EFFECTS OF URBAN DEVELOPMENT ON VERTEBRATE WILDLIFE POPULATIONS IN SCHMEECKLE RESERVE, UNIVERSITY OF WISCONSIN - STEVENS POINT

by

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A Thesis

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

COLLEGE OF NATURAL RESOURCES

UNIVERSITY OF WISCONSIN

Stevens Point, Wisconsin

December 1980

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ABSTRACT

The influence of various urban developments upon vertebrate wildlife distributions and abundance was studied in Schmeeckle Reserve on the University of Wisconsin - Stevens Point campus in central Wisconsin, Mar 1977 to Mar 1979.

Developments included the completion and use of a new highway, the evacuation of an existing roadway, wetland drainage, and the construction of multi-purpose recreational trails.

Breeding bird abundance was constant in 1977 and 1978 in all habitats unaltered by development. Trail construction apparently increased breeding bird abundance in pine habitat but had no effect upon birds in other habitats. Breeding bird abundance in wetlands nearly tripled in 1978 after dams were installed to restore original wetland conditions. Removal of vehicular traffic from an abandoned roadway increased bird abundance in adjacent mixed woodland habitat. The addition of traffic along a new roadway had no apparent effect upon bird abundance in adjacent habitats.

Amphibians became more abundant in 1978 when wetlands were reflooded. Frog and toad breeding areas expanded to include much of the reflooded area. The new road served as a barrier to some amphibians and caused direct mortality to several species.

Snakes were less abundant in the wetlands after reflooding, but other habitat alterations had no noticeable effect upon their populations. Turtles were rare on the reserve.

Shrews increased slightly in abundance from 1977 to 1978 in undisturbed habitats while other small mammal species became less abundant. Severe

flooding reduced small mammal populations except Sorex arcticus, less severe flooding of wetland habitat evidently allowed populations of other small mammals to increase.

Wetland restoration in 1978 attracted muskrats, mink, and beaver. Skunks and weasels increased in abundance also, possibly in response to the increase in their small mammal prey on the wetland periphery.

Cottontail rabbits were adversely affected by the wetland restoration. Gray squirrels declined in habitats disturbed by development.

Development on the reserve increased white-tailed deer mortality but did not reduce their use of the area. Immigration of deer from adjacent areas allowed annual repopulation of the reserve.

Preservation of Schmeeckle Reserve's habitats and wildlife diversity is desirable because the area is used as an outdoor laboratory, primarily by the university's College of Natural Resources and Biology Department. Preservation of the reserve and its wildlife depends upon its proper management by the university and regulation of incompatible uses.

ACKNOWLEDGEMENTS

I thank my advisor, Neil F. Payne, for his enthusiasm and suggestions throughout the study, his confidence in me from the beginning, and for performing the difficult task of editing the manuscript.

I thank the other members of my graduate committee: Raymond K. Anderson, Robert W. Miller, and Garry N. Knopf for their suggestions and interest throughout the study, and for reviewing the manuscript.

Other members of the faculty that provided assistance were Guy Baldassarre, Vincent Heig, Dave Hillier, Fred Hilpert, Lyle Nauman, and Charley White.

The UWSP Foundation, Inc. partially funded the study, through which Mary Williams was especially helpful. My parents provided financial support during the time I was involved in the study.

I thank my fellow graduate students, especially Bill Clark, Bruce Folley, Jim Hoefler, Ron Peterson, and Don Sasse. Stan Skutek provided considerable assistance with field work. Mike Lemke, John Giordano, John Bath, and Denise Parsons also made substantial contributions of time to the study.

Members of the student chapter of The Wildlife Society provided assistance through the small mammal committee and individuals.

Special thanks go to Paulette Tichenor for her conscientious typing and personal sacrifice of time.

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INTRODUCTION

Each year, the construction of roads and parks in Wisconsin destroys or alters thousands of hectares of natural wildlife habitat. Although these types of developments obviously affect wildlife populations, specific impacts of these developments on the wildlife community have not been documented in Wisconsin.

This thesis presents the effects of developments on vertebrate wildlife populations and distributions on Schmeeckle Reserve, University of Wisconsin-Stevens Point (UWSP) in central Wisconsin.

Between Mar 1977 and Mar 1979, a new highway, Michigan Ave., was completed through the study area; street lights were installed, Reserve St. was abandoned and street lights thereon were removed. The natural water regime of the area was disturbed by construction; pedestrian trails were cut through the area in conjunction with designating most of the study area as Schmeeckle Reserve, a multi-purpose park.

The objective of this study was to determine whether changes occurred in vertebrate wildlife abundance and distribution associated with the completion of Michigan Ave., the abandonment of Reserve St., the interruption of water drainage patterns, and the construction of trails.

The study area is used for academic purposes by UWSP's College of Natural Resources (CNR), and the Biology, Physical Education, and Art Departments, and receives recreational use by students and the citizens of Stevens Point.

Nomenclature of birds, mammals, reptiles and amphibians conforms to Bull and Farrand (1977), Jones et al. (1975), and Collins et al. (1978), respectively.

STUDY AREA

Physical Characteristics

Stevens Point is located in Portage County, central Wisconsin. This portion of Portage County is within the geographical region known as the Northern Highland, an expansive peneplain that includes most of northern Wisconsin (Martin 1965). The City of Stevens Point also lies within the driftless area, an area bypassed by the prehistoric continental ice sheets, and having a characteristically flat topography. Stevens Point also lies within the Tension Zone (Fig. 1), which separates Wisconsin's 2 distinct flouristic provinces (Curtis and McIntosh 1951). The zone contains many plant species characteristic of both the prairie and boreal elements marking the southern range limits of many northern species and the northern range limits of many southern species, giving the zone many unique and diverse vegetational communities (Curtis 1959). This zone marks the range limits of many associated animal species as well (Griggs 1914, Greene 1935).

The climate of the area is classified as humid continental (Finley 1965). The July mean temperature is 23^{o}C, and the Jan mean is -10^{o}C. Recorded temperature extremes are 46^{o}C and -43^{o}C. The region has an average growing season for native plants of 170 days. Average precipitation is 79 cm annually, with a normal winter snowfall of 101-127 cm.

The 83-ha Schmeeckle Reserve is located within the Stevens Point city limits just north of the UWSP campus proper. The study area (Fig. 2) is bounded on the north by North Point Dr. Two privately-owned 4-ha tracts of land adjoin this road and are developed with residences. North of North Point Dr. and west of Reserve St. lies an expansive commercial development. Undeveloped, privately-owned, woodlands and wetlands occur

