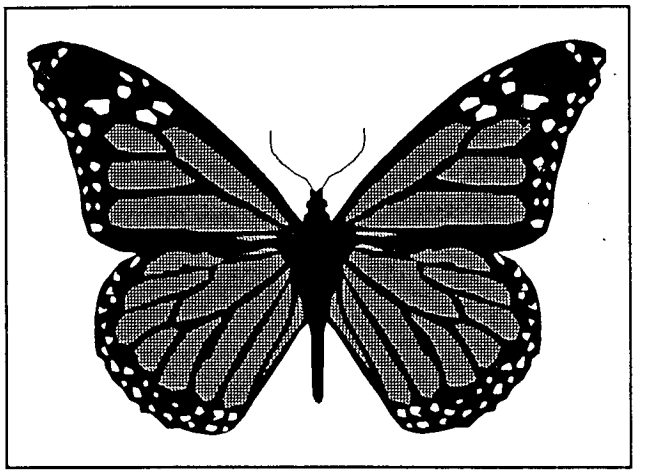
ACQUISITION AND DEVELOPMENT OF BIOLOGICAL AND GEOGRAPHICAL SPATIAL DATA FOR WALNUT CREEK NATIONAL WILDLIFE REFUGE 1990-1994



FINAL REPORT

SUBMITTED TO WALNUT CREEK NWR

by

Erwin E. Klaas and Todd R. Bishop
Iowa Cooperative Fish & Wildlife Research Unit
Iowa State University
Ames, IA 50011

Cooperative Agreement No. 14-16-0009-1560 RWO No. 29

June 30, 1995

ACQUISITION AND DEVELOPMENT OF BIOLOGICAL AND GEOGRAPHICAL SPATIAL DATA FOR WALNUT CREEK NATIONAL WILDLIFE REFUGE 1990-1994

I.

Acquisition of Baseline Geographical Spatial Data for Walnut Creek National Wildlife Refuge

II.

Development of GIS Data Layers for Walnut Creek National Wildlife Refuge

III.

Inventory of Prairie Remnants for Possible Local Sources of Seed for Restoration at Walnut Creek National Wildlife Refuge

IV.

Acquisition of Baseline Biological Data for Walnut Creek National Wildlife Refuge

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ACQUISITION AND DEVELOPMENT OF BIOLOGICAL AND GEOGRAPHICAL SPATIAL DATA FOR WALNUT CREEK NATIONAL WILDLIFE REFUGE, 1990-1994

EXECUTIVE SUMMARY

Baseline information on topography, soils, vegetation, transportation, land ownership, and surface water was acquired and GIS data files prepared. The data were used to prepare environmental assessments and impact statements required for the establishment of Walnut Creek National Wildlife Refuge.

Additional GIS data layers were prepared as needed from available imagery and data files to perform specific inventory and research activities. Most data files are stored in ARC/INFO format but many files have been converted to MIPS and EPPL7 formats as well. Vegetation and land use data was verified in 1991 by on-the-ground surveys. Additional data were acquired on soils and aerial photography (1986, 1989, 1990, 1991) from four separate sources and digitized. Original land survey township maps were digitized.

An inventory of prairie remnants in a 38-county area surrounding Walnut Creek NWR was initiated to identify potential sources of seeds to be used in prairie reconstruction. A GIS data base was designed to provide geographic location and site-quality information for each of the sources located. Original field data records of seed source information was provided to the refuge.

A faunal survey was initiated in 1994 to obtain baseline information on birds, mammals, and selected invertebrate groups including butterflies, moths, ants, grasshoppers, and ground-dwelling invertebrates. Voucher specimens of invertebrates are temporarily stored at the Iowa Cooperative Fish & Wildlife Research Unit until completion of laboratory space in the refuge's research laboratories.

PREFACE

Walnut Creek National Wildlife Refuge and Prairie Learning Center was established by Congress in 1990. The refuge is located about 20 miles east of Des Moines, Iowa near the town of Prairie City. Within a few weeks after enabling legislation for the refuge was passed into law, the Regional Director, Fish & Wildlife Service, asked the Iowa Cooperative Fish & Wildlife Research Unit, then under the leadership of Dr. Paul Vohs, to acquire geographical spatial data for the proposed refuge and develop the capability for applying Geographical Information System (GIS) technology for use in planning, environmental assessment, and eventually habitat restoration activities and evaluation. Dr. Vohs and Unit staff met several times with an interim planning team from the FWS regional office to coordinate initial planning for the refuge.

GIS technology was in its infancy in 1990 but was rapidly becoming recognized as an important tool for land managers and researchers. Administrators in the regional office encouraged the Unit to develop a laboratory that could provide state-of-the-art GIS support to Walnut Creek NWR as it developed. With funds provided by a Research Work Order, the Unit acquired computer hardware and software to accomplish the proposed objectives. With approval of the Fish & Wildlife Service, the Unit purchased the GIS software program, Map and Image Processing System (MIPS) from MicroImages, Inc. in Lincoln, Nebraska because of its lower cost, user training and support, and its capability for processing both raster and vector data. Technicians were hired and trained in GIS techniques. Remote sensing data for the proposed refuge was obtained and the process of developing GIS data files began.

A few months later, the Regional Director appointed a permanent planning team to prepare environmental assessments, environmental impact statements, a master plan, and conduct public hearings as required by law. The consulting firm of Wallace, Roberts, and Todd, Inc. (WRT) was hired to assist in the planning process. In Spring 1991, the Unit was instructed to turn over all of the data files that had been accumulated up to that time to WRT. In addition, we were told to send WRT all photography, printed maps, and other materials that we had acquired.

We informed the planning team that surrendering this information could hamper our ability to provide GIS support to the refuge. We were told that WRT would assist us in GIS development, that all of the data would eventually be returned, and that we should cooperate fully with WRT.

A problem in software compatibility became immediately evident. Most of our data files had been prepared using MIPS

software; WRT had sub-contracted with a company to use ARC/INFO software. We were informed that the sub-contractor was experiencing difficulties in converting the data for use with ARC/INFO and WRT requested our assistance. The Unit provided about 160 hours of technician help in converting MIPS raster data into vector data compatible with ARC/INFO software. We do not know the extent to which WRT eventually used our data to construct baseline maps in the design of the environmental impact statement and master plan. The Unit was never cited in any materials published by WRT.

About this same time, the regional office began to develop GIS capabilities and provide training for refuge personnel to perform basic GIS functions on refuges. EPPL7 software was provided for use at Walnut Creek. As these developments took place, the Unit was called on less frequently to provide basic GIS support. As refuge GIS needs changed, the Unit was asked to modify the research work order to accomplish new tasks and objectives that involved GIS applications.

This report is a summary of the primary tasks accomplished and products produced for the refuge during the time this research work order was in effect. The report is organized into four general sections:

1. ACQUISITION OF BASELINE GIS INFORMATION
2. GIS DATA LAYER DEVELOPMENT
3. SURVEY OF PRAIRIE REMNANTS FOR SOURCES OF SEED
4. FAUNAL SURVEY, 1994

PART I

ACQUISITION OF BASELINE GIS INFORMATION

Digitized data files and overlays for use in GIS applications were prepared primarily from US Geological Survey (USGS) 7.5 minute quadrangle maps (Runnels and Prairie City) from 1972, aerial photography (1:58000 scale color infrared (CIR) transparencies) obtained from the Eros Data Center in Sioux Falls, SD, and soil survey maps obtained from the Department of Agronomy at Iowa State University. All data files and overlays prepared up to that time were sent to Wallace, Roberts, and Todd (WRT) in Spring 1991. The files included the following information:

Topography. Topography data for 10-foot contours were digitized from USGS quadrangle maps.

Soils. The Department of Agronomy at Iowa State University made available recent soil survey data in a customized digital format. The Unit converted these files into MIPs format and spliced them into a mosaic to create a complete soils map for the proposed refuge. The soils data included soil mapping-unit boundries and the names of each mapping unit.

Vegetation. Vegetation overlays were prepared from CIR transparencies. Basic vegetation (cropland, woodland, pasture, etc.) was classified by interpretion of the aerial photograpy and ground truthing. Additional overlays showing major woodland habitats classified by dominant canopy species were prepared from ground surveys. An overlay was prepared showing boundaries of all fields on the proposed refuge that had been placed into the Conservation Reserve Program (CRP).

Transportation. Data on roads were taken from USGS quarangle maps. The prepared file included no attributes for the roads.

Land Ownership. A file showing land ownership parcels was prepared from data provided by FWS.

Water. A file showing streams and impounded water (primarily farm ponds) was prepared from USGS quadrangle maps.

Computer files and all photography, printed maps, soil survey maps, and other materials acquired to that point were also submitted to WRT. From the data provided, WRT produced a number of full-color topographical maps of the proposed refuge that were used in public hearings and for planning purposes.

Table 1. File descriptions for GIS and topographic spatial data of Walnut Creek NWR prior to land acquisition.

File Name	Description
WC_BNDRY	Redlands property and proposed refuge boundary.
WC_HYDRO	Streams and impoundments from USGS 7.5' quad maps.
WC_SOILS	Soils from ISU Agronomy Dept. digitized data.
WC_TOPO	10 ft. contour lines from USGS 7.5' quad maps.
WC_VEG	Vegetation/land use from 1:58000 color IR aerial-photos.
WC-OWNER	Ownership parcels within proposed refuge boundary.
WC_TRANS	Transportation system from USGS 7.5' quad maps.
CRPFIELD	CRP fields from Jasper Co. ASCS mapped on 1:58000 IR.
WOODLAND	Woodland communities from J. Pleasants report on WC_VEG.
IRMOS_86	Color IR image from mosaic of scanned transparencies (1:58000).
ASCS_89	Nat. color image from mosaic of ASCS compliance slides.

PART II

GIS DATA LAYER DEVELOPMENT

Various GIS products were produced which can generally be referred to as Data Layer Development. Files have been created from available imagery and previously created data files to perform specific inventory and research activities. Most data files are maintained in both MIPS and ARC/INFO formats to facilitate the use of the most efficient software system for a specific task.

A. Conversion of baseline data layers from ARC/INFO to MIPS and EPPL7 formats.

A group of files containing 13 data layers in ARC/INFO export format were sent to the Unit in July 1991 by John Gless at WRT at our request. We were not informed whether or not the data sent were final versions used by WRT to prepare baseline maps. We responded to a request from the FWS to convert these files to EPPL7 format for on-site installation at the refuge. The following overlay files were converted: topography (10 ft. contour intervals and slopes), soils, vegetation, stream network, watershed and basin boundaries, flood plain, CRP field boundaries, ownership parcels, refuge boundary, political boundaries (county, municipal), utilities, transportation

system, and buildings. EPPL7 formatted files were provided to the refuge.

Version 2.0 of EPPL7 software was loaded on a PC at the refuge. A manual was supplied along with an introductory lesson using the converted files.

B. Ground verified update of vegetation/land use data to 1991.

Data on vegetation and land use was ground verified and updated to 1991. A paper copy of this map was provided to refuge staff.

C. Acquisition of digital soils data.

Soils overlays were updated using data acquired from the statewide digital database (ISPAID). Attributes for this data had been revised to standardize mapping unit names and provide valid attribute values for each county.

D. Acquisition and digitization of aerial photography.

Aerial photographs of the entire refuge were acquired from four separate sources and digitized with a scanner. This photography consists of the following scenes: 1986 1:58000 color IR, 1989 ASCS 35mm slides, 1990 1:40000 B&W, 1990 and 1991 aerial videography, and 1991 1:6600 B&W. The above imagery is maintained in raster format.

E. Bird habitat from 1990 B&W aerial photography.

Vegetation was mapped from the 1990 B&W photography and classified to facilitate bird surveys conducted by Dr. Louis Best, Iowa State University. This file contains considerably more detail than other vegetation layers.

F. Adaptation of watershed data to estimate sediment yield.

Topography and stream network data layer files were converted from EPPL7 to ARC/INFO format for use by a graduate student (Robin McNeely) in Landscape Architecture who applied a watershed model (SWAT) to estimate annual sediment yield values at various points within the Walnut Creek watershed. The following files were converted to ARC/INFO and copies provided to McNeely: BASEMAP, BNDRY, FLOODWC, HYDRO, ORDER, OWNER, PLNTG, PRESET, SHEDS, NATIVE.

G. Digitization of original land survey township maps.

Township maps created by surveyors during the original Iowa land survey conducted in the 1860's were digitized. Data were prepared to determine changes in stream systems and riparian

habitat since settlement. Current data were digitized from county atlas maps and aerial photographs. These data were then used to produce a report on historical changes to Walnut Creek watershed in Jasper County (Anderson and Bishop 1994).

Table 2. GIS files containing various data layers developed from best available maps and remote sensing data.

File Name	Description
HYPERVID	Indexed stack of aerial video frames (Spring 1991).
HYPER_BW	Indexed stack of aerial photos (1:6600 - 11/91).
WC_VEG91	Modified version of WC_VEG from ground-truth data.
WALJSOIL	Soils from state digital database with ISPAID attrib.
SOILSUT	Suitability of soil map units to prairie/timber/sav.
SOIL_SER	Soils series.
SOIL_ASO	Soils associations.
WTRSHED	Walnut Creek watershed boundry interpreted from USGS 7.5'.
WTR_HAB	Land use map created for EPA watershed study (1:40000).
WTR_SAMP	Node vector of stream sampling locations.
SUBSHEDS	Sub-basins corresponding to in-stream sampling locations.
CRP_93	Verification of CRP fields from Jasper Co. ASCS (1993).
BIRDHABT	Vegetation classified for bird survey design (1:40000).
BWMOS_90	B&W image from mosaic of scanned transp (1:40000).
OLS_HABS	Habitats from OLS (1860s) cartographer's map.
OLS_STRS	Stream courses from OLS (1860s) cartographer's map.
CLS_INTR	Intermittent streams classed by nature of stream bed.
RIPARIAN	Vegetation map clipped to 100 m stream buffer.
STREAM90	Stream channels mapped from 1990 B&W transparencies.
DRAINPAT	Drainage pattern mapped from 1986 CIR transparencies.

Literature Cited

Andersen, K. L. and T. R. Bishop. 1994. Conversion of presettlement survey data into digital maps utilizing geographical information systems. Pp. 251-263 *in* Proceedings of the Fourth Annual Iowa Space Conference, Iowa Space Grant Consortium, Iowa City, Iowa. NOvember 4-5, 1994.

PART III

SURVEY OF PRAIRIE REMNANTS FOR SOURCES OF SEED

In 1992, an inventory of prairie remnants in a 38-county area surrounding Walnut Creek refuge was begun. The purpose of the inventory was to identify potential sources of prairie plant seeds to be used in prairie reconstruction on the refuge and to integrate this information into a GIS database. The database was designed to hold geographical location and site-quality information for each of the prairie remnants located.

Attributes were recorded for 16 of the 38 counties and digital data were prepared for 4 of these counties. Work was suspended, however, due to changes in data structures used by MIPS software and the user interface developed for ARC/INFO. The Unit obtained ESRI ARC/VIEW software from other fund sources and it became clear that the vector format used in ARC/VIEW was a much more viable alternative than raster format used by the MIPS hyperindex software for development of the seed source database. However, changing over to the ARCVIEW data structure required that data entry and digital data had to be structured differently. This work was not completed because of insufficient funds.

Original field data records of seed source information was provided to the refuge.

Table 3. GIS files covering counties in central Iowa identified as potential sources of prairie seed. Files are in MIPS format.

File Name	Description
Entire 38-county area	
IAHABIT	: State habaitat regions with study area overlay.
IAGEOLGY	: State geologic regions with study area overlay.
STUDYARE	: Outline of study area with hot boxes for habitat and geology display.
SURVCNTY	: Vector of county lines for counties in survey.
STATCNTY	: Vector of county lines for entire state.
Story, Boone, Greene, and Dallas counties only.	
TWNM	: Mosaic of township plat maps.
PRAR	: Locations of prairies.
TRAN	: County transportation map.

