroptera); Perlodidae (Plecoptera); and Ephydridae (Diptera). Five taxa were found only at HR1. These were Curculionidae (Coleoptera); Leptoceridae, Glossosomatidae and Rhyacophilidae (Trichoptera); and Psychodidae (Diptera). In no case were any of these unique families present in large numbers. The most numerous was 5 rhyacophilids at HR1.

Density, measured as the number of individuals per square meter of stream bottom to a depth of approximately 5 cm, in the riffle community (Table 5a) was highest at PR11, followed by HR1 and PR1. For the pool community (Table 5b), PR1 density was greatest and HR1 was least (only a single organism was found).

Diversity parameters (Table 5c) were depressed at all three sites due to the high number of chironomids present. This is most evident at PR11 where 92% of the macroinvertebrates present were members of this family. Consequently, family diversity was significantly different from that at PR1 ($t_{0.05(1), \approx 200} = 4.09$, $p < 0.005$) and HR1 ($t_{0.05(1), \approx 200} = 4.78$, $p < 0.005$). There was no significant difference between PR1 and HR1 ($t_{0.05(1), \approx 200} = 0.514$, $p > 0.25$). When Chironomids were excluded from the analysis, however, PR1 and PR11 family diversities were most similar ($t_{0.05(1), \approx 200} = 0.635$, $p > 0.25$). HR1, however, differs from both ($t_{0.05(1), \approx 200} = 6.15$, $p \ll 0.005$; $t_{0.05(1), \approx 200} = 5.68$, $p \ll 0.005$; when compared to PR1 and PR11, respectively).

Community similarity indices (Table 5d) reflect this same trend: PR1 and PR11 are most similar, and, depending on the index used and whether chironomids are included or excluded, PR1 and HR1, or PR11 and HR1, least similar.

DISCUSSION

In Section II, we reported 41 taxa of benthic macroinvertebrates collected from 10 Paddy's Run sites between 20 November and 18 December 1986. When sorting and final identification to genus or species level is complete, we expect some 50-60 taxa to have been present during February 1987 instead of the 40 reported herein (Tables 5a and 5b). As previously noted (Section II), this is a substantial increase over the 19 taxa reported by Pomeroy and co-workers (1977).

This would also represent an increase of 20-50% above the 41 taxa present during winter 1986. An increase should be expected in the spring due to life history of the organisms involved.

Our current findings support those reported in Section II; three genera reported by Pomeroy et al. (1977), *Agraylea*, *Microvelia* and *Sphaerium*, were absent from Paddy's Run and Harker's Run. Further sampling would be necessary to determine whether this is significant, as two of these genera, *Agraylea* and *Microvelia* are usually found only during warmer weather (Merritt and Cummins 1984). The third, *Sphaerium*, may be rare and not show up without extensive sampling.

The fact that overall benthic density in the riffle at PR11 was nearly twice that at PR1 and 50% greater than at HR1 may be due to several factors. First, the stream characteristics are somewhat different at PR11. The stream is generally more shallow and slow moving there than at either PR1 or HR1. In addition to the FMPC, other industrial facilities are located upstream of PR11. Some agricultural input may also accrue between the FMPC and PR11. Thus, conditions for growth and proliferation may be better due to nutrient influxes and stream substrate heterogeneity at PR11 than at any other site sampled. Algal growth (pers. observation) seemed to be greater at this site.

Benthic density in the pool at PR11, which was very low as compared to that at the PR1 pool, could reflect the fact that water levels tend to fluctuate greatly in areas of Paddy's Run downstream of PR4 (see Fig. 2). Thus, the PR1 pool, a

relatively stable community, should contain greater numbers of organisms as well as taxa. In addition, the substrate of the PR11 pool is more homogeneous than that of PR1 (Facemire, unpublished data). Ricklefs (1973) stated that species density generally decreases with a decrease in habitat heterogeneity. In the present case, the same phenomenon seems to also cause a decrease in overall density.

While diversity indices (Table 5c) were much lower than those normally reported for such streams (Section II), diversity indices calculated using any taxonomic level above species are always depressed (Hughes 1978). Furthermore, the heavy preponderance of the Chironomidae at each site also caused depressed diversity values. This is amply illustrated by comparison of indices calculated when the midges are excluded (Table 5c). The reader is cautioned, however, that diversity indices calculated from family level data are not only depressed, but are also not proportionate to species level calculations (Hughes 1978). A more thorough discussion including data from PR3, PR5 and HR2 is provided in Section IV of this report.

FISH: MARCH

STUDY SITES

Six sites (1, 2, 3, 5, 9 and 11; Fig. 2) in Paddy's Run (PR) were sampled on March 26-28, 1987. PR1 served as a reference site for Paddy's Run. Two sites (1 and 2, Fig. 3) in Harker's

Run (HR), Butler County, Ohio were sampled on April 9, 1987. All sites consisted of one pool and an adjacent riffle.

Harker's Run is a small, second-order stream (Ferrier and Wissing 1979) that is similar to other well-oxygenated, hardwater streams in the area and includes a diverse ichthyofauna (Mundahl and Ingersoll 1983). While Harker's Run does not become intermittent to the extent that Paddy's Run does during the summer months, its flow is reduced enough at times to restrict the movement of fish between sites. Although Paddy's Run is a third-order stream (Section I) and would therefore be expected to be inhabited by more fish species than Harker's Run (Kuehne 1962; Lotrich 1973), the site characteristics are similar enough between the two streams to justify using Harker's Run fish populations for comparison purposes.

METHODS

Prior to sampling at a site, each pool and riffle was separated by minnow seines (4mm mesh) to prevent the movement of fish between areas. Fish were collected using a minnow seine (4mm mesh), a backpack shocker and dip net. Each pool and riffle was sampled for 20 min, with at least 10 min of the sampling time spent with a seine. There were two exceptions. The pool at PR3 was sampled for 15 min using only a seine. This sampling effort yielded over 500 fish, the largest proportion of which were age 1 fish (yearlings, < 25mm standard length). Because of the large sample and the difficulty in identifying large numbers of young fish in the field, no further sampling

was done. The consistency of the species composition of several consecutive seining efforts suggested that our site characterization would not be enhanced by further sampling. The sample data from this pool were standardized to a sampling effort of 20 min. The riffle at PR6 was sampled for 20 min. using only a seine.

Fish caught at each site were held in collecting buckets until the end of the sampling period. At the end of each sampling period, fish were identified, enumerated, and returned to the stream at their capture location. Up to 20 specimens of stoneroller minnow (*Campostoma anomalum*), bluntnose minnow (*Pimephales notatus*), white sucker (*Catostomus commersoni*), spotfin shiner (*Notropis spilopterus*), and rosefin shiner (*Notropis ardens*) from each site were individually bagged, packed on dry ice and returned to the lab for electrophoretic analysis. Fish were identified with the aid of keys by Pflieger (1975) and Trautman (1981).

Catch data for each pool and riffle were used to calculate an index of catch per unit effort (Gulland 1969, Ricker 1975) and the proportion of catch. The mean catch per unit effort and proportion of total catch were calculated to establish the abundance of each species throughout the stream reach. A species diversity index was calculated from catch data for Paddy's Run and Harker's Run for each site and for all sites combined using a modified Shannon-Weaver function (Lloyd et al. 1968).

RESULTS

A total of 2,153 fish, representing 18 species, were tallied from the six sites in Paddy's Run. Three sunfish (*Lepomis* sp.) were collected from Paddy's Run. Two of the three specimens were age 1 fish and could not be keyed to species. The third specimen most closely resembled the longear sunfish (*Lepomis megalotis*), but did not possess all of the key characteristics described for this species by Trautman (1981). This suggests hybridization within the genus, *Lepomis*. Consequently, all sunfish were condensed into one group, *Lepomis* complex, for statistical purposes. The catch per unit effort and proportion of catch for each species at each site are shown in Tables 6-11. The mean catch per unit effort and proportion of total catch are presented in Table 12.

A total of 447 fish, representing 13 species, were collected from the two sites in Harker's Run. The catch per unit effort and proportion of catch data for each site are shown in Tables 13-14. The mean catch per unit effort and proportion of total catch are presented in Table 15. Modified Shannon-Weaver indices (*d'*) for both locations are presented in Table 16, along with indices calculated from collections of June, 1986, for PR1-3 (data provided by Section I).

DISCUSSION

The March, 1987, collection from Paddy's Run was dominated by cyprinids and percids (darters). Numerically, bluntnose minnow, stoneroller minnow, and spotfin shiner dominated the

collection. Rosefin shiners, orangethroat darters (*Etheostoma spectabile*), and fantail darters (*Etheostoma flabellare*) were also major components of the ichthyofauna.

The modified Shannon-Weaver indices calculated for the individual sites (Table 16) indicate that there is a large amount of variability in species diversity in Paddy's Run. PR2 had the highest species diversity (d'= 3.2) and PR5 had the lowest (d'= 1.1). PR2 and PR4 had species diversity equal to or greater than the control (PR1). PR3 and PR9 had very low species diversity relative to the other four sites. PR3 and PR9 are located a short distance downstream from the drainage ditch north of the railroad trestle and the storm sewer outfall, respectively.

The March, 1987, collection from Paddy's Run contained seven species that were not identified in the June, 1986, collection. Six of these species, suckermouth minnow (*Phenacobius mirabilis*), sand shiner (*Notropis stramineus*), emerald shiner (*Notropis atherinoides*), sunfish (*Lepomis* sp.), rainbow darter (*Etheostoma caeruleum*) and redbelly dace (*Phoxinus erythrogaster*) were very rare. The sixth species, the spotfin shiner, was one of the dominant species in the March collection.

Overall, a greater number of species were present in the March, 1987, collection as compared to the June, 1986, collection. The increased number of species in the spring collection may be attributed to an increased ability of fish to move between sites resulting from the resumption of water flow along the entire reach of Paddy's Run. It was reported (Section

I) that during the June, 1986, sampling period, much of the stream consisted of isolated pools and riffles and that the stream was virtually dry from the K-65 tanks to a location between Willey Road and New Haven Road As might be expected from this, and the fact that samples were collected from a greater number of sites in March, 1987, than in June, 1986, the combined modified Shannon-Weaver indices were slightly greater in the March collection (2.9 vs. 2.7).

The March, 1987, collection from Paddy's Run contained four species that were not found in Harker's Run. All four species, suckermouth minnow (*Phenacobius mirabilis*), sand shiner, emerald shiner, and sunfish were very rare. Comparison of the modified Shannon-Weaver indices for the combined sites from both locations (Table 16) indicates that Harker's Run had greater species diversity than Paddy's Run (3.3 vs.2.9) when considering the March, 1987 communities. Species diversity indices are a function of both species number (species richness) and the relative abundance of each species represented in the sample. Harker's Run had lower species richness relative to Paddy's Run but had a more even distribution of abundance among the species that were present. This is reflected by *J'*, the evenness index. This value was 0.89 and 0.69 for Harker's Run and Paddy's Run, respectively.

FISH: JUNE

STUDY SITES

Six sites (1, 2, 3, 5, 10 and 11; Fig. 2) in Paddy's Run were sampled on June 18-19, 1987. PR1 served as the control site for Paddy's Run. Two sites (1 and 2, Fig. 3) in Harker's Run, Butler County, Ohio were sampled on June 17, 1987. A pool and an adjacent riffle were sampled at each site, with the exception of PR5 and PR10. Due to dry conditions, there was no riffle habitat at either of these sites.

A description of Harker's Run and justification for using fish populations from that stream for comparison purposes are provided in a previous section of this report (see Fish: March, Study Sites).

METHODS

Methods and data analysis generally followed those reported in the March fish section of this report with the following exceptions. (1) Fish were collected by seining for 15 minutes rather than 20 minutes. Electrofishing did not improve the March, 1987, sampling effort and therefore, was not used.

(2) The riffle at HR1 was very short (9 m) and poorly defined. Consequently, it was only sampled for five minutes. The data from this riffle were extrapolated to reflect a 15 min sampling effort.

RESULTS

A total of 1925 fish, representing 18 species, were tallied

from the six sites in Paddy's Run. Six specimens of sunfish (*Lepomis* sp.) were obtained from this sampling effort. Five of the six specimens appeared to be hybrids involving bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), and orangespotted sunfish (*Lepomis humilus*). The sixth specimen was a fairly pure bluegill. All sunfish were combined into one group, *Lepomis* complex, for statistical purposes. The catch per unit effort and proportion of catch for each species at each site are shown in Tables 17-22. The mean catch per unit effort and proportion of total catch are presented in Table 23.

A total of 1326 fish, representing 14 species, were tallied from the two sites in Harker's Run. The catch per unit effort and proportion of catch data for each site are shown in Tables 24-25. The mean catch per unit effort and proportion of total catch are presented in Table 26. Modified Shannon-Weaver indices (*d'*) for both locations are presented in Table 27, along with indices calculated from collections of June, 1986, for Paddy's Run sites 1-3 (data provided from Section I) and from collections of March, 1987, for Paddy's Run and Harker's Run.

DISCUSSION

During the June, 1987, sampling period water levels in Paddy's Run were very low. PR5 and PR10 were reduced to isolated pools with no riffle habitat. Between these two sites, Paddy's Run was completely dry and therefore, no sample was obtained at PR9.

The June, 1987, collection from Paddy's Run was dominated

by cyprinids and percids (darters). Numerically, stoneroller minnow (*Campostoma anomalum*), orangethroat darter (*Etheostoma spectabile*), and johnny darter (*Etheostoma nigrum*) dominated the collection. Bluntnose minnow (*Pimephales notatus*), rosefin shiner (*Notropis ardens*), silverjaw minnow (*Ericymba buccata*), and creek chub (*Semotilus atromaculatus*) were also major components of the ichthyofauna. Spotfin shiner (*Notropis spilopterus*), which was very abundant in the March, 1987, collection, made up only a small fraction of the June, 1987, sample. Suckermouth minnow (*Phenacobius mirabilis*), which was very rare in the March collection, was absent in the June sample. Largemouth bass (*Micropterus salmoides*), which was absent from the June, 1986, and March, 1987, collections was represented in the June sample.

The modified Shannon-Weaver indices calculated for the individual sites (Table 11) indicates that there is a large amount of variability in species diversity in Paddy's Run. PR2 had the highest species diversity (d'= 3.0) and PR11 had the lowest (d'= 2.3). The range of values for the species diversity index narrowed from March to June, due to an increase in diversity at some sites. Most notable was PR3, which showed a dramatic increase in species diversity from March to June. These increases may have resulted from the forced congregation of fish into areas that still had sufficient water to support them.

The June, 1987, collection from Paddy's Run contained four species that were not found in Harker's Run. All four species,

emerald shiner (*Notropis atherinoides*), sand shiner (*Notropis stramineus*), rainbow darter (*Etheostoma caeruleum*), and largemouth bass were very rare. Paddy's Run and Harker's Run also differed in the sunfish species present. The Paddy's Run collection contained bluegill and hybrids involving bluegill, orangespotted sunfish, and green sunfish, while the Harker's Run collection contained only one orangespotted sunfish. Comparison of the modified Shannon-Weaver indices for the combined sites from both locations (Table 27) indicates that Paddy's Run had greater overall species diversity (3.2 vs 2.7) during June, 1987. The maximum value of the Shannon-Weaver species diversity index is, however, dependent upon the number of species present within the community. Eighteen species were present in Paddy's Run as opposed to only 14 in Harker's Run. For a valid comparison between the two, Pielou's evenness of abundance index, *J'*, should be used. These values (0.77 and 0.71 for Paddy's Run and Harker's Run, respectively) are not significantly different.

SPRING MIGRANT BIRDS

METHODS

Counts of spring migrant birds were conducted twice weekly from April through May, 1987. Because of their transient nature, no attempts were made to obtain estimates of population densities, nor were our counts restricted to the fixed transects (Fig. 1). In order to obtain complete coverage, teams of 2-6

observers covered the FMPC site during each count period. Woodlots, pine plantations and riparian habitats were covered more thoroughly than were pasture communities. This report excludes all breeding or wintering residents previously reported (Sections I, II), all migratory waterfowl, and other avian taxa (e.g., gulls and terns) not expected to utilize FMPC habitats. For offsite comparisons we tabulated the spring migrants at Oxford, Ohio and Hueston Woods State Park, Butler/Preble County, Ohio, during the same count period. Included also are noteworthy species suspected of breeding on the FMPC which were not reported on our breeding bird census (Section I).

RESULTS

Twelve migrant species were recorded on the FMPC during the spring of 1987. Twice as many species were scored off the FMPC during the same count period (Table 28). Six species were unique to the FMPC, and 18 recorded offsite were not found within the confines of the FMPC. FMPC riparian and woodlot habitats were richest. Seven of 12 (58.3%) and nine of 12 (75.0%) species were recorded in the riparian and woodlots, respectively (see Appendix A, Part II, Catalogue of species of the FMPC).

DISCUSSION

Although Battelle (1981) provided a list of all the birds of southwestern Ohio in their environmental report to the FMPC, no previous inventories of spring migrants have been made onsite. Our FMPC totals are similar to those reported for two

1987 day-long "May Counts" traditionally taken yearly by local Audubon groups. The Oxford Audubon Bird-a-thon tabulated 15 migrant species on April 26 in Whitewater County Park and Lawrenceburg, Indiana, and another Oxford Audubon Society group recorded 13 species on May 16. Species composition varied considerably across these counts. All Audubon groups within the Cincinnati-Oxford area reported lower numbers of migrants than in previous years. Because of the unseasonably warm and dry spring, there were no pronounced peak days of abundance. Rather, the migrants this spring seemed to trickle through.

The May counts, the FMPC counts, and our offsite areas had lower than normal records for migrant thrushes and warblers. Reduced numbers of thrushes were recorded for veerys (*Hylocichla fuscescens*), gray-cheeked thrushes (*H. m. minima*) and Swainson's thrushes (*H. ustulata swainsoni*). Seven common migrant warblers were not recorded on the FMPC or on any of the 4 area May counts we had access to. They were the Nashville warbler (*Vermivora r. ruficapilla*), magnolia warbler (*Dendroica magnolia*), black-throated blue warbler (*D. c. caerulescens*), bay-breasted warbler (*D. castanea*), cerulean warbler (*D. cerulea*), Louisiana waterthrush (*Seiurus motacilla*), and Canada warbler (*Wilsonia canadensis*). Thus, the pattern of spring migrant birds on the FMPC did not differ appreciably from that of the surrounding area.

ADDITIONAL BREEDERS

Wood ducks (*Aix sponsa*) were suspected of breeding on the

FMPC (Section I). During our spring counts this year one pair was consistently flushed from a nest tree along Paddy's Run near the NW corner of W3 (Fig. 1). Thus, this species should be included in the FMPC list of birds breeding on the site.

A pair of house finches (*Carpodacus mexicanus*) was observed at the same location on all of our counts in W2, and another pair frequented an offsite spruce nursery located several hundred meters north of the northern boundary fence. House finches are of interest because of the recent rapid westward expansion of their breeding ranges. Originally of western origin and found in cities, suburbs and farms, they were introduced in eastern New York in 1940 and reached western Illinois by 1980 (Peterson 1980). House finches are not included on any of the check-lists for southwestern Ohio (Trautman and Trautman 1968; Austing and Imbrogno 1976; Peterson 1982). They were first reported in this area on the Hamilton-Fairfield Christmas Bird Count in 1982 (Heilman 1983). Populations have been reported to increase explosively. First reported at winter feeders in central New York in 1971 they numbered over 5000/100 feeders within eleven years (Burtt and Burtt 1984) and are predicted to become one of the most numerous resident species in New York along with European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*). Recent studies (Kricher 1983) show that the declines of house sparrows in the northeastern U.S. are well correlated to increases in house finch populations. As house finches become more established locally, they may be a common breeder at the

FMPC within a few years.

GROWTH AND REPRODUCTIVE SUCCESS IN DOVES AND ROBINS

INTRODUCTION

Growth analyses have been shown to be a sensitive measure of environmental stress in game animals (Fendly and Brisbin 1977), gulls (Gilbertson and Fox 1977), eagles (Helander et al. 1982), and in passerine birds (Zach and Mayoh 1984). Birds have been useful in monitoring environmental radionuclides at atomic waste sites (Willard 1960), at cooling reservoirs (Brisbin et al. 1973) and at nuclear power stations (Levy et al. 1975). Subsequent growth depression of nestlings has been found in experimentally irradiated tree swallow (*Tachycineta bicolor*) eggs (Zach and Mayoh 1986) and nestlings (Zach and Mayoh 1984), and experimentally irradiated chick (*Gallus domesticus*) embryos (Essenberg 1935, Bless and Romanoff 1943, Muller and Moreng 1966, Tyler et al. 1967). Results from chick embryo studies suggest that exposure to high level radiation during development may lead to reduced fertility (Muller and Moreng 1963; Mraz and Woody 1973) and stunting (Muller and Moreng 1966, Tyler et al. 1967). Constant low-level radiation exposure may be a potential risk to FMPC birds.

As part of an intensive year-long baseline ecological study, preliminary investigations were initiated in late spring 1987 in order to characterize growth and reproductive success in birds at the FMPC. Mourning doves (*Zenaida macroura*) and

American robins (*Turdus migratorius*) are ideally suited for this study. They were among the most abundant breeding (Section I) and wintering (Section II) species onsite, thus being continually present on plant property. Both doves and robins are open-nesting species having similar hatching and fledging success (Young 1955), however, they differ in territorial behavior and diet.

Doves defend only the immediate vicinity of the nest (type IV territory; Welty 1982) and probably feed onsite in open weedy areas or in adjacent offsite grain fields. Only traces of insect or other animal foods are eaten; corn, wheat and grass seeds are the three top-ranked plant foods for Ohio dove populations (Martin et al. 1951:111). Young doves are not fed these foods directly, but are fed 'pigeon milk' which is produced by the mother's crop (Welty 1982).

Robins, on the other hand, defend relatively small territories (Wisconsin populations averaged 1200 m^2; Young 1951) for mating, nesting and feeding (type I territory; Welty 1982) and prefer clearings, lawns and orchards when foraging. Seventy nine percent of their spring diet is animal foods, chiefly earthworms, ground beetles and dung beetles (Martin et al. 1951); the food of nestling robins is chiefly insect larvae and earthworms. Thus, these secondary consumers are more likely to feed in or near their nesting sites than are granivorous doves. Because doves and robins occupy different trophic levels within the FMPC ecosystem, they may be affected differently by environmental stress at the FMPC (Levy et al. 1982).

METHODS

Dove and robin nests from the northern (PP1) and southern (PP2) pines (Fig. 1) and from the Miami University campus/Hueston Woods State Park were followed through fledging. The growth parameters measured included egg and chick weights, and the length of the wing, last primary, third toe, and bill. Measurements of each parameter for each species were taken daily. Experimentals and controls were measured at the same age. Average asymptotic values were used in the final computations of the results. Clutch size, hatching and fledging success were calculated for each species by habitat type.

RESULTS

Clutch sizes of doves from the FMPC sites were not significantly ($p > 0.05$) different from each other or from offsite populations (Table 29). Hatching success of PP1 doves was significantly ($p < 0.05$) lower as compared to PP2. Fledging success was significantly ($p < 0.05$) lower in the northern pines as compared to the southern pine and offsite populations. Egg weights did not differ significantly ($p > 0.05$) across habitats (Table 30). There were no significant ($p > 0.05$) differences in any of the 5 growth statistics measured in prefledging mourning doves by habitat type; FMPC nestlings were similar to offsite populations (Table 31).

Average clutch size and hatching success of robins did not differ significantly ($p > 0.05$) among the sampling sites (Table

29). Fledging success was significantly ($p < 0.05$) lower in the southern pines as compared to offsite populations. Robin eggs from the northern pines (Table 30) weighed significantly ($p < 0.01$) less than eggs from offsite populations and from the southern pines; however, eggs from offsite populations and from the southern pines were similar in weight. FMPC robins also showed suppressed growth in 4 of the 5 prefledging growth parameters measured (Table 31). Prefledging robin weights were significantly ($p < 0.05$) lower in nestlings from the northern pines as compared to offsite populations. FMPC robins from both pine plantations showed a significant ($p < 0.01$) reduction in the length of the last primary and in wing length, and prefledglings from the southern pines showed a significant ($p < 0.01$) reduction in the length of the bill. No significant ($p > 0.05$) differences existed in the length of the third toe between FMPC birds and offsite populations.

DISCUSSION

Statistically significant differences were found in the mortality rates of eggs and nestlings of FMPC doves and robins. Hatching success was significantly ($p < 0.05$) lower for mourning doves from the northern as compared to the southern pines; fledging success of doves was significantly ($p < 0.05$) reduced in PP1 as compared to offsite populations, and significantly ($p < 0.05$) reduced for robin nestlings from PP2 as compared to offsite populations. There were no observable signs of deformity in any of the FMPC hatchlings we studied.

Growth of FMPC robins was much more severely suppressed than in FMPC doves which may be related to differences in diet. In other studies, mean radionuclide body burdens for robins have been reported to be more than three times that of mourning doves collected from the same site (Levy et al. 1976). Differences were attributable to the trophic levels each species occupied within the same local habitat (i.e., insectivorous species had significantly higher body burdens than did granivorous species). This is significant when considering differences found in the growth patterns between robins and doves on the FMPC.

THREATENED AND ENDANGERED SPECIES

No federally endangered plant or animal species were observed on the FMPC. One avian species was recorded onsite which appears on the "Rare Species of Native Ohio Wild Animals" list (DNAP-ODNR 1982). Cooper's hawks (*Accipiter cooperii*) were frequently sighted in the northern and southern pines. This species is listed as an uncommon, but regular, breeder in the Cincinnati area (CNC 1978), a non-breeder in Hueston Woods (Osborne and Smallwood 1982), and a threatened breeder in Ohio (DNAP-ODNR 1982). Cooper's hawks have been reported during summer and winter on the FMPC (Sections I, II). They are considered an uncommon to common spring migrant in Ohio (Trautman and Trautman 1968). We estimate two pairs on the FMPC.

ENVIRONMENTAL POPULATION GENETICS

BENTHIC MACROINVERTEBRATES

STUDY SITES

Benthic macroinvertebrates were collected from nine riffle/pool sites on Paddy's Run (Fig. 2) from November 18 - December 20, 1986. Seven of the sites (2-9; samples from sites 5 and 6 were accidentally combined) lay within the boundaries of the FMPC. Physical characteristics of the riffles and pools have been previously summarized (Section II). In February 1987 we collected benthos samples from sites 1, 3, 5 and 11 in Paddy's Run and a site in Harker's Run, approximately 2 km from Oxford, Butler Co., OH. This latter study site served as a reference sample.

At each site we attempted to collect a minimum of 20 specimens of each of the following benthic macroinvertebrates: mayflies (*Stenonema femoratum*), midges (*Chironomus tentans*) and isopods (*Lirceus fontinalis*). Samples from a given site are identified by the date of collection, e.g., 116 (November 1986) or 27 (February 1987), followed by the site number (name); they are referenced in this manner throughout the remainder of this section.

ELECTROPHORETIC METHODS

Specimens were stored frozen at -70 C until needed for electrophoresis. At the appropriate time individuals were thawed, homogenized manually in spot plates without extractant and electrophoresed immediately. Loci analyzed and buffers used are detailed in Table 32. Gels were 15% Sigma starch (Karlin and Guttman 1981) except for the LiOH system which was made with 13% Sigma starch.

Histochemical procedures followed Harris and Hopkinson (1976) and Selander et al. (1971). After the gels were stained, the genotypic composition of each sample at each locus was determined and recorded. Genotypic data were analyzed using the BIOSYS-I computer program (Swofford and Selander 1981). Allele frequencies, deviations from expected genotypic proportions assuming Hardy-Weinberg equilibrium conditions and amount of genetic variation were determined. Chi-square (X^2) contingency tests for interpopulation heterogeneity were performed. See Section I for discussion of Hardy-Weinberg equilibrium and methods for determination of expected genotypic proportions and heterozygosity.

RESULTS

Stenonema femoratum - mayfly

Six loci (EST-1, EST-2, GPI-1, MDH-1, NSP-1, PGM-1) were variable in most mayfly samples (Table 33). Allelic diversity was similar in all samples (Table 34) as was the percentage of polymorphic loci. Mean direct-count heterozygosity was similar

to expected in all samples except 116-3, 116-5/6 and 116-8; at these sites actual heterozygosity was approximately one-half expected. Significant deviations from values expected under conditions of Hardy-Weinberg equilibrium occurred at all sites but were more concentrated at sites 3, 5/6, 8 and 10 where the non-conformation index (the summation of the number of loci that deviate significantly from expected genotypic proportions in samples from a site divided by the number of variable loci in samples from that site) was between 50% and 67% (Table 35). All instances of non-conformation, except for NSP at site 10 were determined by heterozygote deficiencies; there was an excess of heterozygotes at NSP in mayflies from site 10.

Contingency X^2 analyses demonstrate significant differences among all mayfly population samples from November 1986 (Table 36); 67% of the comparisons deviated significantly. Pairwise analyses between mayflies from adjacent sites indicate that changes occur over short distances and are not determined by distance. Mayflies from sites 1 and 2 are heterogeneous at only one locus (GPI-1, $p \leq 0.05$) and heterogeneity does not occur at any locus between insects from sites 2 and 10. However, 67% of the polymorphic loci exhibit heterogeneity over the short distance between sites 2 and 3. While heterogeneity does not exist between mayflies from site 8 compared with site 9 or from site 9 compared with site 10, contingency X^2 comparisons between *Stenonema* from site 8 and from site 10 indicate heterogeneity at 50% of the variable loci. Comparisons between mayflies from site 2 with those from either sites 8 or 9 were heterogeneous at

33% of the variable loci ($p \leq 0.01$ and $p \leq 0.05$, respectively).

The February 1987 data indicate that the percent non-conformation remains elevated at sites 3 and 5 compared with site 1 (Table 35). Two new sites were sampled at this time. Site 11, below the New Haven Road bridge has a non-conformation index of 0.67; this is the highest for the *Stenonema* in the February samples. Site HR, the offsite reference sample, and site 1, above the FMPC, have the lowest index values. When all populations are compared, significant ($p \leq 0.01$) heterogeneity was found only at the GPI-1 locus (Table 36). Three sites (1, 3, 5/6) were sampled on both dates. The greatest changes occurred in the *Stenonema* from site 3 (Table 36); 67% of the variable loci were significantly ($p \leq 0.01$) different between the two sampling dates. This contrasts with a change at only 17% of the loci at site 1 ($p \leq 0.05$) and 33% at site 5/6 ($p \leq 0.05$).