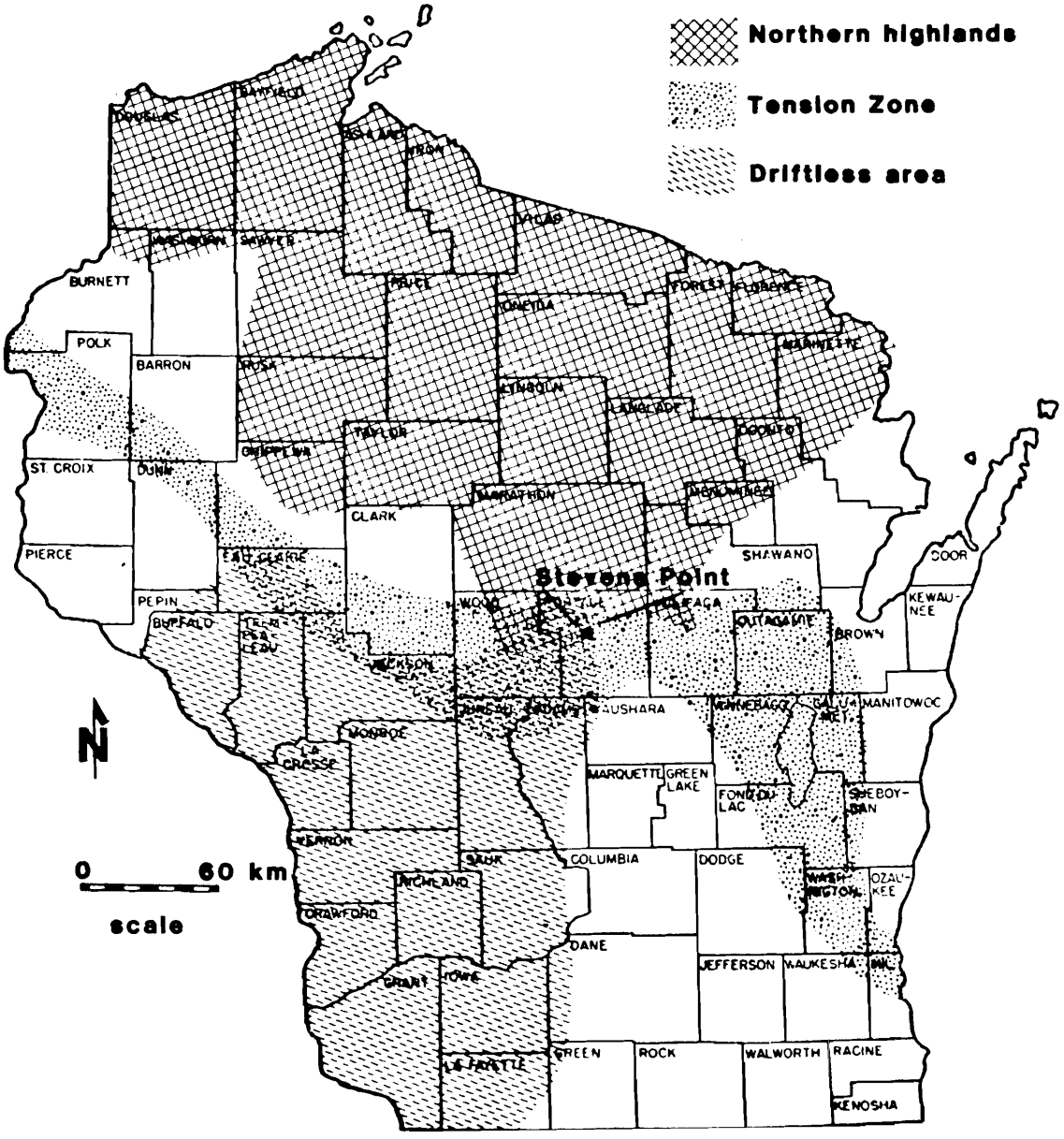


Figure 1. Location of the tension zone, northern highlands, and driftless area overlap in relation to Stevens Point, Wisconsin.

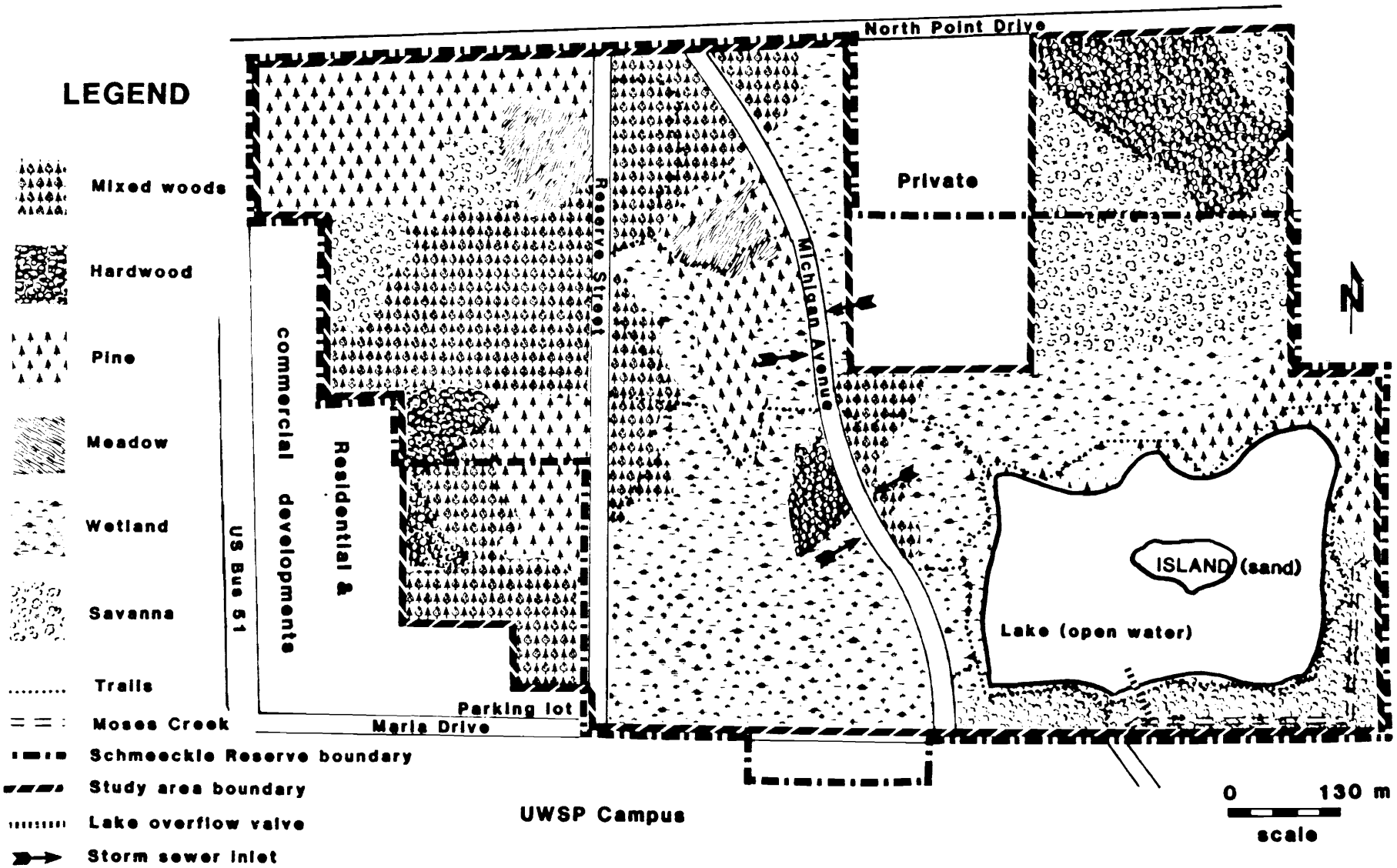


Figure 2. Schmeeckle Reserve study area, physical and vegetational characteristics, and surrounding land use.

east of the commercially-developed area. Maria Dr. constitutes the southern boundary of the study area. The western boundary of the area is U.S. Highway 51 (Business Route) and associated commercial and residential developments. The eastern border of the area is undeveloped, commercially-zoned private land.