Table 4. Database files for plant surveys of prairie remnants in 16 counties in central Iowa. Counties include: Appanoose, Benton, Boone, Clarke, Dallas, Davis, Decatur, Greene, Guthrie, Iowa, Jasper, Lucas, Ringgold, Story, Union, Wayne. Files are in D-BASE-IV format.

File Name	Description
GRASSDAT	: Cumulative species list of observed grasses.
FORBDAT	: Cumulative species list of observed forbs.
WEEDDAT	: Cumulative species list of observed weeds.
WOODDAT	: Cumulative species list of observed woody plants.
OWNRINFO	: Contact information for property owners/managers.
LOCALE	: Legal description of each site (TWP, RANGE, SECTION).
SITEDESC	: General description of quality of each site.
HARVEST	: Information pertaining to seed harvest at each site.
OWNRSHP	: Ownership information for each site.
FORBLST	: List of forbs observed at each site.
GRASLST	: List of grasses observed at each site.
WEEDLST	: List of weeds observed at each site.
WOODLST	: List of woody species observed at each site.

PART IV

FAUNAL SURVEY OF WALNUT CREEK NATIONAL WILDLIFE REFUGE, 1994

The long term goals of Walnut Creek Refuge are to preserve and increase biodiversity through sound land stewardship, to protect fish and wildlife resources, to provide an outdoor learning program for people of all ages, to document the process of ecological restoration through scientific research, and to provide opportunities for the public to utilize, associate with, learn about, and enjoy fish and wildlife resources.

To implement these goals the Fish & Wildlife Service intends to restore or reconstruct as nearly as possible the natural biotic communities that existed at the time of settlement by Euro-Americans (circa 1840). According to historical evidence, tallgrass prairie was the primary community that occupied what is now Walnut Creek Refuge, but oak savanna and riparian communities were also present. Restoration and reconstruction of these ecosystems will entail selecting and re-establishing an authentic mix of species.. Efforts will also be made to restore original ecological relationships and functions at least as they are known. Exotic species or organisms intrinsic to other environments will be discouraged and eliminated if possible.

Much of the area to be returned to prairie has been intensively farmed for over 100 years. Remnant patches of highly degraded prairie and savanna still exist and it is possible that these areas can be restored with intensive management. Land that has been in cropland or pasture will require complete reconstruction.

Participants in a planning workshop held in Prairie City, Iowa in May 1993 identified a number of areas in which information was needed to evaluate and monitor ecological restoration on the refuge (Roelle and Hamilton 1993). Information needs consisted of five priority areas: Presettlement History, Monitoring, Development of Restoration and Management Techniques, Education and Human Dimensions, and Basic Ecology.

With regard to monitoring, the workshop determined that a thorough abiotic and biotic assessment of Walnut Creek Refuge is needed prior to any significant restoration or reconstruction. Moreover, a sustained, long-term monitoring program is needed to measure progress (or lack thereof) of the refuge's stated goals and objectives. Workshop participants recommended monitoring of soils, hydrology, water quality, plants, vertebrate and invertebrate organisms with particular emphasis on species or groups that would serve as indicators

of the intended restored ecosystems.

Part IV of this report provides the results of the first intensive surveys of the fauna of Walnut Creek NWR. These surveys provide baseline data for monitoring change in ecological communities as prairie and savanna ecosystems are restored and reconstructed. Field work was conducted from 20 May to 15 August 1994.

Insects represent the most diverse of all the animal groups that inhabit terrestrial habitats. The restoration of prairie and savanna ecosystems at Walnut Creek Refuge will have a potentially profound effect on the presence and abundance of hundreds of insect species. Many orders of insects contain species that are important agricultural pests. Native prairie areas are not normally reservoirs of pest species but there is the potential that neighboring farmers may perceive that the refuge is a source of pest species. Therefore, from time-to-time it may be important to document the presence and relative abundance of pest species and nonpest relatives.

Certain insect groups have been found to be linked to prairie remnants in Illinois and these groups may serve as indicators of the relative success of the restoration process (Ron Panzer, Northeastern University, personal communication). Panzer, who calls these prairie reliant species, suggests that the Orders Lepidoptera (butterflies and moths) and Homoptera (leafhoppers and treehoppers) have the highest proportion of habitat reliant species. The Orthoptera (grasshoppers, katydids, crickets) and Coleoptera (beetles) are abundant in prairie and savanna habitats and could provide a means for monitoring change in biodiversity because they are well-known taxonomically and are not as diverse. However, there are no reliant species known from these groups. The Homoptera are the most diverse group but species identification requires special preparation procedures of the animal's genitalia. In addition there are relatively few insect taxonomists who can identify Homopteran species. Andy Hamilton, Carlon College, Ottawa, Ontario is one who has expressed an interest in assisting with the identification of leafhoppers.

Various species of beetles are active at different times of the year and monitoring of beetles should span the period from March to November. The ants (Order Hymenoptera, Family Formicidae) represent another diverse group that is abundant in prairies and a few species may be reliant species (James Traeger, Missouri Botanical Society-Shaw Arboretum, Gray Summit, Missouri, personal communication).

The following groups of animals were surveyed:

Birds (entire refuge), medium-sized mammals (entire refuge), butterflies (28 remnant prairie tracts); grasshoppers and katydids (entire refuge); moths (12 remnant prairie tracts); ants (12 remnant prairie tracts); ground-dwelling invertebrates (12 remnant prairie tracts).

Techniques used in these surveys varied according to the kind of animals being surveyed. Birds and mammals were censused throughout the refuge, whereas surveys of most insect groups focused on 28 of 31 remnant tracts of habitat (Fig 1 - Remnants) that were classified by refuge biologist Pauline Drobney into four categories (I, II, III, IV) based on plant criteria (Table 5). Category I includes remnant patches judged to be of the highest quality of vegetation with the best potential for restoration of prairie or savanna communities. Category IV remnants (10, 22, 24) had the lowest quality vegetation and animals were not sampled in these remnants.

In this first year of biological surveys, we used 3 approaches to survey insects:

(1) We inventoried Lepidopterans (butterflies and moths) on remnant patches. No endangered species of butterflies are known to occur in this part of Iowa. Relative abundance information would be desireable, but because remnant patches are small and there was danger of trampling small populations of important plant species, we were only able to determine presence or absence of butterfly species.

(2) Clusters of pitfall traps were used to sample ground dwelling insects and other ground invertebrates on 12 Category I remnant patches.

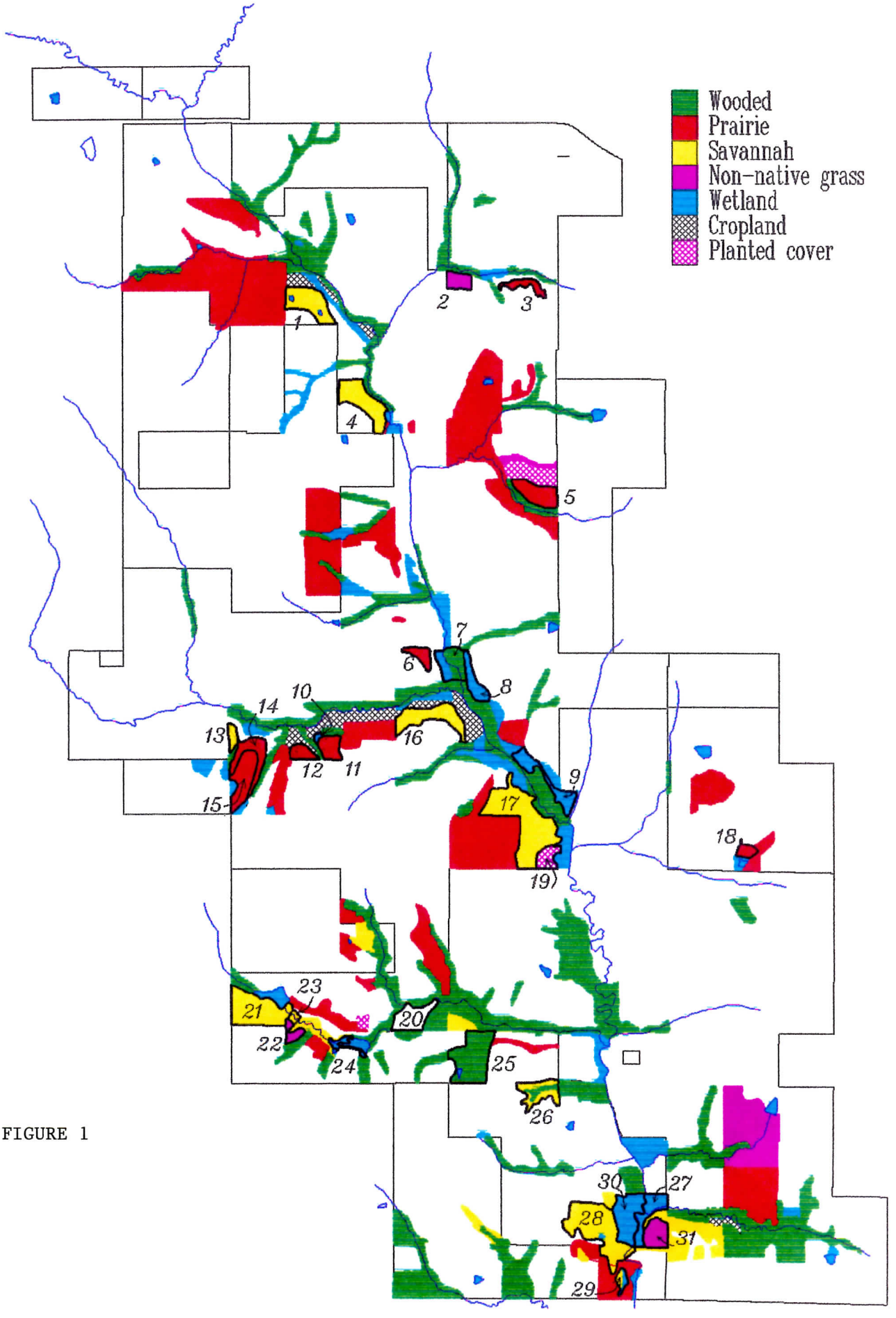
(3) Species of the Order Orthoptera, with special attention to the grasshoppers (Family Acrididae), were inventoried for presence or absence in each quarter section of refuge property.

(4) Ants were surveyed on the 12 Category I remnant habitat patches.

Literature Cited

Roelle, James E. and Hamilton, David B. 1993. Monitoring and research at Walnut Creek National Wildlife Refuge. Report on the results of the workshop. U.S. Fish & Wildlife Service, National Ecology Research Center, Fort Collins, CO

Fig. 1 - Map of 31 remnant habitat patches, Walnut Creek NWR, 1994.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Savannah
Non-native grass
Wetland
Cropland
Planted cover
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FIGURE 1

Table 5. Remnant habitat patches at Walnut Creek NWR, 1994. Remnant numbers 10, 22 and 24 were not sampled because they were rated as having poor vegetation quality.

Remnant Number	Name	Vegetation Category	Area(Ha)	Perimeter(Km)
1	TWO PONDS	II	6.01	1.01
2	SWAN'S OLD FIELD	II	2.09	0.38
3	MUSTACHE	II	1.74	0.61
4	DOGLEG	I	6.61	0.86
5	CONEFLOWER	I	4.35	0.59
6	TRIANGLE	I	1.63	0.42
7	TOUCH-ME-NOT	II	4.46	0.89
8	NO NAME	II	2.81	0.61
9	PACIFIC BISECT	III	4.31	1.07
10	Not sampled	IV	0.30	0.17
11	DON'S 1	I	2.53	0.42
12	DON'S 2	I	1.73	0.37
13	BAPTISIA	I	1.06	0.31
14	HORSESHOE	II	4.00	1.07
15	TALL BROME	II	5.27	0.76
16	BUZZARD HEAD	I	6.41	1.04
17	THORN VALLEY	I	16.09	1.55
18	BADGER DIGS	I	1.15	0.32
19	SWITCHGRASS	III	2.27	0.44
20	BASSWOOD HILL	II	4.43	0.65
21	GAME FARM #1	I	8.98	0.90
22	Not sampled	IV	1.34	0.43
23	GAME FARM #3	III	0.54	0.19
24	Not Sampled	IV	1.13	0.68
25	WIGGINS WOODS	I	9.37	2.01
26	MAIDEN HAIR HOLLOW	I	4.32	1.70
27	GIANT ST JOHNS WORT	II	3.88	0.89
28	BIRDHEAD	II	12.46	1.47
29	SOUTH AMERICA	III	1.11	0.59
30	SEDGE WREN MEADOW	II	6.36	0.81
31	LONE OAK HILL	II	3.52	0.46

IV. FAUNAL SURVEY OF WALNUT CREEK NWR, 1994

SURVEY OF BIRDS

Birds represent one of the most conspicuous groups of animals present on Walnut Creek National Wildlife Refuge. As ecological reconstruction on the refuge progresses and prairie and savanna communities replace cropland as the dominant land cover, it is expected that the diversity and abundance of grassland bird species will increase. However, woodland and edge species may decrease in numbers or even disappear with the elimination of woodlands, fencerows, farmsteads and other edge habitats. Baseline information is needed to document these changes over time and to evaluate the progress of ecosystem reconstruction.

This survey was undertaken to determine the diversity and relative abundance of resident bird species present in major habitats on the refuge in the summer of 1994. The survey was designed to gain an overall perspective of change at the scale of the entire refuge.

Methods:

A GIS overlay was prepared with vegetation cover classified into four broad categories (forest, cropland, herbaceous, and riparian)(Fig. 2). Bird survey points were selected using the GIS. First, 20 Universal Transverse Mercator (UTM) X-Y coordinates were chosen, and then points were chosen randomly within each of the four vegetation classes (total=80) and plotted as closed circles on the GIS file (Table 6). Second, an additional 6 points in each vegetation class were chosen nonrandomly to ensure that all primary patches of existing vegetation were sampled, or to fill in large areas that were missed with randomly drawn points. The refuge was divided into northern and southern halves to facilitate sampling and an even number of points chosen in each half. Two points (50 and 54), classified as cropland at the start of the survey, were not farmed and were reclassified as herbaceous for the purpose of this report. Vegetative cover of riparian habitat varied from grass waterways bordered by cropland to woodland. Third, 20 alternate points were chosen (5 in each habitat class) to be used in case the first choices turned out to be inaccessible in the field or inappropriately placed. Bird Survey Plots are on GIS file: SURVPLOT.

Numbered points with their UTM X-Y coordinates are listed in Table 6. The code in the column listed 'class' indicates the vegetation class and whether the point was randomly picked (RND), selected (SEL), or is an alternate (ALT). Points were

Fig. 2 - Map of bird survey plots, Walnut Creek NWR, 1994. Plots are color coded to indicate general habitat characteristics of the plot.