Chironomus tentans - midge

Two loci (GPI-1, MPI-1) were variable in the midges examined (Table 37). Mean number of alleles per locus ranged from 3.0 to 4.0 (Table 38). Direct-count heterozygosity at these two loci ranged from 23% to 51% (Table 38). November samples from sites 3 and 10 were the least heterozygous while greatest heterozygosity occurred in the February sample from site 1. Mean direct-count heterozygosity was slightly above half that expected under conditions of Hardy-Weinberg equilibrium in the November sample from site 3 and less than

half that expected in the site 10 sample (Table 38). Genotypic distributions were generally in accord with those expected under conditions of Hardy-Weinberg equilibrium (Table 39); however, significant deviations occurred at sites 1, 3 and 10. Contingency X^2 analyses indicate allele frequencies were homogeneous both for comparisons among samples grouped by date of collection and between samples from the same site collected on different dates (Table 40).

Lirceus fontinalis - isopod

Two (EST, GPI-1) of the loci analyzed were variable (Table 37); all samples of isopods exhibited two GPI alleles and a minimum of three EST alleles appear to be segregating in each population. Mean direct-count heterozygosity at these two loci ranged from 25% in the November sample from site 1 to 67% in the sample from site 10 (Table 38). Values for direct-count heterozygosity in most samples approximated those expected under conditions of Hardy-Weinberg equilibrium. However, the November collections from sites 1, 2 and 3 exhibited less than 64% of the expected variability (Table 38); this reduction in heterozygosity is reflected in the significant deviations from expected genotypic proportions (Table 39). Allele frequencies at the EST locus were significantly heterogeneous when comparisons were made among all Paddy's Run samples collected in November 1986 (Table 40) and when the two samples from site 1 were compared.

DISCUSSION

As benthic animals in Paddy's Run, mayflies are subject to pulsed runoff caused by periods of heavy rain and may be subject to FMPC waste materials. The fish community surveyed (Section II) represents taxa that occupy all levels of the Paddy's Run water column. A comparison of genetic structure of mayfly populations from above the FMPC with those on and below the FMPC allow us to determine whether changes occur in these organisms within the section of stream sampled.

Significant differences exist between mayflies from site 3 and those from other sites. *Stenonema* from this site had greatly reduced heterozygosity compared with expected values; contingency X^2 analyses demonstrated that 67% of the variable loci in mayflies from this site were significantly different from those in conspecifics from site 2. The distance between sites 2 and 3 is approximately 250 m. Lack of heterogeneity between *Stenonema* samples from sites 2 and 10, separated by approximately 2500 m, indicates that distance between sites within the stream is not a determinant of mayfly population heterogeneity.

The differences observed in *Stenonema* were also found in fish populations studied earlier (Section II). A non-conformation index was developed to determine correspondence of genotypic proportions to expected values for the fish community at each sampled site. Their data indicated a significantly higher percent non-conformation in the fish from site 3 than from site 2.

Significant variation also occurred among mayflies from sites in Paddy's Run at the southern end of the FMPC. Sixty-seven percent (four of six) of the variable loci in *Stenonema* from site 8 significantly varied from expected genotypic distributions; this degree of non-conformation paralleled mayfly samples from only site 3. Two variable loci failed to conform to expected values in *Stenonema* samples from sites immediately upstream (site 5/6) and downstream (site 9) from site 8. Chi-square heterogeneity tests indicate that while all individual locus comparisons between mayfly samples from adjacent sites (sites 8 vs 9; sites 9 vs 10) are non-significant, 50% of the heterogeneity comparisons between *Stenonema* from sites 8 and 10 show significant differentiation. These data suggest that selection is occurring on *Stenonema* specific to sediments at site 8 and there is a gradual change in possible effects on population structure downstream. Since heterogeneity does not exist in any comparison between mayflies from sites 2 and 10, recovery from the effects of perturbation at site 8 appears to be complete by site 10.

Only two (11%) of the loci were polymorphic in *Lirceus*. Isopod data from the 1986 sample indicate that populations from sites 1-3 in Paddy's Run were different genetically from those from site 4 and downstream. Significant lack of conformation to expected values under conditions of Hardy-Weinberg equilibrium occurred 83% of the time in the November sample from sites 1-3; only 10% of the 1986 collections from downstream sites were significantly different from expected. The only significant

deviation from expected genotypic proportions in the February 1987 sample was GPI-1 in the offsite reference sample. Thus, the genetic data suggest that either natural or human environmental disturbance upstream from site 1 in Paddy's Run caused a change in genetic structure of the isopod populations present in November 1986 at sites 1-3; subsequent to the 1986 sampling date, environmental conditions were altered and isopod population genetic structure in the upstream sites mirrored that present downstream. The FMPC does not appear to be affecting *Lirceus* genetic structure.

Data from analyses of midges are more difficult to interpret for several reasons. First, the percent polymorphic loci (14%) was lower than in mayflies (40%) and, therefore, only two loci were available for study. Second, midge taxonomy is extremely difficult. Presently, the most reliable species identifications are based on wing venation and internal genitalia of emerged adults or polytene chromosome analysis of larvae (Brennan 1981); we had to homogenize larvae in our analysis and, although electrophoretic patterns did not suggest that our samples were composed of mixed species, we cannot be certain that only one species was used. Third, *Chironomus* was not present at Harker's Run or at sites 1 and 2 in the November sample from Paddy's Run; this genus is usually present in sediments where environmental oxygen is low due to microbial decomposition of organic matter (Brennan 1981). We were able to collect it in February 1987. This episodic occurrence of *Chironomus* tends to negate its significance as a candidate for

monitoring genetic changes due to environmental disturbance.

RABBITS

METHODS

Ten eastern cottontail rabbits (*Sylvilagus floridanus*) were collected (March 19 - April 3, 1987) from the northern pine stand (PP-1, Fig. 1) and six were obtained from offsite areas. Rabbits on the FMPC were live-trapped using the trap design of Edwards (1975); offsite animals were collected by various methods between March 20 and June 3, 1987. Trapping effort at the FMPC yielded 16.1 cottontails per 1000 trap nights. Similar data are not available for offsite collections.

Equal portions of selected organs (heart, kidney, lung, liver and biceps femoris muscle) were removed from each rabbit and stored frozen at -70°C. Immediately prior to electrophoresis tissues from each rabbit were homogenized together and centrifuged at 18,000 g at 4°C. The supernatant was collected and used for electrophoretic analysis. Loci analyzed and buffers used are detailed in Table 1. Gels were 15% Sigma starch (Karlin and Guttman 1981) except for the LiOH system which was made with 13% Sigma starch.

Histochemical procedures followed Harris and Hopkinson (1976) and Selander et al. (1971). After the gels were stained, the genotypic composition of each sample at each locus was determined and recorded. Genotypic data were analyzed using the BIOSYS-I computer program (Swofford and Selander 1981).

Allele frequencies, deviations from expected genotypic proportions assuming Hardy-Weinberg equilibrium conditions, and amount of genetic variation were determined.

RESULTS

Half of the loci examined (AAT-1, AAT-2, ALD-2, GPI, IDH-2, LDH, MDH-1, MDH-2, PEP-2, SOD-1, SOD-2, TPI) were monomorphic in the two samples. No more than three alleles occurred at a polymorphic locus (Table 41). Allele frequencies and genetic variability parameters (Table 42) were similar in the two samples. A significant ($p < 0.01$) deviation from Hardy-Weinberg expected genotypic proportions occurred for the EST-1 locus in the offsite sample. Small sample sizes precluded the use of X^2 contingency tests for analysis of potential heterogeneity among groups.

DISCUSSION

The two *Sylvilagus floridanus* samples were genetically very similar. Rabbits onsite and offsite possessed the same level of genetic variation averaging 44% polymorphic loci and 16% heterozygosity. Scribner and Warren (1986) reported much lower levels of variation (P=23%; H=3%) in *S. floridanus* from Texas.

Genetic differences were not observed between the FMPC and offsite *S. floridanus* sampled, however rabbits are highly vagile and have large home ranges (Edwards, pers. com.). The rabbits caught in the northern pine plantation might have been transients or might only occur in the pine plantations for short periods of a day or week. Unequivocal data can only be obtained

after long-term monitoring of movements of these animals indicate the percentage of time they occur on the FMPC.

SUMMARY AND CONCLUSIONS

Vegetation was the dominant ground cover in 10 of 11 habitats studied on the FMPC during the spring, 1987. Litter was an important component of the ground cover in pine plantations and woodlots.

The vegetative cover on the FMPC was made up of 143 species of herbaceous plants. Almost two-thirds of the species found at the FMPC were present in only one or two of the 11 habitats. The species that were found throughout the FMPC were also the most abundant. Seventy species, including many grasses (Poaceae) and mustards (Brassicaceae), were found that have never been reported on the FMPC. Twelve species were found at the FMPC that have not been documented offsite in nearby parks and preserves.

High floral diversity was found in the northern pine plantation (PP1), southeastern woodlot (W2), and northern riparian system (RN1) as compared to similar onsite communities. Although more species were documented in spring than in summer (Section I), diversities by habitat were generally higher in summer. Spring community similarity patterns paralleled those of the summer.

Six important plant families and 10 species were listed as missing or in low abundance at the FMPC. The most notable

absences were squirrel-corn (*Dicentra canadensis*) and Dutchman's breeches (*D. cucullaria*), both of which have been documented in good abundance from several nearby offsite locations.

Forty taxa of benthic macroinvertebrates were collected from two onsite riffle/pool sampling stations on Paddy's Run and one similar offsite station on Harker's Run during February, 1987. Twenty-six, 21 and 20 taxa were collected at Paddy's Run site 1 (PR1), Paddy's Run site 11 (PR11), and Harker's Run site 1 (HR1), respectively. Representatives from 9 families were present at all three sampling locations. Non-biting midges (Chironomidae) constituted from 84 to 92% of all organisms, depending on site. Chironomids were present at every site and were usually 10-20 times more abundant than the next most dominant taxa. Diversity parameters were depressed at all three sites due to the high number of chironomids present. When Chironomids were excluded from the analysis, family diversity was near normal. As expected, the benthic communities on Paddy's Run were more similar to each other than to Harker's Run.

Benthic density in the riffle at PR11 was nearly twice that at PR1 and 50% greater than at HR1. High density at PR11 may be due to influxes of nutrient from agricultural and industrial runoff upstream, or to stream and substrate characteristics, or both. For the pool community, PR1 density was greatest and HR1 was least. Low benthic density in the pool at Harker's Run may be attributable to the low abundance of detritus and other organic material which could serve as food for benthic animals.

Nineteen fish species were collected in March (18 species) and June (18 species) from 6 sites on Paddy's Run in 1987. Thirteen species were collected in June, 1986, when only 3 sites were collected (Section I). The March 1987 collection was dominated by the bluntnose minnow, with the stoneroller minnow, rosefin shiner, orangethroat darter, and fantail darter also comprising a large proportion of the total community. In June, 1987, the stoneroller minnow was the dominant species, while the bluntnose minnow, silverjaw minnow, creek chub, johnny darter, and orangethroat darter each constituted a major portion of the piscine community.

Two stations were also sampled in Harker's Run. Fourteen total taxa were collected during the March and June sampling periods. Like Paddy's Run, Harker's Run was dominated by cyprinids and percids (darters). Fewer species were expected in Harker's Run because fewer sites were sampled and because Harker's Run is a lower order stream.

Based on this survey, Paddy's Run appears to support a diverse ichthyofauna. A modified Shannon-Weaver diversity index yielded overall values somewhat lower than Harker's Run in March, but higher in June. An examination of diversity at each site in Paddy's Run yielded several notable results. Site 2, located near the north boundary of FMPC, was consistently the most diverse site examined in Paddy's Run. Site 9, sampled only in March because of the lack of water in June, was by far the least diverse. Site 3 also had a low diversity in March, 1987, but was considerably more diverse in June, 1986 and 1987.

Increased diversity in June may have been caused by low water levels which forced fish to congregate. Sites 3 and 9 are located a short distance downstream from the drainage ditch north of the railroad trestle and the storm sewer outfall, respectively. At this time, it is not known whether the low species diversity observed at these sites in March was caused by runoff from these sources or some other factors affecting habitat quality.

Twelve species of spring migrant birds were recorded on the FMPC and 24 species from offsite areas. FMPC riparian and woodlot habitats were the richest, supporting 58% to 75% of the migrant species, respectively. The pattern of avian spring migration on the FMPC was characterized by few species, low numbers and no pronounced peaks of abundance. This pattern was similar to reports from offsite locations in southwestern Ohio during the same count period.

Two new breeding birds were added to the FMPC list bringing the total to 85. The new species were the wood duck (*Aix sponsa*) and house finch (*Carpodacus mexicanus*). The latter is important because of its recent explosive range expansion in southwestern Ohio.

Reproductive success and growth parameters of mourning doves (*Zenaida macroura*) and American robins (*Turdus migratorius*) were monitored from two onsite and two offsite locations during late spring, 1987. Hatching and fledging success of doves was significantly lower in the northern pines as compared to the southern pines. Nestlings of onsite dove

populations did not differ significantly from offsite nestlings in any of the five growth parameters measured. FMPC robin eggs from the northern pines weighed significantly less than robin eggs from the southern pines. FMPC robins showed significant suppressed growth in four of the five prefledging growth parameters measured. Species differences in suppressed growth could be attributed to species specific differences in diet or to potential onsite physiological stressors, including differences in accumulating radiological or chemical loads. Results suggest that FMPC populations may not be as healthy as previously reported (WMCO 1987:60).

No federally endangered plants or animals were recorded onsite. Cooper's hawks (*Accipiter cooperii*) were frequently sighted in the northern and southern pines. Cooper's hawks have been reported onsite during summer and winter and are listed as "threatened " in Ohio.

Five hundred and eighty four benthic macroinvertebrates [214 *Stenonema femoratum* (mayflies), 170 *Chironomus tentans* (midges) and 200 *Lirceus fontinalis* (isopods)] were collected from sites on Paddy's Run and an offsite reference creek and examined using starch gel electrophoresis. In addition, 10 eastern cottontail rabbits (*Sylvilagus floridanus*) trapped on the northern pine plantation and six others obtained offsite were compared using electrophoretic techniques.

Mayfly genetic data indicate that significant differences exist in population genetic structure at two sites (sites 3 and 8) in Paddy's Run. These changes in genetic structure occur

over a small distance. Similar patterns at site 3 have been reported for fish population genetic structure (Section II).

Genetic data from isopods suggest that natural or man-made disturbance above site 1 (north of the FMPC boundary) is affecting population structure. Significant deviations in genotypic distribution occurred in the November sample of isopods from sites 1 -3 as compared to *Lirceus* from other sites sampled.

Significant heterogeneity was not found between or among midge samples although significant deviations from expected genotypic proportions occurred at several sites. *Chironomus* tended to occur episodically and could only be collected at a site when adequate detritus was available; therefore, comparisons of seasonal patterns could not be determined.

Eastern cottontail rabbits from onsite and offsite did not differ genetically. However, unlike the benthic macroinvertebrates studied, rabbits are highly vagile and the amount of time that cottontails sampled from the FMPC actually spent onsite is unknown.

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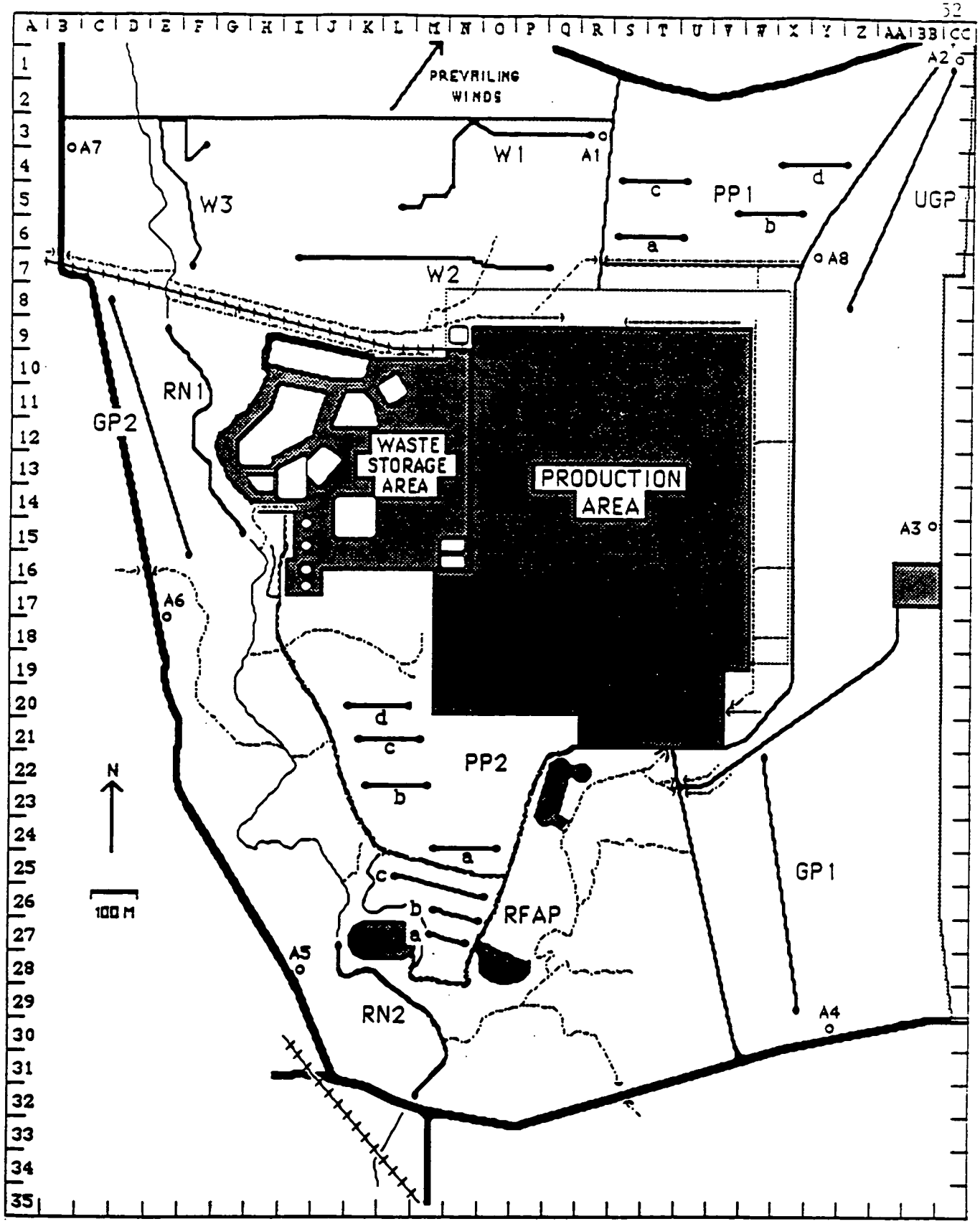

Figure 1. Locations of the permanent transects established and air monitoring stations(A) at the FMPC. UGP=ungrazed pasture; GP=grazed pasture; PP=pine plantation; RFAP=reclaimed fly ash pile; W=woodlot; RN=riparian.

290

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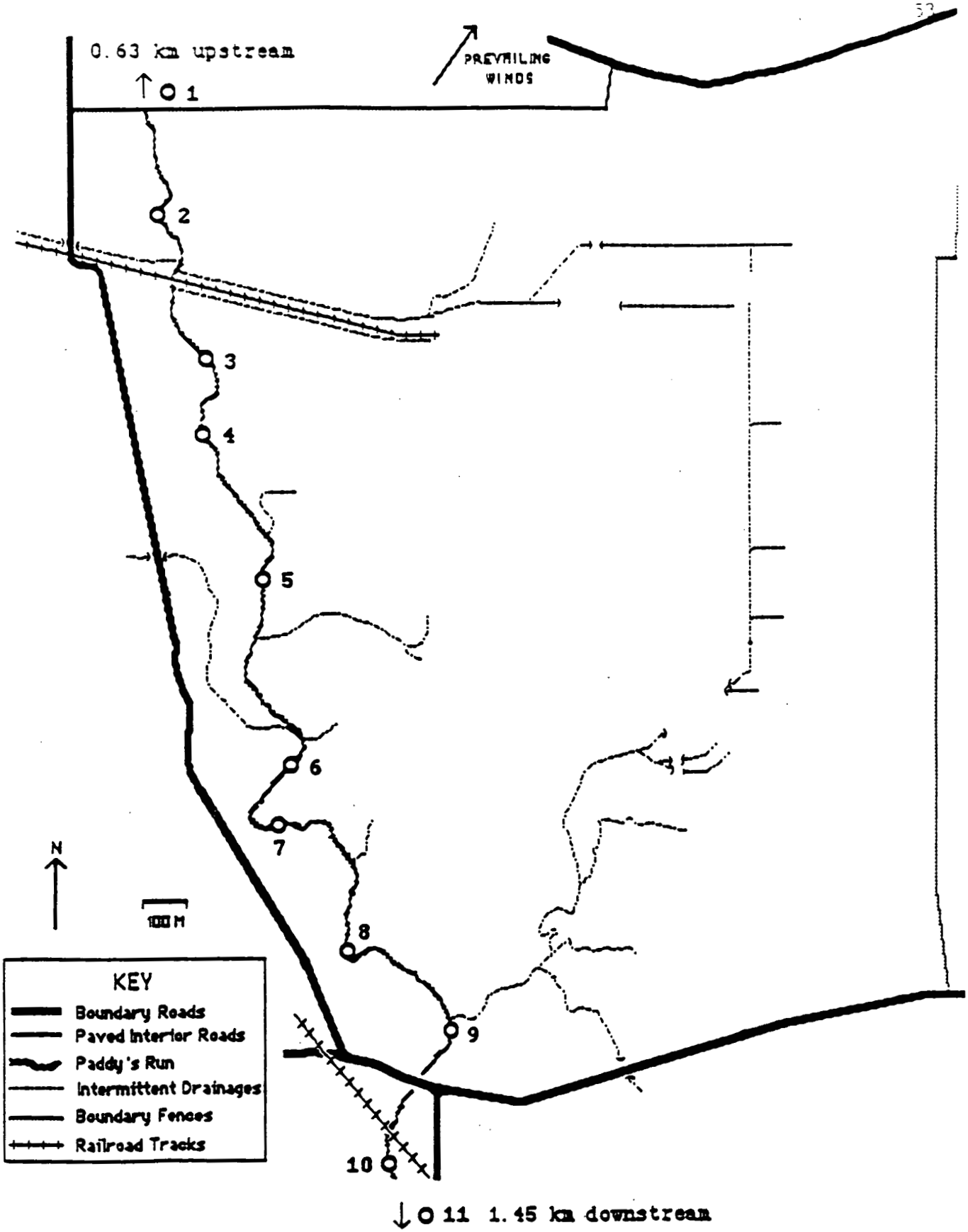

Figure 2. Fish and benthic sampling sites on Paddy's Run.

290

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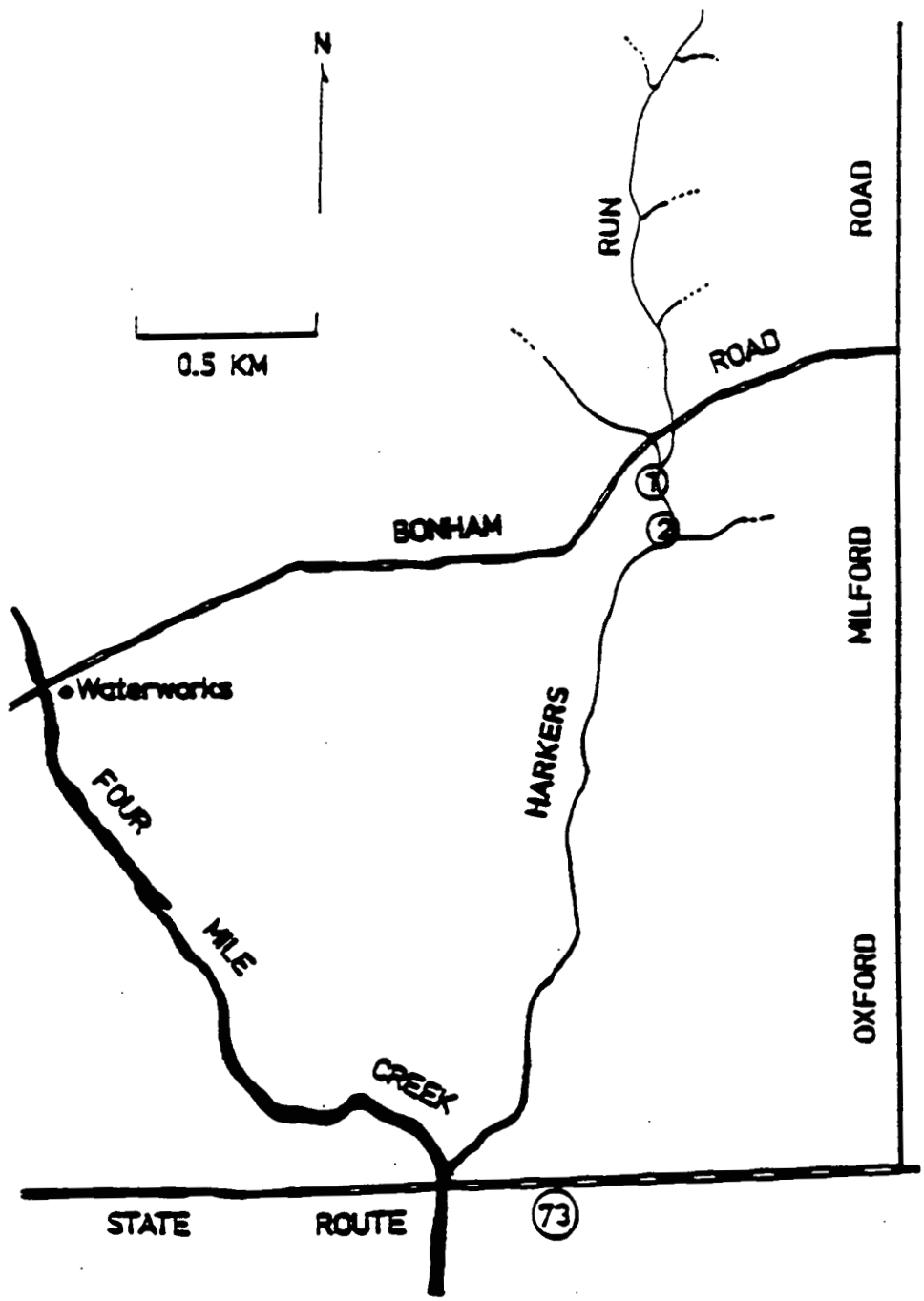

Figure 3. Fish and benthos sampling sites on Harker's Run, Butler County, Ohio.

290

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340

Table 1. Relative (%) cover of herbaceous vegetation at the FMPC, spring, 1987.