The study area is situated on a glacial outwash plain about 12 m thick, atop granite bedrock. Fragments of this bedrock protrude above the surface in some parts of the area. Soils are sandy, primarily Roscommon and similar series (Strand and Associates, Inc. 1974). Although these soils are considered only "fair" for agriculture, they are well-suited for wetland wildlife food and cover.

The surface of the area slopes gently from north to south with an elevation of 336-332 m. The general flow of surface water is from north to south, but drainage is slow due to low relief and wooded areas. There are several small channels within the area, but drainage is in sheet form, primarily. During wet seasons, the ground water table is at or above ground level, resulting in standing water over the lower portions of the area. Ground water is moderately hard and low in iron and chlorides.

Land Use Changes

The study area was undeveloped until 1975 except for Reserve St., a moderately-used, 2-lane asphalt road. In 1974, 2 environmental impact assessments (EIA) were prepared for 2 proposed major projects which began the following year. Warzyn Engineering and Service Co., Inc., consulting engineers, prepared the EIA for the lake construction at Michigan Ave. and Maria Dr. (Warzyn Engineering and Service Co., Inc. 1974). Concurrently, the City of Stevens Point contracted John A. Strand & Associates, Inc.,

to prepare an EIA for the extension of Michigan Ave. north through the study area (Strand and Associates, Inc. 1974). Both of these projects began during fall 1975.

In Mar 1977, when this study began, the new Michigan Ave. roadbed was in place and consisted of a gravel base about 2 m thick. A perforated 30-76 cm diameter storm sewer main extended the length of the new extension beneath the roadbed at ground level. This main was equipped with 4 inlets at the base of the roadbed to drain the wetlands (Fig. 2).

Drainage by the perforated main itself continues, but in Jan 1978 dams were installed in the storm sewer inlets to prevent drainage until water in the adjacent wetlands reached a level of about 40 cm. The dams effectively reflooded the wetlands and recreated pre-1975 natural conditions.

The Michigan Ave. extension was fitted with a curb and gutter and gutter drainage traps, paved, and opened to traffic in July 1978.

North Point Dr. had been widened to 4 lanes west of Reserve St. in 1974. This alteration filled a creekbed and prevented the normal water flow from the wetlands north of the street into the study area. These wetlands were replaced with storage ponds. The overflow from these ponds was directed into the storm sewer beneath North Point Dr. In Mar 1978, a small channel was constructed to connect the natural creekbed south of the street to the storm sewer inlet opposite the storage ponds. A small dam was placed in the sewer main to direct pond water out the southern inlet into the channel and creekbed rather than down the storm sewer main beneath North Point Dr. During heavy rains, most of the storm sewer flow rushes over the dam in the main and passes the southern inlet.

Reserve St. was closed to traffic after Dec 1977, and the blacktop surface was removed during Oct 1978. North Point Dr. was widened to 4 lanes east of Reserve St. in the fall 1978.

Fill was removed from the study area to provide sand for the construction of the Michigan Ave. extension. An artificial 9.7-ha lake with a 0.7-ha island (Fig. 2) was created in 1977 at the excavation site on the study area.

The lake contained little water during the spring of 1977, but gradually filled by seepage and reached capacity in May 1978. Further increases in water level are prevented by an overflow valve which empties into Moses Creek. The lake contained no vegetation and its bare banks were subject to severe erosion. In June and Aug 1977 the banks were seeded with oats (Avena sativa) and rye (Secale cereale) to prevent erosion, and aquatic vegetation was planted in the lake. The lake remains a very oligotrophic body of water, containing very little organic matter, and maintained 8 ppm oxygen through the 1977-78 winter.

Since 1976, UWSP and UWSP Foundation, Inc. had sought funds to develop most of the study area into a recreational area. Funds were obtained from various sources and most of the study area was designated Schmeeckle Reserve in 1978. Development of the study area began with the 1977 seeding of the lake banks and the construction of trails through most of the area east of Reserve St. These trails (Fig. 2) averaged nearly 2 m wide and were covered with wood chips, except for wooden boardwalks through the wetland areas. By Aug 1978, trails were complete except for the boardwalks.

Human Use

The study area is used most heavily for academic purposes by the UWSP

Biology Department and CNR. The area serves as an outdoor laboratory for biology courses, and for courses in ecology, zoology, botony, soils, forestry, and wildlife.

Recreational use by students and the community is heavy and includes such activities as hunting, jogging, cross-country skiing, camping, and picnicing. Sun bathing and swimming at the lake constituted the major warm-weather recreation 1977-1979, often attracting over 1000 people daily. Although several of the most popular activities were prohibited by city ordinances and/or UWSP, inadequate enforcement efforts allowed their continued pursuit during this study.

Vegetation

There have been numerous fires on the study area, and these have contributed to the creation and maintenance of vegetational diversity.

In 1957 a major fire burned most of the central and southwest study area. The most recent major fire burned about 8 ha of the central study area in 1966.

Camping with campfires is popular on the study area and presents a constant risk of ignition throughout the warm months. Dead trees often are cut for firewood and burned or removed from the study area. Birch trees (Betula papyrifera) have been nearly eliminated from some parts of the area as a result of cutting and girdling.

There are many diverse vegetational communities within the study area. A partial plant species list for the area was compiled for the EIAs filed for the lake (Warzyn Engineering Service Co., Inc. 1974) and new road construction (Strand and Associates, Inc. 1974). No complete plant list exists at this writing.

To facilitate vertebrate censuses, I lumped plant communities into 6 major cover-types based upon dominant species of plants characteristic of the habitat (Fig. 2, Table 1).

Habitat described as pine contains jack pine (Pinus banksiana), white pine (P. strobus), and/or red pine (P. resinosa) as the predominant overstory. Hardwoods include oaks (Quercus rubra, Q. alba, Q. ellipsoidalis), maples (Acer rubrum, A. saccharinum, A. negundo), elms (Ulmus americana, U. rubra), trembling aspen (Populus tremuloides), and white birch. Mixed woods habitat has an overstory containing both hardwoods and pines (especially white pine). Wetlands are low-lying areas, usually containing shrub communities, typically speckled alder (Alnus rugosa), and willows (Salix spp.), or bluejoint (Calamagrostis canadensis), and rushes (Juncus effusus, J. bufonius, J. tenuis, J. canadensis, J. acuminatus). Savanna areas are relatively open and interspersed with a low density of oaks, especially Q. ellipsoidalis. Meadows are open areas dominated by grasses (Bromus spp., Glyceria spp., Poa spp., Eragrostis spp., Elymus spp., Agrostis spp., Digitaria spp., Panicum spp., and others), and often small shrubs, especially roses (Rubus hispidus, R. flagellarius, R. allegheniensis, R. pubescens), and sweet fern (Comptonia peregrina).

Table 1. Habitat types on Schmeeckle Reserve study area, UWSP.

Habitat Type	Hectares	% of Reserve
Mixed woods	15.6	19.0
Hardwoods	5.7	7.0
Pine woods	14.3	17.0
Wetland	24.7	30.0
Meadow	4.1	4.0
Savanna	8.9	11.0
Lake (open water)	9.0	11.0
Island (sand)	0.7	1.0
Total	83.0	100.0

METHODS

Vertebrate censuses were conducted before and after various developments (Table 2). Comparisons of vertebrate populations present on the area in 1977 and 1978, in areas disturbed by developments, were used to determine the effect of those developments on wildlife. Where possible, comparisons between populations in similar, but undisturbed habitats also were made.