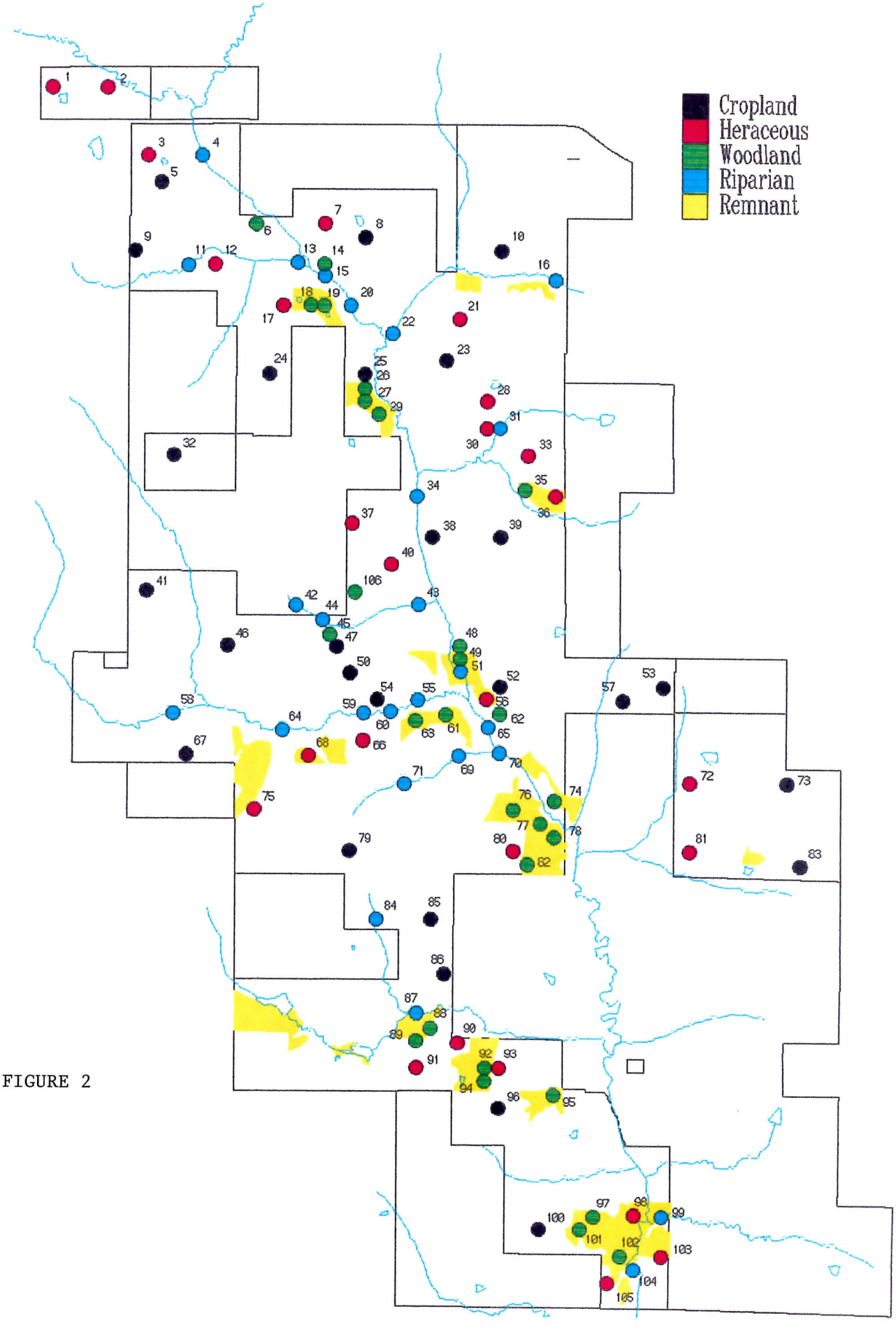


FIGURE 2

then plotted manually on 7.5 minute USGS quadrangle maps and on 2-ft. contour maps provided by the refuge for use in locating points in the field.

The final design had 106 survey points (28 Woodland, 28 herbaceous, 26 riparian, 24 cropland). These points were located in the field and marked with 1-meter-long wooden stakes. Each stake was marked with pink flagging and with the number of the survey point written on the stake in waterproof ink.

Point count procedures generally followed Ralph et al. (1993). Birds were counted three times on each of 106 randomly selected circular plots within the four habitat classes.

All birds seen or heard were counted for 10 min. within a circular plot measuring 50-meter in radius from the survey point in the center of the plot. Point counts were done during a 47-day period between 26 May and 11 July. Counts were not done in the rain or high winds. Counts were done between 5 and 9 AM (CDT) during peak periods when birds sing.

Ideally, points to be censused each day should be chosen at random. However, to reduce travel time the refuge was divided in half and plots chosen in each half on alternate days i.e., 6-8 points per observer were chosen at random from the north half of the refuge one day, and another sample of points from the south half the next day. Randomization ensures that an unbiased survey of the refuge is obtained; it is especially important if more than one person is doing the counting.

Results:

A total of 70 species of birds were detected at least once (Table 7). The list includes most of the common breeding birds of the region.

Twelve species occurred at least once on 30 percent or more of the 106 plots (Table 7). In order of frequency, these were: Red-winged Blackbird (70% of plots), Common Yellowthroat (56%), Gray Catbird (45%), American Robin (45%), Northern Cardinal (45%), House Wren (43%), Song Sparrow (40%), Rose-breasted Grosbeak (40%), Mourning Dove (37%), Brown-headed Cowbird (34%), Blue Jay (33%), and Dickcissel (31%).

The ten most abundant species (total individuals counted) over all plots were Red-winged Blackbird, House Wren, Gray Catbird, Common Yellowthroat, American Robin, Northern Cardinal, Dickcissel, Song Sparrow, Blue Jay, and Mourning Dove (Table 8).

The Red-winged Blackbird was the most common species on herbaceous (24 of 28) and cropland plots (19 of 24) and occurred

in all four habitats. The Song Sparrow also occurred in all habitats but was the most common species on riparian plots (25 of 26). The Northern Cardinal was most common on woodland plots (28 of 28) although the House Wren was a close second (26 of 28).

Only a few species were unique to only one habitat. The Bobolink, Chipping Sparrow, American Kestrel, and Ruby-throated Hummingbird were seen only on herbaceous plots. The Canada Goose (a flock of 9 landed in a field during a plot census), Upland Sandpiper, and Cliff Swallow were each recorded on one plot in cropland habitat. Several Upland Sandpipers were seen in herbaceous habitat but not on census plots. The Ovenbird, Great-blue Heron, American Woodcock, and Spotted Sandpiper were recorded only on riparian plots. The American Crow, Eastern Tufted Titmouse, Red-eyed Vireo, Hairy Woodpecker, Rufous-sided Towhee, Chimney Swift, and Bell's Vireo were unique to woodland plots.

Riparian habitat had the highest species richness with 53 species, followed by woodland with 50 species, herbaceous with 43, and rowcrop with 32.

Seven species occurred on our census plots that are of special concern to the U.S. Fish & Wildlife Service or the Iowa Department of Natural Resources because of declining populations over much of their breeding range. These are the Dickcissel, Grasshopper Sparrow, Western Meadowlark, Bobolink, Eastern Meadowlark, Upland Sandpiper, and Bell's Vireo. The Short-eared Owl was not seen on census plots but 4 fledglings (as indicated by remnants of down feathers) and 1 adult were seen on May 25, 1995. This constitutes a probable rare breeding record for the state of Iowa.

Species of special concern that were not recorded during our survey are: Red-shouldered Hawk, Northern Harrier, Barn Owl, American Bittern, Cerulean Warbler, Loggerhead Shrike, and Henslow's Sparrow. Prairie and savanna restoration on the refuge should create favorable habitat for the Northern Harrier, American Bittern, Loggerhead Shrike, and Henslow's Sparrow. All four of these species nest elswhere in Iowa and it will be interesting to see if and when these species nest on the refuge. Barn Owls will benefit from the addition of grassland as foraging habitat but the lack of barns and other suitable structures may limit their nesting on the refuge. The Red-shouldered Hawk and Cerulean Warbler require extensive tracts of mature forest and it is unlikely that these two species will ever become established as breeding birds on the refuge unless restoration objectives change.

In early August, a photograph (Kodachrome slide) was taken at the center of each circular census plot while facing due north. Census data are stored in D-BASE IV files (Table 23).

Original field data sheets are on file at the Iowa Cooperative Fish and Wildlife Research Unit, 11 Science II, Iowa State University, Ames, Iowa.

Discussion and Recommendations

The techniques used in this first year's survey worked well. Three replicate counts were easily accomplished by two observers. In future years, one observer should be able to complete three replicate counts of up to 130 points between mid-May and mid-July. One or two more years of data should be acquired and evaluated before making major changes in the census procedures.

The number of plots should be increased to accomodate additional land acquired for the refuge and to increase the number of sampling points within habitats. Ralph *et al.* (1993, *ibid*) recommend a minimum of 30 plots per habitat type when censusing without replication. Although cropland is being rapidly converted to grassland, this habitat type should continue to be sampled, if possible, to provide a contrast with restored areas. Counts should not start earlier than May 15 to avoid counting migrants.

This survey design will provide good estimates of relative abundance and species richness, and correlations can be made between these variables and vegetation or other factors. Vegetation measurements should be made on each plot to connect bird counts directly to habitat features. However, many studies have shown that birds select habitat based on general structure rather than specific plant species. Thus, the four habitat categories we have used may be sufficient for monitoring change on the refuge. These surveys conducted over several years should provide good information for monitoring changes in bird populations over time. It is probable that restored prairie and savanna will provide improved habitat for wintering birds and we recommend that winter surveys be started as soon as possible. A transect method should be used to census winter birds.

We recommend that census points be marked with permanent stakes or that a GPS system be acquired that will permit relocating points from year to year. A 6- or 7-ft. steel fence post painted green with a white or orange top would be inconspicuous and yet be easily found. These sampling points could also be used as reference point to census and monitor other fauna.

Literature Cited

Ralph, C.J., G.R. Geupel, P. Pyle, T.E. Martin, and D.F. DeSante. 1993. Handbook of Field Methods for Monitoring Landbirds. USDA Forest Service Pulication, PSW-GTR 144, Albany, CA.

Table 6. Survey points used for bird surveys at Walnut Creek NWR, Summer 1994. MIPS No. identifies the plot on the MIPS GIS file. X-Y coordinates are UTM (Universal Transmercator). Vegetation class codes are: HERB=Herbaceous, RPRN=Riparian, CRPL=Cropland, WOOD=Woodland. Location codes indicate the method by which points were located: RND=random within vegetation class, SEL=selected, or ALT=alternate random points.

PLOT NO	MIPS NO	X-Coord.	Y-Coord.	CLASS	Location
1	32	474316.04	4605595.00	HERB	RND
2	33	474715.68	4605594.65	HERB	RND
3	34	475016.04	4605095.00	HERB	RND
4	94	475417.54	4605093.56	RPRN	SEL
5	1	475116.04	4604895.00	CRPL	RND
6	63	475816.21	4604592.66	WOOD	RND
7	35	476320.12	4604596.77	HERB	SEL
8	2	476616.86	4604493.73	CRPL	RND
9	3	474921.02	4604394.97	CRPL	RND
10	4	477616.04	4604395.00	CRPL	SEL
11	95	475319.57	4604288.35	RPRN	RND
12	36	475516.04	4604295.00	HERB	RND
13	123	476121.44	4604308.59	RPRN	RND
14	64	476317.65	4604300.34	WOOD	RND
15	96	476320.72	4604209.28	RPRN	RND
16	124	478013.20	4604182.57	RPRN	RND
17	37	476016.04	4603995.00	HERB	RND
18	128	476216.98	4603997.21	WOOD	RND
19	80	476316.04	4603995.00	WOOD	RND
20	97	476511.38	4603995.41	RPRN	RND
21	38	477310.76	4603895.75	HERB	RND
22	98	476820.49	4603790.50	RPRN	SEL
23	5	477216.04	4603595.00	CRPL	RND
24	6	475916.04	4603495.00	CRPL	SEL
25	7	476615.90	4603492.47	CRPL	RND
26	129	476616.49	4603387.71	WOOD	RND
27	81	476616.61	4603294.94	WOOD	RND
28	39	477516.04	4603295.00	HERB	RND
29	65	476720.90	4603199.85	WOOD	SEL
30	40	477513.64	4603096.72	HERB	RND
31	125	477610.83	4603098.77	RPRN	RND
32	8	475216.04	4602895.00	CRPL	SEL
33	41	477816.04	4602895.00	HERB	RND
34	100	477003.42	4602595.00	RPRN	SEL
35	84	477793.10	4602641.73	WOOD	SEL
36	42	478016.08	4602595.12	HERB	SEL
37	43	476525.76	4602395.10	HERB	RND
38	9	477116.04	4602295.00	CRPL	RND
39	10	477616.04	4602295.00	CRPL	RND
40	44	476816.04	4602095.00	HERB	SEL

Table 6 (cont.). Survey points used for bird surveys at Walnut Creek NWR, Summer 1994. MIPS No. X-Y coordinates are UTM (Universal Transmercator). Vegetation class codes are: HERB=Herbaceous, RPRN=Riparian, CRPL=Cropland, WOOD=Woodland. Location codes indicate the method by which points were located: RND=random within vegetation class, SEL=selected, ALT=alternate random points.

PLOT NO	MIPS NO	X-Coord.	Y-Coord.	CLASS	Location
41	11	475016.04	4601895.00	CRPL	RND
42	101	476117.10	4601791.39	RPRN	RND
43	102	477015.91	4601798.98	RPRN	RND
44	103	476312.81	4601683.36	RPRN	RND
45	86	476365.79	4601575.97	WOOD	SEL
46	12	475616.04	4601495.00	CRPL	RND
47	13	476416.09	4601488.13	CRPL	RND
48	83	477320.31	4601493.10	WOOD	RND
49	82	477322.14	4601401.14	WOOD	RND
50	14	476516.04	4601295.00	CRPL	RND
51	104	477326.40	4601306.70	RPRN	RND
52	15	477616.04	4601195.00	CRPL	RND
53	16	478816.04	4601195.00	CRPL	RND
54	17	476715.90	4601099.37	CRPL	RND
55	105	477014.50	4601098.00	RPRN	RND
56	45	477517.43	4601103.89	HERB	RND
57	18	478516.04	4601095.00	CRPL	RND
58	108	475217.64	4600995.42	RPRN	RND
59	106	476615.82	4601001.06	RPRN	RND
60	107	476815.44	4601012.16	RPRN	RND
61	66	477219.66	4600988.88	WOOD	RND
62	67	477614.55	4600993.54	WOOD	RND
63	87	476997.88	4600944.66	WOOD	SEL
64	110	476019.59	4600875.21	RPRN	RND
65	109	477530.19	4600897.21	RPRN	RND
66	46	476612.07	4600799.07	HERB	RND
67	19	475316.04	4600695.00	CRPL	RND
68	47	476212.02	4600688.61	HERB	RND
69	112	477315.80	4600688.93	RPRN	RND
70	111	477613.97	4600709.39	RPRN	SEL
71	113	476918.29	4600484.99	RPRN	RND
72	48	479016.04	4600495.00	HERB	RND
73	20	479716.04	4600495.00	CRPL	RND
74	85	478017.39	4600360.87	WOOD	SEL
75	49	475816.04	4600295.00	HERB	RND
76	68	477715.99	4600293.82	WOOD	RND
77	69	477916.04	4600195.00	WOOD	RND
78	70	478016.04	4600095.00	WOOD	RND
79	21	476516.04	4599995.00	CRPL	SEL
80	50	477716.04	4599995.00	HERB	SEL
81	51	479016.04	4599995.00	HERB	RND

Table 6 (cont.). Survey points used for bird surveys at Walnut Creek NWR, Summer 1994. MIPS No. identifies the plot on the MIPS GIS file. X-Y coordinates are UTM (Universal Transmercator). Vegetation class codes are: HERB=Herbaceous, RPRN=Riparian, CRPL=Cropland, WOOD=Woodland. Location codes indicate the method by which points were located: RND=random within vegetation class, SEL=selected, or ALT=alternate random points.