SPECIES	TRANSECTS										
	UGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
Equisetaceae											
Equisetum arvense Common horsetail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Pinaceae											
Pinus nigra Austrian pine	0.0	0.0	0.0	0.0	2.7	0.9	0.0	0.0	0.0	0.0	0.0
Pinus strobus White pine	0.0	0.0	0.0	0.0	1.7	4.4	0.0	0.0	0.0	0.0	0.0
Poaceae											
Bromus ciliatus Fringed brome	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Bromus inermis Smooth brome	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Bromus commutatus Hairy brome	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0
Bromus sp. Brome	0.8	0.0	1.7	1.3	7.5	9.6	0.0	0.0	0.0	0.0	20.4
Festuca rubra Red fescue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Festuca elatior Meadow fescue	0.0	0.0	0.0	0.0	0.0	0.0	10.8	0.0	3.0	0.0	0.0
Festuca obtusa Nodding fescue	0.0	0.0	0.0	0.0	1.4	0.0	0.0	1.0	0.0	4.1	0.0
Festuca sp. Fescue	52.6	52.4	59.6	30.5	7.3	10.5	0.0	0.0	0.0	1.3	0.5
Poa annua Annual bluegrass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
Poa compressa Canada bluegrass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.2
Poa pratensis Kentucky bluegrass	23.3	31.7	26.9	30.9	7.7	9.1	14.0	0.2	11.2	0.4	1.0
Poa sp. Bluegrass	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	1.3	0.0
Dactylis glomerata Orchard grass	22.5	0.0	0.8	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0
Agropyron sp. Wheatgrass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	0.0	0.0	0.0
Elymus virginicus Virginia wild-rye	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0
Elymus villosus Hairy wild-rye	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Hystrix patula Bottlebrush	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.2	0.0
Digitaria sp. Crabgrass	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown grasses	0.0	0.2	2.5	0.0	1.4	0.0	0.0	0.0	0.0	2.8	0.3
Cyperaceae											
Carex conjuncta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Carex scoparia Broom sedge	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Carex amphibola Narrowleaf sedge	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Carex blanda Woodland sedge	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	0.8	0.0	0.0
Carex sp. Sedge	•	0.2	1.7	0.0	2.9	3.8	0.0	0.0	0.0	0.2	0.7
Liliaceae											
Allium canadense Wild onion	0.8	0.0	0.0	0.0	0.0	0.0	0.5	0.2	0.3	0.9	0.3
Hemerocallis fulva Day lilly	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
Smilacina racemosa False Solomon's seal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	•	0.2	+

SPECIES	TRANSECTS										
	UGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
Trillium sessile Sessile trillium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	+
Smilax sp. Greenbrier	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0
Salicaceae											
Salix sp. Willow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0
Betulaceae											
Betula sp. Birch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Ulmaceae											
Ulmus rubra Slippery elm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3
Ulmus americana American elm	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2
Celtis occidentalis Hackberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
Urticaceae											
*Urtica dioica** Nettle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3
Boehmeria cylindrica False nettle	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.9	0.0
Aristolochiaceae											
Asarum canadense Wild ginger	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	•	0.2	0.0
Polygonaceae											
Rumex crispus Curly dock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Rumex sp. Dock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
Chenopodiaceae											
Chenopodium album Lamb's quarters	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Portulacaceae											
Claytonia virginica Spring beauty	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	•	0.2	0.0
Caryophyllaceae											
Stellaria media Common chickweed	0.0	0.3	0.0	+	0.5	0.0	6.8	9.7	12.3	6.9	20.1
Cerastium vulgatum Mouse-ear chickweed	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saponaria officinalis Bouncing bet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Ranunculaceae											
Ranunculus arbortivus Kidneyleaf buttercup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5
Ranunculus sp. Buttercup	0.0	+	0.0	0.4	0.0	1.1	0.8	2.2	0.0	0.2	•
Berberidaceae											
Podophyllum peltatum May apple	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	•
Papaveraceae											
Sanguinaria canadensis Bloodroot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	•	0.0	+
Fumariaceae											
Corydalis flavula Golden corydalis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	+	+
Brassicaceae											
Draba verna Whitlow-grass	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Thlaspi sp. Pennycress	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Capsella bursa-pastoris Shepard's purse	0.0	2.7	0.0	•	0.0	0.0	0.0	0.0	0.0	0.0	•
Allaria officinalis Garlic mustard	0.0	0.0	0.0	0.0	0.2	0.0	2.7	0.0	2.8	21.7	6.9
Barbarea vulgaris Winter cress	0.0	•	0.0	0.4	0.7	1.5	0.0	0.2	0.0	0.0	0.2
Dentaria laciniata Cut-leaved toothwort	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	+

SPECIES	TRANSECTS										
	UGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
Arabis laevigata Smooth rock cress	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Arabis sp. Rock cress	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Platanaceae											
Platanus occidentalis American sycamore	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.6	0.0
Rosaceae											
Potentilla canadensis Dwarf cinquefoil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Potentilla simplex Common cinquefoil	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0
Geum vernum Spring avens	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.8	1.8	0.0	0.0
Geum sp. Avens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.2	0.0
Rubus occidentalis Black raspberry	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	+0.4	0.0
Rubus sp.	0.0	0.0	0.0	0.0	0.3	6.2	0.5	2.2	0.0	0.0	0.0
Rosa multiflora Multiflowered rose	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.3	0.3	1.3	0.0
Prunus hortulana Goose plum		0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Prunus serotina Wild cherry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0
Prunus sp. Cherry	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Leguminosae											
Trifolium pratense Red clover	+	0.3	0.0	0.0	0.3	0.0	1.3	4.7	0.2	0.0	0.0
Trifolium repens White clover	+	6.6	3.4	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0
Melilotus officinalis Yellow sweet clover	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.2
Medicago lupulina Black medick	0.0	0.0	0.0	8.0	0.2	0.0	0.3	0.8	0.0	0.0	0.0
Robinia pseudoacacia Black locust	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Cercis canadensis Redbud	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Oxalidaceae											
*Oxalis stricta** Yellow wood-sorrel	•	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.2
Oxalis sp. Wood-sorrel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Anacardiaceae											
Rhus radicans Poison ivy	0.0	0.0	0.0	3.1	0.5	2.7	0.0	1.5	0.0	5.6	0.7
Celastraceae											
Celastrus scandens Bittersweet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Aceraceae											
Acer saccharum Sugar maple	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.2
Acer rubrum Red maple	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Acer negundo Box elder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	2.8	1.9
Hippocastanaceae											
Aesculus glabra Ohio buckeye	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Balsaminaceae											
Impatiens sp. Touch-me-not	0.0	0.0	0.0	0.0	0.2	0.0	2.3	0.0	1.3	0.9	0.5
Vitaceae											
Parthenocissus quinquefolia Virginia creeper	0.0	0.0	0.0	0.0	2.4	0.2	0.0	0.0	0.0	1.3	0.0

SPECIES	TRANSECTS										
	UGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
Vitis sp. Grape	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.0	0.2	0.3
Vitus riparia Riverbank grape	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	•	0.0
Violaceae											
Viola sp. Violet	•	0.0	0.0	0.0	0.2	0.2	0.0	0.0	1.0	0.4	0.2
Umbelliferae											
Sanicula sp. Black snakeroot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Chaerophyllum procumbens Wild chervil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	•	0.0
Osmorhiza claytoni Sweet cicely	0.0	0.0	0.0	0.0	0.2	0.0	0.3	0.8	1.8	0.2	0.3
Conium maculatum Poison hemlock	0.0	•	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.4	0.2
Pastinaca sativa Wild parsnip	0.0	0.0	0.0	0.0	2.9	0.7	0.0	0.0	0.0	0.0	0.0
Daucus carota Wild carrot	•	0.0	0.0	0.0	1.5	0.5	0.0	0.7	0.0	0.9	0.0
Cornaceae											
Cornus racemosa Red-panicle dogwood	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.5	0.0	0.0	0.0
Cornus sp. Dogwood	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Primulaceae											
Lysimachia nummularia Moneywort	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.2	•
Lysimachia sp. Loosestrife	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Epilobium sp. Willow-herb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	•
Oenothera biennis Common evening-primrose	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	•	0.0
Oleaceae											
Fraxinus americana White ash	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.8	0.0
Apocynaceae											
Apocynum sp. Dogbane	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Asclepiadaceae											
Asclepias syriaca Common milkweed	•	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Asclepias sp. Milkweed	0.0	0.0	0.0	0.9	0.0	1.3	0.0	0.0	0.0	0.0	0.2
Convolvulaceae											
Convolvulus sp. Bindweed	0.0	0.0	0.0	0.0	6.6	4.4	0.0	0.0	0.0	0.4	0.0
Polemoniaceae											
Phlox divaricata Blue phlox	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	•
Hydrophyllaceae											
Phacelia purshii Miami mist	0.0	0.0	0.0	0.0	0.0	0.0	1.3	3.3	0.0	3.0	2.8
Boraginaceae											
Mertensia virginica Virginica mertensia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	•
Labiatae											
Glechoma hederacea Ground-ivy	0.0	0.0	0.0	0.0	0.5	4.4	2.2	1.2	1.2	1.9	0.5
Lamium purpurium Purple dead-nettle	0.0	•	0.0	•	•	0.0	0.2	0.8	0.3	0.0	0.3
Lamium amplexicaule Henbit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	•
Unknown mint	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Scrophulariaceae											
Veronica sp. Speedwell	0.0	0.0	0.0	0.0	•	0.2	0.0	0.0	0.0	0.0	•
Veronica peregrina Purslane speedwell	0.0	•	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SPECIES	TRANSECTS										
	UGP	GP1	GP2	RFAP	PP1	PP2	W1	W2	W3	RN1	RN2
Bignoniaceae											
Campsis radicans Trumpet creeper	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Plantaginaceae											
Plantago major Common plantain	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.2	0.3	0.0	0.0
Plantago lanceolata English plantain	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0
Plantago sp. Plantain	+	1.0	0.0	0.0	+	0.0	0.0	0.0	0.0	0.0	0.0
Rubiaceae											
Galium aparine Cleavers	0.0	0.0	0.0	0.4	4.9	1.1	0.7	0.8	0.8	7.7	2.6
Galium sp. Bedstraw	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.7	0.0	+
Caprifoliaceae											
Lonicera japonica Japanese honeysuckle	0.0	0.0	0.0	0.9	0.0	0.0	1.7	0.0	0.0	0.0	0.0
Lonicera sp. Honeysuckle	0.0	0.0	0.0	2.7	0.0	0.0	0.7	0.0	0.0	0.2	0.3
Sambucus canadensis Common elderberry	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.5	0.0	0.0	0.0
Valerianaceae											
Valerianella sp. Corn salad	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.4	1.0
Valerianella intermedia	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.3	0.0	0.0	0.0
Compositae											
Vernonia gigantea Ironweed	+	0.0	0.0	0.0	+	0.0	0.0	0.0	0.0	0.2	0.0
Eupatorium sp. Thoroughwort	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.4	0.3
Aster sp. Aster	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.9	2.6
Solidago sp. Goldenrod	0.0	0.0	0.0	5.2	8.0	1.8	5.2	9.8	0.8	7.7	1.7
Erigeron sp. Fleabane	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ambrosia sp. Ragweed	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Polymnia sp. Leafcup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.4
Verbesina alternifolia Crown-beard	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Bidens vulgata Beggar-ticks	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Achillea millefolium Yarrow	+	0.3	0.0	+	0.3	0.2	1.5	3.3	0.0	0.0	0.0
Senecio sp. Ragwort	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	+	0.0	+
Cirsium sp. Thistle	+	+	0.0	0.0	1.5	0.0	0.0	0.2	0.0	0.0	0.0
Taraxacum officinale Common dandelion	+	0.0	0.0	+	0.5	0.2	0.3	0.8	0.5	0.4	+
Lactuca biennis Blue lettuce	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Unknown Compositae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Unknown	0.0	0.0	0.0	0.0	0.4	0.8	0.0	0.0	0.0	0.2	0.0
SUBTOTALS	100.0	99.6	100.0	86.8	77.7	84.0	62.3	73.8	47.1	92.3	72.8
Litter	0.0	0.4	0.0	4.1	22.3	15.9	29.0	21.0	46.9	2.1	9.8
Soil	0.0	0.0	0.0	8.1	0.0	0.6	8.7	5.2	6.0	1.5	9.4
Rock	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	4.1	8.0
TOTAL	100	100	100	100	100	100	100	100	100	100	100

*Species identification has been changed from those previously reported (Osborne et al. 1987a): Urtica dioica from U. procera. Oxalis stricta from O. europaea.

Table 2. Community parameters for herbaceous vegetation of the FMPC, spring, 1987.*

HABITAT	Species Richness** (R)	Simpson Diversity (D)	Simpson Dominance (C)	Shannon Diversity (H')	Pielou Evenness (J')
UGP	5(19)	0.624	0.376	1.577	0.679
GP1	12(18)	0.616	0.384	1.786	0.498
GP2	8(8)	0.572	0.428	1.673	0.558
RFAP	15(20)	0.741	0.259	2.467	0.632
PP1	48(52)	0.941	0.059	4.542	0.813
PP2	34(34)	0.895	0.105	3.746	0.736
W1	32(32)	0.892	0.108	3.865	0.773
W2	41(41)	0.934	0.066	4.426	0.826
W3	29(33)	0.864	0.136	3.665	0.755
RN1	67(72)	0.916	0.084	4.606	0.759
RN2	42(60)	0.831	0.169	3.478	0.645

*Values were based on species scored along the transects (Fig. 1) and calculated using log base 2.
**Richness values in parentheses include species observed in the habitat but not scored along transects.

Table 3. Community similarity indices for herbaceous vegetation of the FMPC, spring, 1987.

Similarity Index*	UGP vs GP1	UGP vs GP2	GP1 vs GP2	PP1 vs PP2	RFAP vs UGP	RFAP vs W1	W1 vs W2	W1 vs W3	W2 vs W3	RN1 vs RN2
Jaccard Coefficient	0.133	0.444	0.333	0.375	0.176	0.174	0.431	0.463	0.277	0.283
Quotient of Similarity	0.235	0.615	0.500	0.545	0.300	0.297	0.602	0.633	0.434	0.442
Percent Similarity	75.8	77.4	83.2	53.1	59.2	32.0	40.6	62.0	26.4	37.1
Morisita's Index	0.916	0.931	0.985	0.764	0.829	0.462	0.379	0.821	0.393	0.401

* Indices calculated from percent relative cover (Table 1).

Table 4. Species richness of herbaceous vegetation in the spring and summer at the FMPC.

HABITAT	Species Richness* Spring, 1987 (R)	Species Richness Summer, 1986 (R')	Change in Richness (R-R')	Number of New Species in Spring (N)	Total Species Richness** (R'+N)
UGP	5(19)	22	(-)17	12	34
GP1	12(18)	13	(-) 1	14	27
GP2	8(8)	16	(-) 8	3	19
RFAP	15(20)	29	(-)14	14	43
PP1	48(52)	37	(+)11	28	65
PP2	34(34)	30	(+) 4	18	48
W1	32(32)	38	(-) 6	22	60
W2	41(41)	39	(+) 2	32	71
W3	29(33)	33	(-) 4	24	57
RN1	67(72)	37	(+)30	47	84
RN2	42(60)	43	(-) 1	44	87

*Richness values in parentheses include species observed in the habitat but not scored along transects.
**Total number of herbaceous species found (not necessarily along transects) during summer and spring.

Table 5a. Density (number/square meter) of benthic macroinvertebrates collected from riffles at two sites on Paddy's Run and one site on Hanker's Run, February, 1987.

TAXA	SITE		
	PR1	PR11	HR1
NEMOTODA	3.6	10.7	0.0
MOLLUSCA			
GASTROPODA			
Ancylidae	14.3	28.6	0.0
Physidae	0.0	0.0	0.0
ANNELIDA			
OLIGOCHAETA			
Tubificidae	0.0	0.0	0.0
Enchytraeidae	14.3	342.8	5.3
ARTHROPODA			
CRUSTACEA			
ISOPODA			
Asellidae	14.3	7.1	5.3
DECAPODA			
Cambaridae	0.0	0.0	0.0
ARACHNIDA			
HYDRACARINA	0.0	14.3	16.0
INSECTA			
EPHEMEROPTERA			
Caenidae	3.6	32.1	37.3
Heptageniidae	0.0	3.6	0.0
Baetidae	3.6	0.0	5.3
Ephemeridae	0.0	0.0	0.0
Siphlonuridae	0.0	7.1	0.0
PLECOPTERA			
Capniidae	342.8	64.3	111.9
Nemouridae	3.6	0.0	0.0
Perlodidae	0.0	0.0	0.0
Leuctridae	10.7	0.0	0.0
Taeniopterygidae	7.1	3.6	0.0
COLEOPTERA			
Psephenidae	50.0	25.0	85.3
Elmidae	17.9	21.4	0.0
Curculionidae	0.0	0.0	5.3
Hydraenidae	3.6	0.0	0.0
TRICHOPTERA			
Hydropsychidae	14.3	39.3	90.6
Helicopsychidae	7.1	0.0	549.0
Psychomyiidae	103.6	71.4	42.6
Limnephilidae	3.6	0.0	0.0
Polycentropodidae	10.7	3.6	0.0
Leptoceridae	0.0	0.0	5.3
Glossosomatidae	0.0	0.0	5.3
Rhyacophilidae	0.0	0.0	26.7
LEPIDOPTERA			
Lymnaeidae	0.0	0.0	0.0
DIPTERA			
Chironomidae	4163.8	8395.4	5468.6
Simuliidae	0.0	21.4	32.0
Tipulidae	10.7	35.7	5.3
Psychodidae	0.0	0.0	10.7
Tabanidae	17.9	7.1	0.0
Empididae	0.0	10.7	5.3
Ceratopogonidae	0.0	0.0	5.3
Ephydridae	0.0	3.6	0.0
Unidentified	3.6	0.0	0.0
TOTAL	4824.4	9148.9	6518.6

Table 5b. Density (number/square meter) of benthic macroinvertebrates collected from pools at two sites on Paddy's Run and one site on Harker's Run, February, 1987.

TAXA	SITE		
	PR1	PR11	HR1
NEMOTODA	15.9	0.0	0.0
ANNELIDA			
OLIGOCHAETA			
Tubificidae	31.8	0.0	0.0
Enchytraeidae	286.5	0.0	0.0
ARTHROPODA			
INSECTA			
EPHEMEROPTERA			
Caenidae	47.7	0.0	0.0
Ephemeridae	15.9	0.0	0.0
PLECOPTERA			
Capniidae	0.0	0.0	15.9
Perlodidae	0.0	31.8	0.0
TRICHOPTERA			
Psychomyiidae	15.9	0.0	0.0
LEPIDOPTERA			
Lymnaeidae	15.9	0.0	0.0
DIPTERA			
Chironomidae	3374.0	206.9	0.0
Ceratopogonidae	63.7	0.0	0.0
TOTAL	3867.3	238.7	15.9

Table 5c. Community parameters for benthic macroinvertebrates of Paddy's Run and Harker's Run, Februrary, 1987.*

SITE	Number of Families	Simpson Diversity (D)	Simpson Dominance (C)	Shannon Diversity (H')	Pielou Evenness (J')
PR1	26	0.254(0.779)	0.746(0.221)	1.012(3.109)	0.215(0.670)
PR11	21	0.156(0.772)	0.844(0.228)	0.663(3.056)	0.151(0.707)
HR1	20	0.289(0.701)	0.711(0.299)	1.057(2.589)	0.245(0.610)

*Values in parentheses exclude Chironomidae. All values were calculated using log base 2.

Table 5d. Community similarity indices for benthic macroinvertebrates of Paddy's Run and Harker's Run, February, 1987*.

SIMILARITY INDEX	PR1 vs. PR11	PR1 vs. HR1	PR11 vs. HR1
Jaccard Coefficient	0.424	0.352	0.413
Quotient of Similarity	0.595	0.521	0.585
Percent Similarity	90.9(46.4)	88.1(28.4)	86.9(30.8)
Morisita's Index	0.995(0.453)	0.993(0.255)	0.990(0.097)

*Similarity values in parentheses exclude Chironomidae.

Table 6. Catch data for fish collected from Paddy's Run, Site 1, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/20 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	2	0	0.01	0.00
White sucker *Catostomus commersoni*	2	0	0.01	0.00
Stoneroller minnow *Campostoma anomalum*	8	7	0.04	0.07
Bluntnose minnow *Pimephales notatus*	70	9	0.37	0.10
Rosefin shiner *Notropis ardens*	55	4	0.29	0.04
Striped shiner *Notropis chrysocephalus*	10	1	0.05	0.01
Spotfin shiner *Notropis spilopterus*	8	0	0.04	0.00
Blacknose dace *Rhinichthys atratulus*	0	1	0.00	0.01
Johnny darter *Etheostoma nigrum*	31	2	0.17	0.02
Orangethroat darter *Etheostoma spectabile*	0	39	0.00	0.42
Fantail darter *Etheostoma flabellare*	1	31	0.01	0.33
Totals =	187	94	0.99	1.00

Table 7. Catch data for fish collected from Paddy's Run, Site 2, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/20 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	2	0	0.01	0.00
White sucker *Catostomus commersoni*	5	0	0.02	0.00
Stoneroller minnow *Campostoma anomalum*	26	12	0.11	0.09
Bluntnose minnow *Pimephales notatus*	23	0	0.10	0.00
Silverjaw minnow *Ericymba buccata*	13	0	0.05	0.00
Rosefin shiner *Notropis ardens*	59	0	0.25	0.00
Striped shiner *Notropis chrysocephalus*	34	0	0.14	0.00
Spotfin shiner *Notropis spilopterus*	51	0	0.21	0.00
Sand shiner *Notropis stramineus*	2	0	0.01	0.00
Emerald shiner *Notropis atherinoides*	1	0	0.004	0.00
Blacknose dace *Rhinichthys atratulus*	0	5	0.00	0.04
Johnny darter *Etheostoma nigrum*	8	0	0.03	0.00
Orangethroat darter *Etheostoma spectabile*	9	40	0.04	0.33
Fantail darter *Etheostoma flabellare*	6	66	0.025	0.54
Totals =	239	123	1.00	1.00

Table 8. Catch data for fish collected from Paddy's Run, Site 3, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/20 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	3	1	0.006	0.02
Stoneroller minnow *Campostoma anomalum*	3	31	0.006	0.48
Bluntnose minnow *Pimephales notatus*	387	8	0.75	0.12
Rosefin shiner *Notropis ardens*	17	0	0.03	0.00
Spotfin shiner *Notropis spilopterus*	73	0	0.14	0.00
Blacknose dace *Rhinichthys atratulus*	5	5	0.01	0.07
Redbelly dace *Phoxinus erythrogaster*	1	0	0.002	0.00
Johnny darter *Etheostoma nigrum*	24	0	0.05	0.00
Orangethroat darter *Etheostoma spectabile*	4	15	0.01	0.23
Fantail darter *Etheostoma flabellare*	0	5	0.00	0.07
Sunfish *Lepomis complex*	1	0	0.002	0.00
Totals =	518	65	1.006	0.99

Table 9. Catch data for fish collected from Paddy's Run, Site 5, expressed as catch per unit effort and proportion of catch. The site collected was located one pool/riffle above that indicated in Fig. 2.

Species	Catch per unit effort (fish/20 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	6	10	0.13	0.09
Stoneroller minnow *Campostoma anomalum*	17	33	0.38	0.31
Bluntnose minnow *Pimephales notatus*	3	9	0.07	0.09
Silverjaw minnow *Ericymba buccata*	0	2	0.00	0.02
Striped shiner *Notropis chrysocephalus*	4	5	0.09	0.05
Spotfin shiner *Notropis spilopterus*	6	14	0.13	0.13
Johnny darter *Etheostoma nigrum*	2	0	0.04	0.00
Orangethroat darter *Etheostoma spectabile*	4	28	0.09	0.27
Fantail darter *Etheostoma flabellare*	3	4	0.07	0.04
Totals =	45	105	1.00	1.00

Table 10. Catch data for fish collected from Paddy's Run, Site 9, expressed as catch per unit effort and proportion of catch. The site collected was located one pool/riffle below that indicated in Fig. 2.

Species	Catch per unit effort (fish/20 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	4	0	0.36	0.00
Stoneroller minnow *Campostoma anomalum*	6	13	0.55	0.93
Orangethroat darter *Etheostoma spectabile*	0	1	0.00	0.07
Sunfish *Lepomis complex*	1	0	0.09	0.00
Totals =	11	14	1.00	1.00

Table 11. Catch data for fish collected from Paddy's Run, Site 11, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/20 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	42	2	0.08	0.01
White sucker *Catostomus commersoni*	8	0	0.02	0.00
Stoneroller minnow *Campostoma anomalum*	92	22	0.17	0.10
Bluntnose minnow *Pimephales notatus*	268	3	0.51	0.01
Silverjaw minnow *Ericymba buccata*	6	0	0.01	0.00
Suckermouth minnow *Phenacobius mirabilis*	0	2	0.00	0.01
Rosefin shiner *Notropis ardens*	1	9	0.002	0.04
Spotfin shiner *Notropis spilopterus*	69	0	0.13	0.00
Blacknose dace *Rhinichthys atratulus*	8	4	0.02	0.02
Johnny darter *Etheostoma nigrum*	11	5	0.02	0.02
Orangethroat darter *Etheostoma spectabile*	22	146	0.04	0.65
Fantail darter *Etheostoma flabellare*	0	30	0.00	0.13
Rainbow darter *Etheostoma caeruleum*	0	1	0.00	0.001
Sunfish *Lepomis complex*	1	0	0.002	0.00
Totals =	528	224	1.004	1.00

Table 12. Total fish catch data for Paddy's Run. Mean catch per unit effort (CPUE) calculated for 6 pools and 6 riffles.

Species	N	Proportion of total catch	Mean (± S.E.) CPUE (f/20 min)
Creek chub *Semotilus atromaculatus*	72	0.03	6.0(3.4)
White sucker *Catostomus commersoni*	15	0.01	1.3(0.8)
Silverjaw minnow *Ericymba buccata*	21	0.01	1.8(1.1)
Stoneroller minnow *Campostoma anomalum*	270	0.13	22.5(6.9)
Bluntnose minnow *Pimephales notatus*	780	0.34	65.0(36.6)
Suckermouth minnow *Phenacobius mirabilis*	2	0.001	0.2(0.2)
Rosefin shiner *Notropis ardens*	145	0.07	12.1 (6.2)
Striped shiner *Notropis chrysocephalus*	54	0.02	4.5(2.8)
Spotfin shiner *Notropis spilopterus*	221	0.10	18.4(8.2)
Sand shiner *Notropis stramineus*	2	0.001	0.2(0.2)
Emerald shiner *Notropis atherinoides*	1	0.001	0.1(0.1)
Blacknose dace *Rhinichthys atratulus*	28	0.02	2.3(0.8)
Redbelly dace *Phoxinus erythrogaster*	1	0.001	0.1(0.1)
Johnny darter *Etheostoma nigrum*	83	0.04	6.9(3.0)
Orangethroat darter *Etheostoma spectabile*	308	0.16	25.7(11.7)
Fantail darter *Etheostoma flabellare*	146	0.07	12.1(5.9)
Rainbow darter *Etheostoma caeruleum*	1	0.001	0.1 (0.1)
Sunfish *Lepomis complex*	3	0.001	0.3(0.13)
Totals	2153	1.006	

Table 13. Catch data for fish collected from Harker's Run, Site 1, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/20 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	14	20	0.10	0.19
White sucker *Catostomus commersoni*	1	0	0.01	0.00
Stoneroller minnow *Campostoma anomalum*	6	11	0.04	0.11
Bluntnose minnow *Pimephales notatus*	28	2	0.20	0.02
Silverjaw minnow *Ericymba buccata*	47	0	0.33	0.00
Striped shiner *Notropis chrysocephalus*	8	6	0.06	0.06
Spotfin shiner *Notropis spilopterus*	20	2	0.14	0.02
Blacknose dace *Rhinichthys atratulus*	3	22	0.02	0.21
Johnny darter *Etheostoma nigrum*	13	5	0.09	0.05
Orangethroat darter *Etheostoma spectabile*	0	2	0.00	0.02
Fantail darter *Etheostoma flabellare*	1	34	0.01	0.32
Totals =	141	104	1.00	1.00

Table 14. Catch data for fish collected from Harker's Run, Site 2, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/20 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	19	9	0.23	0.08
White sucker *Catostomus commersoni*	7	6	0.09	0.05
Stoneroller minnow *Campostoma anomalum*	4	42	0.05	0.35
Bluntnose minnow *Pimephales notatus*	10	0	0.12	0.00
Rosefin shiner *Notropis ardens*	1	0	0.01	0.00
Striped shiner *Notropis chrysocephalus*	10	5	0.12	0.04
Spotfin shiner *Notropis spilopterus*	10	0	0.12	0.00
Blacknose dace *Rhinichthys atratulus*	0	7	0.00	0.06
Redbelly dace *Phoxinus erythrogaster*	12	0	0.14	0.00
Johnny darter *Etheostoma nigrum*	10	0	0.12	0.00
Fantail darter *Etheostoma flabellare*	0	50	0.00	0.42
Totals =	83	119	1.00	1.00

Table 15. Total fish catch data for Harker's Run. Mean catch per unit effort (CPUE) calculated for 2 pools and 2 riffles.

Species	N	Proportion of total catch	Mean (± S.E.) CPUE (f/20 min)
Creek chub *Semotilus atromaculatus*	62	0.14	15.5(2.5)
White sucker *Catostomus commersoni*	14	0.03	3.5(1.8)
Silverjaw minnow *Ericymba buccata*	47	0.11	11.8(11.8)
Stoneroller minnow *Campostoma anomalum*	63	0.14	15.8(8.9)
Bluntnose minnow *Pimephales notatus*	40	0.09	10.0(6.4)
Rosefin shiner *Notropis ardens*	1	0.002	0.3(0.3)
Striped shiner *Notropis chrysocephalus*	29	0.064	7.3(1.1)
Spotfin shiner *Notropis spilopterus*	32	0.07	8.0(4.5)
Blacknose dace *Rhinichthys atratulus*	32	0.07	8.0(4.9)
Redbelly dace *Phoxinus erythrogaster*	12	0.03	3.0(3.0)
Johnny darter *Etheostoma nigrum*	28	0.06	7.0(2.9)
Orangethroat darter *Etheostoma spectabile*	2	0.004	0.5(0.5)
Fantail darter *Etheostoma flabellare*	85	0.19	21.3(12.4)
Totals	447	1.000	

Table 16. Modified Shannon-Weaver indices (d') calculated from catch data for Paddy's Run (June, 1986, and March, 1987, collections) and Harkers Run (March,1987, collection).