Birds

Six permanent transects (A-F) were established which passed through all 6 major habitat types, collectively (Appendix A). Various census points were established along each transect in each habitat type intersected.

I censused birds along these transects by walking routes each day beginning at dawn (Davis 1942). I remained at each census point along the transect 5 minutes and recorded all birds seen or heard (Odum 1950). I used Chandler et al. (1966) and 7x35 binoculars to aid species identification when necessary. No bird censuses were conducted during unfavorable weather conditions (Dumas 1950, Robbins 1970). Census seasons were scheduled to conform to Wisconsin bird migration and nesting sequences (Barger et al. 1975, Gromme 1963).

Spring Migrant Birds

Spring birds were censused along each transect 8 times 20 Mar-15 May 1977 and 1978. Comparisons were made between the number of species observed in each habitat each year. Because migration periods often vary in timing and magnitude, no statistical comparison of bird abundance the 2 years was attempted.

Woodcock (Philohela minor) were censused by counts of all displaying males. All peenting grounds were located at dusk and recorded on a map

Table 2. Chronology of developments and vertebrate censuses on Schmeeckle Reserve, UWSP.

1977	Event
Jan	Lake excavation complete, Michigan Ave. roadbed and storm sewers in place, wetlands actively drained
Mar-May	Spring bird census
Apr	Michigan Ave. construction resumes after ground thaws
Apr-Oct	Reptile and amphibian censuses
May-Jul	Summer nesting bird census
Jun-Aug	Trail construction
Jul	Michigan Ave. extension complete, open for traffic
Aug	Lights installed along Michigan Ave.
Aug-Nov	Large mammal census
Sep-Nov	Fall bird census
Oct	Small mammal census
Dec	Reserve St. closed for traffic
1978	
Jan-Feb	Winter bird census
Mar	Storm sewers dammed, wetlands reflooded
Mar-May	Spring bird census
Apr-Oct	Reptile and amphibian censuses
May-Jul	Summer bird census
Aug-Nov	Large mammal census
Sep-Nov	Fall bird census
Oct	Reserve St. blacktop removed, lights removed
Oct	Small mammal census
1979	
Jan-Feb	Winter bird census

15 Apr-15 May 1977 and 1978. Three visits to each peenting ground located during this period confirmed their consistent use.

Ruffed grouse (Bonasa umbellus) also were censused by complete counts of drumming males. Each drumming stage in consistent use was located and recorded on a map 15 Apr-15 May 1977 and 1978.

I made nocturnal visits to the area irregularly to detect the presence of owls (Strigidae) which I felt may have been under-sampled using the transect censuses alone.

Summer Nesting Birds

As with the spring migrants, nesting birds were censused along Transects A-F (Appendix A). I censused each transect 8 times 16 May-15 July. Holmes and Sturges (1975) and others have demonstrated that the bird community of a given area during breeding season is not normally affected by differences in timing and duration of migrations, if habitats remain unchanged. To determine whether this observation held true for the study area, and to test the influences of various developments on breeding birds, nesting species were assigned an index of abundance (IA) (Kendeigh 1944) which accounted for both the frequency with which each species was observed and the number of individuals observed. I computed an IA for each species based upon the combined observations from all census points located in each habitat type (Appendix B) and subjected to similar disturbances between the 1977 and 1978 censuses.

Any species not observed during 1 of the 2 census seasons was assigned an IA of 0.000. Indicies for all species observed from these groups of census points (Appendix C) were combined to express the overall bird abundance for each habitat. These indicies for 1977 were compared to those for 1978 with a matched T-test. These comparisons provided a means

to determine the influence of any given development in each habitat type affected. Similar comparisons of 1977 and 1978 data in all habitats not affected (Appendix C) provided a "control" for comparison.

Fall Migrant Birds

Fall migrants were censused on each transect 5 times 15 Sep-15 Nov 1977 and 1978. Because of potential migration pattern differences, no statistical comparisons of bird abundance were made. The only habitat change caused by development between the fall 1977 and 1978 was increased wetland flooding in parts of the reserve. All other habitats were in similar condition the 2 years.

Birds observed during the fall censuses were assigned a catagory of relative abundance as abundant (multiple individuals observed on each visit to the area), common (at least 1 individual observed on nearly every visit to the area), uncommon (1 or more individuals observed on less than half of all visits to the area), or rare (species observed only once or twice during the census season).

Winter Resident Birds

Winter birds were censused along the transects 5 times 1 Jan-15 Feb 1978 and 1979. As with the fall migrants, species were assigned to catagories of relative abundance.

Reptiles

I recorded all sightings of reptiles encountered incidentally, and searched all habitats for snakes and turtles on an irregular basis 1 Apr-15 Oct 1977 and 1978.

Painted turtles (Crysemys picta) were captured at every opportunity and marked (Cagle 1939) to facilitate population estimates based upon recaptures.

All snakes observed during the summer bird censuses on transects A-F were recorded, and their numbers and species composition compared between the 2 years to determine relative changes in abundance due to developments.

Amphibians

I located and mapped anuran breeding grounds each spring based upon the presence of singing males. Changes in population sizes and distributions were detected by comparing the numbers and sizes of breeding grounds in 1977 with those of 1978.

All habitats were searched for frogs, toads, and salamanders Apr-Oct 1977 and 1978 in various climatic conditions and times of day. Also, I recorded incidental observations of species.

On 2 Oct 1978 I captured and toe-clipped frogs on Michigan Ave. to allow calculation of their mortality based upon recaptures the following day.

Mammals

All observations of mammals were recorded by date, habitat observed in, and their activity.

Small Mammals

I trapped small mammals in all habitat types during fall 1977 and 1978 (Appendix D) in 8 0.2-ha plots (Appendix A). Museum Special snap traps baited with a mixture of peanut butter, suet, oatmeal, and raisins (Taber and Cowan 1971), and unbaited pitfall (MacLeod and Lethiecq 1963) traps were used in each plot. The abundance of each small mammal species within each plot was expressed as captures/1000 trap-nights (t-n). These indicies were compared between the 2 years to determine relative population changes.

Larger Mammals

Larger mammals, including squirrels, lagomorphs, and mustelids, were trapped on each of 4 traplines (I-IV) (Appendix A) during the fall 1977 and 1978 (Appendix E).

Wooden box traps (Mosby 1955), baited with peanut butter, were placed on the ground along traplines about 30 m apart to capture mustelids, sciurids, and lagomorphs. In 1978, Sherman metal box traps were placed along each trapline, in trees about 60 m apart, in addition to the wooden traps. The tree traps were used to catch flying squirrels (Glaucomys spp.), primarily.

Each captured animal was marked with 2 numbered metal eartags, sexed, aged, and released. The population changes of these species between 1977 and 1978 were determined by comparing captures/unit effort and population estimates based upon recaptures of marked individuals (Schnabel 1938).

White-tailed Deer

White-tailed deer (Odocoileus virginianus) populations and their habitat use were determined each year, by direct counts of individuals, tracks, beds, and scats. During the 1977-78 winter I trapped 2 deer with rocket nets over a corn bait pile (Appendix A). These deer were marked with radio collars and eartags. I used telemetry to determine bedding areas on 320 occasions 28 Jan-3 Aug 1978.