PLOT NO	MIPS NO	X-Coord.	Y-Coord.	CLASS	Location
82	11	475016.04	4601895.00	CRPL	RND
83	22	479816.04	4599895.00	CRPL	RND
84	114	476714.55	4599495.40	RPRN	RND
85	23	477116.04	4599495.00	CRPL	RND
86	24	477214.00	4599093.32	CRPL	RND
87	115	477014.67	4598806.42	RPRN	SEL
88	72	477116.04	4598695.00	WOOD	RND
89	73	477011.02	4598602.78	WOOD	SEL
90	52	477315.41	4598585.84	HERB	RND
91	53	477013.39	4598397.43	HERB	SEL
92	74	477515.22	4598395.58	WOOD	RND
93	54	477617.34	4598394.12	HERB	RND
94	75	477511.08	4598295.62	WOOD	RND
95	76	478016.78	4598194.10	WOOD	RND
96	25	477616.04	4598095.00	CRPL	SEL
97	77	478314.94	4597289.19	WOOD	RND
98	55	478610.08	4597301.12	HERB	RND
99	116	478813.88	4597292.13	RPRN	RND
100	26	477916.04	4597195.00	CRPL	SEL
101	78	478216.18	4597194.95	WOOD	RND
102	79	478513.09	4596994.98	WOOD	RND
103	56	478816.04	4596995.00	HERB	RND
104	117	478613.70	4596895.48	RPRN	SEL
105	57	478421.84	4596794.51	HERB	SEL
106	88	476549.30	4601888.23	WOOD	SEL
107	91	478316.47	4597101.54	WOOD	ALT
108	92	478416.04	4597194.71	WOOD	ALT
109	130	478419.06	4597290.50	WOOD	ALT
110	31	477016.04	4599695.00	CRPL	ALT
111	62	479516.66	4599895.86	HERB	ALT
112	90	477616.62	4600294.49	WOOD	ALT
113	89	477720.09	4600388.22	WOOD	ALT
114	61	479216.04	4600395.00	HERB	ALT
115	60	477716.04	4600795.00	HERB	ALT
116	122	474816.94	4600913.25	RPRN	ALT
117	121	475719.42	4600993.85	RPRN	ALT
118	120	477395.43	4601092.94	RPRN	ALT
119	119	477216.26	4602785.10	RPRN	ALT
120	59	478016.04	4602895.00	HERB	ALT
121	30	476716.04	4604195.00	CRPL	ALT

Table 6 (cont.). Survey points used for bird surveys at Walnut Creek NWR, Summer 1994. MIPS No. identifies the plot on the MIPS GIS file. X-Y coordinates are UTM (Universal Transmercator). Vegetation class codes are: HERB=Herbaceous, RPRN=Riparian, CRPL=Cropland, WOOD=Woodland. Location codes indicate the method by which points were located: RND=random within vegetation class, SEL=selected, or ALT=alternate random points.

PLOT NO	MIPS NO	X-Coord.	Y-Coord.	CLASS	Location
122	29	478016.04	4604295.00	CRPL	ALT
123	28	477016.04	4604395.00	CRPL	ALT
124	27	475315.80	4604795.21	CRPL	ALT
125	58	474915.99	4605398.36	HERB	ALT
126	118	474825.97	4605614.80	RPRN	ALT

Table 7. Frequency of occurrence of 70 bird species (species detected at least once during one of 3 replicate 10-minute counts) on 106 50-meter-radius circular plots in four habitat types, Walnut Creek NWR, 26 May to 11 July 1994. Number of plots censused is given in parentheses under each habitat class.

	Frequency of Occurrence				
Species	All Plots (106)	Cropland (24)	Herbaceous (28)	Riparian (26)	Woodland (28)
Red-winged Blackbird	74	19	24	21	10
Common Yellowthroat	59	3	16	23	17
Gray Catbird	48	0	4	20	24
American Robin	48	5	7	21	15
Northern Cardinal	48	2	3	15	28
House Wren	46	0	5	15	26
Song Sparrow	42	3	5	25	9
Rose-breasted Grosbeak	42	1	3	16	22
Mourning Dove	39	3	6	11	19
Brown-headed Cowbird	36	8	7	12	9
Blue Jay	35	2	5	6	22
Dickcissel	33	7	19	7	0
Black-capped Chickadee	28	0	0	9	19
Northern Oriole	28	1	4	11	12
Indigo Bunting	27	0	3	7	17
American Goldfinch	26	1	7	10	8
Western Meadowlark	25	9	8	7	1
Yellow-billed Cuckoo	22	0	0	4	18
Downy Woodpecker	21	0	2	5	14
Eastern Wood Pewee	20	0	0	6	14
Killdeer	19	14	2	3	0
White-breasted Nuthatch	19	0	0	7	12
Brown Thrasher	18	3	5	4	6
Red-headed Woodpecker	16	0	1	6	9
Cedar Waxwing	15	0	2	6	7
Vesper Sparrow	15	10	2	3	0
Grasshopper Sparrow	14	6	6	1	1
Barn Swallow	14	5	7	2	0
Great-crested Flycatcher	14	0	1	4	9
Red-bellied Woodpecker	13	0	0	4	9
Common Grackle	12	1	3	4	4
Sedge Wren	11	1	8	2	0
Willow Flycatcher	11	0	0	10	1
Yellow Warbler	11	0	1	7	3
Northern Flicker	11	1	0	4	6
Field Sparrow	10	0	4	1	5
Red-tailed Hawk	10	1	0	5	4
Ring-necked Pheasant	9	3	3	2	1

Table 7 (cont.). Frequency of occurrence of 70 bird species (species detected at least once during one of 3 replicate 10-minute counts) on 106 50-meter-radius circular plots in four habitat types, Walnut Creek NWR, 26 May to 11 July 1994. Number of plots censused is given in parentheses under each habitat class.

	Frequency of Occurrence				
Species	All Plots (106)	Cropland (24)	Herbaceous (28)	Riparian (26)	Wood-land (28)
Eastern Kingbird	8	2	2	3	1
European Starling	7	2	1	1	3
Horned Lark	7	5	1	1	0
Warbling Vireo	6	0	1	3	2
Black-billed Cuckoo	6	0	0	3	3
Eastern Meadowlark	4	1	1	0	2
Wood Duck	4	0	0	1	3
Barred Owl	4	0	1	0	3
Bobolink	3	0	3	0	0
Eastern Bluebird	3	1	0	2	0
American Crow	3	0	0	0	3
Eastern Tufted Titmouse	3	0	0	0	3
Bobwhite	3	1	1	1	0
Eastern Phoebe	3	0	0	2	1
Mallard	2	0	1	1	0
Upland Sandpiper	2	2	0	0	0
Red-eyed Vireo	2	0	0	0	2
Belted Kingfisher	2	0	0	1	1
Ovenbird	2	0	0	2	0
Orchard Oriole	2	0	1	0	1
Hairy Woodpecker	1	0	0	0	1
Canada Goose	1	1	0	0	0
Great Blue Heron	1	0	0	1	0
Chipping Sparrow	1	0	1	0	0
Rufous-sided Towhee	1	0	0	0	1
Chimney Swift	1	0	0	0	1
Cliff Swallow	1	1	0	0	0
American Kestrel	1	0	1	0	0
American Woodcock	1	0	0	1	0
Bell's Vireo	1	0	0	0	1
Spotted Sandpiper	1	0	0	1	0
Ruby-throated Hummingbird	1	0	1	0	0

Table 8. Relative abundance of 70 bird species (total individuals counted) on 106 50-meter-radius circular plots in four habitat types, Walnut Creek NWR, 26 May to 11 July 1994. Three 10-minute counts were conducted on each plot. Number of plots censused is given in parentheses under each habitat type.

	Total Individuals Counted by Habitat Type				
Species	All Plots (106)	Cropland (24)	Herbaceous (28)	Riparian (26)	Woodland (28)
Red-winged Blackbird	546	79	240	208	19
House Wren	213	0	11	78	124
Gray Catbird	142	0	5	50	87
Common Yellowthroat	132	3	34	63	32
American Robin	115	7	13	58	37
Northern Cardinal	115	2	3	31	79
Dickcissel	99	14	73	12	0
Song Sparrow	99	6	7	68	18
Blue Jay	78	2	8	15	53
Mourning Dove	78	4	9	26	39
Brown-headed Cowbird	68	17	14	19	18
Rose-breasted Grosbeak	67	1	3	26	37
Black-capped Chickadee	63	0	0	19	44
American Goldfinch	51	3	18	21	9
Killdeer	50	44	2	4	0
Indigo Bunting	49	0	7	9	33
Sedge Wren	49	1	42	6	0
Grasshopper Sparrow	44	14	28	1	1
Downy Woodpecker	39	0	2	9	28
Northern Oriole	39	1	5	17	16
Western Meadowlark	37	12	14	10	1
White-breasted Nuthatch	33	0	0	11	22
Yellow-billed Cuckoo	33	0	0	4	29
Brown Thrasher	32	5	11	6	10
Cedar Waxwing	32	0	3	12	17
Barn Swallow	27	11	13	3	0
European Starling	26	16	1	4	5
Eastern Wood Pewee	24	0	0	6	18
Field Sparrow	24	0	13	1	10
Horned Lark	23	18	1	4	0
Ring-necked Pheasant	22	4	14	3	1
Common Grackle	21	3	3	7	8
Red-headed Woodpecker	21	0	1	7	13
Vesper Sparrow	21	13	4	4	0
Willow Flycatcher	20	0	0	19	1
Yellow Warbler	18	0	1	14	3
Great-crested Flycatcher	15	0	1	5	9
Red-bellied Woodpecker	14	0	0	4	10

Table 8 (cont.). Relative abundance of 70 bird species (total individuals counted) on 106 50-meter-radius circular plots in four habitat types, Walnut Creek NWR, 26 May to 11 July 1994. Three 10-minute counts were conducted on each plot. Number of plots censused is given in parentheses under each habitat type.

	Frequency of Occurrence				
Species	All Plots (106)	Cropland (24)	Herbaceous (28)	Riparian (26)	Woodland (28)
Northern Flicker	14	1	0	5	8
Red-tailed Hawk	13	1	0	7	5
Eastern Kingbird	12	2	3	6	1
Bobolink	10	0	10	0	0
Canada Goose	9	9	0	0	0
Eastern Bluebird	8	1	0	7	0
Warbling Vireo	8	0	1	5	2
Black-billed Cuckoo	7	0	0	4	3
Eastern Meadowlark	6	2	1	0	3
Wood Duck	6	0	0	1	5
Mallard	4	0	2	2	0
Barred Owl	4	0	1	0	3
American Crow	4	0	0	0	4
Upland Sandpiper	3	3	0	0	0
Eastern Tufted Titmouse	3	0	0	0	3
Red-eyed Vireo	3	0	0	0	3
Bobwhite	3	1	1	1	0
Eastern Phoebe	3	0	0	2	1
Hairy Woodpecker	2	0	0	0	2
Belted Kingfisher	2	0	0	1	1
Ovenbird	2	0	0	2	0
Orchard Oriole	2	0	1	0	1
Great Blue Heron	2	0	0	2	0
Chipping Sparrow	1	0	1	0	0
Rufous-sided Towhee	1	0	0	0	1
Chimney Swift	1	0	0	0	1
Cliff Swallow	1	1	0	0	0
American Kestrel	1	0	1	0	0
American Woodcock	1	0	0	1	0
Bell's Vireo	1	0	0	0	1
Spotted Sandpiper	1	0	0	1	0
Ruby-throated Hummingbird	1	0	1	0	0

IV. FAUNAL SURVEY OF WALNUT CREEK NWR, 1994

SURVEY OF RESIDENT MAMMALS: PREDATOR AND FURBEARER POPULATIONS.

Hayslett and Danielson (1994) conducted a study of small mammal diversity in the summer of 1992 on and near refuge land. They used snap traps to assess mammal populations in three grassland habitats: replanted native grass, old-fields, and prairie remnants with relatively more diverse prairie vegetation than the other two habitats. A total of 501 individuals representing 9 species were captured. Calculated small mammal diversity indices and abundances were similar for all three habitat types. Further analysis of the pooled data indicated that small mammal species may be responding more to vegetation structure than to plant composition. Species captured included *Reithrodontomys megalotis*, western harvest mouse; *Peromyscus maniculatus*, deer mouse; *Peromyscus leucopus*, white-footed mouse; *Microtus pennsylvanicus*, meadow vole; *Microtus ochrogaster*, prairie vole; *Mus musculus*, house mouse; *Zapus hudsonius*, meadow jumping mouse; *Blarina brevicauda*, short-tailed shrew; and *Sorex cinereus*, masked shrew. All species, except the house mouse, were found in all 3 habitat types: the house mouse was found only in replanted native grass.

Predators are one of the most important groups of mammals occurring on the refuge because of their potential impact on restoration of other species, potential for causing conflicts with neighboring landowners, and because some may be harvested as furbearers. As the vegetation and the landscape of the refuge change, relative abundance of predators will likely shift. The purpose of this work unit was to assess the presence of various mammalian furbearer and predator species on the refuge and to provide baseline information for documenting changes in abundance over time.

Objectives:

1. Quantify the relative abundance and distribution of the following species on the refuge: opossum, beaver, muskrat, coyote, red fox, gray fox, raccoon, striped skunk, badger, least weasel, long-tailed weasel, mink, and otter.

2. Relate the distribution to major habitat classes on the refuge.

Methods:

We assessed relative abundance and distribution of the above species using a combination of a track (and other sign) survey, a trapping survey, and a call survey. It was not possible to estimate population density of any of these species with this extensively-designed survey. If periodic censusing were continued, it would be possible to detect relative changes in the

mammal community, and their distribution in relation to habitat classes.

There were 4 components to the sampling which was conducted between 15 May and 30 June.

a). A track and sign survey was designed to detect opossum, coyote, foxes, raccoon, skunk, badger, and mink. It is a modification of sampling procedures used by the U.S. Fish and Wildlife Service to sample predators in waterfowl production areas of North America (Sargeant et al. 1993). The refuge was divided into quarter sections (Figure 3) on land owned by the refuge (or nearly so). Track sampling was conducted 2 days after precipitation had eliminated all previous tracks. An observer spent 1 hour in each quarter section systematically searching for tracks, scats, burrows or other sign. Indications of these species were recorded and classified by habitat class where sign was seen. Four quarter sections were sampled each day. Pairs of quarters were associated with one another and blocked into the north or south half of the refuge to minimize travel. Order of sampling was then selected randomly to average seasonal and observer effects. From this survey, we estimated the proportion of quarter sections where species were present and related presence to habitat classes.

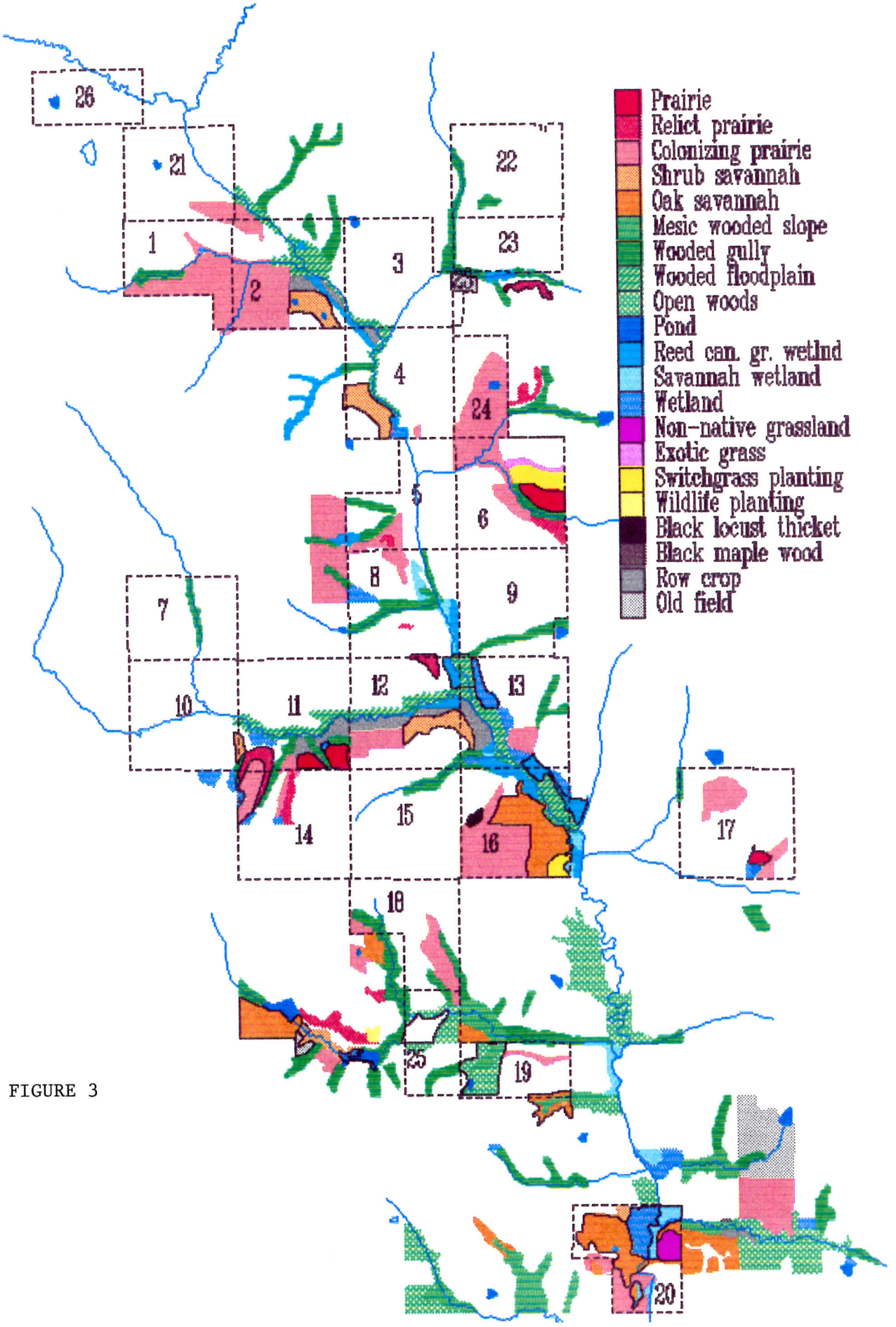
b). A trapping survey was designed to detect medium-sized predators including opossum, raccoon, skunk, badger, mink, long-tailed and least weasel. The trapping survey supplemented the track survey, especially for difficult to observe species such as the weasels. We trapped each sample quarter section with 3 large live-traps and 2 small traps for 4 consecutive nights. Traps were baited with fish oil based scent (large predators) or mouse scent (for weasels) and were placed along natural travel lanes to maximize captures. Sampling was conducted concurrently with the track survey. From these data we obtained additional information on the species presence and habitat relations throughout the refuge.

c). We estimated presence of beaver, muskrat, and mink by walking the length of all drainages in sample quarters and recorded presence of sign. This survey was in addition to the track survey and was completed within the same time frame. We also express these results as proportion of quarter sections where species were present.

d). A call-elicit survey was conducted once during the summer for coyotes and foxes. Stops were made along roads as close to each sample quarter as possible and a siren was sounded to elicit response from the animals.