Site Number	Paddy's Run		Harker's Run
	Jun-86	Mar-87	Mar-87
1	2.9	2.8	3.1
2	2.6	3.2	3.0
3	1.3	1.7	
4		2.6	
5		1.1	
6		2.6	
combined	2.7	2.9	3.3

Table 17. Catch data for fish collected from Paddy's Run, Site 1, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/15 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	7	2	0.02	0.04
White sucker *Catostomus commersoni*	5	0	0.02	0.00
Stoneroller minnow *Campostoma anomalum*	155	8	0.47	0.15
Bluntnose minnow *Pimephales notatus*	54	0	0.16	0.00
Rosefin shiner *Notropis ardens*	80	0	0.24	0.00
Striped shiner *Notropis chrysocephalus*	10	0	0.03	0.00
Spotfin shiner *Notropis spilopterus*	3	0	0.01	0.00
Blacknose dace *Rhinichthys atratulus*	1	12	0.003	0.22
Redbelly dace *Phoxinus erythrogaster*	1	0	0.003	0.00
Johnny darter *Etheostoma nigrum*	12	0	0.04	0.00
Orangethroat darter *Etheostoma spectabile*	0	23	0.00	0.42
Fantail darter *Etheostoma flabellare*	3	10	0.01	0.18
Totals =	332	55	1.006	1.01

Table 18. Catch data for fish collected from Paddy's Run, Site 2, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/15 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	46	0	0.13	0.00
White sucker *Catostomus commersoni*	4	0	0.01	0.00
Stoneroller minnow *Campostoma anomalum*	154	10	0.44	0.13
Bluntnose minnow *Pimephales notatus*	27	0	0.08	0.00
Silverjaw minnow *Ericymba buccata*	19	0	0.05	0.00
Rosefin shiner *Notropis ardens*	25	0	0.07	0.00
Striped shiner *Notropis chrysocephalus*	13	0	0.04	0.00
Spotfin shiner *Notropis spilopterus*	8	0	0.02	0.00
Blacknose dace *Rhinichthys atratulus*	3	6	0.01	0.08
Redbelly dace *Phoxinus erythrogaster*	3	0	0.01	0.00
Johnny darter *Etheostoma nigrum*	28	1	0.08	0.01
Orangethroat darter *Etheostoma spectabile*	18	18	0.05	0.23
Fantail darter *Etheostoma flabellare*	2	42	0.01	0.54
Rainbow darter *Etheostoma caeruleum*	0	1	0.00	0.01
Largemouth bass *Micropterus salmoides*	2	0	0.01	0.00
Totals =	352	78	1.00	1.00

Table 19. Catch data for fish collected from Paddy's Run, Site 3, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/15 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	28	1	0.06	0.010
Stoneroller minnow *Campostoma anomalum*	99	66	0.23	0.38
White sucker *Catostomus commersoni*	4	0	0.01	0.00
Bluntnose minnow *Pimephales notatus*	121	6	0.28	0.03
Silverjaw minnow *Ericymba buccata*	43	0	0.10	0.00
Rosefin shiner *Notropis ardens*	8	0	0.02	0.00
Spotfin shiner *Notropis spilopterus*	13	0	0.03	0.00
Sand shiner *Notropis stramineus*	1	0	0.002	0.00
Emerald shiner *Notropis atherinoides*	0	1	0.00	0.01
Blacknose dace *Rhinichthys atratulus*	11	10	0.03	0.06
Johnny darter *Etheostoma nigrum*	85	14	0.19	0.08
Orangethroat darter *Etheostoma spectabile*	20	60	0.05	0.34
Fantail darter *Etheostoma flabellare*	1	16	0.002	0.09
Largemouth bass *Micropterus salmoides*	1	0	0.002	0.00
Totals =	439	174	1.016	1.00

Table 20. Catch data for fish collected from Paddy's Run, Site 5, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/15 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	8	0	0.04	0.00
White sucker *Catostomus commersoni*	8	0	0.04	0.00
Stoneroller minnow *Campostoma anomalum*	4	0	0.02	0.00
Bluntnose minnow *Pimephales notatus*	14	0	0.07	0.00
Silverjaw minnow *Ericymba buccata*	57	0	0.29	0.00
Rosefin shiner *Notropis ardens*	10	0	0.05	0.00
Spotfin shiner *Notropis spilopterus*	13	0	0.07	0.00
Johnny darter *Etheostoma nigrum*	77	0	0.39	0.00
Largemouth bass *Micropterus salmoides*	5	0	0.03	0.00
Sunfish *Lepomis complex*	1	0	0.01	0.00
Totals =	197	0	1.01	0.00

Table 21. Catch data for fish collected from Paddy's Run, Site 10, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/15 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	9	0	0.09	0.00
White sucker *Catostomus commersoni*	4	0	0.04	0.00
Stoneroller minnow *Campostoma anomalum*	3	0	0.03	0.00
Bluntnose minnow *Pimephales notatus*	4	0	0.04	0.00
Silverjaw minnow *Ericymba buccata*	10	0	0.10	0.00
Rosefin shiner *Notropis ardens*	1	0	0.01	0.00
Spotfin shiner *Notropis spilopterus*	4	0	0.04	0.00
Blacknose dace *Rhinichthys atratulus*	4	0	0.04	0.00
Johnny darter *Etheostoma nigrum*	47	0	0.48	0.00
Fantail darter *Etheostoma flabellare*	6	0	0.06	0.00
Largemouth bass *Micropterus salmoides*	1	0	0.01	0.00
Sunfish *Lepomis complex*	4	0	0.04	0.00
Totals =	97	0	0.98	0.00

Table 22. Catch data for fish collected from Paddy's Run, Site 11, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/15 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	37	0	0.36	0.00
Stoneroller minnow *Campostoma anomalum*	4	0	0.04	0.00
Bluntnose minnow *Pimephales notatus*	9	0	0.09	0.00
Silverjaw minnow *Ericymba buccata*	1	0	0.01	0.00
Spotfin shiner *Notropis spilopterus*	5	0	0.05	0.00
Blacknose dace *Rhinichthys atratulus*	12	4	0.12	0.04
Johnny darter *Etheostoma nigrum*	9	0	0.09	0.00
Orangethroat darter *Etheostoma spectabile*	24	73	0.24	0.74
Fantail darter *Etheostoma flabellare*	0	22	0.00	0.22
Sunfish *Lepomis complex*	1	0	0.01	0.00
Totals =	102	99	1.01	1.00

Table 23. Total fish catch data for Paddy's Run. Mean catch per unit effort (CPUE) calculated for 6 pools and 4 riffles.

Species	N	Proportion of total catch	Mean (± S.E.) CPUE (f/15 min)
Creek chub *Semotilus atromaculatus*	138	0.07	13.8(5.3)
White sucker *Catostomus commersoni*	25	0.01	2.5(0.9)
Silverjaw minnow *Ericymba buccata*	131	0.07	13.1(6.5)
Stoneroller minnow *Campostoma anomalum*	503	0.26	50.3(20.2)
Bluntnose minnow *Pimephales notatus*	235	0.12	23.5(12.1)
Rosefin shiner *Notropis ardens*	124	0.06	12.4 (7.9)
Striped shiner *Notropis chrysocephalus*	27	0.01	2.7(1.5)
Spotfin shiner *Notropis spilopterus*	46	0.02	4.6(1.6)
Sand shiner *Notropis stramineus*	1	0.001	0.1(0.1)
Emerald shiner *Notropis atherinoides*	1	0.001	0.1(0.1)
Blacknose dace *Rhinichthys atratulus*	63	0.03	6.3(1.5)
Redbelly dace *Phoxinus erythrogaster*	4	0.002	0.4(0.3)
Johnny darter *Etheostoma nigrum*	273	0.14	27.3(10.1)
Orangethroat darter *Etheostoma spectabile*	236	0.12	23.6(7.8)
Fantail darter *Etheostoma flabellare*	102	0.05	10.2(4.2)
Rainbow darter *Etheostoma caeruleum*	1	0.001	0.1 (0.1)
Largemouth bass *Micropterus salmoides*	9	0.005	0.9(0.5)
Sunfish *Lepomis complex*	6	0.003	0.6(0.4)
Totals	1925	0.973	

Table 24. Catch data for fish collected from Harker's Run, Site 1, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/15 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	65	39	0.11	0.41
White sucker *Catostomus commersoni*	105	3	0.18	0.03
Stoneroller minnow *Campostoma anomalum*	170	12	0.28	0.13
Bluntnose minnow *Pimephales notatus*	17	0	0.03	0.00
Silverjaw minnow *Ericymba buccata*	145	0	0.24	0.00
Striped shiner *Notropis chrysocephalus*	4	0	0.01	0.00
Spotfin shiner *Notropis spilopterus*	5	0	0.01	0.00
Blacknose dace *Rhinichthys atratulus*	9	0	0.02	0.00
Redbelly dace *Phoxinus erythrogaster*	28	3	0.05	0.03
Johnny darter *Etheostoma nigrum*	49	15	0.08	0.16
Orangethroat darter *Etheostoma spectabile*	2	3	0.003	0.03
Fantail darter *Etheostoma flabellare*	0	21	0.00	0.22
Totals =	599	96	1.013	1.01

Table 25. Catch data for fish collected from Harker's Run, Site 2, expressed as catch per unit effort and proportion of catch.

Species	Catch per unit effort (fish/15 min)		Proportion of catch	
	Pool	Riffle	Pool	Riffle
Creek chub *Semotilus atromaculatus*	45	47	0.08	0.52
White sucker *Catostomus commersoni*	40	3	0.07	0.03
Silverjaw minnow *Ericymba buccata*	6	0	0.01	0.00
Stoneroller minnow *Campostoma anomalum*	361	16	0.67	0.18
Bluntnose minnow *Pimephales notatus*	17	1	0.03	0.01
Rosefin shiner *Notropis ardens*	14	0	0.03	0.00
Striped shiner *Notropis chrysocephalus*	13	0	0.02	0.00
Spotfin shiner *Notropis spilopterus*	18	0	0.03	0.00
Blacknose dace *Rhinichthys atratulus*	0	12	0.00	0.13
Redbelly dace *Phoxinus erythrogaster*	7	0	0.01	0.00
Johnny darter *Etheostoma nigrum*	18	4	0.03	0.04
Fantail darter *Etheostoma flabellare*	0	8	0.00	0.09
Orangespotted sunfish *Lepomis humilus*	1	0	0.002	0.00
Totals =	540	91	0.982	1.00

Table 26. Total fish catch data for Harker's Run. Mean catch per unit effort (CPUE) calculated for 2 pools and 2 riffles.

Species	N	Proportion of total catch	Mean (± S.E.) CPUE (f/15 min)
Creek chub *Semotilus atromaculatus*	196	0.15	49.0(5.6)
White sucker *Catostomus commersoni*	151	0.11	37.8(24.1)
Silverjaw minnow *Ericymba buccata*	151	0.11	37.8(35.8)
Stoneroller minnow *Campostoma anomalum*	559	0.42	139.8(82.4)
Bluntnose minnow *Pimephales notatus*	35	0.03	8.8(4.8)
Rosefin shiner *Notropis ardens*	14	0.01	3.5(3.5)
Striped shiner *Notropis chrysocephalus*	17	0.01	4.3(3.1)
Spotfin shiner *Notropis spilopterus*	23	0.02	5.8(4.3)
Blacknose dace *Rhinichthys atratulus*	21	0.02	5.3(3.1)
Redbelly dace *Phoxinus erythrogaster*	38	0.03	9.5(6.3)
Johnny darter *Etheostoma nigrum*	86	0.06	21.5(9.7)
Orangethroat darter *Etheostoma spectabile*	5	0.003	1.3(0.8)
Fantail darter *Etheostoma flabellare*	29	0.02	7.3(5.0)
Orangespotted sunfish *Lepomis humilus*	1	0.001	0.3(0.3)
Totals	1326	0.997	

290

Table 27. Modified Shannon-Weaver indices (d') calculated from catch data for Paddy's Run (June, 1986; March, 1987; and June, 1987, collections) and Harker's Run (March, 1987, and June, 1987, collections).

Site Number	Paddy's Run			Harker's Run	
	Jun-86	Mar-87	Jun-87	Mar-87	Jun-87
1		2.8	2.6	3.1	2.8
2	2.9	3.2	3.0	3.0	2.2
3	2.6	1.7	2.9		
4	1.3				
5		2.6	2.5		
9		1.1			
10			2.7		
11		2.6	2.3		
combined	2.7	2.9	3.2	3.3	2.7

381

Table 28. Occurrence of spring migrant birds on the FMPC as compared to off-site sampling stations, April through May, 1987. Pluses indicate presence, blanks absence.

SPECIES	FMPC	OFF-SITE
semipalmated plover		+
lesser yellowlegs		+
solitary sandpiper	+	+
yellow-bellied sapsucker		+
golden-crowned kinglet		+
ruby-crowned kinglet		+
Swainson's thrush		+
hermit thrush		+
solitary vireo	+	+
blue-winged warbler	+	
Tennessee warbler	+	+
northern parula		+
chestnut-sided warbler		+
cape may warbler		+
yellow-rumped warbler	+	+
black-throated green warbler	+	+
blackburnian warbler		+
prairie warbler		+
palm warbler		+
blackpoll warbler	+	+
black-and-white warbler		+
American redstart	+	
prothonotary warbler		+
ovenbird		+
northern waterthrush	+	
mourning warbler	+	
yellow-breasted chat		+
rose-breasted grosbeak	+	
swamp sparrow	+	
rusty blackbird		+
TOTALS	12	24

Table 29. Reproductive parameters [means ± SE (N)] of mourning doves and American robins in the northern pine plantation (PP1), southern pine plantation (PP2), and Miami University campus/Hueston Woods State Park (offsite), spring 1987.

REPRODUCTIVE PARAMETER	MOURNING DOVE			AMERICAN ROBIN		
	OFFSITE	PP1	PP2	OFFSITE	PP1	PP2
Number of Clutches	15	31	27	29	15	24
Clutch Size*	1.93 ± 0.07 (15) A	1.96 ± 0.04 (26) A	2.00 ± 0.00 (23) A	3.30 ± 0.18 (27) A	3.75 ± 0.13 (12) A	3.49 ± 0.12 (23) A
Number of Hatchlings*	1.60 ±0.20 (15) AB	1.21 ± 0.17 (29) B	1.63 ± 0.13 (24) A	2.81 ± 0.24 (26) A	2.31 ± 0.47 (13) A	2.30 ± 0.36 (20) A
Number of Fledglings*	1.29 ± .24 (14) A	0.75 ± 0.18 (28) B	1.29 ± 0.20 (21) A	2.84 ± 0.26 (19) A	2.00 ± 0.48 (13) AB	1.74 ± 0.37 (19) B
Percent Fledged	66.7	44.7	72.5	87	54.2	41.8

* Values along rows that do not share the same letters are significantly different ($P < .05$).

Table 30. Egg weights [means ± SE (N)] of mourning doves and American robins in the northern pine plantation (PP1), southern pine plantation (PP2), and Miami University campus/Hueston Woods State Park (offsite), spring 1987.

SPECIES	OFFSITE	PP1	PP2
MOURNING DOVE	6.23 ± 0.18 (13)	6.25 ± 0.12 (46)	6.32 ± 0.13 (33)
AMERICAN ROBIN	6.00 ± 0.16 (22)	5.81 ± 0.12 (41)**	6.22 ± 0.11 (44)

** P< .01 as compared to offsite populations.

Table 31. Weights and morphometrics of prefledgling mourning doves and American robins in the northern pine plantation (PP1), southern pine plantation (PP1), and Miami University Campus/Hueston Woods State Park (offsite), spring 1987. Values (means ± SE) represent asymptotic values before fledging.

PARAMETER	MOURNING DOVE			AMERICAN ROBIN		
	OFFSITE	PP1	PP2	OFFSITE	PP1	PP2
Number of Fledglings	12	11	17	35	20	24
Weight (g)	64.8 ± 2.4	64.1 ± 2.9	63.2 ± 2.0	56.4 ± 0.5	54.2 ± 0.9*	55.8 ± 0.8
Wing Chord (mm)	80.2 ± 3.4	79.0 ± 3.4	76.1 ± 2.7	72.3 ± 1.1	65.8 ± 2.1**	64.2 ± 2.5**
Primary Length (mm) a*	34.6 ± 2.1	33.9 ± 2.0	32.4 ± 1.7	37.2 ± 1.0	31.3 ± 1.6**	30.3 ± 1.9**
Culmen Length (mm)	13.7 ± 0.3	13.6 ± 0.4	13.7 ± 0.3	15.5 ± 0.2	15.4 ± 0.2	14.5 ± 0.2***
Length of 3rd Toe (mm)	21.7 ± 0.5	20.2 ± 0.5	19.8 ± 0.3	24.0 ± 0.4	23.4 ± 0.4	23.4 ± 0.2

a* The outermost primary for each species was measured (#10 for mourning doves and #9 for American robins).
* $P < .05$ when compared to controls.
** $P < .01$ when compared to controls.
*** $P < .01$ when compared to PP1 and the control.

Table 32. Buffers utilized and enzyme systems analyzed in each species examined. Number of loci examined are listed in parentheses.

LOCUS	TAXON			
	STENONEMA	*LIRCEUS*	*CHIRONOMUS*	*SYLVILAGUS*
Adenylate kinase (ADK)	C&T(1)			
Alcohol dehydrogenase (ADH)	C&T(1)			
Aldolase (ALD)		RW		LiOH(2)
Aspartate amino transferase (AAT)				LiOH(2)
Diaphorase (DIA)	LiOH(1)	LiOH(2)	LiOH(1)	
Esterase (alpha napthyl acetate; A-EST)	RW(3)	RW(2)	TB(1)	LiOH(3)
Glucose 6-phosphate dehydrogenase (G6PD)		LiOH(1)		
Glucose phosphate isomerase (GPI)	RW(1)	TC(1)	C&T(1)	TC(2)
Glutamate dehydrogenase				TC(1)
Isocitrate dehydrogenase (ICD)			LiOH(2)	TC,CT(1,1)
Lactate dehydrogenase (LDH)		LiOH(1)		TC(1)
Leucine amino peptidase (LAP)	TC(1)	TC(2)	RW(2)	
Malate dehydrogenase (MDH)	C&T(2)	C&T(2,4)		TC(2)
Malic enzyme (ME)			RW(1)	ME(1)
Mannose phosphate isomerase (MPI)			TB(1)	LiOH(1)
Non-specific protein (NSP)	TC(2)	TC(1)		
Peptidase (PEP)		TC(2)	LiOH(1)	
6-Phosphogluconate dehydrogenase (6PGD)				TC(1)
Phosphoglucomutase (PGM)	LiOH(1)	C&T(1,2)	RW(2)	TC(3)
Superoxide dismutase (SOD)	C&T(1)	RW(1)	TB(1)	LiOH(2)
Triose phosphate isomerase (TPI)	RW(1)	RW(1)	RW(1)	TC(1)
Xanthine dehydrogenase (Xdh)				

TC = Tris-citrate, pH 8.0 (Selander et al. 1971)
RW = Gel: Tris-citrate; electrode: Lithium borate; pH 8.5 (Ridgway et al. 1970)
LiOH = Lithium hydroxide, pH 8.1/8.4 (Selander et al. 1971)
C&T = Citric acid, 4-(3-aminopropyl)morpholine, pH 6.1 (Clayton and Tretiak 1972)
TB = Tris-borate-EDTA, pH 8.0 (Selander et al. 1971)

Table 33. Allele frequencies at polymorphic loci in mayfly samples.

		POPULATION												
		116-1	116-2	116-3	116-4	116-5/6	116-8	116-9	116-10	27-1	27-3	27-5	27-11	27-HR
	N	21	21	14	17	11	18	8	13	19	20	10	18	24
LOCUS														
EST-1	A	0.93	1.00	0.86	0.94	0.46	0.81	0.88	0.96	0.95	1.00	1.00	0.88	0.94
	B	0.07		0.14	0.06	0.54	0.19	0.12	0.04	0.05			0.12	0.06
EST-2	A	0.07	0.08	0.29	0.15		0.06		0.23			0.10	0.08	
	B	0.86	0.85	0.50	0.82	1.00	0.67	0.94	0.73	0.94	0.94	0.90	0.86	1.00
	C	0.07	0.07	0.21	0.03		0.22		0.04	0.06	0.06		0.03	
	D						0.05	0.06					0.03	
GPI-1	A	0.07	0.30	0.11	0.09	0.23	0.24	0.07	0.19	0.06	0.08	0.20	0.12	0.17
	B	0.55	0.38	0.54	0.44	0.36	0.53	0.79	0.54	0.50	0.30	0.35	0.73	0.67
	C	0.38	0.32	0.21	0.44	0.41	0.23	0.14	0.23	0.44	0.62	0.30	0.12	0.14
	D				0.03				0.04			0.15	0.03	0.02
	E			0.14										
MDH-1	A	0.95	0.97	0.83	0.82	1.00	0.95	0.88	1.00	0.90	1.00	0.80	0.89	1.00
	B	0.05	0.03	0.17	0.18		0.05	0.12		0.10		0.20	0.11	
NSP-1	A	0.62	0.74	0.67	0.71	0.64	0.81	0.63	0.54	0.63	0.73	0.50	0.44	0.58
	B	0.38	0.26	0.33	0.29	0.36	0.19	0.37	0.46	0.37	0.27	0.50	0.56	0.42
PGM-1	A	0.12	0.24	0.39	0.03	0.18	0.03		0.08	0.03	0.18	0.10	0.14	0.21
	B	0.88	0.74	0.39	0.94	0.82	0.75	1.00	0.92	0.84	0.80	0.90	0.78	0.77
	C		0.02	0.22	0.03		0.22			0.11	0.02		0.08	0.02
	D									0.02				

Table 34. Genetic variability in populations of mayflies sampled.

POPULATION	MEAN NO. OF ALLELES PER LOCUS	PERCENTAGE OF LOCI POLYMORPHIC	MEAN HETEROZYGOSITY	
			DIRECT-COUNT	HARDY-WEINBERG EXPECTED
116-1	1.5	40.0	0.27	0.29
116-2	1.5	33.3	0.22	0.30
116-3	1.7	40.0	0.27	0.52
116-4	1.3	40.0	0.27	0.31
116-5/6	1.3	26.7	0.18	0.33
116-8	1.7	40.0	0.19	0.38
116-9	1.4	33.3	0.21	0.25
116-10	1.5	33.3	0.27	0.30
27-1	1.5	40.0	0.22	0.29
27-3	1.4	26.7	0.16	0.23
27-5	1.5	33.3	0.24	0.34
27-11	1.7	40.0	0.25	0.34
27-HR	1.5	26.7	0.27	0.25

Table 35. Tests for conformation of genotypic distribution in mayfly samples to expected under Hardy-Weinberg equilibrium. Levene's (1949) correction factor for small samples has been utilized.

	POPULATION												
LOCUS	116-1 1	116-2 2	116-3 3	116-4 4	116-5/6 5	116-8 6	116-9 7	116-10 8	27-1 9	27-3 10	27-5 11	27-11 12	27-HR 13
EST-1	**		**	NS	**	NS	NS	NS	NS			**	NS
EST-2	NS	NS	**	NS		**	NS	*	NS	**	**	**	
GPI-1	*	**	**	NS	*	**	**	NS	**	**	NS	NS	NS
MDH-1	NS	NS	NS	NS		NS	**		NS		**	**	
PGM-1	NS	NS	**	NS	NS	*		**	NS	NS	NS	**	NS
NSP-1	NS	NS	NS	NS	NS	*	NS	**a	NS	NS	NS	NS	**

*p ≤ 0.05, **p ≤ 0.01, NS = not significant, blank = invariant.

a Due to heterozygous excess; all others due to heterozygous deficiency.

Table 36. Contingency chi-square analyses for genetic heterogeneity among mayfly populations from different sites/dates.

LOCUS	All Samples Paddy's Run Nov-86	All Samples Paddy's Run Feb-87	Site 1 by Date	Site 3 by Date	Site 5(6) by Date	Paddy's Run Site 1 vs Site 2 Nov-86	Paddy's Run Site 1 vs Site 3 Nov-86	Paddy's Run Site 2 vs Site 3 Nov-86	Paddy's Run Site 8 vs Site 9 Nov-86	Paddy's Run Site 8 vs Site 10 Nov-86	Paddy's Run Site 9 vs Site 10 Nov-86	Paddy's Run Site 2 vs Site 8 Nov-86	Paddy's Run Site 2 vs Site 9 Nov-86	Paddy's Run Site 2 vs Site 10 Nov-86
EST-1	**	NS	NS	**	**	NS	NS	**	NS	NS	NS	**	*	NS
EST-2	**	NS	NS	**	NS	NS	**	**	NS	*	NS	NS	NS	NS
GPI-1	**	**	NS	**	NS	*	*	*	NS	NS	NS	NS	*	NS
MDH-1	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
PGM-1	**	NS	*	**	NS	NS	**	**	NS	*	NS	**	NS	NS
NSP-1	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS

*p ≤ 0.05, **p ≤ 0.01, NS = not significant.

Table 37. Allele frequencies at polymorphic loci in midge and isopod samples.

		POPULATION													
		116-1	116-2	116-3	116-4	116-5	116-7	116-8	116-9	116-10	27-1	27-3	27-5	27-11	27-HR
Chironomus															
LOCUS															
	N			20	18	16	21	10		7	23	20	20	15	
GPI-1	A			0.10	0.08	0.03	0.05			0.07	0.07	0.05	0.03	0.07	
	B			0.73	0.81	0.88	0.71	0.70		0.71	0.85	0.78	0.78	0.80	
	C			0.18	0.11	0.09	0.24	0.30		0.21	0.09	0.12	0.17	0.13	
	D											0.05			
	E												0.02		
MPI-1	A				0.07	0.04	0.04							0.04	
	B			0.41	0.61	0.32	0.35	0.22		0.42	0.45	0.69	0.56	0.57	
	C			0.50	0.21	0.64	0.50	0.50		0.42	0.45	0.25	0.38	0.18	
	D			0.09	0.11		0.12	0.22		0.16	0.05	0.05	0.06	0.11	
	E							0.06			0.05			0.11	
Lirceus															
LOCUS															
	N	10	21	31	20		12	20	21	6	10	10	20	10	9
EST	A	0.30	0.35	0.48	0.50		0.75	0.55	0.69	0.67	0.80	0.75	0.70	0.75	0.56
	B	0.65	0.48	0.29	0.34		0.08	0.24	0.19	0.08	0.10	0.05		0.05	0.28
	C	0.05	0.17	0.23	0.16		0.17	0.21	0.12	0.16	0.10	0.25	0.28	0.20	0.16
	D									0.08			0.02		
GPI-1	A	0.75	0.71	0.63	0.65		0.71	0.65	0.67	0.67	0.65	0.70	0.45	0.69	0.36
	B	0.25	0.29	0.37	0.35		0.29	0.35	0.33	0.33	0.35	0.30	0.55	0.31	0.64

Table 38. Genetic variability in populations of midges and isopods sampled.

POPULATION	MEAN NO. OF ALLELES PER LOCUS	MEAN HETEROZYGOSITY: DIRECT-COUNT	MEAN HETEROZYGOSITY: HARDY-WEINBERG EXPECTED
Chironomus			
116-3	3.0	0.29	0.52
116-4	3.5	0.44	0.47
116-5	3.0	0.38	0.37
116-7	3.5	0.40	0.54
116-8	3.0	0.42	0.56
116-10	3.0	0.23	0.58
27-1	3.5	0.51	0.45
27-3	3.5	0.30	0.43
27-5	3.5	0.36	0.48
27-11	4.0	0.45	0.50
Lirceus			
116-1	2.5	0.25	0.45
116-2	2.5	0.31	0.53
116-3	2.5	0.36	0.56
116-4	2.5	0.52	0.55
116-7	2.5	0.38	0.43
116-8	2.5	0.60	0.54
116-9	2.5	0.42	0.48
116-10	3.0	0.67	0.52
27-1	2.5	0.41	0.56
27-3	2.5	0.35	0.42
27-5	2.5	0.50	0.46
27-11	2.5	0.45	0.48
27-HR	2.5	0.44	0.44

Table 39. Tests for conformation of genotypic distribution in midge and isopod samples to expected under Hardy-Weinberg equilibrium. Levene's (1949) correction factor for small samples has been utilized.

LOCUS	POPULATION													
	116-1	116-2	116-3	116-4	116-5	116-7	116-8	116-9	116-10	27-1	27-3	27-5	27-11	27-HR
Chironomus														
GPI-1			NS	NS	NS	NS	NS		NS	NS	**	NS	NS	
MPI-1			**	NS	NS	NS	NS		**	**	*	NS	NS	
Lirceus														
EST	NS	**	**	NS		NS	**	NS	NS	NS	NS	NS	NS	NS
GPI-1	**	**	*	NS		NS	NS	NS	NS	NS	NS	NS	NS	*

*p ≤ 0.05, **p ≤ 0.01, NS = not significant, blank = specimens unavailable.

Table 40. Contingency chi-square analyses for genetic heterogeneity among midge and isopod populations from different sites/dates.

LOCUS	All Samples Paddy's Run Nov-86	All Samples Paddy's Run Feb-87	Site 1 by Date	Site 3 by Date	Site 5 by Date
Chironomus					
GPI-1	NS	NS		NS	NS
MPI-1	NS	NS		NS	NS
Lirceus					
EST	**	NS	**	NS	
GPI-1	NS	NS	NS	NS	

**$p \leq 0.01$, NS = not significant, blank = specimens unavailable.

Table 41. Allele frequencies at polymorphic loci in rabbit samples.

LOCUS	N	OFFSITE 6	FMPC 10	LOCUS	N	OFFSITE 6	FMPC 10
ALD-1	A	0.92	1.00	MPI	A	0.33	0.25
	B	0.08			B	0.67	0.70
					C		0.05
EST-1	A	0.17					
	B	0.83	0.85	ME	A	0.17	0.15
	C		0.15		B	0.83	0.85
EST-2	A	0.42	0.45	PGM-1	A	0.30	0.35
	B	0.48	0.55		B	0.70	0.65
EST-3	A	0.92	1.00	PGM-2	A	0.25	0.25
	B	0.08			B	0.75	0.75
GDH	A	0.67	0.80	PGM-3	A	1.00	0.95
	B	0.33	0.20		B		0.05
IDH-1	A	0.17		6PG	A	0.42	0.20
	B	0.75	0.15		B	0.58	0.70
	C	0.08	0.85		C		0.10

Table 42. Genetic variability in populations of rabbits sampled.

POPULATION	MEAN NO. OF ALLELES PER LOCUS	PERCENTAGE OF LOCI POLYMORPHIC	MEAN HETEROZYGOSITY	
			DIRECT-COUNT	HARDY-WEINBERG EXPECTED
OFFSITE	1.5	45.8	15.7	17.9
FMPC	1.5	41.7	16.2	15.0

290

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397

SECTION IV

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER

April-June, 1987

290

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399

TABLE OF CONTENTS

INTRODUCTION 1

STUDY SITE AND METHODS 2

FAUNA

- Benthic Macroinvertebrates 3
- Threatened and Endangered Species 12

ENVIRONMENTAL POPULATION GENETICS

- Benthic Macroinvertebrates 12
- Treefrogs 17

SUMMARY AND CONCLUSIONS

- Benthic Macroinvertebrates 22
- Environmental Population Genetics 23

ACKNOWLEDGEMENTS 24

FIGURES 26

TABLES 29

290

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461

INTRODUCTION

Previous baseline and ecological studies (reported in Sections I, II, and III) conducted during 1986 and 1987 at the Feed Materials Production Center (FMPC) included seasonal population or community estimates of the herbaceous and woody vegetation, terrestrial invertebrates, benthic macroinvertebrates, fish, birds, small mammals, rabbits, game animals and growth rates in doves and robins. Results suggest the terrestrial flora and fauna are stressed by current land management practices, and the benthic and fish fauna are stressed at specific locations within the FMPC drainages. Results (see Sections I, II, III) of our environmental population genetic analyses of dandelions, benthic macroinvertebrates, amphibians and fish document changes in population structure occurring in many of the FMPC populations studied.

The present study, under WMCO Subcontract No. E-75969, concludes our survey, inventory and ecological characterization of the terrestrial flora and fauna, and aquatic fauna inhabiting the FMPC. This report includes results of the characterization of the benthic community of Paddy's Run, and Harker's Run, an offsite stream of similar size and age. Results of our studies on the spring flora and spring migrant birds at the FMPC were previously reported (Section III).

In addition, mayflies from selected sites in Paddy's Run and treefrog tadpoles from the FMPC were compared to those from offsite populations. This was done to determine whether

290

significant differences in population genetic structure might result from FMPC operations.