RESULTS

Birds

I observed 154 species of birds on the reserve 20 Mar 1977-20 Mar 1979 (Table 3).

This species list confirms the lists of 34 species contained in the 2 EIAs (Strand and Associates, Inc. 1974, Warzyn Engineering Service Co., Inc. 1974) with the exception of the long-billed marsh wren (Cistothorus palustris).

Spring Migrant Birds

The census of spring migrants yielded 73 and 86 species in 1977 and 1978, respectively (Table 3). Because a similar difference in species diversity was observed when only unchanged habitats were considered (Fig. 3), no statistical comparison of diversity in affected habitats would have been meaningful.

There were 10 woodcock peenting grounds in regular use during both 1977 and 1978 (Fig. 4), indicating no overall change in the population between the 2 years. Seven of the grounds used in 1977 were reused in 1978. Of the 3 abandoned, 2 were flooded in 1978, and the other was unaffected by land use changes but appeared to have been in marginal habitat. There were no changes in locations used west of Reserve St. (Fig. 4), an area not influenced by habitat change. Of the 3 new grounds in 1978, 2 were located on trails constructed near the lake, and only 45 m from 1 of the peenting grounds flooded and abandoned in 1978.

Ruffed grouse regularly used 7 drumming sites in 1977, only 5 of which were reused the following year. No new drumming sites were found in 1978 (Fig. 4). Of the 2 sites abandoned in 1978, only the site near the intersection of Michigan Ave. and North Point Dr. may have been

Table 3. Bird species observed on Schmeeckle Reserve 20 Mar 1977-20 Mar 1979.

Family Species	1977	1978
Gaviidae (Loons)		
Common loon (*Gavia immer*)	X	X
Podicipediadae (Grebes)		
Horned grebe (*Podiceps nigricollis*)		X
Pied-billed grebe (*Podilymbus podiceps*)	X	
Ardeidae (Herons)		
Great blue heron (*Ardea herodias*)	X	X
Green heron (*Butorides striatus*)		X
American bittern (*Botaurus lentiginosus*)		X
Anatidae (Waterfowl)		
Canada goose (*Branta canadensis*)[a]	X	X
Mallard (*Anas platyrhynchos*)	X	X
Black duck (*A. rubripes*)		
Pintail (*A. acuta*)		X
Green-winged teal (*A. crecca*)		
Blue-winged teal (*A. discors*)	X	X
Wood duck (*Aix sponsa*)	X	X
Lesser scaup (*Aythya affinis*)		
Common goldeneye (*Bucephala clangula*)		X
Bufflehead (*B. albeola*)		X
Common merganser (*Mergus merganser*)	X	X
Carthartidae (Vultures)		
Turkey vulture (*Cathartes aura*)[a]		
Accipitridae (Hawks, Falcons, Eagles)		

Table 3. Continued.

Family	Species	1977	1978
	Northern goshawk (*Accipiter gentilis*)	X	
	Cooper's hawk (*A. cooperii*)		X
	Sharp-shinned hawk (*A. striatus*)		
	Red-tailed hawk (*Buteo jamaicensis*)	X	X
	Red-shouldered hawk (*B. lineatus*)		X
	Broad-winged hawk (*B. platypterus*)		X
	Rough-legged hawk (*B. lagopus*)		X
	Bald eagle (*Haliaeetus leucocephalus*)[a]	X	
	Northern harrier (*Circus syaneus*)		X
	Osprey (*Pandion haliaetus*)[a]		
	Merlin (*Falco columbarius*)		
	American kestrel (*F. sparerius*)	X	
Tetraonidae (Grouse)			
	Ruffed grouse (*Bonasa umbellus*)	X	X
Phasianidae (Quails, Partridges, Pheasants)			
	Ring-necked pheasant (*Phasianus colchicus*)		
Rallidae (Rails, Gallinules, Coots)			
	American coot (*Fulica americana*)		
Charadriidae (Plovers)			
	Killdeer (*Charadrius vociferus*)	X	X
Scolopacidae (Sandpipers)			
	Spotted sandpiper (*Actitis macularia*)		X
	Short-billed dowitcher (*Limnodromus griseus*)		
	American woodcock (*Philohela minor*)	X	X
	Common snipe (*Cappella gallinago*)	X	X

Table 3. Continued.

Family	Species	1977	1978
Laridae (Gulls)			
	Herring gull (*Larus argentatus*)		X
	Ring-billed gull (*L. delawarensis*)	X	X
Columbidae (Pigeons, Doves)			
	Rock dove (*Columba livia*)		X
	Mourning dove (*Zenaida macroura*)	X	X
Strigidae (Owls)			
	Common screech owl (*Otus asio*)	X	
	Great horned owl (*Bubo virginianus*)		X
	Barred owl (*Strix varia*)	X	
	Saw-whet owl (*Aegolius acadicus*)	X	X
Caprimulgidae (Goatsuckers)			
	Whip-poor-will (*Caprimulgus vociferus*)	X	X
	Common nighthawk (*Chordeiles minor*)	X	X
Apodidae (Swifts)			
	Chimney swift (*Chaetura pelagica*)	X	X
Trochilidae (Hummingbirds)			
	Ruby-throated hummingbird (*Archilochus colubris*)		X
Alcedinidae (Kingfishers)			
	Belted kingfisher (*Megaceryle alcyon*)	X	X
Picidae (Woodpeckers)			
	Common flicker (*Colaptes auratus*)	X	X
	Pileated woodpecker (*Dryocopus pileatus*)	X	X
	Red-bellied woodpecker (*Centurus carolinus*)		
	Yellow-bellied sapsucker (*Sphyrapicus varius*)	X	

Table 3. Continued.

Family	Species	1977	1978
	Hairy woodpecker (*Picoides villosus*)	X	X
	Downy woodpecker (*P. pubescens*)	X	X
Tyrannidae (Tyrant Flycatchers)			
	Eastern kingbird (*Tyrannus tyrannus*)		X
	Great-crested flycatcher (*Myiarchus crinitus*)	X	X
	Eastern phoebe (*Sayornis phoebe*)		X
	Willow flycatcher (*Empidonax traillii*)		
	Least flycatcher (*E. minimus*)	X	
	Eastern peewee (*Contopus virens*)	X	X
	Olive-sided flycatcher (*Nuttallornis borealis*)		
Alandidae (Larks)			
	Horned lark (*Eremophila alpestris*)		X
Hirundinidae (Swallows)			
	Tree swallow (*Iridoprocne bicolor*)	X	X
	Bank swallow (*Riparia riparis*)		
	Barn swallow (*Hirundo rustica*)		X
	Purple martin (*Progne subis*)	X	
Corvidae (Jays, Magpies, Crows)			
	Blue jay (*Cyanocitta cristata*)	X	X
	Northern raven (*Corvus corax*)		
	American crow (*C. brachyrhynchos*)	X	X
Paridae (Chickadees, Titmice)			
	Black-capped chickadee (*Parus atricapillus*)	X	X
	Boreal chickadee (*P. hudsonicus*)		
	Eastern tufted titmouse (*P. bicolor*)		

Table 3. Continued.