Mammals seen during bird surveys were also recorded.

Fig. 3 - Map of quarter-sections used for mammal and grasshopper surveys, Walnut Creek NWR, 1994. Colors represent various vegetation communities. Areas in white were cropland.


Prairie
Relict prairie
Colonizing prairie
Shrub savannah
Oak savannah
Mesic wooded slope
Wooded gully
Wooded floodplain
Open woods
Pond
Reed can. gr. wetlnd
Savannah wetland
Wetland
Non-native grassland
Exotic grass
Switchgrass planting
Wildlife planting
Black locust thicket
Black maple wood
Row crop
Old field
26
21
22
1
3
23
2
4
24
5
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8
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FIGURE 3

Results

We detected 20 species of medium- or large-sized mammals during our work at the refuge (Table 9). Ten species were detected during the track and stream surveys including domestic dog and cat. We did not detect the presence of gray fox, least weasel, or otter although we expected to do so. Raccoons and muskrats were ubiquitous. Five beaver dams were present on Walnut Creek and its tributaries and sign of beaver was found along 50% of the surveyed sections of stream. No coyotes responded to the siren sounds although tracks or scats were commonly found in the surveyed sections. However, the estimate of 30% occurence is probably inflated because observers sometimes confused dog and coyote tracks; the true prevalence is likely less. These limited data do not suggest that red fox avoided areas with coyotes or dogs, although others have noted this tendency (Sargeant et al. 1993). Badger were relatively common, and generally detected in quarter sections dominated by cropland. The low detection of Virginia opossum and striped skunk is surprising because we think these mammals are common at the refuge. A striped skunk was caught in a live trap in remnant 23 but tracks were not found in the track survey. The greatest number of species (5) was detected in a section dominated by cropland (quarter-section 10, Figure 3).

We do not think the habitat at the refuge will ever be suitable for gray fox because of lack of extensive woodland. Otter may be transient from nearby Red Rock Reservoir but Walnut Creek is marginal habitat for this species. The future status of three species which are of special concern in Iowa, the southern bog lemming, least shrew, and spotted skunk, is uncertain because the location of the nearest populations is unknown. Southern bog lemmings are found in bogs and wet prairies, which are not likely to be common at the refuge. Prairie habitat for least shrews might become suitable. Spotted skunks in Iowa are most common around farmsteads and rock piles or outcrops in prairies. The future distribution of badgers at the refuge will be determined by the distribution of their principle prey: pocket gophers and ground squirrels.

The track/sign survey was an effective means of detecting mammals over a large area of the refuge. Trapping was not cost efficient although it could be used in the future to specifically detect species such as least weasels or small rodents. The siren-elicit survey was less effective than the track survey at detecting coyotes. Mammal survey data is stored in D-BASE IV file labeled MAMMDAT (Table 23).

Shrews (Order Insectivora, Family Soricidae)

We collected 16 specimens of the masked shrew (*Sorex cinereus*) and 3 specimens of the least shrew (*Cryptotis parva*)

(Table 10) in pitfall traps used to sample ground dwelling invertebrates. Specimens were identified using keys provided in Bowles (1975). According to Bowles (1975), the masked shrew is relatively common in northern and central Iowa where it occupies a variety of habitats including moist grassy areas, forest and woodland. The least shrew occurs throughout the southern half of Iowa and northward through the eastern part of the state (Bowles 1975). The geographic ranges of these two species overlap throughout much of southern Iowa and one or the other species may be locally dominant where they occur together. Little is known of the habitat requirements of the least shrew but it occurs in both grassy and woodland areas. Both species were captured on remnants 4 and 13; the masked shrew occurred in 6 of the 12 remnant habitat patches (Table 10).

Fleas collected in the same traps with the shrews undoubtedly were carried into the traps by the shrews (see survey of ground invertebrates-fleas).

Literature Cited:

Bowles, J. B. 1975. Distribution and biogeography of mammals of Iowa. Texas Tech University, The Museum Special Publication No. 9.

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Sargeant, A. B., R. J. Greenwood, M. A. Sovada, and T. L. Shaffer. 1993. Distribution and abundance of predators that affect duck production--Prairie Pothole Region. U. S. Fish Wildl. Serv. Resour. Publ. 194. 96pp.

Table 9. Medium-sized mammals detected during track or stream surveys at Walnut Creek NWR, 1994. Blanks indicate species that were not included in the systematic surveys.

Species	Percent of Quarter Sections
Raccoon	100
Muskrat	75
Beaver	50
Mink	38
Coyote	30
Red fox	20
Badger	15
Virginia opossum	5
Striped skunk	0
Long-tailed weasel	0
Eastern cottontail	
Eastern chipmunk	
Woodchuck	
Thirteen-lined ground squirrel	
Fox squirrel	
Plains pocket gopher	
White-tailed deer	
Dog	20
Cat	5

Table 10. Species and numbers (N) of shrews taken in pitfall traps at Walnut Creek NWR, 30 June-11 August, 1994.

Species	N	Remnant	Date
Masked Shrew	1	4	7 July
	2	4	14 July
	1	4	11 August
	2	5	4 August
	2	11	30 June
	2	11	4 August
	1	13	14 July
	3	17	7 July
	1	17	14 July
	1	26	7 July
Least Shrew	1	4	30 June
	2	13	7 July

IV. FAUNAL SURVEY OF WALNUT CREEK NWR, 1994

SURVEY OF ANTS

Ants represent one of the most diverse and ubiquitous group of insects in the world. Hölldobler and Wilson (1990) remarked that "...ants are everywhere, but only occasionally noticed." Ants are an important component of all terrestrial ecosystems and perform many essential functions. They turn as much soil volume as earthworms and employ the most complex forms of chemical communication and social organization of any animals (Hölldobler and Wilson 1990). Local diversity can be substantial even in temperate zones; 23 genera and 87 species were found in 5.6 km^2 in Michigan (Talbot 1975), and 30 genera and 76 species in 8 km^2 in Florida (Van Pelt 1956)

In most terrestrial habitats, ants are among the leading predators of other insects and small invertebrates. In some regions of the world, ants are sufficiently dense to reduce the abundance of ground dwelling spiders and carabid beetles (Hölldobler and Wilson 1990). Other groups are important herbivores and granivores and some species, particularly the leaf-cutting ants of the tropics, are serious agricultural pests. In the temperate forests of New York, they are responsible for the dispersal of nearly one-third of the herbaceous plant species (Handel et al. 1981). Ants transport large amounts of nutrients from plant and animal remains, mixing these materials with

excavated soil. The soil surface is thus broken into a mosaic of nutrient concentrations and this in turn creates patchy distributions of plant growth, especially during early stages of succession.

Ants also serve as scavengers and help to facilitate the decomposition of organic material. Many species of ants have symbiotic relationships with other arthropods and plants. One of the best known is the culturing of aphids by ants to produce honeydew which the ants eat as food. Although a few species of ants have been found to forage on nectar in flowers, the ants are not considered to be important plant pollinators.

Thus, ants are an important component of any ecosystem and a complete list of species should be compiled for Walnut Creek NWR. The response of ant communities to restoration should prove most interesting.

Methods

Ants were collected with an aspirator from 20 bait stations laid out along a trail in Category I remnant habitat patches (See descriptions, Table 5). Samples were also collected from six cornfields designated as QS1, QS4, QS14, QS15, South Cornfield, or Gamefarm Field (See Mammal Section) for comparison. Ants were collected over a two-hour period and preserved in alcohol. Remnant patches and fields were sampled only once.

Ants were also collected in pitfall traps (see section on ground invertebrates).

Results

A total of 29 species of ants captured at bait stations were identified by James Traeger, Shaw Arboretum of the Missouri Botanical Garden, Gray Summit, Missouri. Dr. Traeger reports that ants from remnants 3 and 4 are interesting mixes of open- and wooded-habitat species, as though from a habitat in transition (i.e. undergoing succession). Otherwise, the species that are specialists are pretty much where they "ought to be". Dr. Traeger is continuing his analysis of the distribution of species to determine if there are any consistent patterns that can be used as indicators of change.

Tapinoma sessile occurred in the most number of samples: 3 crop fields, and 16 remnant patches. This species also ranked first in the number of individuals within samples from two of the three cornfields and nine of the 16 remnants. *Formica incerta* was the next most common species; it occurred in four cornfields and 11 remnant patches. However, it ranked first in relative abundance of individuals in only one sample (remnant 20).

Ants from pitfall traps were sent to Dr. James Traeger but he had not finished identifications as of June 1995.

Taxonomic Notes from Dr. Traeger: Some names are tentative. For example, *Formica glacialis* and *F. subsericea* are sibling species and are difficult to separate with small samples. *Formica incerta* may actually be two sibling species like the two above. Species in the genus *Myrmica* are always difficult to identify but all of the *Myrmica* species in these samples are common and fairly readily identifiable species.

Ant data are stored on D-BASE IV files: ANT_NAME, WC_ANTS, ANTS (Table 23).

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Talbot, M. 1975. A list of the ants (Hymenoptera: Formicidae) of the Edwin S. George Reserve, Livingston County, Michigan. *Great Lakes Entomologist*, 8(4):245-246.

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Table 11. Ant Species found at Walnut Creek NWR, 1994.

ANT SPECIES	Remnant Fields and Quarter Sections (QS) Where Found
Aphaenogaster carolinensis	QS1, QS14, QS15, 3, 4, 12, 14, 15, 17, 31
Aphaenogaster tennesseensis	4, 17
Camponotus pennsylvanicus	1, 4. 7, 9, 17, 31
Camponotus subbarbatus	17
Crematogaster cerasi	11, 12, 13, 16, 27
Dolichoderus plagiatus	13
Dolichoderus taschenbergi	16
Formica subsericea	QS15, So. Cornfield, 3, 4, 5, 12, 15, 18
Formica nitidiventris	QS4, So. Cornfield, Gamefarm field, 12, 13, 14,16, 20, 27, 31
Formica lasioides	3, 13, 31
Formica montana	2, 3, 5, 11, 14, 15, 18, 27
Formica exsectoides	4, 15, 16, 26
Formica incerta	QS4, QS15, So. Cornfield, Gamefarm field, 4, 5, 11, 12, 13, 14, 16, 19, 20, 27, 31
Formica glacialis	11, 14, 15, 25
Formica dakotensis	13
Lasius alienus	QS15, 11, 17, 20
Lasius neoniger	QS1, QS14, So. Cornfield, Gamefarm field, 3, 11,
Leptothorax ambiguus	3, 4, 11, 12, 13, 14, 16, 19, 31
Leptothorax curvispinosus	4, 7, 9, 17, 21, 25, 26
Myrmica spatulata	1, 3, 4, 9, 14, 20, 31
Myrmica punctiventris	1, 21, 25
Myrmica americana	3, 11, 16, 19
Myrmica lobicornis	4, 20
Myrmica fracticornis	20
Paratrechina parvula	So. Cornfield, 5
Prenolepis imparis	QS1
Solenopsis molesta	5
Stenamma brevicorne	9
Tapinoma sessile	QS1, So. Cornfield, Gamefarm field, 1, 3, 4, 7, 9, 11, 12, 13, 14, 15, 16, 17, 21, 25, 26, 31

IV. FAUNAL SURVEY OF WALNUT CREEK NWR, 1994

SURVEY OF BUTTERFLIES AND MOTHS

The insect order Lepidoptera (butterflies and moths) is an economically and esthetically important group. The caterpillar stages of most species in this group are herbivorous and many are important agricultural pests. As adults many species are nectar feeders and could be important as pollinators. Many species serve as hosts for parasitic and parasitoid insects. Moths and butterflies are also preferred prey for most species of insectivorous birds. Lepidopterans have esthetic appeal to the general public because of their beauty and are often represented in art and literature. Butterflies rank just behind birds and mammals in popularity as watchable wildlife.

About 125 species of butterflies are known from the state of Iowa of which 70 are found in prairies. About 20 of these species are found only on prairies which are in relatively good condition (Fleckenstein 1988). No endangered species of butterflies or moths are known to occur on or near Walnut Creek NWR (John Fleckenstein, Iowa Department of Natural Resources, personal communication). The dakota skipper (*Hesperia dacotae*), a butterfly that occurs in northwest Iowa only on Cayler Prairie in Dickinson County, is on the state endangered species list and is a candidate for listing as a federally endangered species (U.S. Fish & Wildlife Service 1994). Ecological restoration at Walnut Creek may provide the opportunity to introduce populations of butterflies, such as the regal fritillary, *Speyeria idalia*, that are at risk because of habitat losses.

We focused our studies of butterflies and moths on the remnant habitat patches. Relative abundance information would be desireable, but because remnant patches are small and there is danger of trampling small populations of important plants species, we attempted only to determine presence or absence of butterfly and moth species.

Methods:

Butterflies

We surveyed butterflies on 28 of the remnant habitat patches (Categories I-III) (Table 5). Observers were trained in identification prior to starting the surveys and field guides were provided for use in the field. Each remnant was surveyed once each week from mid-June to mid-August. We attempted to collect individuals of each species observed, including both sexes of dimorphic species, to verify sight identifications. We used 17-inch aerial nets to collect butterflies. Observers walked along a meandering transect about 6 meters wide in each remnant patch. Actual paths walked were changed each week to reduce

trampling of vegetation. The length of the sampling period was limited to a maximum of 1 hour but actual time spent in each remnant was recorded so that time/unit area can be estimated. Surveys were done between 10AM and 3 PM (CDT) on days with 50% or less cloud cover and minimal wind. We saved a small collection of voucher specimens of each species (Table 12). Specimens were killed with ethyl acetate or by freezing, pinned and labeled and stored in standard museum trays. After voucher specimens were collected, specimens caught in the field for positive identification were released. Sight identifications were used as much as possible.

Field data forms included the following information: Date, locality, remnant number and name, observer, Time (Start and end), temperature, cloud cover, wind conditions, relative certainity of sight identification, and general comments.