Appendix A, Part IV includes a catalog of benthic species surveyed at the FMPC during the current quarter. Appendix B includes a list of incidental sightings at the FMPC.

Results of this study are discussed with respect to seasonal changes in population or community structure and to other onsite or offsite studies of biotic community structure or environmental stress as appropriate.

STUDY SITE AND METHODS

Aquatic benthic macroinvertebrates were censused at sites along Paddy's Run (Fig. 1) and Harker's Run (Fig. 2). Harker's Run has been used as an offsite reference stream (see Section III, for a description). Benthic macroinvertebrates were censused and mapped by sampling sites on Paddy's Run or Harker's Run. All endangered species found are listed and included in Addendum III to the Catalogue of Species of the FMPC. Prior to commencing the study, sampling and electrophoretic protocols were submitted to WMCO for approval.

Standard community indices were used to reduce the data. Results are expressed by habitat type in terms of density (number per unit area), or number per unit effort (e.g., number of fish per 30 minutes of sampling). Additional parameters were also calculated. Species richness (*R*) is the number of species found. Relative frequency of occurrence is the proportion of

403

individuals of each species in the sample with respect to the total number of individuals sampled. The latter data were used to assign estimates of abundance in Appendix A, Catalogue of Species of the FMPC.

Species diversity was calculated using the Shannon-Weaver (1949) formula ($H' = -\sum p_i \ln p_i$) and Simpson's Index, ($D = \sum n_1(n_1-1)/n(n-1)$; Simpson 1949). Species dominance (C) was calculated from the index of Simpson (1949). Evenness of distribution and abundance (J') was calculated using the methods outlined in Pielou (1966). The Jaccard Coefficient (Jaccard 1908) and the Coefficient of Similarity (Whittaker 1975) were used as measures of qualitative community similarity in terms of presence or absence of species. Percent Similarity (Whittaker 1975) and Morisita's Index (Morisita 1959) were used as measures of quantitative community similarity with respect to the number of individuals of each species present. Additional synthesis of the data is treated in each section.

All taxa were catalogued according to frequency of occurrence by habitat type (Part III, Appendix A). Representative specimens are housed in the Robert A. Hefner Museum of Zoology, Miami University, Oxford, Ohio 45056.

BENTHIC MACROINVERTEBRATES

METHODS

Benthic macroinvertebrates were collected 26-27 February 1987 at sites 1, 3, 5 and 11 (Fig. 1) on Paddy's Run (PR) and

sites 1 and 2 (Fig. 2) on Harker's Run (HR). Paddy's Run was dry downstream of PR5, thus PR9 could not be sampled as planned. The physical characteristics of the riffles and pools of Paddy's Run have been characterized elsewhere (Section II) and preliminary observations (Facemire, unpublished data) indicated the Harker's Run sites were similar in nature to those in Paddy's Run.

At each sampling location, 3 samples were collected from the riffle immediately above (PR1, HR1, HR2) or below (PR3, PR5, PR11) the pool using a Surber stream bottom sampler (total sample area = 0.28 m^2; mesh size = 508 µm; Merritt et al. 1984). Larger rocks were removed from the area enclosed by the sampler frame and were carefully scrubbed clean. The organisms so removed were collected in a bucket. The remaining substrate was disturbed to a depth of 3-5 cm. The contents of the bucket and the sampler were placed into labeled collection bottles, preserved with either 10% formalin or 70% ethyl alcohol, and stored in our laboratory awaiting sorting.

Two samples, one from near the shore and one from the deeper mid-channel area, were collected from each pool. In each case, the top 5 cm of substrate (gravel, sand, sediment, detritus, etc.) was removed with a stainless-steel sampler (total sample area = 0.063 m^2). Sub-samples were then washed using a No. 35 standard testing sieve (mesh size = 500 µm). Organisms were floated to the surface, placed in collection jars, and preserved as noted above.

In the laboratory, all benthic organisms were sorted by family, counted, and stored for future reference. Identification was accomplished using taxonomic keys by Wiggins (1977), Pennak (1978), Borrer et al. (1981) and Merritt and Cummins (1984). Densities (no./m^2) were calculated for all organisms in both riffle and pool areas of the streams. Standard community and similarity indices (see Introduction) were used for data analysis. The taxa identified from the four Paddy's Run sites are included in Appendix A, Catalog of Species.

RESULTS

A total of 16,266 organisms representing 47 families were identified; 10,091 from Paddy's Run and 6,175 from Harker's Run (Tables 1,2). Twenty-five, 18, 11 and 21 taxa were collected at PR1, PR3, PR5 and PR11, respectively. In Harker's Run, 23 taxa were found at HR1 and 21 at HR2. In every case, larval or pupal forms of the non-biting midges (Chironomidae) were most numerous (91% of the total; varying from 81 to 98% depending on site); usually present in numbers 10-50 times greater than the next most dominant taxa. Chironomidae were present at every sampling location with the exception of the pools at Harker's Run. HR1 contained only a single organism, a stone fly (Capniidae) and no organisms were found in the pool at HR2.

Representatives from four families were present at all sampling locations: isopods (Asellidae: Isopoda); mayflies

(Caenidae: Ephemeroptera); stoneflies (Capniidae: Plecoptera); and non-biting midges (Chironomidae: Diptera).

Several taxa were unique to each site. Nemourids and taeniopterigids (Plecoptera), hydraenids (Coleoptera), limnephilids (Trichoptera), and lymnaeids (Lepidoptera) were found only at PR1. Only the family Cambaridae (Decapoda) was unique to PR3. The families Physididae (Gastropoda), Sminthuridae (Collembola) and Scolionidae (Hymenoptera) were represented only at PR5 by a single individual from each. At PR11, one individual from the family Ephydridae (Diptera) was found. Eight taxa were found only in Harker's Run. These were represented by an unidentified fresh-water clam (Pelecypoda); a sialid (Megaloptera); one each brachycentrid, leptocerid and glossosomatid (Trichoptera); several individuals of the family Philopotamidae (Trichoptera); four dolichipodids and a psychodid (Diptera). Only Philopotamidae and Psychodidae were common to both HR1 and HR2, and only in the case of the Philopotamidae were any of these unique families present in large numbers. One hundred forty-four and 96 individuals of this family were found in the riffles at HR1 and HR2, respectively. Second most numerous was 2 psychodids each at HR1 and HR2.

Total density, measured as the number of individuals per square meter of stream bottom to a depth of approximately 5 cm, in the riffle community (Table 1) was highest at HR2, and lowest at PR1. For the pool community (Table 2), PR3 density was greatest and HR2 was least (no organisms were found).

Diversity parameters (Table 3) were depressed at all sites due to the high number of chironomids present. This was most evident, where a sufficient number of organisms were present to allow calculation, at the PR3 pool where over 98% of the macroinvertebrates present were members of this family (however, *H'* was lowest, under similar constraints, at the pool at PR5).

When Chironomids were excluded from the analysis, diversity indices generally increased. The only exception was at the pool at PR1. With the removal of the chironomids from the calculation, *H'* decreased in value for that location. Community similarity indices (Tables 4a,b) were highly ambiguous when chironomids were included in the calculations and interpretation was essentially impossible; for this reason, the taxon was excluded. Further discussion of these indices appears hereafter. A comparison of taxa present in the two streams appears in Table 5.

DISCUSSION

In Section II, we reported 41 taxa (representing some 30 families) of benthic macroinvertebrates collected from 10 Paddy's Run sites between 20 November and 18 December 1986. The 47 families reported herein (Tables 1 and 2) represent a substantial increase over the 19 taxa reported by Pomeroy and co-workers (1977) and more than 1.5 times the number of families present during November and December 1986. Larger numbers of taxa, however, should be expected in early spring as most do not begin emerging until water temperatures rise (Merritt and

Cummins 1984) and thus would still be present in late February. If sorted to genus or species level, we would expect some 60-100 taxa to have been present during February 1987.

The fact that overall density in the riffle at PR11 was nearly twice that at PR1 and 50% greater than at HR1 may be due to several factors. First, the stream characteristics were somewhat different at PR11. The stream was generally more shallow and slower moving there than at either PR1 or HR1. In addition to the FMPC, other industrial facilities are located upstream of PR11. Some agricultural input may also accrue between the FMPC and PR11. Thus, conditions for growth and proliferation may have been better due to nutrient influxes and stream conditions at PR11 than at any other Paddy's Run site sampled. Algal growth (Facemire, personal observation) seemed to have been greater at this site.

The same explanation does not hold for the high density at the PR3 riffle. This riffle was similar in appearance to PR1. Electrophoretic data presented in Section III, however, indicated this site to be stressed. Odum (1985) predicted that environmental stress should lead to a decrease in diversity and a concomitant increase in dominance. This seems to have been the case at PR3.

The dominant organismal group, the non-biting midges, composed 94.1% of the total number of individuals in the PR3 riffle as opposed to only 85.9% at PR1. The fact that there were more than twice as many of them at PR3 when compared to PR1 may be due to increased organic material or to a slight

difference in substrate size as both have been shown to affect chironomid numbers (Merritt and Cummins 1984, Pennak 1978). The areas with the highest densities, the pool at PR3 and the riffle at HR2, were apparently under similar influences, as again, chironomids were highly dominant (98.5% and 89.7% of the total number of individuals, respectively). Most of the chironomids from the PR3 pool were 4th-instar larvae.

The extremely low densities noted in the pools at Harker's Run were probably due to the fact that the substrate of both pools was nearly devoid of any form of detritus or other organic material which could serve as food for benthic animals. The relatively homogeneous substrate of the pool at PR11 (Facemire, unpublished data), could account for the low density there as Ricklefs (1973) predicted decreased densities with a decrease in habitat heterogeneity.

While diversity indices (Table 3) were much lower than those normally reported for such streams (see Section II), diversity indices calculated using any taxonomic level above species are always depressed (Hughes 1978). Furthermore, the heavy preponderance of the Chironomidae at each site also caused extreme depression of diversity values. This is amply illustrated by comparison of indices calculated when the midges are excluded (Table 3). The reader is cautioned, however, that diversity indices calculated from family level data are not only depressed, but are also not proportionate to species level calculations (Hughes 1978).

Community similarity analysis results were somewhat dependent upon the index used. Whittaker's Percent Similarity (Whittaker 1975) and Morisita's Index (Morisita 1959) both show (Table 4a) PR1 was more similar to other sites on Paddy's Run than to either Harker's Run location, and that the two Harker's Run sites were more similar to each other than to any other location. Those data presented in Table 5 support these conclusions. In addition, a clear trend was evident as one progressed downstream from PR1, the control site on Paddy's Run. Each subsequent location was generally less similar to PR1 than the one preceding it; which we believe to be a clear indication of increasing environmental impact with distance from the stream source, a phenomenon not to be unexpected under most circumstances. HR2 was more similar to all Paddy's Run sites than was HR1. This may be due to increased habitat heterogeneity at HR2 when compared to HR1, or to the fact that a small tributary empties into Harker's Run at HR2.

If one considers both Jaccard's Index (Jaccard 1908) and Whittaker's Coefficient of Similarity (Whittaker 1975), however (Table 4b), PR1 and PR11 were most similar in that stream, but PR1 was more similar to the two Harker's Run sites than to PR5. Individually, Jaccard's Index indicates HR1 and HR2 to have been most similar to one another rather than to any location on Paddy's Run, but the Coefficient of Similarity index shows HR1 to be most similar to PR11 and more like PR3 than HR2. The reason for these anomalies is not clear, but is likely an artifact of the differences in the calculations for the various

indices. At any rate, because of these ambiguities, no clear statement regarding community similarity is possible other than as noted above regarding the trend for Paddy's Run. Substrate analysis for the two streams might add to the overall understanding of benthic community structure in both Paddy's Run and Harker's Run.

Species presence and absence data (Tables 1,2) tend to support the proposition that PR1 and PR11 are more similar to one another than to either PR3 or PR5. Four taxa (round worms, Nematoda; limpets, Ancylidae; water pennies, Psephenidae; caddis flies, Psychomyiidae) found at PR1 and PR11 were not present elsewhere in the stream. Two of these, water pennies (Psephenidae: Coleoptera; Mundahl, personal communication) and limpets (Ancylidae: Gastropoda; Pennak 1978) are often found in areas of low environmental stress. Chandler (1970), in the process of developing a biotic index based upon presence or absence of benthic macroinvertebrates in British streams, listed several families; the presence of which indicated a relative lack of pollution or stress. Two of the four which headed his list, Perlodidae and Taeniopterygidae (both larval stoneflies, Plecoptera), were also found at these two sites; the former at PR11 and the latter at PR1. Regarding stress, PR1 appears to be least stressed, as this was the only site sampled where Helicopsychidae, a caddis fly (Trichoptera) larvae, were found in February, 1987. This organism is only present in unpolluted waters (Mundahl, personal communication; during a preliminary census taken in May, 1986, this organism was found in Paddy's

Run only above the K-65 area). In addition, species richness was highest at PR1, gradually decreasing with the downstream sites until reaching PR11. Nearly twice the number of species found at PR5 were present at this most-downstream site.

In conclusion, whereas a relatively diverse macroinvertebrate fauna were found present in Paddy's Run, some data indicated moderate to severe environmental stress in the stream below PR1 with, perhaps, some recovery occurring at PR11. It is probable that the low water table leading to a dry streambed below PR5 could account for part of those phenomena observed during the sampling period.

THREATENED AND ENDANGERED SPECIES

We did not record any species on the FMPC from April-June, 1987 which are included on the Ohio or Federal list of Rare and Endangered Species.

ENVIRONMENTAL POPULATION GENETICS

BENTHIC MACROINVERTEBRATES

STUDY SITES

As part of our continuing investigation of the possibility of stress on mayfly (*Stenonema femoratum*) population genetic structure (Section III), mayflies were collected from sites 1, 3, 5 and 11 in Paddy's Run (Fig. 1) from April 28 - May 7, 1987.

Physical characteristics of the riffles and pools have been summarized (Section II).

At each site we attempted to collect a minimum of 20 mayflies. Samples from a given site are identified by the date of collection, e.g., 57 (May 1987), followed by the site number; they are referenced in this manner throughout the remainder of this section.

ELECTROPHORETIC METHODS

Specimens were stored frozen at -70 C until needed for electrophoresis. At the appropriate time individuals were thawed, homogenized manually in spot plates without extractant and electrophoresed. Loci analyzed and buffers used are detailed in Table 6. Gels were 15% Sigma starch (Karlin and Guttman 1981) except for the LiOH system which was made with 13% Sigma starch.

Histochemical procedures followed Harris and Hopkinson (1976) and Selander et al. (1971). After the gels were stained, the genotypic composition of each sample at each locus was determined and recorded. Genotypic data were analyzed using the BIOSYS-I computer program (Swofford and Selander 1981). Allele frequencies, deviations from expected genotypic proportions assuming Hardy-Weinberg equilibrium conditions and amount of genetic variation were determined. Chi-square contingency tests for interpopulation heterogeneity were performed. See Section I for a discussion of Hardy-Weinberg equilibrium and methods for

determination of expected genotypic proportions and heterozygosity.

RESULTS

Four loci (GPI-1, MDH-1, PGM-1, TPI) were variable and consistently resolvable in most mayfly samples (Table 7); techniques for analysis of TPI were developed subsequent to analysis of November and February samples (Section III). Allelic diversity was similar in all samples (Table 8) with either three or all of the variable loci being polymorphic in a single sample. Mean direct-count heterozygosity was quite different from expected values in all samples (Table 8); actual heterozygosity ranged from approximately one-third (site 11) to one-half expected. Significant deviations from values expected under conditions of Hardy-Weinberg equilibrium occurred at all sites but were most concentrated at sites 3 and 11 where the non-conformation index (Section II) was 67% and 100%, respectively (Table 9). All instances of non-conformation were determined by heterozygote deficiencies.

Contingency X^2 analyses demonstrate significant differences among mayfly population samples from May 1987 (Table 10); 50% of the comparisons deviated significantly. Mayflies from each site sampled in May 1987 were compared to those from every other site; pairwise analyses indicate that most significant heterogeneity involves the sample from site 11 (Table 10). *Stenonema* from site 11 differ significantly from those collected at sites 1 and 5 at 75% of the variable loci. Comparisons

between populations from sites 1 and 3, 3 and 5, 1 and 5 and 3 and 11 show significant heterogeneity only at the TPI locus.

Analyses for heterogeneity over time (from November to May) indicate that allele frequencies appear relatively stable at sites 1 and 5, with only GPI at the former site exhibiting a significant shift. In contrast, 67% of the variable loci analyzed in each temporal sample from sites 3 and 11 demonstrated significant heterogeneity in allele frequency.

DISCUSSION

In Section III, we examined the population genetic structure of mayflies collected in November 1986 and February 1987 from sites in Paddy's Run and found that genetic changes occurred over short distances. This study found that mayflies from sites 1 and 2 (Figure 1) were heterogeneous at only one locus (GPI-1, $p \leq 0.05$) and heterogeneity did not occur at any locus between insects from sites 2 and 10. However, 67% of the polymorphic loci exhibited heterogeneity over the short distance between sites 2 and 3. Heterogeneity did not occur between mayflies from site 8 compared with site 9 or from site 9 compared with site 10. Contingency X^2 comparisons between *Stenonema* from site 8 and from site 10 indicated heterogeneity at 50% of the variable loci. Comparisons between mayflies from site 2 with those from either sites 8 or 9 were heterogeneous at 33% of the variable loci ($p \leq 0.01$ and $p \leq 0.05$, respectively).

Their February 1987 data indicated that the percent non-conformation remained elevated at sites 3 and 5 compared with

site 1. They included a new site, 11, below the New Haven Road bridge; this population had a non-conformation index of 0.67, the highest for the *Stenonema* in the February samples. When all populations sampled in February were compared, significant ($p \leq 0.01$) heterogeneity was found only at the GPI-1 locus. Three sites (1, 3, 5/6) were sampled on both dates. Major changes occurred in the *Stenonema* from site 3; 67% of the variable loci were significantly ($p \leq 0.01$) different between the two sampling dates. This contrasted with a change at only 17% of the loci at site 1 ($p \leq 0.05$) and 33% at site 5/6 ($p \leq 0.05$).

Patterns in the May 1987 mayfly samples tended to parallel those in November 1986 and February 1987. Non-conformation was high in all samples (≥ 0.50) but highest in populations from sites 3 and 11 (0.67 and 1.00, respectively). When allele frequencies were compared among populations on an individual locus basis, significant heterogeneity occurred at 50% of the variable loci; this level is intermediate between the February (17%) and November (67%) values. *Stenonema* from site 11 show marked differentiation relative to other samples, exhibiting significant heterogeneity at all variable loci, except PGM-1, when compared with mayflies from either sites 1 or 5.

Sections I, II and III provide data which address the possible relationship between environmental disturbances and population genetic structure. The investigators noted evidence indicating that stress impacted fish and invertebrate genetic structure at sites 3 and 8. The November, 1986 mayfly sample (Section III) exhibited dimunition of significant heterogeneity

between sites 8 and 10; sampling in May 1987 shows that effects are manifested in populations further downstream. The present data suggest that stress continues to affect benthic populations at site 3. It also appears that alterations exist in the genetic structure of downstream *Stenonema* populations between sites 5 and 11.

TREEFROGS

As part of our intensive year-long baseline ecological study, we characterized the degree of genetic polymorphism and heterozygosity in selected FMPC populations using electrophoretic techniques. These data are being used as an indicator of stress by comparing populations on and off the FMPC reservation.

Anurans (frogs and toads) are ideal organisms for use as monitors of environmental stress. They breed and lay their eggs in water and the tadpoles spend from one to three months (depending on the species) developing in aquatic habitats; during the tadpole stage they are herbivores feeding predominantly on algae. Upon metamorphosis anurans become terrestrial carnivores. They may stay around their natal pond or disperse up to 10 km (Ewert 1969). However, their first breeding season they demonstrate a remarkable fidelity to their natal site and most will migrate directly back to the pond in which they developed (Christein, Guttman and Taylor 1979).

Adults will continue to return to the same site year after year (Oldham 1967) and cases exist of individuals returning to the site of a natal pond long after it has been obliterated (Heusser 1960).

We studied treefrogs (spring peeper; *Hyla crucifer*) because they are one of the most abundant anuran species in the vicinity of the FMPC and because they breed onsite (Section I). Spring peeper females each deposit approximately 900 eggs, egg hatch occurs in 6 days and tadpoles require about 45 days in water before metamorphosis (Gosner and Rossman 1960). First reproduction occurs at one year of age (Collins 1975) and the longevity record for a treefrog of this genus is 14 years of age (Bowler 1977).

Spring peeper tadpoles (N=60) were collected from an ephemeral pond, surrounded by mowed grass, within the waste pit area about 150 m south of Waste Pit 6 (Figure 3) in May 1986 (Section I). However, at the time of the 1986 sampling, we were unable to locate an offsite population. Here we report data from a 1987 resampling of treefrogs from the site in the waste pit area and compare these spring peepers with an offsite population. We also report patterns in the FMPC *Hyla crucifer* tadpole population over a two year period.

METHODS

Resampling occurred from the ephemeral pond (N=20) in May 1987. An offsite sample (N=20) was also collected from Indian Creek County Park, Butler County, Ohio at that time.

Structural enzyme loci were electrophoretically analyzed (Table 6) in all three samples of *H. crucifer* and genotypic data were examined for differences in genetic structure using BIOSYS-1 (Swofford and Selander 1981; see Section I for detailed methods).

RESULTS

Six of the loci examined were variable (Table 11). A unique allele, GPI^C, occurred in FMPC populations in both years; this allele was not present in the offsite sample. Genotypic proportions for samples of FMPC tadpoles were significantly different from expected under conditions of Hardy-Weinberg equilibrium (1986: 2 loci (6PGD, LDH-1), $p < 0.01$; 1987: LDH-1, $p < 0.01$); these differences were due to heterozygote deficiencies. However, over all loci, mean-direct count heterozygosities of the FMPC samples were similar to expected. Genotypic proportions at all loci were not significantly different from expected in the offsite population. Contingency X^2 tests indicated that allelic proportions were, with one exception (6PGD, $p < 0.01$), homogeneous between the two FMPC samples. In contrast, comparisons between the 1987 FMPC and offsite samples demonstrated significant heterogeneity at 57% of the loci studied (GDH, LDH-1, $p = 0.05$; GPI, 6PGD $p < 0.01$).

DISCUSSION

Two of the six variable loci showed significant differences from Hardy-Weinberg expectations in the FMPC tadpole samples;

none were significantly different from expected in the offsite *Hyla*. The offsite and the 1987 FMPC samples were significantly different at four polymorphic loci.

In both years there was a significant ($p < 0.001$) deficiency of heterozygotes at the lactate dehydrogenase (LDH-1) locus in the treefrogs from the FMPC; the 1987 FMPC and offsite tadpole samples were significantly ($p < 0.05$) different at this locus. Major differences in respiratory metabolism (DiMichele and Powers 1984) and developmental rate (DiMichele and Taylor 1981) in fish have been shown to be directly correlated with specific LDH genotypes.

A significant, unique allele at the glucose phosphate isomerase (GPI) locus was found in the FMPC treefrog tadpoles. GPI is an essential glycolytic enzyme. The allele, GPI^C, is a null (inactive under assay conditions). It was present in FMPC samples from both years with a frequency of approximately 20% and was expressed only in heterozygous condition. This allele was not present in tadpoles from offsite and significant heterogeneity ($p < 0.001$) existed between FMPC and offsite tadpoles at this locus. Guttman (1985) recently reviewed the literature on biochemical population genetics of frogs and toads and did not find any instance of a null allele at a glycolytic enzyme locus. Null alleles have occasionally been found at glycolytic enzyme loci in other organisms and they are often associated with disease; for example, G6PD deficiencies cause severe anemias in man (Spiess 1977). However, GPI homozygous nulls have been demonstrated to be lethal. Burkhart et al.

(1984) analyzed null alleles in *Drosophila* and noted that GPI was the only essential locus among those studied; the null was lethal as a homozygote. Hydrops fetalis or immediate neonatal death of humans has recently been shown to be caused by GPI deficiency (Ravindranth et al. 1987).

Selection pressures act on the genetic variation in populations and this genetic variation is often essential for the survival of the species (Soule 1986). The result of natural selection is the alteration of genotypic proportions from that found without selection. If new alleles arising in a population are recessives, they may be propagated through subsequent generations in heterozygous condition without being subject to selection directly. Mating between two heterozygotes (carriers) will produce 25% offspring homozygous for this recessive allele. If the allele is lethal in homozygous condition, 25% of the offspring will not survive. In such situations, following selection, the lethal allele appears only in heterozygous condition e.g., sickle cell anemia (Merrell 1975) and hydrops fetalis (Ravindranath et al. 1987) in humans and the yellow lethal in mice (Merrell 1975). We believe that the null GPI allele found in *Hyla crucifer* on the FMPC is, when homozygous, lethal during early development; therefore, the only treefrogs that we could collect with that allele would be heterozygotes. Laboratory experiments are necessary to prove whether the null GPI allele is lethal when homozygous.

Our data suggest significant effects of FMPC operations on the *Hyla crucifer* breeding in the waste pit area. However, our

offsite sample of spring peepers was collected approximately 15 km from the FMPC. Heavy metals and radionuclides, such as those found in the waste pit area, have been shown to be mutagenic. Additional sampling from ponds immediately around the FMPC must occur before the cause and site of origin for the null GPI allele can be unequivocally determined.

Metamorphosed spring peepers migrate offsite and while most return as sexually mature adults the following spring, some join other breeding populations (Ewert 1969), possibly introducing a deleterious allele into gene pools offsite. The fidelity that anurans show to a natal area, even after elimination of their pond (Heusser 1960), coupled with their high fecundity and longevity, indicate that they will continue to attempt to breed onsite in the waste pit area.

SUMMARY AND CONCLUSIONS

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected from Paddy's Run and Harker's Run on February 27 and 28, 1987. A total of 16,266 organisms representing 47 families were identified. The most abundant were the non-biting midges (Chironomidae), which comprised approximately 98% of the total number of individuals. There was a decline in species richness, indicative of increasing stress, in Paddy's Run from PR1 downstream to below PR5 with an increase noted at PR11. Community similarity indices (Chironomidae excluded) generally supported this trend.

Diversity was higher, however, at PR11 riffles (with Chironomidae excluded) than at other Paddy's Run sites but lower than at either site at Harker's Run.

Species richness was greatest at PR1 and HR1. PR11 and HR2 ranked second in the number of taxa present in each stream. A large number of taxa was usually not indicative of high density. The density at PR3, where only 18 taxa were present as compared to 25 taxa at PR1, was nearly three times that present at PR1. A similar phenomenon was noted when comparing HR1 and HR2, although the magnitude was somewhat less.

These data, in addition to presence and absence data, support our previous findings that Paddy's Run is stressed downstream of PR1.

Environmental Population Genetics

One hundred and seven mayflies (*Stenonema femoratum*) were collected from sites on Paddy's Run Creek and examined using starch gel electrophoresis. In addition, 20 spring peeper (*Hyla crucifer*) tadpoles were captured in an ephemeral pond in the waste pit area and an offsite treefrog tadpole sample was obtained from a park near Reily, Ohio; these were compared using electrophoretic techniques.

Mayfly genetic data indicate that significant changes in population genetic structure occur at, or upstream of, sites 3 and 11. Mayflies from site 11 demonstrated the greatest reduction in variability from expected values; allele

frequencies obtained for this sample were significantly different from all other synchronic samples. Also, the highest index of non-conformation occurred in insects from sites 3 and 11. These data support prior studies (Sections II, III) and suggest stress in Paddy's Run at a minimum of two locations (between sites 1 and 3 and between sites 5 and 11).

Electrophoretic analysis of treefrog tadpoles from the waste pit area demonstrated the continued (Section I) deficiency of heterozygotes, at a lactate dehydrogenase locus. A null (inactive) allele at the glucose phosphate isomerase (GPI) enzyme locus was again present in significant frequency (approximately 20%) in the FMPC population. This GPI allele was not present in the offsite sample. The null allele may have resulted from a mutation occurring in treefrogs found in the waste pit area and is being perpetuated. Analysis of additional spring peepers from ponds immediately around the FMPC must occur before the site where the null GPI allele originated can be unequivocally determined.

ACKNOWLEDGEMENTS

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Stacy Hocker, Vince LaPolla and Michael Osborne. Benthic genetic studies were supervised by Lee Weigt and Kirsten Lehtoma conducted the electrophoretic analyses of treefrog tadpoles with assistance from Amy Baumgardner, Sharmila Ballal, Pari Beig, David Hock, Leslie Holton, Chris Holton, Denise LeJune, Celeste Slade and Brian Walsh.