Family Species	1977	1978
Sittidae (Nuthatches)		
White-breasted nuthatch (Sitta carolinensis)	X	X
Red-breasted nuthatch (S. canadensis)		X
Certhiidae (Creepers)		
Brown creeper (Certhia familiaris)		
Troglodytidae (Wrens)		
House wren (Troglodytes aedon)	X	X
Mimidae (Thrashers)		
Gray catbird (Dumetella carolinensis)	X	X
Brown thrasher (Taxostoma rufum)	X	
Turdidae (Thrushes)		
American robin (Turdus migratorius)	X	X
Wood thrush (Hylocichla mustelina)	X	
Hermit thrush (Catharus guttatus)		
Swainson's thrush (C. ustulatus)		X
Veery (C. fuscescens)	X	X
Eastern bluebird (Sialia sialis)		
Sylviidae (Gnatcatchers, Kinglets)		
Blue-gray gnatcatcher (Polioptila caerulea)	X	
Golden-crowned kinglet (Regulus satrapa)		
Ruby-crowned kinglet (R. calendula)	X	
Bombycillidae (Waxwings)		
Cedar waxwing (Bombycilla cendrorum)	X	X
Laniidae (Shrikes)		
Northern shrike (Lanius excubitor)		

Table 3. Continued.

Family	Species	1977	1978
Sturnidae (Starlings)			
	European starling (Sturnus vulgaris)	X	X
Vireonidae (Vireos)			
	Yellow-throated vireo (Vireo flavifrons)		
	Solitary vireo (V. solitarius)		
	Red-eyed vireo (V. olivaceus)		
	Philadelphia vireo (V. philadelphicus)		
	Warbling vireo (V. gilvus)		X
Parulidae (Wood Warblers)			
	Black and white warbler (Mniotilta varia)	X	X
	Blue-winged warbler (Vermivora pinus)		
	Tennessee warbler (V. peregrina)		
	Nashville warbler (V. ruficapilla)		
	Yellow warbler (Dendroica petechia)	X	X
	Magnolia warbler (D. magnolia)		
	Cape May warbler (D. tigrina)		
	Black-throated blue warbler (D. caerulescens)		
	Yellow-rumped warbler (D. dominica)	X	X
	Black-throated green warbler (D. virens)		
	Blackburnian warbler (D. fusca)		
	Chestnut-sided warbler (D. pensylvanica)		
	Bay-breasted warbler (D. castanea)		
	Blackpoll warbler (D. striata)		
	Pine warbler (D. pinus)	X	X
	Palm warbler (D. palmarum)		

Table 3. Continued.

Family	Species	1977	1978
	Ovenbird (*Seiurus aurocapillus*)	X	X
	Kentucky warbler (*Oporornis formosus*)		
	Common yellowthroat (*Geothlypis trichas*)		X
	Canada warbler (*Wilsonia canadensis*)		X
	American redstart (*Setophaga ruticilla*)	X	
Ploceidae (Weaver Finches)			
	House sparrow (*Passer domesticus*)	X	X
Icteridae (Blackbirds)			
	Eastern meadowlark (*Sturnella magna*)	X	
	Western meadowlark (*S. neglecta*)		
	Red-winged blackbird (*Agelaius phoeniceus*)	X	X
	Northern oriole (*Icterus glabula*)	X	X
	Brewer's blackbird (*Euphagus cyanocephalus*)		
	Common grackle (*Quiscalus quiscula*)	X	X
	Brown-headed cowbird (*Molothrus ater*)	X	X
Thraupidae (Tanagers)			
	Scarlet tanager (*Piranga olivacea*)		X
Fringillidae (Finches, Sparrows)			
	Northern cardinal (*Cardinalis cardinalis*)	X	X
	Rose-breasted grosbeak (*Pheucticus ludovicianus*)	X	X
	Indigo bunting (*Passerina cyanea*)		X
	Evening grosbeak (*Hesperiphona vespertina*)	X	X
	Purple finch (*Carpodacus purpureus*)		X
	Pine grosbeak (*Pinicola enucleator*)		
	Hoary redpoll (*Carduelis hornemanni*)		

Table 3. Continued.

Family	Species	1977	1978
	Common redpoll (C. flammea)		
	Pine siskin (C. pinus)		X
	American goldfinch (C. tristis)	X	X
	Red crossbill (Loxia curvirostra)		
	Rufous-sided towhee (Pipilo erythrophalmus)	X	X
	Savanna sparrow (Passerculus sandwichensis)		
	Grasshopper sparrow (Ammodramus savannarum)		
	Vesper sparrow (Pooecetes gramineus)		
	Lark sparrow (Chondestes grammacus)		
	Northern junco (Junco hyemalis)	X	X
	American tree sparrow (Spizella arborea)		
	Chipping sparrow (S. passerina)	X	X
	Clay-colored sparrow (S. pallida)	X	X
	Field sparrow (S. pusilla)	X	X
	White-throated sparrow (Zonotrichia albicollis)	X	X
	Fox sparrow (Passerella iliaca)	X	
	Swamp sparrow (Melospiza geogiana)		X
	Song sparrow (M. melodia)	X	X
	Snow bunting (Plectophenax nivalis)		

[a]Observed in airspace over Schmeeckle Reserve, no apparent use of the reserve's habitat.