Moths

We collected moths at night using a battery-powered black light and a gas lantern. White and yellow cotton bed sheets were hung near the lights as reflectors. We captured moths attracted to the lights by picking or netting from sheets and vegetation. Moths were killed in ethyl acetate jars and frozen for later pinning and drying. Each of the category I remnant habitat patches were sampled at least once during the period mid-June to mid-August. A sampling period consisted of a 2-hour period of darkness between 1 and 5 AM.

RESULTS

We identified 51 species of butterflies during the course of the summer field work. We collected and preserved voucher specimens of 47 species (Table 12); they are stored in the Iowa State Insect Collection. We sight indentified the mourning cloak (*Mitoura grynea*), olive hairstreak (*Nymphalis antiopa*), dun skipper (*Euphyes vestris*), and painted lady (*Vanessa cardui*) in the field, but could not capture voucher specimens of these species. Specimens of four species were collected off remnant habitat patches but were not seen during surveys: northern broken dash, sedge skipper, giant swallowtail, and banded hairstreak. The specimen of the giant swallowtail was collected at night in remnant 17, perched on a low tree limb.

Species richness of butterflies in remnant habitat patches corresponded fairly well to vegetation category ranking and to patch size (Table 13) with large category I patches having the most species. An exception was remnant 9, a 4.3 ha, category III patch, on which 20 species of butterflies were recorded. Remnants 4 and 6, both category I patches, had only 10 and 6 species of butterflies but were also relatively small in size.

The most common species in frequency of occurance were the cabbage white, pearly crescentspot, common sulpher, and great spangled fritillary; they occurred on 24 or more of the 28 remnant patches during the survey (Table 14). Twelve species were sighted on only one remnant habitat patch.

Butterfly species were tentatively identified by comparison with plates in Opler (1992), Richard and Heitzman (1987) and Glassberg (1993). Identifications need to be verified.

We collected approximately 750 specimens of moths representing 12 families and at least 147 species (Table 15). Dr. Robert Lewis, Entomology Department, Iowa State University, identified the moths according to family and estimated the number of species. Many of the moth species can be later identified by comparison with specimens in the Iowa State Insect Collection; others will have to be identified by specialists in moth taxonomy.

Butterfly data are stored in six D-BASE IV files (Table 23).

Literature Cited

Fleckenstein, J. 1988. The world of the butterfly. *Iowa Conservationist*, May:15-19.

Opler, P. A. 1992. *A field guide to eastern butterflies*. The Peterson Field Guide Series. Houghton Mifflin Co., Boston.

Glassberg, J. 1993. *Butterflies through binoculars*. Oxford University Press. New York.

Richard, J. and J. E. Heitzman. 1987. Moths and butterflies of Missouri. Missouri Department of Conservation, Jefferson City.

U.S. Fish & Wildlife Service. *Endangered Species Facts*. Region 3, April 1994.

Table 12. Voucher specimens of butterflies collected in remnant habitat patches at Walnut Creek NWR, June-August 1994. Preserved specimens are stored in the Insect Collection of Iowa State University.

Genus/species	Common Name	No. Specimens Preserved
Epargyreus clarus	Silver-spotted skipper	2
Pyrgus communis	Checkered skipper	1♂
Pholisora catullus	Common sootywing	6
Anchyloxypha numitor	Least skipper	5
Thymelicus lineola	European skipper	4
Polites themistocles	Tawny-edged skipper	1
Wallengrenia egeremet	Northern broken dash	1
Pompeius verna	Little glassywing	4
Atrytone logan	Delaware skipper	1
Problema byssus	Byssus skipper	3
Poanes hobomok	Hobomok skipper	2
Euphyes dion	Sedge skipper	1
Papilio polyxenes	Black swallowtail	3♂,5♀
Papilio cresphontes	Giant swallowtail	1
Papilio glaucus	Tiger swallowtail	3♂,1♀
Pieris rapae	Cabbage White	2♂,6♀
Colias philodice	Common sulphur	6♂,5♀
" "	" " (albino)	5♀
Colias eurytheme	Orange sulpher	6♂,3♀
Eurema lisa	Little sulpher	3
Nathalis iole	Dainty sulpher	1
Fenisca tarquinius	Harvester	1
Lycaena xanthoides	Great gray copper	5
Lycaena hyllus	Bronze copper	3
Satyrium calanus	Banded hairstreak	2
Satyrium caryaevorum	Hickory hairstreak	2
Satyrium liparops	Striped hairstreak	6
Satyrium titus	Coral hairstreak	2
Everes comyntas	Eastern tailed blue	4
Celastrina argiolus	Spring azure	6
Speyeria cybele	Great spangled fritillary	4
Boloria bellona	Meadow fritillary	5
Chlosyne nycteis	Silvery crescentspot	4
Phyciodes tharos	Pearly crescentspot	11
Polygonia interrogationis	Question mark	3
Polygonia comma	Comma	6
Polygonia progne	Gray comma	2
Vanessa virginiensis	American painted lady	3
Vanessa atalanta	Red admiral	5
Junonia coenia	Buckeye	4
Limenitis arth. astyanax	Red-spotted purple	1
Limenitis archippus	Viceroy	5

Table 12 (cont.). Voucher specimens of butterflies collected from remnant habitat patches at Walnut Creek NWR, June-August 1994. Preserved specimens are stored in the Insect Collection of Iowa State University.

Genus/species	Common Name	No. Specimens Preserved
Asterocampa celtis	Hackberry	5
Asterocampa clyton	Tawny emperor	4
Enodia anthedon	Pearly eye	4
Megisto cymela	Little wood satyr	3
Cercyonis pegala	Wood nymph	7
Danaus plexippus	Monarch	5♂,6♀

Table 13. Remnant habitat patches ranked according to species richness of butterflies observed in each remnant and survey period. Surveys were conducted during four time periods: 27 June-1 July; 5-10 July; 11-12; 15-18 Jul. Species richness is the total number of unique species observed in all four surveys.

Remnant Number	Vegetation Category	Survey Period 1	2	3	4	Total Species
16	I	11	6	7	15	24
20	II	16	7	11	8	23
9	III	10	9	11	16	20
1	II	8	7	9	11	18
5	I	7	7	7	12	16
11	I	6	7	9	8	16
18	I	7	12	7	8	16
21	I	8	8	7	6	16
25	I	9	9	7	7	16
30	II	8	3	8	5	15
12	I	5	10	8	7	14
17	I	9	3	5	4	13
15	II	9	8	5	7	13
19	III	6	4	5	10	13
13	I	7	5	5	6	12
26	I	4	7	5	2	12
7	II	2	4	6	5	12
3	II	7	5	9	8	11
14	II	9	2	2	3	11
27	II	3	6	6	4	11
28	II	4	6	3	3	11
2	II	8	4	7	5	10
4	I	4	3	4	4	10
29	III	5	3	3	5	10
31	II	2	4	5	3	10
23	III	3	3	3	5	7
6	I	4	2	4	4	6
8	II	2	1	3	3	5

Table 14. Number of remnant habitat patches on which butterfly species were identified during each survey period. The total is the number of unique remnant patches on which the species was observed. A total of 28 remnant patches were surveyed during each period.

Species	Survey Period 1	2	3	4	Total
CABBAGE WHITE	15	28	23	22	28
PEARLY CRESCENTSPOT	20	22	20	14	27
COMMON SULPHER	17	16	18	21	25
GREAT SPANGLED FRITILLARY	17	11	15	12	24
MONARCH	5	11	13	11	19
RED ADMIRAL	12	6	6	9	19
TIGER SWALLOWTAIL	0	3	9	12	18
EASTERN TAILED BLUE	1	3	5	17	18
ORANGE SULPHER	10	6	8	8	17
BLACK SWALLOWTAIL	10	7	10	1	16
COMMON SOOTYWING	7	5	7	6	14
SPRING AZURE	3	2	4	7	13
WOOD NYMPH	1	3	7	7	13
HACKBERRY	6	5	3	1	9
MEADOW FRITILLARY	4	1	3	4	9
SILVERY CRESCENTSPOT	3	5	2	1	9
COMMA	4	3	1	3	9
VICEROY	1	1	1	6	7
QUESTION MARK	3	3	3	2	7
LITTLE WOOD SATYR	5	1	1	1	6
LEAST SKIPPER	4	0	1	3	5
GREAT GREY COPPER	3	1	2	1	5
HICKORY HAIRSTREAK	3	1	0	2	5
RED-SPOTTED PURPLE	4	0	1	1	5
PEARLY EYE	5	3	0	0	5
BRONZE COPPER	3	1	1	1	4
AMERICAN PAINTED LADY	1	1	1	1	4
TAWNY EMPEROR	2	1	0	2	3
STRIPED HAIRSTREAK	1	1	0	1	3
EUROPEAN SKIPPER	2	1	0	0	2
TAWNY-EDGED SKIPPER	1	0	1	0	2
BYSSUS SKIPPER	2	0	0	0	2
LITTLE SULPHER	0	0	1	2	2
CORAL HAIRSTREAK	2	0	0	0	2
BUCKEYE	0	1	1	1	2
SILVER-SPOTTED SKIPPER	1	0	1	1	1
CHECKERED SKIPPER	0	1	0	0	1
LITTLE GLASSYWING	1	0	0	0	1
DELAWARE SKIPPER	1	0	0	0	1

Table 14 (cont.). Number of remnant habitat patches on which butterfly species were identified during each survey period. The total is the number of unique remnant patches on which the species was observed. A total of 28 remnant patches were surveyed during each period.

	Survey Period				
Species	1	2	3	4	Total
HOBOMOK SKIPPER	1	0	0	0	1
DAINTY SULPHER	0	0	0	1	1
DUN SKIPPER	1	0	0	0	1
PAINTED LADY	0	0	1	0	1
HARVESTER	0	0	1	0	1
OLIVE HAIRSTREAK	0	0	0	1	1
GRAY COMMA	0	0	0	1	1
MOURNING CLOAK	0	1	0	0	1

Table 15. Families of moths and estimated minimum number of species collected at Walnut Creek NWR, July-August 1994. Specimens are stored in the Insect Collection, Iowa State University.

Family	Estimate No. Species
Saturniidae	2
Sphingidae	3
Arctiidae	7+
Noctuidae	75+
Notodontidae	8+
Lymantriidae	1
Lasiocampidae	1
Geometridae	21+
Pyralidae	24+
Tortricidae	2
Yponomeutidae	1
Acrolophidae	2
Total Estimated Species	147+
Total Estimated No. of Specimens = 750	

+ Indicates that 1-10 additional species may be present.

IV. FAUNAL SURVEY OF WALNUT CREEK NWR, 1994.

SURVEY OF GRASSHOPPERS, KATYDIDS, CRICKETS

The order Orthoptera (grasshoppers, katydids, crickets) is an economically important group of insects. The order Orthropoda is not as diverse in number of species as some other insect orders such as the Coleoptera, Hemiptera, and Lepidoptera, but most species are large in size and are abundant in prairie and savanna habitats. Most species of Orthropoda are important prey items for birds and other vertebrates and serve as important components of food chains in most terrestrial ecosystems. Some species, such as the mantids, are important predators on other insects and are considered beneficial.

Four species of grasshoppers are serious agricultural pests and account for 90% of reported damage. These four species are: *Melanoplus mexicanus*, the migratory grasshopper, *M. differentialis*, the differential grasshopper, *M. bivitatus*, the two-striped grasshopper, and *M. femurrubrum*, the red-legged grasshopper (Froeschner 1954)

The Orthropoda are relatively well-known taxonomically, however, none of the Orthropoda are known to be reliant species, i.e., dependent on prairies or other plant associations for their existence. Rather, most species in this order tend to be generalists and occur in a wide variety of habitats. Distribution and relative abundance of various orthropod species will probably change with restoration, and monitoring may provide useful information.

Information on the occurrence of major orthropod species at Walnut Creek NWR is needed to handle potential inquiries and complaints from the agriculture community regarding pest species.

Methods

Orthoptera species were collected on each of 26 quarter-sections (See Figure 3). Each major habitat within a quarter-section was sampled by taking 100 sweeps with a 17-inch-diameter sweep net. Orthopterans were killed with ethyl acetate in the field and frozen for later pinning and drying. Only adult specimens were saved because juveniles of this order are difficult to identify to species. Collections were made between July 19 and August 13. Two samples were taken in each major habitat (cropland, herbaceous, riparian, and woodland) within each quarter section. Time between sampling averaged 2 weeks and ranged from 1 to 3 weeks. Sampling at different times was done to increase the probability of detecting species that may have been overlooked as juveniles in the earlier sampling period.

Specimens were identified to species by Todd DeGooyer, Graduate Research Assistant, Entomology Department, Iowa State University, an expert on the Orthropoda. A representative sample of each species was preserved and is stored in the Iowa State Insect Collection, Entomology Department, Iowa State University.

Results

Adults of 12 species of Orthropoda were detected on the refuge (Table 16). *Scudderia furcata*, the fork-tailed bush katydid, was the most common species; it was present on 25 of 26 quarter-sections. Only 2 of the species found present on the refuge are considered potential agricultural pests: *M. differentialis* occurred on 8 of 26 quarter sections, and *M. femurrubrum* on 20 of 26 quarter sections.

All 12 species were found in riparian habitat but only 3 species were found in woodland (Table 17). Herbaceous and cropland each had 8 species present and differed in only one species. The field cricket occurred in cropland in one quarter-section but not in herbaceous habitat. *Neonemobius palustris* occurred only in herbaceous habitat in 5 quarter-sections but not in cropland.

Three species occurred in only one or two quarter sections. *Anaxipha exigua* was found only in riparian habitat in quarter section 15. *Orchelimum gladiator*, the gladiator katydid, occurred only in riparian habitat in quarter section 8. The field cricket, *Gyrllus pennsylvanicus* was present in riparian and cropland habitats in quarter sections 20 and 3. These species were taken infrequently probably because they are not susceptible to capture in sweep nets.

More species were collected during the second time period in early August than during the first period in late July. The increase is probably related to the pheonology of the life cycles; more adults were available for capture in August.

Data on Orthropoda are stored on 3 files in DBASE IV format (Table 23).

Literature Cited

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Table 16. Numbers of voucher specimens of Orthropoda (grasshoppers, katydids, crickets) collected at Walnut Creek NWR, July-August 1994. M = Male, F = Female

Scientific name	Common Name	M	F
Gryllus pennsylvanicus	Field cricket	2	0
Melanoplus differentialis	Differential grasshopper	8	1
Melanoplus femurrubrum	Red-legged grasshopper	4	4
Dissosteria carolina	Carolina grasshopper	4	4
Tettigidea lateralis	Pygmy grasshopper	0	1
Scudderia furcata	Fork-tailed bush katydid	4	4
Neoconocephalus ensiger	Cone-headed grasshopper	4	4
Conocephalus fasciatus	Meadow grasshopper	4	4
Anaxipha exigua	No Common Name	1	2
Neonemobius palustris	No Common Name	2	4
Oecanthus nigricornis	No Common Name	5	3
Orchelimum gladiator	Gladiator katydid	1	0

Table 17. Distribution and occurrence of Orthropoda species within herbaceous, riparian, woodland, and cropland habitats on 26 quarter sections of Walnut Creek NWR, 19 July-13 August, 1994. Presence or absence was determined from sweep-net samples.