290

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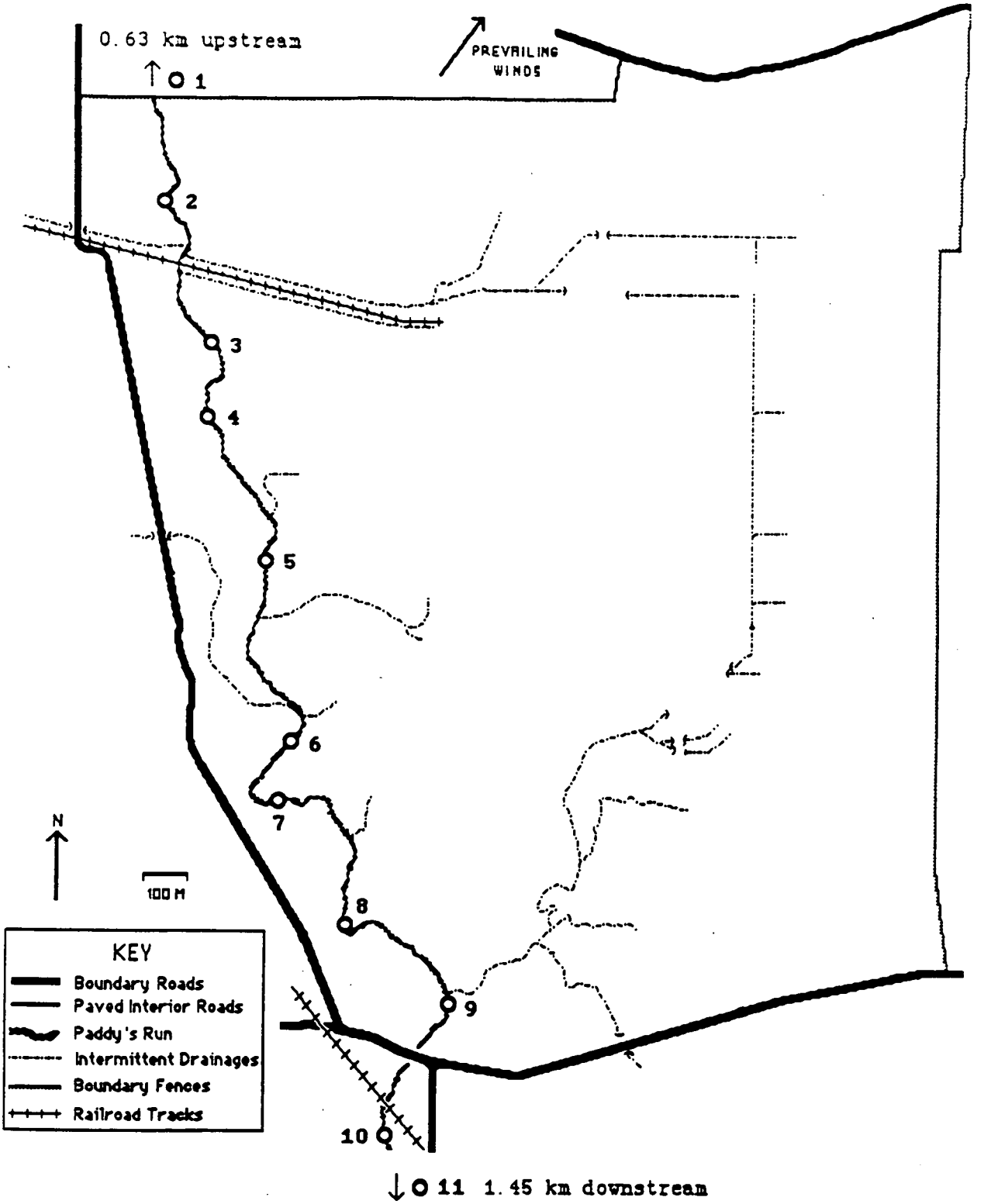

Figure 1. Benthic sampling sites on Paddy's Run.

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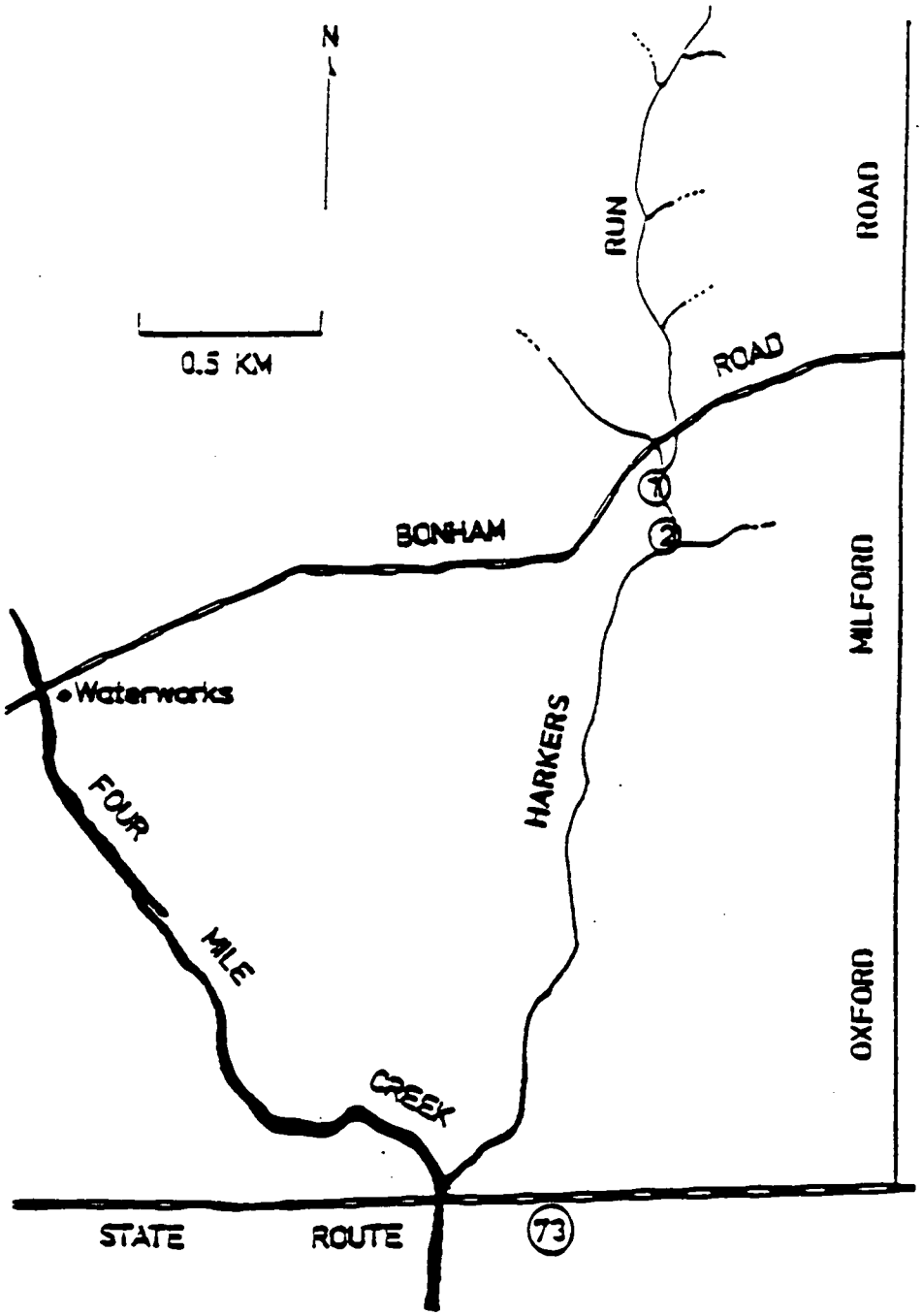

Figure 2. Benthos sampling sites on Harker's Run, Butler County, Ohio.

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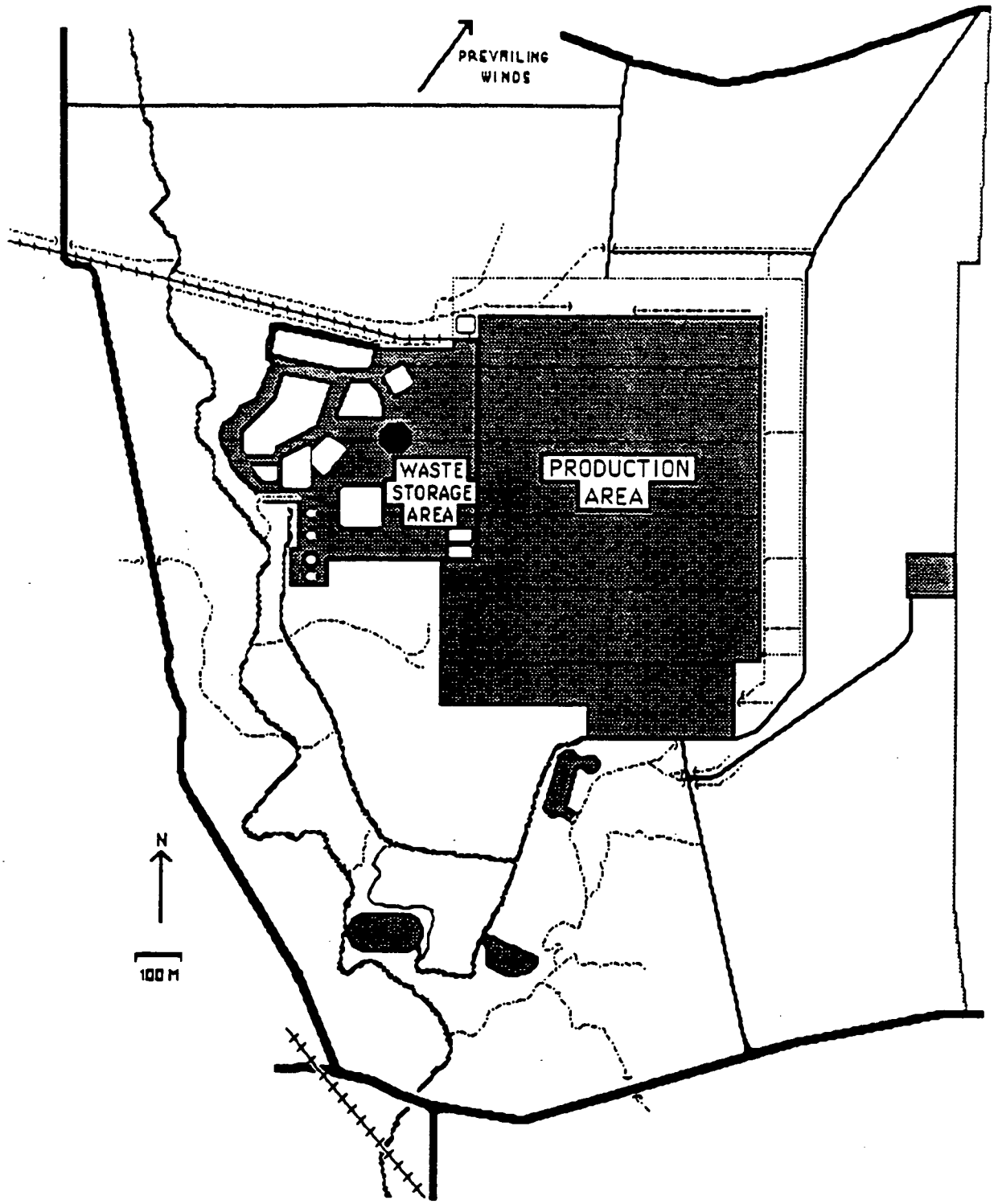

Figure 3. Location of spring peeper (Hyla crucifer) tadpole sample site (solid circle) in the waste storage area at the FMPC.

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Table 1. Density (number/square meter) of benthic macroinvertebrates collected from riffles at four sites on Paddy's Run and two sites on Harker's Run, February, 1987. Numbers in () are the total numbers of organisms collected.

TAXON	SITE					
	PR1	PR3	PR5	PR11	HR1	HR2
NEMATODA	3.6 (1)			10.7 (3)		
MOLLUSCA						
GASTROPODA						
Ancylidae	14.3 (4)			28.6 (8)		
PELECYPODA						3.6 1
ANNELIDA						
OLIGOCHAETA	14.3 (4)	82.1 (23)		342.8 (96)	10.7 (3)	17.9 (5)
ARTHROPODA						
CRUSTACEA						
ISOPODA						
Asellidae	14.3 (4)	14.3 (4)	21.4 (6)	10.7 (3)	3.6 (1)	25.0 (7)
ARACHNIDA						
HYDRACARINA				14.3 (4)	10.7 (3)	3.6 (1)
INSECTA						
EPHEMEROPTERA						
Baetidae	3.6 (1)	3.6 (1)			3.6 (1)	
Caenidae	3.6 (1)	25.0 (7)	7.1 (2)	32.1 (9)	39.3 (11)	42.9 (12)
Heptageniidae		14.3 (4)		3.6 (1)		28.6 (8)
Siphlonuridae		3.6 (1)		7.1 (2)		
COLLEMBOLA						
Sminthuridae			3.6 (1)			
PLECOPTERA						
Capniidae	342.8 (96)	353.5 (99)	53.6 (15)	64.3 (18)	107.1 (30)	42.9 (12)
Leuctridae	10.7 (3)	3.6 (1)				
Nemouridae	3.6 (1)					
Perlodidae					3.6 (1)	
Taeniopterygidae	7.1 (2)					
COLEOPTERA						
Curculionidae					3.6 (1)	
Elmidae	17.9 (5)	7.1 (2)	3.6 (1)	21.4 (6)		50.0 (14)
Hydraenidae	3.6 (1)					
Melyridae		3.6 (1)			3.6 (1)	

Table 1. (Cont.)

TAXON	SITE					
	PR1	PR3	PR5	PR11	HR1	HR2
Psephenidae	50.0 (14)			25.0 (7)	82.1 (23)	153.6 (43)
HYMENOPTERA						
Scelionidae			3.6 (1)			
TRICHOPTERA						
Brachycentridae						3.6 (1)
Glossosomatidae					3.6 (1)	
Helicopsychidae	7.1 (2)				367.8 (103)	250.0 (70)
Hydropsychidae	14.3 (4)	3.6 (1)		39.3 (11)	203.5 (57)	107.1 (30)
Leptoceridae					3.6 (1)	
Limnephilidae	3.6 (1)					
Philopotamidae					514.2 (144)	342.8 (96)
Polycentropodidae	10.7 (3)		3.6 (1)	3.6 (1)		
Psychomyiidae	103.6 (29)			71.4 (20)	28.6 (8)	
Rhyacophilidae		3.6 (1)	7.1 (2)		17.9 (5)	3.6 (1)
DIPTERA						
Ceratopogonidae					3.6 (1)	
Chironomidae	4163.8 (1166)	8538.3 (2391)	6002.9 (1681)	8409.7 (2355)	6431.4 (1801)	12662.8 (3546)
Dolichipodidae						3.6 (1)
Empididae				10.7 (3)	3.6 (1)	14.3 (4)
Ephydridae				3.6 (1)		
Psychodidae		21.4 (6)	32.1 (9)		7.1 (2)	7.1 (2)
Simuliidae				21.4 (6)	67.8 (19)	217.8 (61)
Tabanidae	17.9 (5)			7.1 (2)		
Tipulidae	32.1 (9)			35.7 (10)	10.7 (3)	135.7 (38)
Unidentified	3.6 (1)					
TOTAL	4845.8 (1357)	9077.5 (2542)	6138.5 (1719)	9163.2 (2566)	7931.2 (2221)	14116.2 (3953)

Table 2. Density (number/square meter) of benthic macroinvertebrates collected from pools at four sites on Paddy's Run and two sites on Harker's Run, February, 1987. Numbers in () are the total numbers of organisms collected.

TAXON	SITE					
	PR1	PR3	PR5	PR11	HR1	HR2
NEMATODA	15.9 (1)					
MOLLUSCA						
GASTROPODA						
Physidae			15.9 (1)			
ANNELIDA						
OLIGOCHAETA	286.5 (18)	127.3 (8)				
ARTHROPODA						
CRUSTACEA						
ISOPODA						
Asellidae		127.3 (8)				
DECAPODA						
Cambaridae		15.9 (1)				
INSECTA						
EPHEMEROPTERA						
Caenidae	47.7 (3)	31.8 (2)				
Ephemeridae	15.9 (1)	15.9 (1)				
PLECOPTERA						
Capniidae					15.9 (1)	
Perlodidae				31.8 (2)		
COLEOPTERA						
Curculionidae		15.9 (1)				
Elmidae		15.9 (1)				
TRICHOPTERA						
Psychomyiidae	15.9 (1)					
LEPIDOPTERA						
Lymnaeidae	15.9 (1)					
DIPTERA						
Ceratopogonidae						
Chironomidae	3374.0 (212)	24986.6 (1570)	891.2 (56)	206.9 (13)		
Tipulidae		15.9 (1)				
TOTAL	3835.5 (241)	25368.5 (1594)	907.2 (57)	238.7 (15)	15.9 (1)	0.0 (0)

Table 3. Community parameters for benthic macroinvertebrates of Paddy's Run and Harker's Run, Februrary, 1987.*

SITE	Number of Families *(S)*	Simpson Diversity *(D)*	Simpson Dominance *(C)*	Shannon Diversity *(H')*	Pielou Evenness *(J')*
PR1					
Pool	8	0.221(0.994)	0.780(0.417)	0.226(0.177)	0.250(0.209)
Riffle	22	0.256(0.716)	0.744(0.287)	0.293(0.825)	0.218(0.624)
PR3					
Pool	10	0.030(0.793)	0.970(0.240)	0.045(0.753)	0.045(0.789)
Riffle	14	0.114(0.545)	0.886(0.459)	0.131(0.557)	0.114(0.500)
PR5					
Pool	2	0.035(0.000)	0.965(1.000)	0.038(0.000)	0.126(0.000)
Riffle	10	0.044(0.775)	0.956(0.245)	0.062(0.735)	0.062(0.770)
PR11					
Pool	2	0.248(0.000)	0.768(1.000)	0.171(0.000)	0.568(0.000)
Riffle	20	0.157(0.768)	0.844(0.235)	0.198(0.906)	0.152(0.709)
HR1					
Pool	1	0.000(0.000)	1.000(1.000)	0.000(0.000)	0.000(0.000)
Riffle	23	0.335(0.794)	0.665(0.208)	0.371(0.849)	0.272(0.632)
HR2					
Pool	0	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)
Riffle	21	0.193(0.865)	0.806(0.137)	0.245(0.979)	0.185(0.752)

*Values in parentheses exclude Chironomidae. All values were calculated using log base 10 where applicable.

Table 4a. Community similarity indices for benthic macroinvertebrates (excluding Chironomidae) of Paddy's Run and Harker's Run, February, 1987. Percent similarity (Whittaker 1975) is above the diagonal and Morisita's index (Morisita 1959) is below.

Site	PR1	PR3	PR5	PR11	HR1	HR2
PR1	-	61.6	45.7	46.6	21.3	23.1
PR3	0.918	-	56.2	38.6	16.8	17.3
PR5	0.787	0.837	-	19.9	15.9	25.4
PR11	0.453	0.454	0.200	-	25.9	28.7
HR1	0.206	0.166	0.196	0.106	-	66.5
HR2	0.162	0.116	0.293	0.146	0.877	-

Table 4b. Community similarity indices for benthic macroinvertebrates (excluding Chironomidae) of Paddy's Run and Harker's Run, February, 1987. Jaccard's Coefficient (Jaccard 1908) is above the diagonal and the Coefficient of Similarity (Whittaker 1975) is below.

Site	PR1	PR3	PR5	PR11	HR1	HR2
PR1	-	0.322	0.172	0.419	0.314	0.257
PR3	0.487	-	0.285	0.370	0.392	0.370
PR5	0.294	0.444	-	0.250	0.185	0.250
PR11	0.590	0.540	0.400	-	0.400	0.428
HR1	0.478	0.564	0.312	0.571	-	0.500
HR2	0.409	0.540	0.400	0.600	0.666	-

Table 5. Benthic macroinvertebrate taxa present in Paddy's Run and Harker's Run, February, 1987.

	Present in Paddy's Run	Present in Harker's Run
NEMATODA	X	
MOLLUSCA		
GASTROPODA		
Ancylidae	X	
Physidae	X	
PELECYPODA		X
ANNELIDA		
OLIGOCHAETA	X	X
ARTHROPODA		
CRUSTACEA		
ISOPODA		
Asellidae		
Lirceus fontinalus	X	X
DECAPODA		
Cambaridae		
*Orconectes rusticus**	X	
ARACHNIDA		
HYDRACARINA	X	X
INSECTA		
EPHEMEROPTERA		
Baetidae	X	X
Caenidae	X	X
Ephemeridae	X	
Heptageniidae	X	X
Siphlonuridae	X	
COLLEMBOLA		
Sminthuridae	X	
PLECOPTERA		
Capniidae	X	X
Leuctridae	X	
Nemouridae	X	
Perlodidae	X	X
Taeniopterygidae	X	
MEGALOPTERA		
Sialidae		X
COLEOPTERA		
Curculionidae	X	X
Elmidae	X	X
Hydraenidae	X	
Melyridae	X	X
Psephenidae	X	X

Table 5. Continued

	Present in Paddy's Run	Present in Harker's Run
HYMENOPTERA		
Scelionidae	X	
TRICHOPTERA		
Brachycentridae		X
Glossosomatidae		X
Helicopsychidae	X	X
Hydropsychidae	X	X
Leptoceridae		X
Limnephilidae	X	
Philopotamidae		X
Polycentropodidae	X	
Psychomyiidae	X	X
Rhyacophilidae	X	X
LEPIDOPTERA		
Lymnaeidae	X	
DIPTERA		
Ceratopogonidae	X	X
Chironomidae	X	X
Dolichipodidae		X
Empididae	X	X
Ephydridae	X	
Psychodidae		X
Simuliidae	X	X
Tabanidae	X	
Tipulidae	X	X
TOTAL NUMBER OF TAXA PRESENT	38	30

*Crayfish were observed in both streams, but none were contained in the samples from Harker's Run.

Table 6. Buffers utilized and enzyme systems analyzed in mayflies and treefrogs. Number of loci examined are listed in parentheses.

LOCUS	MAYFLIES	TREEFROGS
Adenylate kinase (ADK)	C&T(1)	
Alcohol dehydrogenase (ADH)	C&T(1)	
Diaphorase (DIA)	LiOH(1)	
Esterase (alpha napthyl acetate; A-EST)	RW(3)	LiOH(1)
Glucose phosphate isomerase (GPI)	RW(1)	C&T(1)
Glutamate dehydrogenase (GDH)		TC(1)
Isocitrate dehydrogenase (ICD)		TC(2)
Lactate dehydrogenase (LDH)		TC(2)
Leucine amino peptidase (LAP)	TC(1)	LiOH(1)
Malate dehydrogenase (MDH)	C&T(2)	C&T(1)
Mannose phosphate isomerase (MPI)	RW(1)	
Non-specific protein (NSP)	TC(2)	
Peptidase (PEP)	LiOH(3)	LiOH(1)
6-Phosphogluconate dehydrogenase (6PGD)		TC(1)
Phosphoglucomutase (PGM)	LiOH(1)	TC(1)
Superoxide dismutase (SOD)	C&T(1)	
Triose phosphate isomerase (TPI)	C&T(1)	

TC = Tris-citrate, pH 8.0 (Selander et al. 1971)
RW = Gel: Tris-citrate; electrode: Lithium borate; pH 8.5 (Ridgway et al. 1970)
LiOH = Lithium hydroxide, pH 8.1/8.4 (Selander et al. 1971)
C&T = Citric acid, 4-(3-aminopropyl)morpholine, pH 6.1 (Clayton and Tretiak 1972)

Table 7. Allele frequencies at polymorphic loci in mayfly samples.

		POPULATION			
		57-1	57-3	57-5	57-11
LOCUS	N	26	19	33	29
GPI-1	A	0.18	0.11	0.16	
	B	0.46	0.47	0.45	0.41
	C	0.27	0.40	0.38	0.46
	D		0.02		0.11
	F	0.09		0.02	0.02
MDH-1	A	0.75	0.91	1.00	1.00
	B	0.25	0.09		
PGM-1	A	0.17	0.47	0.32	0.40
	B	0.83	0.53	0.68	0.60
TPI	A	0.87	1.00	0.97	0.76
	B	0.13		0.03	0.14
	C				0.10

Table 8. Genetic variability in populations of mayflies sampled from four sites in Paddy's Run, May 1987.

POPULATION	MEAN NO. OF ALLELES PER LOCUS	PERCENTAGE OF LOCI POLYMORPHIC	MEAN HETEROZYGOSITY	
			DIRECT-COUNT	HARDY-WEINBERG EXPECTED
57-1	2.5	100.0	0.22	0.42
57-3	2.3	75.0	0.19	0.33
57-5	2.5	100.0	0.22	0.41
57-11	2.5	75.0	0.12	0.38

Table 9. Tests for conformation of genotypic distribution in mayfly samples to expected under Hardy-Weinberg equilibrium. Levene's (1949) correction factor for small samples has been utilized.

LOCUS	57-1	57-3	57-5	57-11
GPI-1	**	*	**	**
MDH-1	NS	NS	NS	
PGM-1	NS	**	**	**
TPI	**		NS	**

*p ≤ 0.05, **p ≤ 0.01, NS = not significant, blank = invariant.

Table 10. Contingency chi-square analyses for genetic heterogeneity among mayfly populations from different sites/dates.

LOCUS	All Samples Paddy's Run May-87	Paddy's Run Site 1 vs Site 3 May-87	Paddy's Run Site 3 vs Site 5 May-87	Paddy's Run Site 5 vs Site 11 May-87	Paddy's Run Site 1 vs Site 5 May-87	Paddy's Run Site 3 vs Site 11 May-87	Paddy's Run Site 1 vs Site 11 May-87	Site 1 by Date	Site 3 by Date	Site 5(6) by Date	Site 11 by Date
GPI-1	**	NS	**	**	NS	NS	**	*	**	NS	**
MDH-1	NS	NS	NS	*	NS	NS	*	NS	NS	NS	NS
PGM-1	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	**
TPI	**	**	**	**	*	**	**				

*$p \leq 0.05$, **$p \leq 0.01$, NS = not significant, blank = not assayed in all samples.

Table 11. Allele frequencies at polymorphic loci in treefrog samples.

LOCUS		POPULATION		
		FMPC 1986	FMPC 1987	Offsite 1987
	N	60	20	20
EST-1	A	0.01		
	B	0.70	0.67	0.47
	C	0.23	0.33	0.38
	D	0.06		0.15
GPI	A	0.07	0.11	0.43
	B	0.75	0.62	0.57
	C	0.18	0.27	
GDH	A	0.05	0.25	
	B	0.95	0.75	1.00
ICD-1	A		0.02	0.03
	B	*	0.93	0.97
	C		0.05	
LDH-1	A	0.28	0.17	0.47
	B	0.40	0.56	0.36
	C	0.15	0.08	0.06
	D	0.17	0.19	0.11
LDH-2	A	0.65	0.50	0.33
	B	0.35	0.50	0.67
6PGD	A	0.24	0.07	
	B	0.49	0.11	0.58
	C	0.27	0.57	0.25
	D		0.25	0.17

* = locus not scored in that population.

Table 12. Genetic variability in populations of treefrogs.

POPULATION	MEAN NO. OF ALLELES PER LOCUS	PERCENTAGE OF LOCI POLYMORPHIC	MEAN HETEROZYGOSITY	
			DIRECT-COUNT	HARDY-WEINBERG EXPECTED
FMPC - 1986	2.1	55	0.20	0.25
FMPC - 1987	2.2	64	0.35	0.33
OFFSITE - 1987	1.9	55	0.26	0.27

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BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER

July, 1986-June, 1987

290

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APPENDIX A

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER

CATALOG OF SPECIES

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APPENDIX A

CATALOG OF SPECIES OF THE FMPC

DESIGN OF THE CATALOG

This catalog describes, in four sections (one for each season, with exceptions), the relative abundance of the flora and fauna surveyed at the FMPC, June, 1986 - June, 1987. Each entry is listed by scientific name, family, and often common name, according to traditional systematic protocol. Entries may be documented by representative specimens deposited in Miami University's Willard Sherman Turrell Herbarium or in the Robert A. Hefner Museum of Zoology. Sampling of terrestrial flora and fauna was conducted along established transects (Fig. 1). Locations of the benthic and fish sampling sites are shown in Fig. 2.

Plant nomenclature is largely that of Gleason and Cronquist (1963). The classification of terrestrial insects follows the terminology of Borrer and DeLong (1954), and Borrer and White (1970). Additional keys used were the works of Slater and Baranowski (1978) and Miller (1971) for hemipterans, Jaques (1951) for Coleoptera; Kaston (1978) was used for the identification of spiders. Identification of benthic macroinvertebrates was accomplished with the aid of taxonomic keys by Flowers and Hilsenhoff (1975), Hilsenhoff (1975), Wiggins (1977), Pennak (1978), Borrer et al. (1981), and Merritt and Cummins (1984). Fish were identified with the aid of keys

by Pfleiger (1975), Trautman (1981) and Auer (1982). Common and scientific names of birds are according to the AOU Check-list (1983), and recent supplements. Nomenclature for mammals follows Katz (1942) and Burt (1957).

Each entry is assigned an estimate of relative abundance by habitat type. Except for the spring migrant birds, estimates of abundance are derived from relative frequency data computed for each taxon. Spring avian abundances were estimated from field observations. The abundance codes provide a general overview of the relative abundance of species among habitats on the FMPC site and are not necessarily indicative of species abundances offsite. These estimates should be refined through replicate sampling and may be expected to vary seasonally.

Abbreviations of the habitats and symbols for the relative abundances used in the catalog are as follows: Habitats: PP = pine plantations; GP = grazed pastures; UGP = ungrazed pastures; RFAP = reclaimed fly ash pile; RN = riparian; W = deciduous woodlots; PR = Paddy's Run. Categories of abundance: A = abundant, very numerous; C = common, seen regularly; O = occasional, seen or collected a few times; R = rare, very seldom seen or collected. A dash shows that a taxon was absent; blanks indicate that the habitat was not sampled.

It is the hope of the authors that these lists will prove useful to those involved in research and interpretation of ecological patterns at the FMPC. We also hope that they will stimulate further replicate and seasonal base-line data sets on the FMPC.