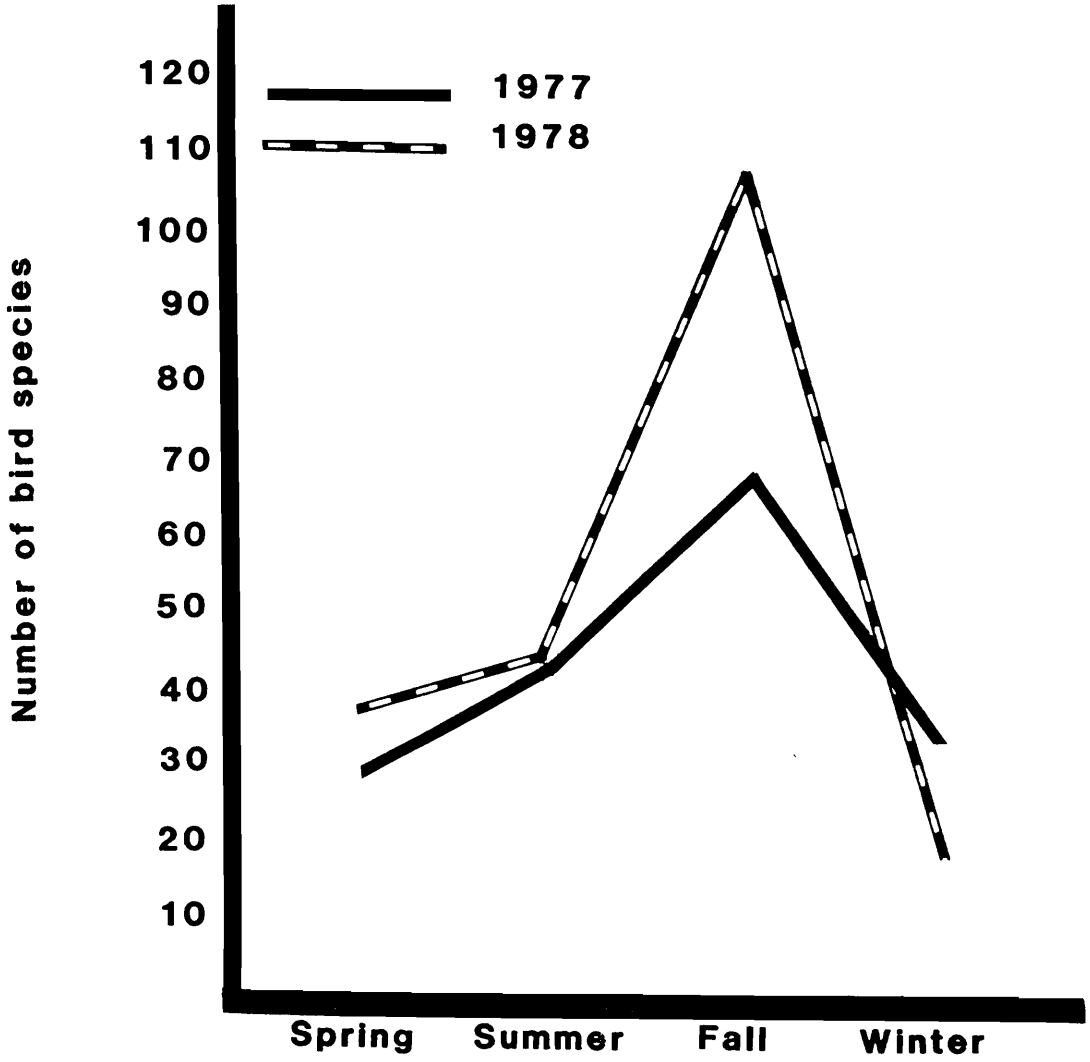


Figure 3. Bird species diversity during each of the 4 season censuses in habitats not affected by land-use changes, 1977 and 1978.

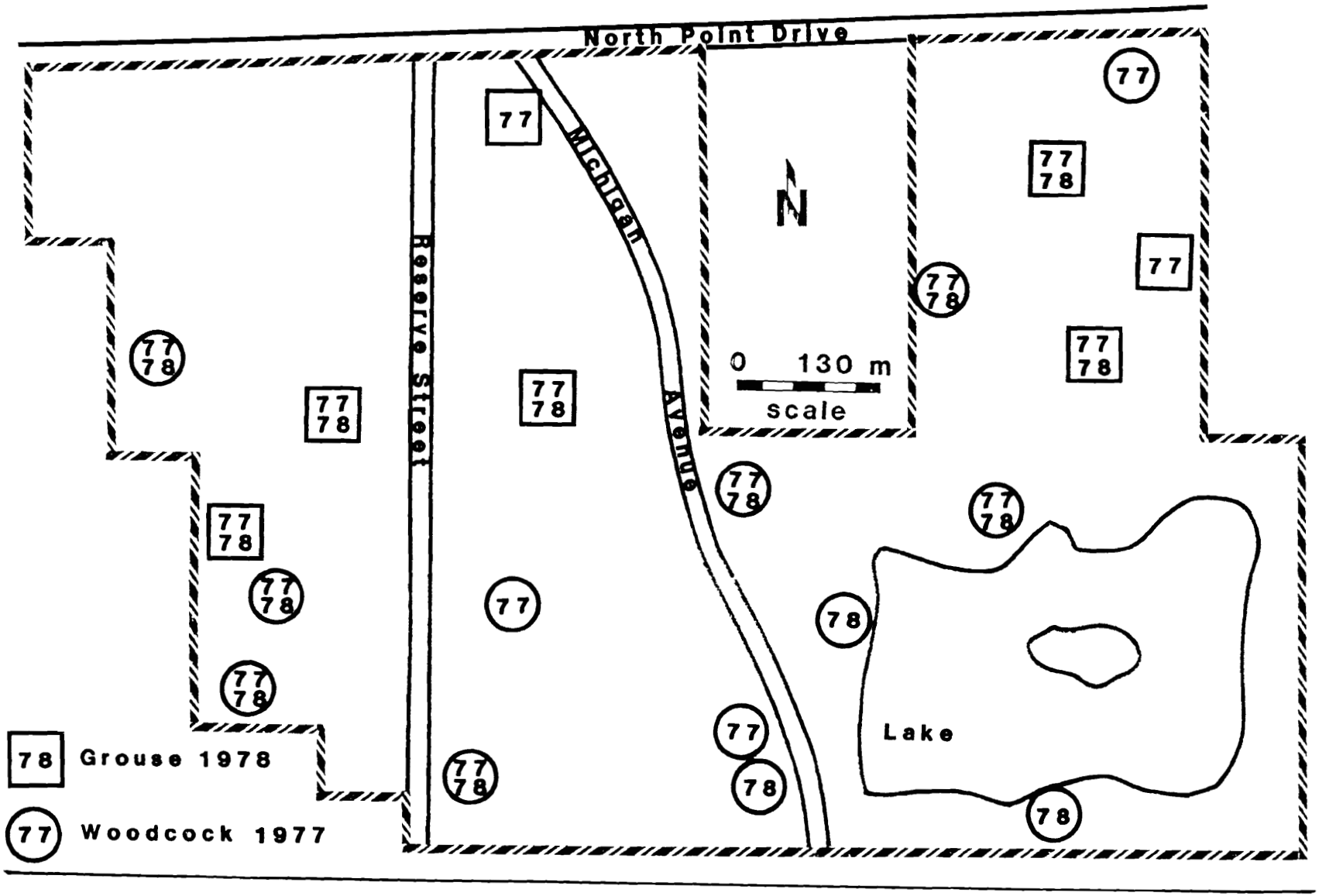


Figure 4. Locations of woodcock peenting grounds and ruffed grouse drumming sites, 1977 and 1978.

disturbed by development. This site was visible from the surface of Michigan Ave.

Summer Nesting Birds

Seventy-one and 73% of the species detected during the spring censuses (Table 3) remained to breed on the reserve in 1977 and 1978, respectively.

Unlike the spring migrants, the number of species observed in all habitats unaltered by development between 1977 and 1978 was nearly constant (Fig. 3).

There were no changes ($P > .05$) in breeding bird abundance in any single habitat unaltered by development (Appendix F) or in all unaltered habitats collectively.

Trails constructed through meadow, mixed woods, and wetland habitats (Fig. 2) did not affect the breeding bird abundance in these habitats. Bird abundance increased ($P < .05$) in pine habitats after trails were constructed there (Appendix G, Table 4). The number of species nesting in pine habitat increased from 29 in 1977 to 33 in 1978 after trails had been cut through the cover type. Nine new species were observed in affected pine habitat in 1978 and 5 observed in 1977 were not present. Of the species present both years, 15 increased in abundance (Appendix G).

Reflooding of the wetlands in 1978 by the dammed storm sewers directly affected only swamp habitat extensively. Some pine habitat flooded temporarily, but the period of inundation was only 3-9 days. Flooded pine habitat showed no difference in bird abundance from when it was dry in 1977.

In the reflooded wetland habitat, the number of bird species using the wetlands as breeding habitat nearly doubled. The IA of breeding

Table 4. Summary of changes in breeding bird abundance 1977-1978 in response to developments in various habitats.