Species	19-31 July Quarter-sections in which Orthropoda were present	1-13 August Quarter sections in which Orthropoda were present
Herbaceous		
Conocephalus fasciatus	21,23	2,6,8,10,11,17,21,24
Dissosteria carolina	2,5,7,8,11,14,15,17,18,21,23	1,2,6-8,11,12,16-22
Melanoplus differentialis	11	8,12
Melanoplus femurrubrum	11,18,26	1,2,4,6,8,9,11,12,15-21,26
Neoconocephalus ensiger	1,6,19,24,26	11,14,16,22,26
Neonemobius palustris	12	1,2,12,15,16
Oecanthus nigricornis		4,12,13,17
Scudderia furcata	2,6-8,10,12-16,18,19,22,24,25	3,4,6,9,10,12-14,16,17,19-21,23-25
Riparian		
Anaxipha exigua		15
Conocephalus fasciatus		4,8,20,21
Dissosteria carolina		11
Gryllus pennsylvanicus	20	
Melanoplus differentialis	12	2,8,12,15,20
Melanoplus femurrubrum	20,21,26	2,3,5,8,11,12,20,21,26
Neoconocephalus ensiger	4,26	15,26
Neonemobius palustris		12
Oecanthus nigricornis		1,5,8,12,20

Table 17 (cont.). Distribution and occurrence of Orthropoda species within herbaceous, riparian, woodland, and cropland habitats on 26 quarter sections of Walnut Creek NWR, 19 July-13 August, 1994. Presence or absence was determined from sweep-net samples.

Species	19-31 July Quarter-sections in which Orthropoda were present	1-13 August Quarter sections in which Orthropoda were present
Orchelimum gladiator		8
Scudderia furcata	3,4,7,8,13,15,20,21,23,25	1,7,10-12,16,23,25
Tettigidea lateralis	11	
Woodland		
Melanoplus femurrubrum		6
Oecanthus nigricornis		12
Scudderia furcata	12	6,12
Cropland		
Conocephalus fasciatus	7,10	7,21,22
Dissosteria carolina	1,5,9,17	2,3,13,18,21,22
Gryllus pennsylvanicus		3
Melanoplus differentialis		1,14
Melanoplus femurrubrum	3	1,2,4,7,8,14,18,21
Neoconocephalus ensiger	1,14	1,4,14,23
Oecanthus nigricornis		2,4,20
Scudderia furcata	1,2,4,9,10,14,21,23	1,3,9,18,20

IV. FAUNAL SURVEY OF WALNUT CREEK NWR, 1994

SURVEY OF GROUND INVERTEBRATES

Invertebrate organisms constitute a large proportion of the total animal biomass in most terrestrial ecosystems. Many live below the soil surface, others live primarily on the ground surface, and still others live on vegetation or in the air. It is likely that certain of these invertebrate communities will show rapid change in diversity and abundance as the soil and vegetative cover changes from agricultural uses to prairie and savanna.

Williams (1993) used terrestrial arthropods to help evaluate the progress of a riparian restoration effort in California. She compared relative abundances of indicator assemblages between reconstructed and reference sites to evaluate the establishment and maintenance of processes critical for the natural function of the reconstructed riparian ecosystem. During the three year study, pollinators and herbivores declined at the reconstructed site suggesting that they may have immigrated or had been introduced with transplanted vegetation, but had difficulty colonizing the site. Other groups, such as detritivores, increased suggesting rapid propagation in these groups.

Remnant habitat patches at Walnut Creek may provide important refugia from which invertebrates may colonize reconstructed areas. Thus, it is important to obtain baseline data on invertebrates in remnant patches for later comparison and evaluation of restored habitats. We collected baseline information on ground invertebrates in remnant habitat patches at Walnut Creek during the summer of 1994.

Methods

We surveyed ground dwelling invertebrates with pitfall traps in each of the 12 Category I remnant patches (Nos. 4, 5, 6, 11, 12, 13, 16, 17, 18, 21, 25, 26) (Figure 4). Methods generally followed Southwood (1978). We installed 4 traps in each of 3 randomly placed clusters. Traps within clusters were placed in the form of a square, 1 meter apart. We dug holes with a soil corer used to make cups on golf greens. The diameter of the hole was the same diameter as the pitfall traps.

Traps were made of empty 2-liter, plastic, soft drink containers cut approximately in half; the upper portion of the container was inverted into the bottom half as a funnel. Drainage holes were punched into the bottom of the plastic bottle. A 2-ounce collecting bottle containing 1 ounce of ethylene glycol was

Fig. 4 - Map of remnant habitat patches showing where ground invertebrates were sampled using pitfall traps (red dots), Walnut Creek NWR, 1994.

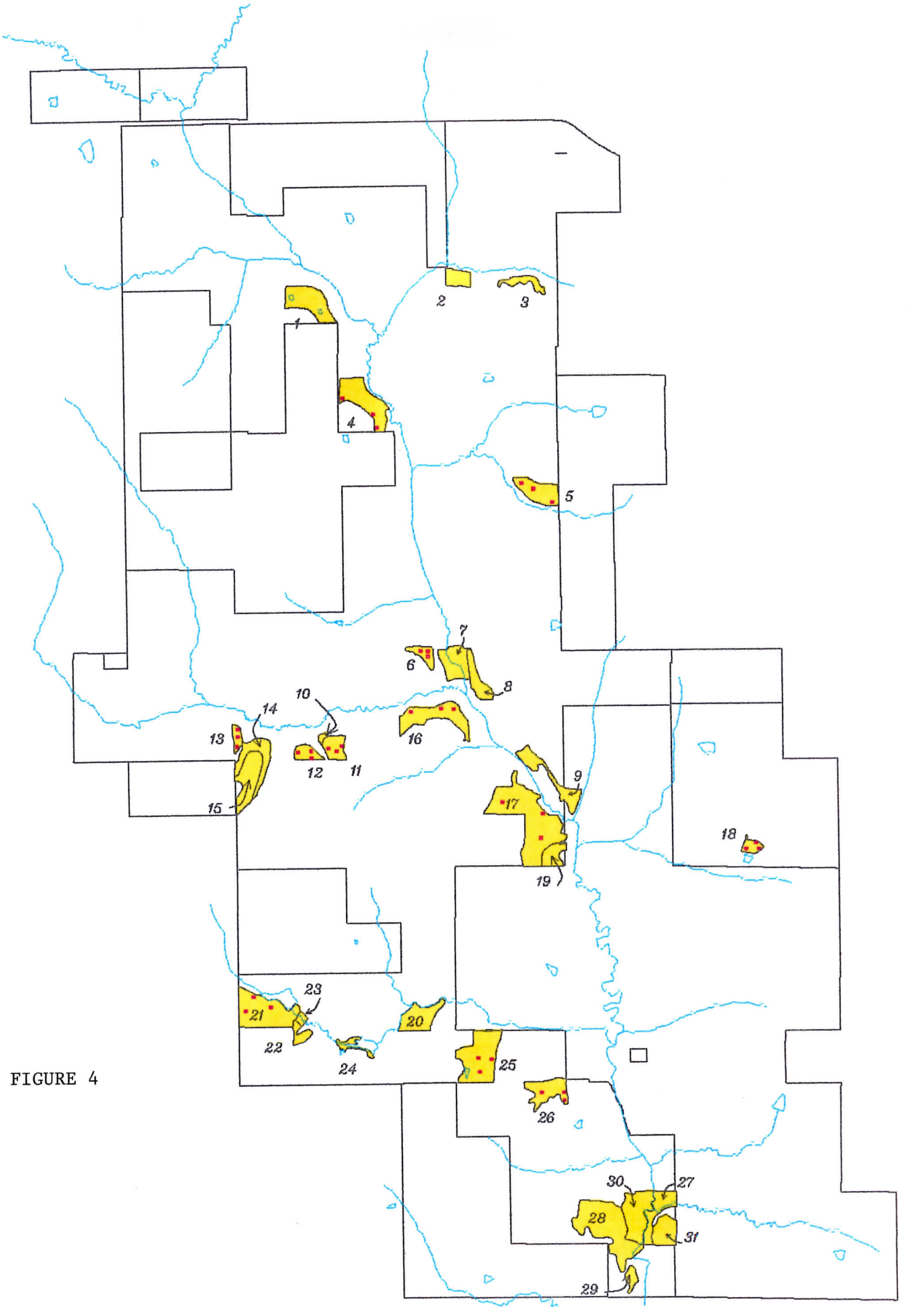
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FIGURE 4

placed in the bottom of the trap under the mouth of the funnel. The top edge of each trap was set so that it was flush with the soil surface. We avoided disturbing the vegetation around the trap during installation.

Traps were left in place for 7 weeks from 23 June through 11 August 1994.We checked traps once each week and after major rain events. We used two sets of collecting jars to facilitate field collections. Each time that traps were checked, we replaced one set of collecting jars with the 2nd set containing fresh ethylene glycol. Invertebrates from each 4-trap cluster were removed from the ethylene glycol, rinsed in tap water, and consolidated into a single bottle containing 70% ethyl alcohol for storage and later identification. The cluster was considered the sampling unit and contents for individual traps were not recorded. The number of successful traps in a cluster was recorded for each sample; the usual number was 4.

Some trap sites were disturbed by unknown animals, probably raccoons or skunks, during the first few weeks of the study. The disturbed traps were often pulled out of the ground or filled with soil and debris. We removed all of the traps in remnant No. 21 after the first week because of severe disturbance problems and the presence of domestic dogs in the area. Usually only one or two of the four traps in a cluster were disturbed.

Collection bottles were labeled with the numbers of the habitat remnant and the number of the trap cluster (ABC). Storage jars were labeled with dates (start and ending), remnant no. and name, and number of cluster.

Invertebrates in each of the field-sample bottles were sorted and identified in the laboratory according to major taxonomic groups (Phylum, Class, Order), then placed in glass vials with 70% ethyl alcohol, and labeled. Arthropods were classified into lower taxa (Class, Order) according to keys in Ross (1956).

We also counted the numbers of individuals within each taxonomic group and sampling period. After counting, we consolidated weekly samples by clusters within remnant habitats to economize storage space. Thus, all of the ants from a remnant were consolidated into 3 samples, 1 for each cluster of traps. Screw-top caps on storage vials were wrapped with permafilm to prevent evaporation and then stored in large glass jars containing alcohol and sealed with a glass bale-type lid.

Results

We collected 218 samples and captured approximately 83,275 individual invertebrates and 14 vertebrates. Three phyla (Annelida, Mollusca, Arthropoda) were represented in all remnants

(Table 18). The Arthropoda was the most numerous group with 5 classes represented; 14 orders of the class Insecta were identified.

We captured four species of vertebrates, 2 amphibians and 2 mammals, in pitfall traps. A total of 13 American toads (*Bufo americana*) were taken on remnants 12, 13, 18, 21, 25, and 26 and, a single specimen of the narrow-mouthed salamander (*Ambystoma texanum*) was caught on remnant 25. Two species of shrews, *Sorex cinerius* (16 individuals) and *Cryptotis parva* (3 individuals) were collected (See Table 10, mammal section).

Data from pitfall samples are given in Tables 18, 19, and 20. All of the specimens of Mollusca were snails and slugs (Gastropoda). The Annelida were all earthworms. Within the Arthropoda, the Class Insecta was the most numerous followed by the Arachnoida. Within the Insecta, the most individuals were found in the order Collembola of which a large proportion occurred in the first week of collecting. The Coleoptera, Hemiptera, and Hymenoptera were also abundant.

Identification of all specimens should be regarded as tentative. Confirmation and identification to the species level will require the assistance of taxonomists who specialize in a particular taxon.

Pitfall trapping is a relatively easy method of obtaining information on ground invertebrates and large numbers of individuals are captured. However, processing and identification of samples becomes a serious logistic problem. The design of future collections should consider targeting selected groups of invertebrates, such as the ants, that may be of greatest importance to restoration objectives and evaluation. Many species have short (days or weeks) adult stages and hatch or emerge at various times during the growing season. Thus, sampling probably should be less intensive than the design used in 1994, and extend from March through October.

Data on invertebrates collected in pitfall traps are stored on file labeled PITFALL in DBASE IV format.

NOTES ON SELECTED SAMPLES.

Mollusca, Gastropoda (Snails and slugs)

We sent 22 vials containing gastropods collected in pitfall traps to Dr. Bill Gilbert, Biology Department, Simpson College, Indianola, Iowa. Each of the 22 vials represents 7 weeks of sampling from 4 pitfall traps in a cluster. We labeled each vial with the number of the remnant patch and cluster (A, B, or C). Samples sent to Dr. Gilbert are as follows: 4ABC, 5A, 6ABC, 11 ABC, 12ABC, 13ABC, 16ABC, 17AB, 18BC, 21B, 25BC, and 26BC.

Crustacea, Decopoda (Crayfish)

A single specimen of the crayfish, *Procambrus gracilis*, was collected in a pitfall trap in Remnant 5 (Coneflower) during the week of June 23-30, 1994. The specimen was identified using taxonomic keys in Hobbs and Jass (1988). The large body size and the structure of the first pleopod (Form I) indicates that it was a mature, sexually active male (Phillips 1980). Phillips (*ibid.*) reports that he did not collect any males of this species in his extensive survey conducted in 1977 but reports several mature males in the collection at Coe College. His distribution map of the species shows no specimen records for Jasper County.

P. gracilis has a limited distribution in the Midwest and in Iowa is restricted to the southeastern part of the state (Hobbs and Jass 1988). It is commonly found in wet prairies where it excavates burrows that may reach several meters in depth. A "chimney" made of mud excavated from the burrow is usually associated with the entrance to the burrow. Fire does not seem to affect these animals because of their burrowing habit although males move around on the surface during the breeding season which may be prolonged from spring into late summer.

The crawfish frog (*Rana areolata*) gets its name from its habit of living in burrows of this species and perhaps other species of crayfish. The distributional range of the northern subspecies of the crawfish frog is roughly similar to that of *P. gracilis* (Conant 1958). The crawfish frog is rare and only found in a few localities within its range. It is known from northern Missouri but has not been reported in Iowa for many years.

Crustacea, Isopoda (Wood lice, pill bugs)

Isopods occurred in all remnants (Table 21) and were identified by Barbara Klausmeier, Milwaukee Public Museum, Milwaukee, WI (Table 21). All specimens were of the same species, *Trachelipus rathkei*. Individual isopods varied in size as a function of age, but no attempt was made to separate adults and juveniles in the counts. The sex ratio was essentially even and 24 percent of all female specimens were carrying either eggs or young (Table 21). The numbers of trap-weeks within clusters and remnant habitat patches vary because of disturbance by unknown animals. Trapping effort should be considered in comparing relative abundance in space or time.

Insecta, Hymenoptera, Formicidae (Ants)

Ants taken in pitfall samples were sent to James Traeger for identification (See Ant Section).

Insecta, Siphonaptera (Fleas)

Two species of fleas were collected in pitfall samples (Table 22) and identified by Dr. Robert Lewis, Entomology Department, Iowa State University as *Corrodopsylla curvata curvata* (Roths. 1915) and *Ctenophthalamus pseudagyrtes pseudagyrtes* (Baker 1904). He reports that both species are parasites of shrews (Family Soricidae), although *Ctenophthalmus p. pseudagyrtes* occurs on a broad range of hosts. The specimens of fleas may have entered pitfall traps with shrews that were taken in these traps.

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Table 18. Total individuals of invertebrate taxa captured on each of 12 remnant habitat patches, Walnut Creek NWR, 23 June-11 August, 1994. The total possible trap-weeks for each remnant is 84 (12 traps X 7 weeks).

REMNANT	TRAP-WEEKS	NO. TAXA	NO. INDIVIDUALS
4	73	16	3599
5	83	12	13355
6	80	17	13771
11	71	16	9556
12	74	17	5374
13	61	14	5643
16	72	14	6249
17	50	17	1842
18	84	15	14238
21	5	12	300
25	39	17	2595
26	45	17	6753
12	737	23	83275

Table 19. Taxa and numbers of individual invertebrates captured each week in pitfall traps on 12 remnant habitat patches, Walnut Creek NWR, June 23-August 11, 1994. Numbers in parentheses the number of remnant habitat patches on which an individual taxon was found each week.