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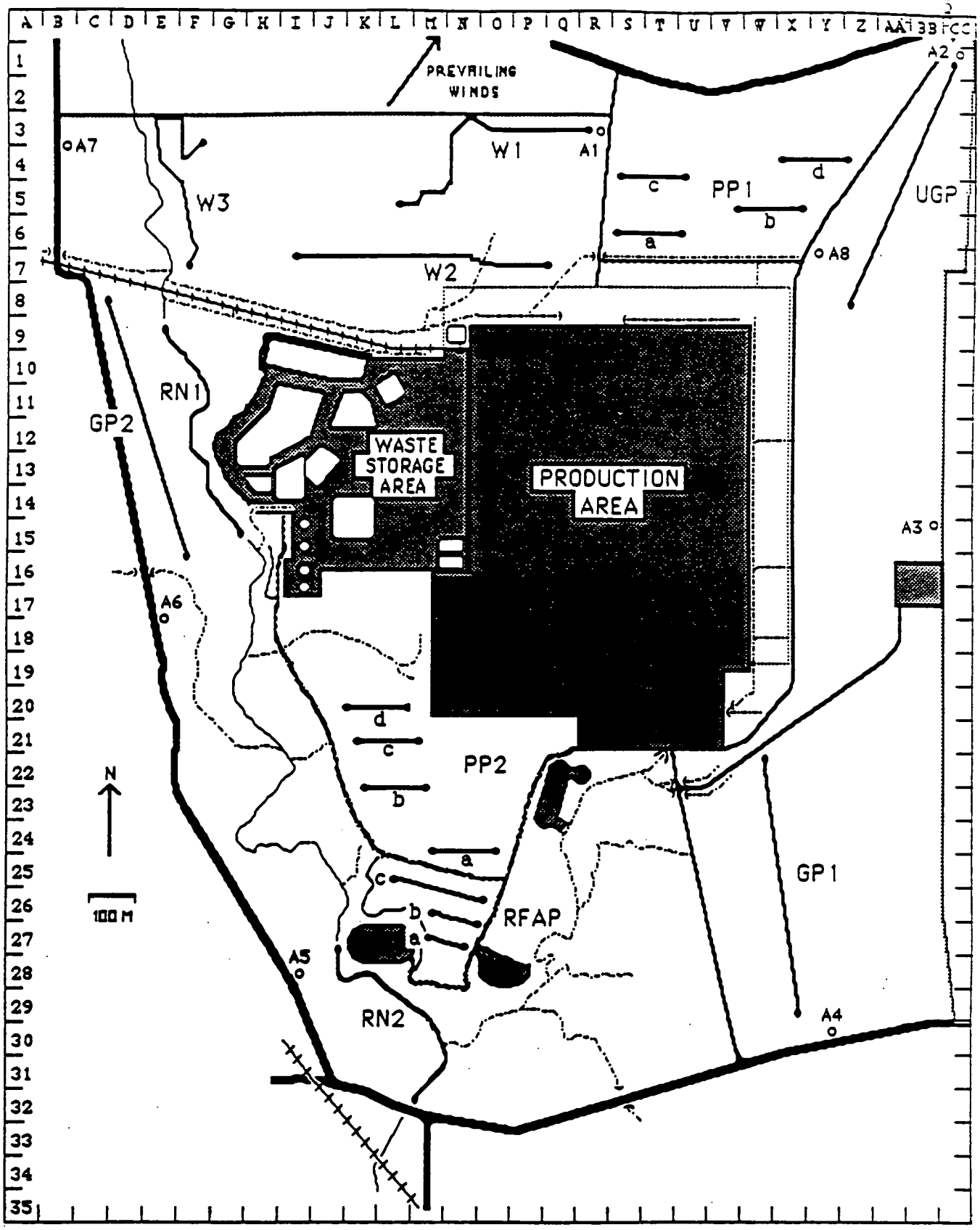

Figure 1. Locations of the permanent transects established and air monitoring stations(A) at the FMPC. UGP=ungrazed pasture; GP=grazed pasture; PP=pine plantation; RFAP=reclaimed fly ash pile; W=woodlot; RN=riparian.

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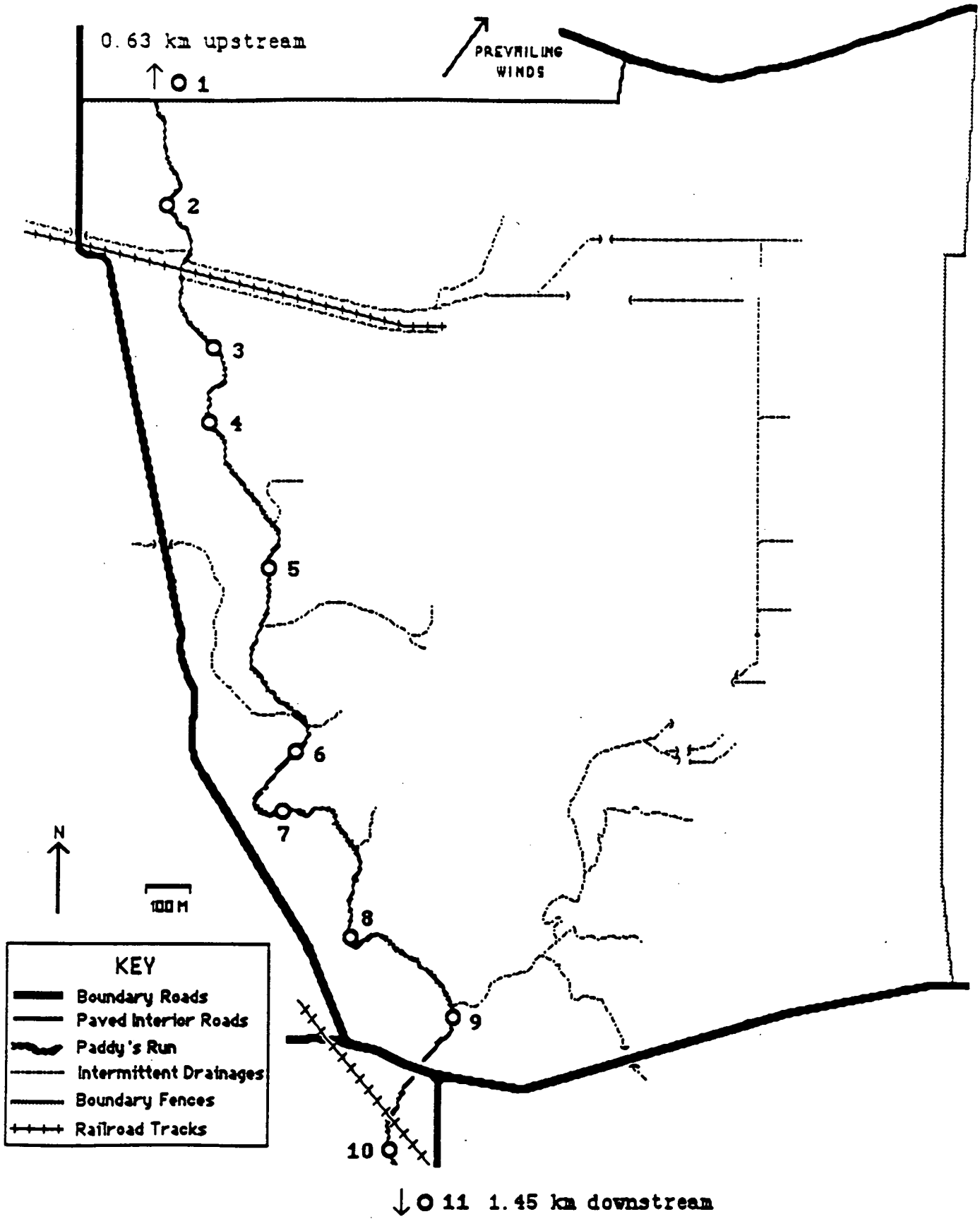

Figure 2. Fish sampling sites on Paddy's Run.

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Part I

June-August, 1986

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APPENDIX A. Catalogue of species. Frequency of abundance of flora and fauna at FMPC, June - September,1 1986. Habitats: PP = pine plantations; GP = grazed pastures; UGP = ungrazed pastures; RFAP = reclaimed fly ash piles; RN = riparian; W = deciduous woodlots; PR = Paddy's Run. Categories of abundance: A = abundant, very numerous; C = common, seen regularly; O = occassional, seen or collected a few times; R = rare, very seldom seen or collected. A dash shows that a taxon was absent; blanks indicate that the habitat was not sampled.

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
HERBACEOUS VEGETATION							
Equisetaceae							
Equisetum arvense Common horsetail	-	-	-	-	R	-	
Poaceae							
Phleum pratense Timothy-grass	O	R	R	O	-	-	
Agrostis alba Redtop	R	R	R	-	-	R	
Poa pratensis Kentucky bluegrass	O	C	O	-	R	O	
Festuca rubea Red fescue-grass	C	A	A	-	O	O	
Festuca elatior Meadow-fescue	C	A	F	G	O	O	
Echinocloa crusgalli Barnyard grass	-	-	-	-	R	R	
Setaris sp. Bristly foxtail	-	-	-	-	R	-	
Digitaria filiformis Slender crabgrass	-	-	-	-	R	-	
Poacea sp.	R	-	-	C	R	R	
Cyperaceae							
Carex sp. Sedge	R	-	-	R	-	O	
Commelinaceae							
Commelina communis Dayflower	-	-	-	-	R	-	
Juncaceae							
Juncus tenuis Slender rush	-	R	R	-	-	R	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Liliaceae							
Smilax sp.	-	-	-	-	R	-	
Allium canadense Wild garlic	R	-	-	-	-	-	
Urticaceae							
Urtica procera Nettle	-	-	-	-	O	-	
Pilea pumila Clearweed	R	-	-	-	O -	C	
Aristolochiaceae							
Asarum canadense Wild ginger	-	-	-	-	R	R	
Polygonaceae							
Polygonum hydropiperoide Mild water-pepper	-	-	-	-	R	R	
Polygonum persicaria Lady-thumb	-	-	-	-	R	R	
Polygonum cilinode Climbing buckwheat	R	-	-	-	R	-	
Polygonum sp. Smartweed	-	-	-	-	R	-	
Rumex obtusifolius Blunt-leaved dock	-	-	-	-	-	R	
Rumex sp. Dock	-	-	-	-	-	R	
Tovara virginiana Jumpseed	-	-	-	-	-	R	
Caryophyllaceae							
Saponaria officinalis Soapwort	-	-	-	-	R	-	
Brassicaceae							
Unknown genus sp.	-	-	-	-	-	R	
Saxifragaceae							
Heuchera americana Rock-geranium	-	-	-	-	R	O	
Platanaceae							
Platanus occidentalis American sycamore	-	-	-	-	R	-	
Rosaceae							
Geum canadense Avens	R	-	-	R	R	O	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Agrimonia parviflora Small flowered agrimony	-	-	-	-	-	O	
Rubus allegheniensis Blackberry	O	-	-	R	0	0	
Rosa multiflora Multiflora rose	R	R	-	-	-	O	
Leguminosae							
Trifolium repens White clover	R	0	R	-	R	R	
Medicago lupulina Black medick	R	R	R	R	R	R	
Apios americana Ground-nut	R	-	-	-	R	-	
Trifolium pratense Red clover	-	R	-	-	-	-	
Melilotus alba White sweet clover	-	-	-	R	-	-	
Robinia pseudoacacia Black locust	-	-	-	R	-	-	
Oxalidaceae							
Oxalis sp.	R	-	-	-	R	R	
Oxalis europea Wood-sorrel	O	-	-	-	-	-	
Euphorbiaceae							
Acalypha rhomboidea Copperleaf	O	-	R	-	-	R	
Balsaminaceae							
Impatiens sp. Touch-me-not	-	-	-	-	R	O	
Vitaceae							
Parthenocissus quinquefolia Virginia creeper	R	-	-	R	O	C	
Vitis sp. Grape	R	-	-	R	R	R	
Hypericaceae							
Hypericum sp. St. Johnswort	R	-	-	-	-	-	
Violaceae							
Viola sp. Violet	R	-	-	-	O	O	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Umbelliferae							
Sanicula canadensis Black snakeroot	-	-	-	-	-	O	
Daucus carota Wild carrot	R	-	-	R	R	R	
Pastinaca sativa Parsnips	R	-	-	R	-	-	
Carum carvi Caraway	-	-	-	-	-	R	
Primulaceae							
Lysimachia nummularia Moneywort	-	-	-	-	R	R	
Oleaceae							
Fraxinus sp. Ash	-	-	-	-	R	-	
Apocynaceae							
Apocynum sp. Dogbane	O	-	-	-	-	-	
Asclepiadaceae							
Asclepias sp. Milkweed	0	-	-	R	R	R	
Convolvulaceae							
Convolvulus sepium Hedge-bindweed	R	-	-	-	R	-	
Convolvulus arvensis Field-bindweed	O	-	R	-	R	R	
Convolvulus sp. Bindweed	O	-	-	O	-	-	
Ipomoea sp. Morning-glory	-	-	-	-	R	-	
Ipomoea pandurata Wild potato-vine	O	-	-	-	-	-	
Verbenaceae							
Verbena urticifolia White vervain	R	-	-	-	R	O	
Labiatae							
Prunella vulgaris Heal-all	R	-	-	-	-	-	
Leonurus cardiaca Common motherwort	R	-	-	-	-	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Glechoma hederacea Ground-ivy	O	R	-	-	O	O	
Solanaceae							
Physalis heterophylla Ground cherry	-	-	R	-	-	-	
Solanum carolinense Horse-nettle	R	R	R	-	-	R	
Datura stramonium Jimsonweed	R	-	-	R	-	-	
Scrophulariaceae							
Verbascum blattaria Moth-mullein	-	-	R	-	-	-	
Bignoniaceae							
Campsis radicans Trumpet-flower	O	-	-	R	-	-	
Plantaginaceae							
Plantago major Common plantain	-	-	R	-	-	R	
Plantago lanceolata English plantain	0	C	R	-	-	-	
Rubiaceae							
Galium aparine Cleavers	-	-	-	-	-	R	
Caprifoliaceae							
Lonicera sp. Honeysuckle	R	-	-	R	R	O	
Lonicera japonica Japanese honeysuckle	-	-	-	R	R	-	
Sambucus canadensis Common elder	-	-	-	-	-	R	
Dipsacaceae							
Dipsacus sylvestris Teasel	R	-	-	R	-	-	
Campanulaceae							
Campanula americana Tall Bellflower	-	-	-	-	R	-	
Compositae							
Vernonia altissima Ironweed	O	O	O	R	R	O	
Eupatorium rugosum White snakeroot	-	-	-	R	R	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Eupatorium sp. Thoroughwort	-		-	-	-	R	
Aster sp. Aster	R	R	-	-	R	R	
Solidago sp. Goldenrod	C	-	R	C	C	C	
Erigeron annuus Daisy fleabone	-	-	-	-	-	R	
Helianthus tuberosus Sunflower	-	-	-	-	O	-	
Actinomeris alternifolia	-	-	-	-	O	-	
Bidens vulgata Beggar-ticks	O	-	-	-	O	-	
Silphium trifoliatum Rosinweed	-	-	-	-	O	-	
Achillea millefolium Yarrow	R	R	R	-	-	R	
Cirsium arvense Canada thistle	-	-	R	-	-	-	
Cirsium sp. Thistle	-	-	-	R	-	-	
Cirsium altissimum Tall thistle	O	-	-	-	-	-	
Arctium sp. Burdock	-	-	-	-	R	-	
Cichorium intybus Chicory	-	R	R	-	-	-	
Taraxacum officinale Common dandelion	R	O	R	R	-	R	
Ambrosia artemisiifolia Common ragweed	O	-	C	R	R	R	
Ambrosia sp. Ragweed	-	-	-	R	-	-	
Ambrosia trifida Giant ragweed	R	-	-	R	R	-	
Xanthium echinatum Cocklebur	-	-	-	-	R	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
WOODY VEGETATION							
Pinaceae							
Pinus strobus Eastern pine	A			-	-	-	
Pinus nigra Austrian pine	A			-	-	-	
Picea excelsa Norway spruce	R						
Cupressaceae							
Juniperus virginiana Eastern red cedar	-			-	-	R	
Liliaceae							
Smilax glauca Sawbrier	-			-	O	-	
Salicaceae							
Salix nigra Black willow	-			-	R	-	
Populus deltoides Eastern cottonwood	-			A	C	R	
Juglandaceae							
Juglans nigra Black walnut	-			-	C	O	
Carya laciniosa Shellbark hickory	-			-	-	C	
Carya ovata Shagbark hickory	-			-	R	-	
Carya cordiformis Bitternut hickory	-			-	R	R	
Carya tomentosa Mockernut hickory	-			-	-	R	
Fagaceae							
Quercus prinus Chestnut oak	-			-	-	O	
Quercus muehlenbergii Chinquapin oak	-			-	R	-	
Quercus rubra Northern red oak	-			-	-	O	
Quercus imbricaria Shingle oak	-			-	R	O	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Quercus bicolor Swamp white oak	-			-	R	-	
Ulmaceae							
Ulmus americanus American elm	-			C	A	A	
Ulmus rubra Slippery elm	-			-	C	O	
Celtis occidentalis Hackberry	-			-	C	C	
Moraceae							
Maclura pomifera Osage orange	-			-	-	-	
Platanaceae							
Platanus occidentalis American sycamore	-			-	O	C	
Rosaceae							
Prunus serotina Black cherry	-			-	R	O	
Crataegus sp. Hawthorn sp.	-			-	R	-	
Rosa multiflora Multiflora rose	-			-	O	C	
Rosa setigera Prairie rose	-			R	-	-	
Rubus occidentalis Black raspberry	-			-	-	R	
Rubus allegheniensis Blackberry	-			-	R	C	
Leguminosae							
Cercis canadensis Redbud	-			R	-	-	
Gymnocladus dioica Kentucky coffeetree	-			-	-	R	
Gleditsia triacanthos Honey locust	-			-	R	R	
Robinia pseudoacacia Black locust	-			C	R	R	
Rutaceae							
Dictamnus albus Burning bush	-			R	O	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Anacardiaceae							
Rhus radicans Poison ivy	-			A	A	0	
Aceraceae							
Acer saccharum Sugar maple	-			-	R	O	
Acer rubrum Red maple	-			-	-	R	
Acer saccharinum Silver maple	-			-	R	R	
Acer nigrum Black maple	-			-	R	-	
Acer negundo Boxelder	-			O	A	C	
Hippocastanaceae							
Aesculus glabra Ohio buckeye	-			-	O	C	
Vitaceae							
Vitis sp. Grape vine	-			-	C	C	
Pathenocissus quinquefolia Virginia creeper	-			-	O	R	
Cornaceae							
Cornus drummondii Roughleaf dogwood	-			-	R	C	
Ebenaceae							
Diospyrus virginiana Common persimmon	-			-	-	R	
Oleaceae							
Fraxinus americana White ash	-			-	R	C	
Bignoniaceae							
Campsis radicans Trumpet creeper	-			-	C	O	
Caprifoliaceae							
Lonicera sp. Honeysuckle	-			-	0	C	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
FISH							
Catastomidae							
Catastomus commersoni White sucker							O
Cyprinidae							
Semotilus atromaculatus Creek chub							A
Ericymba buccata Silverjaw minnow							O
Campostoma anomalum Stoneroller minnow							A
Pimephales notatus Bluntnose minnow							A
Notropis ardens Rosefin shiner							O
Notropis chrysocephalus Striped shiner							R
Notropis spilopterus Spotfin shiner							R
Notropis whipplei Steelcolor shiner							R
Rhinichthys atratulus Blacknose dace							R
Percidae							
Etheostoma nigrum Johnny darter							C
Etheostoma spectabile Orangethroat darter							C
Etheostoma flabellare Fantail darter							C
AMPHIBIANS							
NOTE: The following catalogue of amphibians and reptiles is based upon incidental sightings only and is not definitive. Further study is planned for Summer, 1987. (X marks presence only; * = breeds in waste pit area)							
ANURA							
Bufonidae							
Bufo americanus * American toad	X		X				X
Ranidae							
Rana catesbeana Bull frog							X

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Rana clamitans Green frog							X
Hylidae							
*Hyla crucifer** Spring peeper							
Acris crepitans Northern cricket frog							X
REPTILES							
SQUAMATA							
Colubridae							
Regina septemvittata Queen snake							X
Nerodia sipedon Northern watersnake							X
Thamnophis butleri Butler's garter snake	X						
Elaphe obsoleta Black rat snake						X	
TESTUDINATA							
Emydidae							
Terrapene carolina Box turtle					X	X	
BIRDS							
CICONIFORMES							
Ardeidae							
Ardea herodias Great blue heron	-	-	-	-	R	-	
Butorides striatus Green-backed heron	-	-	-	-	O	-	
ANSERIFORMES							
Anatidae							
Aix sponsa Wood duck	-	-	-	-	R	-	
Anas platyrhynchos Mallard	-	-	-	-	R	-	
FALCONIFORMES							
Cathartidae							
Cathartes aura Turkey vulture	R	-	R	-	R	R	
Accipitridae							
Circus cyaneus Northern harrier	-	-	R	-	-	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Accipiter cooperii Cooper's hawk	R	-	-	R	R	-	
Buteo jamaicensis Red-tailed hawk	R	O	O	R	R	R	
Falconidae							
Falco sparverius American kestrel	R	R	O	R	R	R	
GALLIFORMES							
Phasianidae							
Colinus virginianus Northern bobwhite	R	O	R	R	R	R	
CHARADRIFORMES							
Charadriidae							
Charadrius vociferus Killdeer	R	O	R	R	O	-	
Scolopacidae							
Tringa solitaria Solitary sandpiper	-	-	-	-	R	-	
Actitus macularia Spotted sandpiper	-	-	-	-	O	-	
Scolopax minor American woodcock	-	-	-	-	-	R	
COLUMBIFORMES							
Columbidae							
Columba livia Rock dove	-	R	-	-	-	-	
Zenaida macroura Mourning dove	A	C	C	C	C	C	
CUCULIFORMES							
Cuculidae							
Coccyzus erythropthalmus Black-billed cuckoo	R	-	-	R	R	R	
Coccyzus americanus Yellow-billed cuckoo	O	-	-	C	C	C	
STRIGIFORMES							
Strigidae							
Otus asio Eastern screech-owl	-	-	-	-	R	-	
Bubo virginianus Great horned owl	R	-	-	-	O	R	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
APODIFORMES							
Apodidae							
Chaetura pelagic Chimney swift	O	R	R	R	C	C	
Trochilidae							
Archilochus colubris Ruby-throated hummingbird	O	-	-	-	R	R	
CORACIFORMES							
Alcedinidae							
Ceryle alcyon Belted kingfisher	-	-	-	-	C	-	
PICIFORMES							
Picidae							
Melanerpes erythrocephalus Red-headed woodpecker	-	-	R	-	R	-	
Melanerpes carolinus Red-bellied woodpecker	-	R	R	R	C	C	
Picoides pubescens Downy woodpecker	O	R	-	C	C	C	
Picoides villosus Hairy woodpecker	-	R	-	R	O	O	
Colaptes auratus Northern flicker	R	O	O	C	C	C	
Dryocopus pileatus Pileated woodpecker	-	-	-	R	R	R	
PASSERIFORMES							
Tyrannidae							
Fluvicolinae							
Contopus virens Eastern wood-pewee	C	-	-	C	C	C	
Empidonax virescens Acadian flycatcher	-	-	-	-	-	R	
Empidonax traillii Willow flycatcher	C	-	R	-	-	R	
Sayornis phoebe Eastern phoebe	-	-	-	O	C	R	
Tyranninae							
Myiarchus crinitus Great crested flycatcher	R	-	-	-	O	O	
Tyrannus tyrannus Eastern kingbird	R	C	C	-	O	R	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Hirundinidae							
Progne subis Purple martin	R	-	-	-	R	-	
Stelgidopteryx serripennis Northern rough-winged swallow	R	R	R	-	C	-	
Hirundo rustica Barn swallow	C	A	A	O	C	-	
Corridae							
Cyanocitta cristata Blue jay	R	O	R	O	A	C	
Corvus brachyrhynchos American crow	R	C	R	R	R	R	
Paridae							
Parus carolinensus Carolina chickadee	R	-	-	O	C	C	
Parus bicolor Tufted titmouse	R	-	-	-	C	C	
Sittidae							
Sitta carolinensis White-breasted nuthatch	-	-	-	-	C	C	
Troglodytidae							
Thryothorus ludovicianus Carolina wren	-	-	-	-	C	O	
Troglodytes aedon House wren	-	-	-	-	C	C	
Muscicapidae							
Sylviinae							
Polioptila caerulea Blue-gray gnatcatcher	R	-	-	R	-	-	
Turdinae							
Sialia sialis Eastern bluebird	-	R	-	R	R	O	
Hylocichla mustelina Wood thrush	-	-	-	-	0	C	
Turdus migratorius American robin	A	C	C	C	A	A	
Mimidae							
Dumetella carolinensis Gray catbird	C	-	-	-	C	C	
Mimus polyglottus Northern mockingbird	-	R	-	-	-	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Toxostoma rufum Brown thrasher	-	-	-	R	R	C	
Bombycillidae							
Bombycilla cedrorum Cedar waxwing	C	-	-	O	O	R	
Sturnidae							
Sturnus vulgaris European starling	R	C	C	-	C	-	
Vireonidae							
Vireo griseus White-eyed vireo	-	-	-	-	-	R	
Vireo gilvus Warbling vireo	-	-	-	-	C	R	
Vireo philadelphicus Philadelphia vireo	-	-	-	-	-	R	
Vireo olivaceus Red-eyed vireo	-	-	-	-	R	R	
Emberizidae							
Parulinae							
Vermivora peregrina Tennessee warbler	-	-	-	-	R	-	
Dendroica petechia Yellow warbler	O	-	-	-	R	R	
Mniotita varia Black-and-white warbler	-	-	-	-	-	R	
Seiurus motacilla Lousiana waterthrush	-	-	-	-	R	-	
Geothlypis trichas Common yellowthroat	C	R	R	C	C	C	
Icteria virens Yellow-breasted chat	-	-	-	-	-	O	
Thraupinae							
Piranga rubra Summer tanager	-	-	-	-	R	R	
Piranga olivacea Scarlet tanager	-	-	-	-	R	O	
Cardinalinae							
Cardinalis cardinalis Northern cardinal	A	R	R	A	A	A	
Pheuticus ludovicianus Rose-breasted grosbeak	-	-	-	-	R	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Passerina cyanea Indigo bunting	C	-	R	C	C	C	
Emberizinae							
Pipilo eyrthropthalmus Rufous-sided towhee	C	-	-	O	C	C	
Spizella passeria Chipping sparrow	C	-	-	-	-	R	
Spizella pusilla Field sparrow	C	-	R	A	C	C	
Passerculus sandwichensis Savannah sparrow	-	C	-	-	-	-	
Ammodramus savannarum Grasshopper sparrow	O	-	-	R	-	-	
Melospiza melodia Song sparrow	A	R	O	C	C	C	
Icterinae							
Agelaius phoeniceus Red-winged blackbird	A	A	A	C	C	R	
Stumella magna Eastern meadowlark	R	A	A	R	R	A	
Quiscalus quiscala Common grackle	C	R	R	R	C	O	
Molothrus ater Brown-headed cowbird	O	-	-	C	C	C	
Icterus spurius Orchard oriole	-	-	-	C	C	R	
Icterus galbula Northern oriole	-	-	-	R	C	O	
Fringillidae							
Carduelis tristis American goldfinch	A	O	O	A	C	C	
Passeridae							
Passer domesticus House sparrow	-	R	-	-	C	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
SMALL MAMMALS							
INSECTIVORA							
Soricidae							
Soricinae							
Blarina brevicauda Short-tailed shrew	-	-	-	A	O	C	
RODENTIA							
Sciuridae							
Sciurinae							
Tamias striatus Eastern chipmunk	-	-	-	-	-	O	
Cricetidae							
Critinae							
Peromyscus maniculatus Deer mouse	C	-	-	-	C	C	
Microtinae							
Microtus pennsylvanicus Meadow vole	O	R	R	-	-	-	
Zapodidae							
Zapodinae							
Zapus hudsonicus Meadow jumping mouse	-	-	-	-	-	R	
GAME ANIMALS							
Odocoileus virginianus White-tailed deer	A	O	C		A	A	
Colinus virginianus Bobwhite quail	R	A	A		O	O	
Sciurus niger Fox squirrel	-	R	R		O	O	
Sylvilagus floridanus Cottontail rabbit	C	C	A		C	C	

290

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507

Part II

October-December, 1986

290

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509

APPENDIX A. Catalogue of species. Frequency of abundance of flora and fauna at FMPC, October-December, 1986. Habitats: PP = pine plantations; GP = grazed pastures; UGP = ungrazed pastures; RFAP = reclaimed fly ash piles; RN = riparian; W = deciduous woodlots; PR = Paddy's Run. Categories of abundance: A = abundant, very numerous; C = common, seen regularly; O = occassional, seen or collected a few times; R = rare, very seldom seen or collected. A dash shows that a taxon was absent; blanks indicate that the habitat was not sampled.