Taxon	Starting date for each 7-day sampling period						
	6/23	6/30	7/8	7/15	7/22	7/29	8/5
Annelida, Oligochaeta	19 (8)	6 (4)	8 (4)	9 (5)	3 (3)	6 (4)	5 (3)
Mollusca, Gastropoda	44 (10)	43 (8)	21 (9)	9 (6)	14 (7)	15 (7)	8 (5)
Arthropoda							
Arachnoidea	5695 (12)	2784 (11)	2548 (11)	2878 (11)	1988 (11)	1848 (11)	1563 (11)
Chilopoda	13 (5)	22 (5)	15 (3)	24 (5)	26 (8)	29 (7)	11 (4)
Diplopoda	36 (10)	38 (9)	41 (8)	56 (6)	44 (9)	54 (9)	37 (7)
Crustacea Decapoda	1 (1)	0	0	0	0	0	0
Crustacea Isopoda	196 (12)	247 (11)	256 (11)	196 (11)	151 (11)	227 (11)	122 (10)
Insecta Coleoptera	1743 (12)	972 (11)	935 (11)	1078 (11)	1039 (11)	734 (11)	828 (11)
Insecta Collembola	13474 (12)	2295 (11)	1394 (11)	1040 (11)	4581 (11)	1585 (11)	2069 (11)
Insecta Diptera	440 (12)	228 (11)	283 (11)	340 (11)	537 (11)	317 (11)	384 (11)
Insecta Hemiptera	2362 (12)	558 (11)	767 (11)	960 (11)	1286 (11)	835 (11)	786 (11)
Insecta Hymenoptera	2833 (12)	980 (11)	2245 (11)	1521 (11)	2132 (11)	1709 (11)	1070 (11)
Insecta Lepidoptera	10 (5)	0	4 (4)	1 (1)	5 (5)	4 (3)	2 (2)
Insecta Mecoptera	1 (1)	0	3 (1)	1 (1)	9 (3)	0	4 (2)
Insecta Neuroptera	0	3 (1)	1 (1)	0	0	0	0
Insecta Odonata	0	0	0	1 (1)	0	1 (1)	0
Insecta Orthoptera	644 (12)	480 (11)	808 (11)	770 (11)	1133 (11)	757 (11)	684 (11)
Insecta Psocoptera	3 (2)	0	2 (1)	2 (1)	1 (1)	6 (1)	1 (1)
Insecta Siphonaptera	6 (2)	1 (1)	2 (1)	0	1 (1)	1 (1)	3 (2)
Insecta Thysanoptera	75 (6)	20 (7)	19 (6)	20 (5)	27 (6)	29 (6)	14 (5)
Insecta Thysanura	4 (2)	2 (1)	0	2 (1)	6 (2)	5 (2)	1 (1)
Total individuals	27599	8679	9352	8908	12983	8162	7592

Table 20. Taxa and numbers of individual organisms captured in pitfall traps in each of 12 remnant habitat patches at Walnut Creek NWR, 23 June-11 August, 1994. Total possible trap-weeks for each remnant is 84 (12 traps X 7 weeks).

REMNANT 4	INDIVIDUALS
Annelida Oligochaeta	3
Mollusca Gastropoda	15
Arthropoda Aranchoide	522
Arthropoda Chilopoda	5
Arthropoda Diplopoda	2
Arthropoda Crustacea-Isopoda	86
Arthropoda Insecta Coleoptera	496
Arthropoda Insecta Collembola	1443
Arthropoda Insecta Diptera	140
Arthropoda Insecta Hemiptera	277
Arthropoda Insecta Hymenoptera	442
Arthropoda Insecta Lepidoptera	3
Arthropoda Insecta Mecoptera	2
Arthropoda Insecta Neuroptera	4
Arthropoda Insecta Orthoptera	156
Arthropoda Insecta Siphonaptera	3
TRAP-WEEKS: 73 NO. TAXA: 16	TOTAL: 3599

REMNANT 5	INDIVIDUALS
Arthropoda Aranchoidea	2294
Arthropoda Chilopoda	6
Arthropoda Diplopoda	88
Arthropoda Crustacea-Decapoda	1
Arthropoda Crustacea-Isopoda	114
Arthropoda Insecta Coleoptera	651
Arthropoda Insecta Collembola	6477
Arthropoda Insecta Diptera	227
Arthropoda Insecta Hemiptera	1486
Arthropoda Insecta Hymenoptera	1385
Arthropoda Insecta Lepidoptera	1
Arthropoda Insecta Orthoptera	625
TRAP-WEEKS: 83 NO. TAXA: 12	TOTAL: 13355

Table 20 (Cont.).--

REMNANT 6	INDIVIDUALS
Annelida Oligochaeta	1
Mollusca Gastropoda	11
Arthropoda Aranchoidea	7075
Arthropoda Chilopoda	10
Arthropoda Diplopoda	6
Arthropoda Crustacea-Isopoda	199
Arthropoda Insecta Coleoptera	365
Arthropoda Insecta Collembola	2350
Arthropoda Insecta Diptera	249
Arthropoda Insecta Hemiptera	957
Arthropoda Insecta Hymenoptera	1003
Arthropoda Insecta Lepidoptera	2
Arthropoda Insecta Odonata	2
Arthropoda Insecta Orthoptera	1507
Arthropoda Insecta Psocoptera	1
Arthropoda Insecta Siphonaptera	1
Arthropoda Insecta Thysanoptera	32

TRAP-WEEKS: 80 NO. TAXA: 17 TOTAL: 13771

REMNANT 11	INDIVIDUALS
Annelida Oligochaeta	3
Mollusca Gastropoda	21
Arthropoda Aranchoidea	2737
Arthropoda Chilopoda	5
Arthropoda Diplopoda	61
Arthropoda Crustacea-Isopoda	64
Arthropoda Insecta Coleoptera	703
Arthropoda Insecta Collembola	2044
Arthropoda Insecta Diptera	204
Arthropoda Insecta Hemiptera	733
Arthropoda Insecta Hymenoptera	2471
Arthropoda Insecta Lepidoptera	3
Arthropoda Insecta Orthoptera	464
Arthropoda Insecta Psocoptera	1
Arthropoda Insecta Siphonaptera	7
Arthropoda Insecta Thysanoptera	35

TRAP-WEEKS: 71 NO. TAXA: 16 TOTAL: 9556

Table 20 (cont.).--

REMNANT 12	INDIVIDUALS
Annelida Oligochaeta	5
Mollusca Gastropoda	23
Arthropoda Aranchoidea	870
Arthropoda Chilopoda	4
Arthropoda Diplopoda	6
Arthropoda Crustacea-Isopoda	64
Arthropoda Insecta Coleoptera	380
Arthropoda Insecta Collembola	1943
Arthropoda Insecta Diptera	174
Arthropoda Insecta Hemiptera	770
Arthropoda Insecta Hymenoptera	658
Arthropoda Insecta Lepidoptera	1
Arthropoda Insecta Mecoptera	1
Arthropoda Insecta Orthoptera	415
Arthropoda Insecta Psocoptera	13
Arthropoda Insecta Thysanoptera	47
Amphibia Anura	2

TRAP-WEEKS: 74 NO. TAXA: 17 TOTAL: 5376

REMNANT 13	INDIVIDUALS
Annelida Oligochaeta	6
Mollusca Gastropoda	28
Arthropoda Aranchoidea	748
Arthropoda Crustacea-Isopoda	244
Arthropoda Insecta Coleoptera	377
Arthropoda Insecta Collembola	2178
Arthropoda Insecta Diptera	183
Arthropoda Insecta Hemiptera	692
Arthropoda Insecta Hymenoptera	698
Arthropoda Insecta Lepidoptera	4
Arthropoda Insecta Orthoptera	460
Arthropoda Insecta Siphonaptera	2
Arthropoda Insecta Thysanoptera	23
Amphibia Anura	1

TRAP-WEEKS: 61 NO. TAXA: 14 TOTAL: 5644

Table 20 (cont.).--

REMNANT 16	INDIVIDUALS
Annelida Oligochaeta	18
Mollusca Gastropoda	27
Arthropoda Aranchoidea	692
Arthropoda Chilopoda	2
Arthropoda Diplopoda	4
Arthropoda Crustacea-Isopoda	140
Arthropoda Insecta Coleoptera	938
Arthropoda Insecta Collembola	1911
Arthropoda Insecta Diptera	210
Arthropoda Insecta Hemiptera	866
Arthropoda Insecta Hymenoptera	1248
Arthropoda Insecta Mecoptera	2
Arthropoda Insecta Orthoptera	163
Arthropoda Insecta Thysanoptera	28

TRAP-WEEKS: 72 NO. TAXA: 14 TOTAL: 6249

REMNANT: 17	INDIVIDUALS
Annelida Oligochaeta	6
Mollusca Gastropoda	5
Arthropoda Aranchoidea	202
Arthropoda Chilopoda	8
Arthropoda Diplopoda	61
Arthropoda Crustacea-Isopoda	97
Arthropoda Insecta Coleoptera	457
Arthropoda Insecta Collembola	557
Arthropoda Insecta Diptera	107
Arthropoda Insecta Hemiptera	65
Arthropoda Insecta Hymenoptera	187
Arthropoda Insecta Lepidoptera	2
Arthropoda Insecta Mecoptera	3
Arthropoda Insecta Orthoptera	79
Arthropoda Insecta Siphonaptera	1
Arthropoda Insecta Thysanoptera	1
Arthropoda Insecta Thysanura	4

TRAP-WEEKS: 50 NO. TAXA: 17 TOTAL: 1842

Table 20 (cont.).--

REMNANT 18	INDIVIDUALS
Annelida Oligochaeta	5
Mollusca Gastropoda	11
Arthropoda Aranchoidea	2831
Arthropoda Chilopoda	84
Arthropoda Diplopoda	24
Arthropoda Crustacea-Isopoda	47
Arthropoda Insecta Coleoptera	1541
Arthropoda Insecta Collembola	5535
Arthropoda Insecta Diptera	631
Arthropoda Insecta Hemiptera	1512
Arthropoda Insecta Hymenoptera	1088
Arthropoda Insecta Lepidoptera	3
Arthropoda Insecta Orthoptera	893
Arthropoda Insecta Thysanoptera	33
Amphibia Anura	1

TRAP-WEEKS: 84 NO. TAXA: 15 TOTAL: 14239

REMNANT 21	INDIVIDUALS
Annelida Oligochaeta	1
Mollusca Gastropoda	1
Arthropoda Aranchoidea	31
Arthropoda Diplopoda	1
Arthropoda Crustacea-Isopoda	5
Arthropoda Insecta Coleoptera	63
Arthropoda Insecta Collembola	133
Arthropoda Insecta Diptera	24
Arthropoda Insecta Hemiptera	7
Arthropoda Insecta Hymenoptera	19
Arthropoda Insecta Orthoptera	15
Amphibia Anura	1

TRAP-WEEKS: 5 NO. TAXA: 12 TOTAL: 301

Table 20 (cont.).--

REMNANT 25	INDIVIDUALS
Annelida Oligochaeta	4
Mollusca Gastropoda	6
Arthropoda Aranchoidea	393
Arthropoda Chilopoda	2
Arthropoda Diplopoda	14
Arthropoda Crustacea-Isopoda	174
Arthropoda Insecta Coleoptera	477
Arthropoda Insecta Collembola	897
Arthropoda Insecta Diptera	169
Arthropoda Insecta Hemiptera	65
Arthropoda Insecta Hymenoptera	191
Arthropoda Insecta Mecoptera	7
Arthropoda Insecta Orthoptera	193
Arthropoda Insecta Thysanoptera	1
Arthropoda Insecta Thysanura	2
Amphibia Anura	2
Amphibia Caudata	1

TRAP-WEEKS: 39 NO. TAXA: 17 TOTAL: 2598

REMNANT 26	INDIVIDUALS
Annelida Oligochaeta	4
Mollusca Gastropoda	6
Arthropoda Aranchoidea	909
Arthropoda Chilopoda	14
Arthropoda Diplopoda	39
Arthropoda Crustacea-Isopoda	161
Arthropoda Insecta Coleoptera	881
Arthropoda Insecta Collembola	970
Arthropoda Insecta Diptera	211
Arthropoda Insecta Hemiptera	124
Arthropoda Insecta Hymenoptera	3100
Arthropoda Insecta Lepidoptera	7
Arthropoda Insecta Mecoptera	3
Arthropoda Insecta Orthoptera	306
Arthropoda Insecta Thysanoptera	4
Arthropoda Insecta Thysanura	14
Amphibia Anura	6

TRAP-WEEKS: 45 NO. TAXA: 17 TOTAL: 6759

TOTAL REMNANTS: 12
TOTAL TRAP-WEEKS: 737
TOTAL TAXA: 23
TOTAL INDIVIDUALS: 83289

Table 21. Numbers of male and female isopods, *Trachelipus rathkei*, collected in pitfall traps in twelve remnant habitat patches. Three clusters of 4 traps (A,B,C) were placed in each habitat patch from 23 June to 11 August 1994 and checked once each week.

Remnant Cluster	Trap-Weeks	Males	Females	Females with eggs	Females with yg.	Totals
4A	19	11	16	3	0	30
4B	26	14	12	6	0	32
4C	26	05	14	2	0	21
5A	28	53	28	4	0	85
5B	27	05	02	1	0	08
5C	28	06	02	1	1	10
6A	28	12	25	4	0	41
6B	27	44	25	10	1	80
6C	25	33	33	5	1	73
11A	19	03	04	2	2	07
11B	28	16	08	1	0	24
11C	24	05	19	3	0	24
12A	25	12	13	2	0	25
12B	23	19	10	1	0	29
12C	26	07	07	0	1	14
13A	12	23	11	4	1	34
13B	23	79	63	5	2	142
13C	26	33	25	5	2	58
16A	24	42	43	9	0	85
16B	21	08	17	4	0	25
16C	27	08	12	4	0	20
17A	09	04	09	2	1	13
17B	19	20	23	7	0	43
17C	22	16	23	7	0	39
18A	28	01	0	0	0	01
18B	28	21	24	7	1	45
18C	28	0	0	0	0	0

Table 21 (cont.). Numbers of male and female isopods, *Trachelipus rathkei*, collected in pitfall traps in twelve remnant habitat patches. Three clusters of 4 traps (A,B,C) were placed in each habitat patch from June 23 to August 11, 1994 and checked once each week.

Remnant Cluster	Trap-Weeks	Males	Females	Females with eggs	Females with yg.	Totals
21A	01	0	0	0	0	0
21B	04	5	0	0	0	05
25A	10	0	0	0	0	0
25B	20	59	59	13	2	118
25C	08	06	11	1	1	17
26A	11	0	0	0	0	11
26B	18	38	43	12	2	81
26C	16	14	22	2	0	36
Totals:	734	622 50.8%	603 49.2%	127 21%	18 3%	1225

Table 22. Species of fleas (Insecta, Order Siphonaptera) collected in pitfall traps, Walnut Creek NWR, 1994.

Remnant	Cluster	Species	Sex
4	C	*Corrodopsylla c. curvata*	2F,1M
6	A	*Ctenophalmus p. pseudagyrtes*	1M
11	A	*Corrodopsylla c. curvata*	3F
11	B	*Corrodopsylla c. curvata*	4F
13	B	*Corrodopsylla c. curvata*	2M
17	B	*Corrodopsylla c. curvata*	1M

Table 23. Files stored in D-BASE IV format containing faunal survey data.

File Name	Description
BTRFL_ID :	Butterfly species list
BTR_Coll :	Voucher specimens of butterflies preserved
CENS_DAT :	Butterfly census data
PLOTDATR :	Butterfly census sites and conditions
PLT_SUMC :	Butterfly census data summarized by plot
SP_SUM :	Butterfly census data summarized by species
GRSNAMES :	Grasshopper species list
GRS_COLL :	Grasshopper specimens in collection
GRSHOPRD :	Grasshopper census data
ANT_NAME :	Ant species list
WC_ANTS :	Ant census information on site location
ANTS :	Ant census data
MAMMDAT :	Mammal census data
BIRDNAME :	Bird species list
ALLBP :	Bird census data and collection conditions
ALLBPSUM :	Bird census data summarized by species
OCCURPCT :	Bird frequency of occurrence by habitat
ARCPLTS :	Bird census data summarized by site and habitat
PLTPHOTO :	List of photographs of bird census points
PITFALL :	Invertebrate data from pitfall traps
WCREPORT.94 :	WordPerfect 6.0 file of 1994 Final Report

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