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
INSECTS							
Collembola							
Entomobryidae	C	C	A	-	-	O	
Poduridae	R	-	-	-	-	-	
Sminthuridae	O	C	O	O	-	O	
Odonata							
Coenagrionidae	-	-	-	-	R	-	
Libellulidae	-	-	-	R	R	-	
Orthoptera							
Acrididae	C	A	A	C	O	C	
Gryllidae	C	C	O	O	C	C	
Mantidae	-	-	-	O	R	R	
Phasmidae	-	-	-	O	-	R	
Tetrididae	-	-	-	-	R	-	
Tettigonidae	C	C	C	O	C	C	
Psocoptera	-	-	-	C	O	R	
Thysanoptera	O	C	C	C	O	O	
Hemiptera							
Anthocoridae	R	R	O	-	O	-	
Aradidae	-	-	-	O	-	-	
Berytidae	O	O	R	R	-	O	
Coreidae	-	-	-	-	R	-	
Corimelaenidae	O	R	R	-	R	-	
Lygaeidae	R	O	O	-	R	O	
Miridae	O	C	C	O	O	O	
Nabidae	R	R	R	-	O	R	
Pentatomidae	R	O	R	O	O	O	
Phymatidae	-	-	R	-	R	-	
Reduviidae	R	O	-	O	O	C	
Rhopalidae	-	R	-	-	-	-	
Saldidae	-	-	-	-	R	-	
Scutteleridae	-	-	-	-	-	R	
Tingididae	-	-	-	O	C	O	
Homoptera							
Acanaloniidae	C	-	-	C	O	C	
Actiopheridae	R	-	-	-	-	-	
Aleyrodidae	-	-	-	-	O	-	
Aphididae	O	O	O	C	C	O	
Cercopidae	C	O	O	O	C	C	
Cicadellidae	A	A	A	A	A	A	
Cicadidae	-	-	-	-	R	-	
Cixiidae	-	-	-	-	O	-	
Coccidae	R	-	-	-	-	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Delphacidae	O	O	-	-	O	-	
Dictyopharidae	O	O	-	-	-	O	
Flatidae	-	-	-	C	O	C	
Fulgoridae	-	R	-	-	-	-	
Issidae	-	-	-	-	R	-	
Membracidae	R	R	-	O	O	O	
Psylliidae	-	-	-	-	O	-	
Neuroptera							
Chrysopidae	-	-	-	O	-	-	
Hemerobiidae	-	-	-	-	R	-	
Coleoptera							
Anthribidae	R	-	-	-	R	-	
Cerambycidae	-	R	-	-	-	R	
Chrysomelidae	A	C	C	C	C	C	
Cicindelidae	-	-	-	O	R	-	
Coccinellidae	R	-	R	-	O	-	
Cucujidae	R	-	-	-	-	-	
Curculionidae	O	C	R	C	O	O	
Elateridae	-	-	-	R	-	-	
Histeridae	-	-	-	-	R	-	
Lampyridae	R	-	R	-	-	O	
Lycidae	-	-	-	-	-	R	
Meloidae	R	O	-	-	-	-	
Mordellidae	O	R	O	R	R	O	
Nitidulidae	-	R	-	-	O	R	
Scarabaeidae	O	R	-	R	O	O	
Staphylinidae	O	-	R	-	-	O	
Strepsiptera	-	-	-	-	R	-	
Mecoptera							
Panorpidae	-	-	-	-	O	O	
Lepidoptera							
Ctenuchidae	-	-	-	-	R	-	
Danaidae	-	-	-	R	R	R	
Lycaenidae	-	-	-	R	-	-	
Noctuidae	R	-	-	R	-	R	
Nymphalidae	-	-	-	O	R	R	
Pieridae	-	R	-	-	-	-	
Diptera							
Agromyzidae	-	-	O	-	R	R	
Anthomyzidae	R	R	-	-	-	-	
Asilidae	R	O	R	O	O	O	
Calliphoridae	R	O	O	R	O	O	
Cecidomyiidae	R	O	-	-	C	O	
Chamaemyiidae	O	-	-	-	-	-	
Chironomidae	-	-	-	-	O	-	
Chloropidae	C	C	C	A	C	C	
Culicidae	R	R	-	-	R	O	
Curtonotidae	-	R	-	-	-	-	
Dolichopodidae	R	R	-	-	O	C	
Drosophilidae	O	O	-	-	O	C	
Empididae	R	-	-	-	R	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Ephydridae	-	-	-	-	O	-	
Heleomyzidae	R	-	R	-	-	-	
Lauxaniidae	-	-	-	-	O	O	
Lonchopteridae	-	R	R	-	-	-	
Micropezidae	-	R	-	-	-	-	
Muscidae	O	C	O	O	O	O	
Mycetophilidae	-	O	-	-	O	O	
Otitidae	-	-	-	-	R	-	
Phoridae	-	O	R	-	O	O	
Piophilidae	-	-	-	-	O	O	
Pipunculidae	O	O	R	O	R	O	
Platystomatidae	-	R	-	-	-	O	
Psychodidae	-	-	-	-	R	-	
Rhagionidae	-	-	R	-	O	-	
Sarcophagidae	O	R	O	O	R	-	
Sciaridae	O	C	C	-	O	O	
Sciomyzidae	O	-	O	R	O	-	
Sepsidae	R	R	O	-	R	O	
Stratiomyidae	-	R	R	-	-	-	
Syrphidae	O	C	R	R	O	O	
Tabanidae	R	O	-	-	-	R	
Tachinidae	O	R	R	-	-	O	
Tephritidae	O	O	C	O	R	O	
Therevidae	R	O	O	-	-	-	
Tipulidae	-	-	-	-	R	O	
Hymenoptera							
Apidae	-	R	R	R	O	R	
Bethylidae	-	-	R	-	R	-	
Braconidae	O	O	O	O	C	C	
Cephidae	R	-	-	-	-	-	
Chalcidoidea	C	C	C	C	C	C	
Colletidae	R	-	R	-	-	-	
Cynipidae	O	O	O	-	O	O	
Diapriidae	O	-	-	-	R	-	
Diprionidae	R	-	-	-	-	-	
Formicidae	C	C	C	C	C	C	
Halictidae	C	O	-	O	O	C	
Ichneumonidae	O	R	R	-	O	O	
Megachilidae	-	-	-	-	R	-	
Platygasteridae	O	O	O	O	O	O	
Pompilidae	-	-	-	-	R	-	
Proctotrupidae	R	-	-	-	-	R	
Scelionidae	-	O	-	-	R	O	
Siricidae	-	-	-	-	-	R	
Sphecidae	R	R	R	R	O	O	
Tenthredinidae	R	-	-	-	-	-	
Vespidae	O	R	-	R	C	O	
Larvae							
Coleoptera	C	-	O	-	-	-	
Lepidoptera	O	-	O	-	-	-	
Trichoptera	-	-	-	-	R	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Non-insects							
Acarina	O	O	C	R	O	O	
Araneida	A	C	C	A	A	A	
Phalangida	R	-	-	-	-	R	
Mollusca							
Gastropoda	-	-	-	-	C	O	

Part III

January-March, 1987

290

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515

APPENDIX A. Catalogue of species. Frequency of abundance of benthic macroinvertebrates at FMPC, February, 1987. Habitats: PP = pine plantations; GP = grazed pastures; UGP = ungrazed pastures; RFAP = reclaimed fly ash piles; RN = riparian; W = deciduous woodlots; PR = Paddy's Run. Categories of abundance: A = abundant, very numerous; C = common, seen regularly; O = occassional, seen or collected a few times; R = rare, very seldom seen or collected. A dash shows that a taxon was absent; blanks indicate that the habitat was not sampled.

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
BENTHIC MACROINVERTEBRATES							
NEMATODA							O*
MOLLUSCA							
GASTROPODA							
Ancylidae							C*
Physidae							R
ANNELIDA							
OLIGOCHAETA							A
ARTHROPODA							
CRUSTACEA							
ISOPODA							
Asellidae							C
DECAPODA							
Cambaridae							C**
ARACHNIDA							
HYDRACARINA							R
INSECTA							
EPHEMEROPTERA							
Baetidae							R
Caenidae							C
Ephemeridae							R
Heptageniidae							O
Siphlonuridae							R
COLLEMBOLA							
Sminthuridae							R
PLECOPTERA							
Capnidae							A
Leuctridae							R
Nemouridae							R
Perlodidae							R
Taeniopterygidae							R
COLEOPTERA							
Curculionidae							R
Elmidae							C
Hydraenidae							R
Melyridae							R
Psephenidae							C*

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
HYMENOPTERA							
Scelionidae							R
TRICHOPTERA							
Helicopsychidae							R
Hydropsychidae							C
Limnephilidae							R
Polycentropodidae							O
Psychomyiidae							C*
Rhyacophilidae							R
LEPIDOPTERA							
Lymnaeidae							R
DIPTERA							
Ceratopogonidae							R
Chironomidae							A
Empididae							R
Ephydridae							R
Simuliidae							C
Tabanidae							O*
Tipulidae							C

*Present only at PR1 and PR11.
**Crayfish were seen at all sites, but were found only in this sample.

Part IV

April-June, 1987

290

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519

APPENDIX A. Catalogue of species. Frequency of abundance of flora and fauna at FMPC, April-June, 1987. Habitats: PP = pine plantations; GP = grazed pastures; UGP = ungrazed pastures; RFAP = reclaimed fly ash piles; RN = riparian; W = deciduous woodlots; PR = Paddy's Run. Categories of abundance: A = abundant, very numerous; C = common, seen regularly; O = occassional, seen or collected a few times; R = rare, very seldom seen or collected. A dash shows that a taxon was absent; blanks indicate that the habitat was not sampled.

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
SPRING FLORA							
Equisetaceae							
Equisetum arvense Common horsetail	-	-	-	-	R	-	
Pinaceae							
Pinus nigra Austrian pine	O	-	-	-	-	-	
Pinus strobus White pine	O	-	-	-	-	-	
Poaceae							
Bromus ciliatus Fringed brome	-	-	-	-	-	R	
Bromus inermis Smooth brome	R	-	-	-	-	-	
Bromus commutatus Hairy brome	-	-	-	-	R	-	
Bromus sp. Brome	C	R	R	R	A	-	
Festuca rubra Red fescue	-	-	-	-	R	-	
Festuca elatior Meadow fescue	-	-	-	-	-	C	
Festuca obtusa Nodding fescue	R	-	-	-	O	R	
Festuca sp. Fescue	C	A	A	A	R	-	
Poa annua Annual bluegrass	-	-	-	-	-	R	
Poa compressa Canada bluegrass	-	-	-	-	-	O	
Poa pratensis Kentucky bluegrass	C	A	A	A	R	C	
Poa sp. Bluegrass	R	-	-	-	R	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Dactylis glomerata Orchard grass	R	R	C	-	-	-	
Agropyron sp. Wheatgrass	-	-	-	-	-	O	
Elymus virginicus Virginia wild-rye	-	-	-	-	R	-	
Elymus villosus Hairy wild-rye	-	-	-	-	R	-	
Hystrix patula Bottlebrush	R	-	-	-	R	-	
Digitaria sp. Crabgrass	-	O	-	-	-	-	
Unknown grasses	R	R	-	-	O	-	
Cyperaceae							
Carex conjuncta	-	-	-	-	R	-	
Carex scoparia Broom sedge	R	-	-	-	-	-	
Carex amphibola Narrowleaf sedge	R	-	-	-	-	-	
Carex blanda Woodland sedge	-	-	-	-	-	O	
Carex sp. Sedge	O	R	R	-	R	-	
Liliaceae							
Allium canadense Wild onion	-	-	R	-	R	R	
Hemerocallis fulva Day lilly	-	-	-	-	-	R	
Smilacina racemosa False Solomon's seal	-	-	-	-	R	R	
Trillium sessile Sessile trillium	-	-	-	-	R	R	
Smilax sp. Greenbrier	-	-	-	-	R	-	
Salicaceae							
Salix sp. Willow	-	-	-	-	R	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Betulaceae							
Betula sp. Birch	-	-	-	-	R	-	
Ulmaceae							
Ulmus rubra Slippery elm	-	-	-	-	R	-	
Ulmus americana American elm	-	-	-	-	R	R	
Celtis occidentalis Hackberry	-	-	-	-	R	-	
Urticaceae							
*Urtica dioica** Nettle	-	-	-	-	R	-	
Boehmeria cylindrica False nettle	-	-	-	R	R	-	
Aristolochiaceae							
Asarum canadense Wild ginger	-	-	-	-	R	R	
Polygonaceae							
Rumex crispus Curly dock	-	-	-	-	R	-	
Rumex sp. Dock	-	-	-	-	R	-	
Chenopodiaceae							
Chenopodium album Lamb's quarters	-	-	-	-	R	-	
Portulacaceae							
Claytonia virginica Spring beauty	-	-	-	-	R	R	
Caryophyllaceae							
Stellaria media Common chickweed	R	R	-	R	C	C	
Cerastium vulgatum Mouse-ear chickweed	-	-	R	-	-	-	
Saponaria officinalis Bouncing bet	-	-	-	-	R	-	
Ranunculaceae							
Ranunculus arbortivus Kidneyleaf buttercup	-	-	-	-	R	R	
Ranunculus sp. Buttercup	R	R	-	R	R	O	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Berberidaceae							
Podophyllum peltatum May apple	-	-	-	-	R	R	
Papaveraceae							
Sanguinaria canadensis Bloodroot	-	-	-	-	R	R	
Fumariaceae							
Corydalis flavula Golden corydalis	-	-	-	-	R	R	
Brassicaceae							
Draba verna Whitlow-grass	-	-	-	R	R	-	
Thlaspi sp. Pennycress	R	-	-	-	-	-	
Capsella bursa-pastoris Shepard's purse	-	R	-	R	R	-	
Allaria officinalis Garlic mustard	R	-	-	-	C	O	
Barbarea vulgaris Winter cress	R	R	-	R	R	R	
Dentaria laciniata Cut-leaved toothwort	-	-	-	-	R	R	
Arabis laevigata Smooth rock cress	-	-	-	-	R	-	
Arabis sp. Rock cress	-	-	-	-	R	-	
Platanaceae							
Platanus occidentalis American sycamore	R	-	-	-	R	R	
Rosaceae							
Potentilla canadensis Dwarf cinquefoil	-	-	-	-	-	R	
Potentilla simplex Common cinquefoil	-	-	-	-	-	R	
Geum vernum Spring avens	-	-	-	-	-	O	
Geum sp. Avens	-	-	-	-	R	O	
Rubus occidentalis Black raspberry	R	-	-	-	R	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Rubus sp.	O	-	-	-	-	R	
Rosa multiflora Multiflowered rose	-	-	-	-	R	O	
Prunus hortulana Goose plum	-	-	-	-	-	R	
Prunus serotina Wild cherry	-	-	-	-	R	R	
Prunus sp. Cherry	R	-	-	-	-	-	
Leguminosae							
Trifolium pratense Red clover	R	R	R	-	-	O	
Trifolium repens White clover	R	C	R	-	-	-	
Melilotus officinalis Yellow sweet clover	R	-	-	-	R	-	
Medicago lupulina Black medick	R	-	-	O	-	R	
Robinia pseudoacacia Black locust	-	-	-	-	R	-	
Cercis canadensis Redbud	-	-	-	-	R	-	
Oxalidaceae							
*Oxalis stricta** Yellow wood-sorrel	R	R	R	-	R	-	
Oxalis sp. Wood sorrel	-	-	-	-	R	-	
Anacardiaceae							
Rhus radicans Poison ivy	O	-	-	O	O	R	
Celastraceae							
Celastrus scandens Bittersweet	-	-	-	-	R	-	
Aceraceae							
Acer saccharum Sugar maple	-	-	-	-	R	-	
Acer rubrum Red maple	-	-	-	-	R	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Acer negundo Box elder	-	-	-	-	R	R	
Hippocastanaceae							
Aeculus glabra Ohio buckeye	-	-	-	-	R	-	
Balsaminaceae							
Impatiens sp. Touch-me-not	R	-	-	-	R	O	
Vitaceae							
Parthenocissus quinquefolia Virginia creeper	R	-	-	-	R	-	
Vitis sp. Grape	-	-	-	-	R	R	
Vitus riparia Riverbank grape	-	-	-	-	R	-	
Violaceae							
Viola sp. Violet	R	-	R	-	R	R	
Umbelliferae							
Sanicula sp. Black snakeroot	-	-	-	-	R	-	
Chaerophyllum procumbens Wild chervil	-	-	-	-	R	R	
Osmorhiza claytoni Sweet cicely	R	-	-	-	R	R	
Conium maculatum Poison hemlock	-	R	-	R	R	-	
Pastinaca sativa Wild parsnip	O	-	-	-	-	-	
Daucus carota Wild carrot	R	-	R	-	R	R	
Cornaceae							
Cornus racemosa Red-panicle dogwood	-	-	-	-	-	R	
Cornus sp. Dogwood	R	-	-	-	-	-	
Primulaceae							
Lysimachia nummularia Moneywort	-	-	-	-	R	R	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Lysimachia sp. Loosestrife	-	-	-	-	R	-	
Epilobium sp. Willow-herb	-	-	-	-	R	-	
Oenothera biennis Common evening-primrose	-	-	-	-	R	-	
Oleaceae							
Fraxinus americana White ash	R	-	-	-	R	-	
Apocynaceae							
Apocynum sp. Dogbane	R	-	-	-	-	-	
Asclepiadaceae							
Asclepias syriaca Common milkweed	-	-	R	-	-	R	
Asclepias sp. Milkweed	R	-	-	R	R	-	
Convolvulaceae							
Convolvulus sp. Bindweed	C	-	-	-	R	-	
Polemoniaceae							
Phlox divaricata Blue phlox	-	-	-	-	R	-	
Hydrophyllaceae							
Phacelia purshii Miami mist	-	-	-	-	O	O	
Boraginaceae							
Mertensia virginica Virginica mertensia	-	-	-	-	R	-	
Labiatae							
Glechoma hederacea Ground-ivy	O	-	-	-	R	O	
Lamium purpureum Purple dead-nettle	R	R	-	R	R	R	
Lamium amplexicaule Henbit	-	-	-	-	R	-	
Unknown mint	R	-	-	-	-	-	
Scrophulariaceae							
Veronica sp. Speedwell	R	-	-	-	R	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Veronica peregrina Purslane speedwell	-	R	-	-	-	-	
Bignoniaceae							
Campsis radicans Trumpet creeper	R	-	-	-	-	-	
Plantaginaceae							
Plantago major Common plantain	-	-	-	-	-	R	
Plantago lanceolata English plantain	-	O	-	-	-	R	
Plantago sp. Plantain	R	R	R	-	-	-	
Rubiaceae							
Galium aparine Cleavers	O	-	-	R	C	R	
Galium sp. Bedstraw	-	-	-	-	R	R	
Caprifoliaceae							
Lonicera japonica Japanese honeysuckle	-	-	-	R	-	R	
Lonicera sp. Honeysuckle	-	-	-	R	R	R	
Sambucus canadensis Common elderberry	R	-	-	-	-	R	
Valerianaceae							
Valerianella sp. Corn salad	-	-	-	R	-	R	
Valerianella intermedia	-	-	-	-	-	R	
Compositae							
Vernonia altissima Ironweed	R	-	R	-	R	-	
Eupatorium sp. Thoroughwort	R	-	-	-	R	-	
Aster sp. Aster	R	-	-	-	R	-	
Solidago sp. Goldenrod	O	-	-	O	O	C	
Erigeron sp. Fleabane	-	-	R	-	-	-	

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Ambrosia sp. Ragweed	R	-	-	-	-	-	
Polymnia sp. Leafcup	-	-	-	-	R	-	
Verbesina alternifolia Crown-beard	-	-	-	-	R	-	
Bidens vulgata Beggar-ticks	R	-	-	-	-	-	
Achillea millefolium Yarrow	R	R	R	R	-	O	
Senecio sp. Ragwort	-	-	-	-	R	R	
Cirsium sp. Thistle	R	R	-	-	-	R	
Taraxacum officinale Common dandelion	R	-	R	R	R	R	
Lactuca biennis Blue lettuce	-	-	-	-	-	R	
Unknown Compositae	-	-	-	-	R	-	

*Species identification has been changed from those previously reported (Osborne et al. 1987a): Urtica dioica from U. procera, Oxalis stricta from O. europaea.

BENTHIC MACROINVERTEBRATES

NEMOTODA	O
MOLLUSCA	
GASTROPODA	
Ancylidae	O
Physidae	R
ANNELIDA	
OLIGOCHAETA	
Tubificidae	R
Enchytraeidae	A
ARTHROPODA	
CRUSTACEA	
ISOPODA	
Asellidae	O
DECAPODA	
Cambaridae	R
ARACHNIDA	
HYDRACARINA	R

290

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
INSECTA							
EPHEMEROPTERA							
Caenidae							C
Heptageniidae							R
Baetidae							R
Ephemeridae							R
Siphlonuridae							R
PLECOPTERA							
Capniidae							A
Nemouridae							R
Perlodidae							R
Leuctridae							R
Taeniopterygidae							R
COLEOPTERA							
Psephenidae							C
Elmidae							O
Hydraenidae							R
TRICHOPTERA							
Hydropsychidae							C
Helicopsychidae							R
Psychomyiidae							C
Limnephilidae							R
Polycentropodidae							O
LEPIDOPTERA							
Lymnaeidae							R
DIPTERA							
Chironomidae							A
Simuliidae							R
Tipulidae							C
Tabanidae							O
Empididae							R
Ceratopogonidae							R
Ephydridae							R
Unidentified							-
FISH (March/June)							
Cyprinidae							
Semotilus atromaculatus Creek chub							O/C
Ericymba buccata Silverjaw minnow							R/C
Campostoma anomalum Stoneroller minnow							A/A
Pimephales notatus Bluntnose minnow							A/A
Phenacobius mirabilis Suckermouth minnow							R / -

529

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
Notropis ardens Rosefin shiner							C/C
Notropis chrysocephalus Striped shiner							O/R
Notropis spilopterus Spotfin shiner							A/O
Notropis stramineus Sand shiner							R/R
Notropis atherinoides Emerald shiner							R/R
Rhinichthys atratulus Blacknose dace							O/O
Phoxinus erythrogaster Redbelly dace							R/R
Catastomidae							
Catastomus commersoni White sucker							R/R
Centrarchidae							
Lepomis complex Sunfish							R/R
Micropterus salmoides Largemouth bass							- / R
Percidae							
Etheostoma nigrum Johnny darter							C/A
Etheostoma spectabile Orangethroat darter							A/A
Etheostoma flabellare Fantail darter							C/C
Etheostoma caeruleum Rainbow darter							R/R

TAXON	HABITATS						
	PP	GP	UGP	RFAP	RN	W	PR
SPRING MIGRANT BIRDS							
CHARADRIIFORMES							
Scolopacidae							
Tringa solitaria Solitary sandpiper	-	-	-	-	O	-	
PASSERIFORMES							
Vireonidae							
Vireo solitarius Solitary vireo	-	-	-	-	-	R	
Emberizidae							
Vermivora pinus Blue-winged warbler	-	-	-	-	-	R	
Vermivora peregrina Tennessee warbler	-	-	-	O	O	C	
Dendroica coronata Yellow-rumped warbler	O	-	-	-	R	C	
Dendroica virens Black-throated green warbler	-	-	-	-	R	R	
Setophaga ruticilla American redstart	-	-	-	-	-	R	
Dendroica striata Blackpoll warbler	-	-	-	-	-	R	
Seiurus noveboracensis Northern waterthrush	-	-	-	-	R	-	
Oporornis philadelphia Mourning warbler	-	-	-	-	R	-	
Pheucticus ludovicianus Rose-breasted grosbeak	-	-	-	-	R	O	
Melospiza georgina Swamp sparrow	-	-	-	-	-	R	
ENDANGERED SPECIES							
FALCONIFORMES							
Accipitridae							
Accipiter cooperi Cooper's hawk	O	-	-	-	-	-	

APPENDIX B

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER

INCIDENTAL SIGHTINGS OF SPECIES

290

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533

APPENDIX B

INCIDENTAL SIGHTINGS OF SPECIES OF THE FEED MATERIALS PRODUCTION CENTER

This list supplements Appendix A and its addenda: The Catalogue of Species of the FMPC, and includes incidental observations of species not recorded by censusing, trapping, collecting or other standardized aquatic or terrestrial survey techniques used to quantify floral and faunal populations of the FMPC from June, 1986 through June, 1987. The list includes species recorded by the Miami University Research Team or WMCO personnel either from direct observation of individuals or from indirect observations of tracks or scat. Because the list includes some organisms from the Waste Storage and Production Areas it represents additional species utilizing the environs of the FMPC.

TAXON	COMMON NAME	SCIENTIFIC NAME
BUTTERFLIES		
	European cabbage	*Pieris rapae*
	Hybrid C. Sulfur+Alfalfa	*Colias e.* X *C. philodice*
	Hackberry butterfly	*Asterocampa celtis*
	E. Tiger swallowtail	*Papilio glaucus*
	Pearl crescent	*Phyciodes tharos*
	E. Black swallowtail	*Papilio polyxenes asterius*
	Common sooty wing	*Pholisora catullus*
	Tawny edged skipper	*Polites themistocles*
	Tawny emperor	*Asterorocammpa clyton*
	Great spangled fritillary	*Speyeria cybele*
	Question mark	*Polygonia interrogationis*
	Meadow fritillary	*Boloria toddi ammiralis*

290

Monarch	*Danaus plexippus*
Red-spotted purple	*Limenitis arthemis*
Buckeye	*Precis lavinia coenia*
Wood nymph	*Cercyonis pegala*
Eastern tailed blue	*Everes comyntas*

MISC. INSECTS AND SPIDERS

Milkweed longhorn	*Tetraopes basalis*
Differential grasshopper	*Melonoplus differentialis*
Short-lanced meadow katydid	*Conocephalus brevipennis*
17 year periodical cicada	*Magicicada* sp.
Black-winged damselfly	*Calopteryx maculata*
Dogday cicada	*Tibicen canicularis*
Grape leaf skeletonizer	*Harrisina americana*
Robberfly	*Promachus* sp.
Black and yellow mud dauber	*Sceliphron caementarium*
Black and yellow argiope	*Argiope aurantia*
Wolf spider	*Lycosa* sp.
Spiny-bellied orb weaver	*Micrathena* sp.

AMPHIBIANS AND REPTILES

Fowler's toad	*Bufo woodhousei fowleri*
Smooth softshell turtle	*Trionyx muticus*
Common snapping turtle	*Chelydra serpentina*

MAMMALS

House mouse	*Mus musculus*
Eastern mole	*Scalopus aquaticus*
Opposum	*Didelphis marsupialis*
Muskrat	*Ondatra zibethica*
Little brown bat	*Myotis lucifugus*
Coyote	*Canis latrans*
Red fox	*Vulpes fulva*

535

Raccoon	*Procyon lotor*
Woodchuck	*Marmota monax*

290

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537

APPENDIX C

BIOLOGICAL AND ECOLOGICAL SITE CHARACTERIZATION OF THE FEED MATERIALS PRODUCTION CENTER

AN ANNOTATED LIST OF TERMS AND DEFINITIONS

290

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539

APPENDIX C

AN ANNOTATED LIST OF TERMS AND DEFINITIONS

It is the purpose of this appendix to attempt to reach a concensus on the use of several common terms frequently used in our Final Reports to WMCO. This selection supplements terminology defined or otherwise referenced within our documents. We hope these terms, defined below, will be useful to the reader and to future workers.

Allele: alternative forms of genes coding for the same trait; situated at the same locus on homologous chromosomes.

Allochronic: occurring at different times of day, on different days, or in different seasons.

Apomict: one reproducing without fertilization.

Benthos: organisms that live along the bottom of streams, rivers, and lakes. (syn. benthic macroinvertebrates).

Census: the result or process of standardized population methods in an attempt to make a complete enumeration (estimate) of all individuals (or taxa) within a specified area or distance (eg. the Emlen Fixed Width Transect Method for estimating breeding birds).

Cohort: those members of a population that are of the same age.

Community: the assemblage of organisms that are associated in a common environment or habitat (eg., the benthic community).

Conspecifics: members of the same species

Count: a. an act or process for obtaining a gross estimate of plant or animal numbers over an area (e.g. Christmas Bird Count, May Count); usually involving only one or several days and the estimate is therefore less precise than a census. b. the process of enumeration or collection; (syn. sample).

Density: the number of organisms per unit area.

Edaphic: pertaining to the soil.

290

Electrophoresis: a technique for separating molecules, particularly proteins, according to the overall electric charge of the molecules.

Fledging: a stage in development when young birds leave the nest; the process of young birds leaving the nest and becoming independent of parental care.

Fledgling: A young bird about ready to leave (fledge) the nest.

FMPC operations: all industrial (chemical and physical) practices conducted onsite concerned with the management, storage, transport, reprocessing and production of uranium metal products (see p. 1, EMR, April 30, 1987).

FMPC waste materials: substances, known or unknown, that are released into the environment by the FMPC during plant operations; (syn. FMPC wastes, waste products).

Frequency: the number of organisms encountered per unit effort (e.g., per hour, station, or kilometer).

Genetic diploidization: the process of silencing multiple copies of genes in polyploid organisms such that the organisms move toward possessing two functional sets of genes.

Genotype: the set of genes possessed by an individual organism; often, its genetic composition at a specific locus or set of loci singled out for discussion.

Habitat: the place where an organism normally lives or where individuals of a population live.

Hardy-Weinberg equilibrium: a rule for predicting genotype frequencies on the basis of gene frequences, under the assumption of random mating and in the absence of selection.

Heterozygote: an organism or state of an organism (heterozygosity) in which the pair of alleles for a trait is composed of different genes (usually dominant and recessive); derived from a zygote formed by the union of gametes of dissimilar genetic constitution. Electrophoretically determined heterozygotes are usually codominant.

Heterozygosity: having the two genes at corresponding loci on homologous chromosomes different for one or more loci.

Homogeneity: the state of populations having statistically similar distribution functions or values.

Hyporheic: the subterranean habitat directly under a stream bed.

Locus: a site on a chromosome occupied by a specific gene; more loosely, the gene itself in all its allelic states.

Macroinvertebrate: An invertebrate (without backbone) species large enough to be seen with the naked eye.

Management practices: the current policy of land use on-site which is not related to the productional operation of the FMPC (e.g., the pasturing of cattle, bulldozing and bushogging of woodlots, mowing of berms, pastures and pine plantings, and the alteration of drainages); (cf. stress).

Monomorphic: a population in which virtually all individuals have the same genotype at a locus.

Onsite: all habitats and drainages within the boundaries of the FMPC, excluding the production area.

Plot: a measured area of land.

Polymorphic: a population in which there are two or more genotypes at a locus.

Pool: a deep place in a stream.

Riffle: a stretch of shallow, choppy water, usually caused by a rocky shoal beneath the surface.

Riparian: pertaining to terrestrial communities along the banks of creeks, rivers and streams.

Sample: the enumeration of populations or taxa by any method from which inferences about the complete populations are made; (syn. count, survey).

Second (2nd) order stream: receives drainages from two or more other non-branching streams.

Species: A group of interbreeding individuals of common ancestry that are reproductively isolated from all other such groups; (syn. population).

Species Diversity: a mathematical index (representation) of a community that combines species richness and the number of individuals of each species.

Species Richness: the number of species in a given area.

Station: the spot, location, at which observations are made by observers along a transect, stream or road for a census (e.g., fish sampling stations along Paddy's Run Creek); (syn. site).

Stress: perturbations, acute or chronic and which affect the quality or structure of terrestrial or aquatic populations or communities. a. physical (e.g., grazing, timbering; cf. management practices). b. chemical (e.g., pesticides, heavy metals, radiological).

Succession: the process by which communities change over time; the replacement of one community by another in an orderly and predictable manner.

Succcessional stage: the degree of maturity in which a community exists through natural or manupulated processes.

Synchronic: at the same time; in synchrony.

Taxon, pl. taxa: any taxonomic group.

Third (3rd) order stream: receives drainages from two or more second order streams.

Transect: a. a sample area, usually linear and continuous, along which the observer moves in a given direction to take frequency counts or fixed distance counts (e.g., the established 600 m transects on the FMPC). b. a census method, (eg., the fixed-width line transect method for censusing winter birds).

Trophic level: the position in the food chain based on the feeding ralationships of populations; the nutritional position of a population in an ecosystem determined by the number of energy-transfer steps to that level.

We: the authors of this document.