Development	Habitat			
	Mixed Woods	Pine	Meadow	Wetland
No development	no change	no change	no change	no change
Trails constructed	no change	increased[a]	no change	no change
Habitat flooded	--	no change	--	increased[b]
Traffic removed	increased[b]	no change	--	no change
Traffic added	no change	no change	--	--
Traffic added and flooded	--	--	--	increased[b]

[a] $P < .05$

[b] $P < .001$

birds nearly tripled (Appendix H). This increase ($P < .001$) (Appendix L, Table 4) reflects the increased density of birds that also were present in 1977 and the increase in the number of species present. Of the species that bred in the wetlands both years, 90% were more abundant after the reflooding of the wetlands in 1978.

The removal of vehicular traffic from the wetland and pine habitats after the closure of Reserve St. in 1978, did not affect breeding bird abundance on census points along this street. Breeding bird abundance increased ($P < .001$) in adjacent mixed woods habitat after Reserve St. was closed (Appendix I). The disturbance caused by the introduction of vehicular traffic to pine and mixed woods habitat along Michigan Ave. in 1978 apparently did not affect breeding bird abundance along that route (Appendix J).

Wetland habitat adjacent to the southern 1/3 of the Michigan Ave. extension was subjected to 2 disturbances simultaneously in 1978; the disturbance by vehicular traffic, and the reflooding of the wetlands. The net result of these developments was an increase ($P < .001$) in breeding bird abundance in the wetland habitat along Michigan Ave. (Appendix K).

Fall Migrant Birds

I observed 75 and 110 bird species during the fall censuses in 1977 and 1978, respectively (Appendix M). Although a portion of the study area wetlands retained water in the fall of 1978, they attracted no species that were not observed in other, unaltered habitats (Fig. 3). Of the 60 species observed both years, 9 were less abundant in 1978 and 11 more abundant (Appendix M).

Winter Resident Birds

The winter seasons held relatively little bird species diversity (Appendix N). There were no habitat changes between the winter censuses in 1977 and 1978 to account for the observed difference in diversity (Appendix N) or overall abundance between the 2 years (Fig. 3).

Reptiles

I observed 7 reptile species (Table 5) on the study area between Mar 1977 and Mar 1978. Of the reptile species the EIAs (Warzyn Engineering Service Co., Inc. 1974, Strand and Associated, Inc. 1974) listed as occurring on the area, I cannot confirm the presence of the eastern hognose snake (Heterodon platyrhinos), northern ringneck snake (Diadophis punctatus), five-lined skink (Eumeces faciatus), or wood turtle (Clemmys insculpta).

A large snapping turtle often was observed during the summers of 1977 and 1978 in the lake. These repeated sightings probably consisted of only 1 individual during each of these summers. The snapping turtle(s) probably were introduced to the lake. To reach the lake independently, a snapping turtle would have had to travel at least 3 km overland through the City of Stevens Point from the Wisconsin River, the nearest known habitat inhabited by snapping turtles. This species is the most aquatic Wisconsin turtle, and rarely leaves the water except to lay eggs (Conant 1975).

I observed painted turtles occasionally during both summers, always in or near the lake. One was crushed on Maria Dr. south of the lake near Moses Creek. Although Moses Creek contained water throughout the 1978 season, no turtles used that habitat.

Table 5. Reptile species observed on the study area, Mar 1977-Mar 1979.

Species
Common snapping turtle (*Chelydra serpentina*)
Painted turtle (*Crysemys picta*)
Eastern fox snake (*Elaphe vulpina*)
Smooth green snake (*Opheodrys vernalis*)
Brown snake (*Storeria dekayi*)
Red-bellied snake (*S. occipitomaculata*)
Eastern garter snake (*Thamnophis sirtalis*)

I captured and marked 3 individuals during the study. Of the marked turtles, 1 was recaptured twice. I observed no nests, eggs, or young to indicate successful turtle reproduction on the study area.

No terrestrial turtles were observed on the study area.

I observed 194 snakes (Table 6) during the study in all habitats collectively. The eastern garter snake was the most common species on the study area, reaching highest densities in the meadow habitat type. They also commonly were observed in wetland and mixed woods habitats.

Red bellied snakes were common only in mixed woods habitat, particularly west of Reserve St. Fox snakes were seldom found except in concentrations around debris and mulch piles. No fox snake hibernacula were found.

The remaining 3 snake species rarely were encountered and are considered uncommon, although they probably were undersampled somewhat due to their secretive habitats and habitat preferences. Most brown snakes were discovered by overturning logs and rotten stumps.

Meadow habitat contained the most snakes/unit area for 3 snake species (Table 6). Although only about 11% of the total number of snakes observed were in meadows, meadow habitat comprises only 4% of the reserve's land area. Nearly all of the study area's meadow habitat is in 2 large openings (Fig. 2). I observed only garter snakes regularly while conducting summer bird censuses. The number of garter snakes observed incidentally on the bird transects indicated a decline in abundance in wetland habitats during 1978 (Table 7).

Amphibians

Salamanders

Of the 4 species of salamanders I observed (Table 8), 2 species

Table 6. Total numbers of snakes observed in each habitat type, 20 Mar 1977-20 Mar 1979.

Snake species	Habitat							Percent of all snakes
	Mixed woods	Hardwoods	Pine	Wetland	Meadow	Savanna	Total	
Eastern garter	41	5	2	46	14	9	117	57
Red-bellied	30	2	7	0	2	1	42	23
Eastern fox	2	3	4	1	2	6	18	12
Smooth green	0	0	0	6	2	3	11	6
Brown	2	0	0	3	1	0	6	2
Total	75	10	13	56	21	19	194	100
Percentage of snakes observed	38.7	5.2	6.7	28.9	10.8	9.8	100.1	
Relative densities of snakes/ha[a]	4.8	1.8	0.9	2.3	5.1	2.1	2.6	

[a]Calculated as total snakes observed ÷ area of habitat (ha)

Table 7. Comparison between the numbers of garter snakes observed on bird census transects 16 May-15 July 1977 and 1978.

Habitat type	1977	1978
Mixed woods	17	16
Hardwoods	0	1
Pine woods	0	0
Wetlands	11	2
Meadow	1	6
Savanna	3	2
Total	32	27

Table 8. Amphibian species observed Mar 1977-Mar 1979.

Salamanders
Blue-spotted salamander (*Ambystoma laterale*)
Tiger salamander (*A. tigrinum*)
Spotted salamander (*A. maculatum*)
Red-backed salamander (*Plethodon cinereus*)
Anurans
American toad (*Bufo americanus*)
Gray treefrog (*Hyla versicolor*)[a]
Spring peeper (*H. crucifer*)
Chorus frog (*Pseudacris triseriata*)
Northern leopard frog (*Rana pipiens*)
Wood frog (*R. sylvatica*)

[a]Possibly *H. chrysoscelis*, correlation of trill speed with temperature was not conducted.

had not been recorded previously (Warzyn Engineering Service Co., Inc. 1974, Strand and Associates, Inc. 1974), the blue-spotted and red-backed salamanders. They were the most abundant salamanders on the study area. No salamander breeding areas were identified, although only ambystomids are confined to standing water for reproduction.

Few salamanders were found before the completion of the Michigan Ave. extension in 1978. Only 1 spotted and 2 tiger salamanders were found before Aug 1978. From Aug-Oct 1978, 1 tiger salamander and 13 blue-spotted and red-backed salamanders were found on the Michigan Ave. roadway.

Salamanders are especially active during periods of precipitation, especially after dark, and often were found on Michigan Ave. on rainy evenings. The roadway functioned as a large and efficient pitfall trap. Once on the roadway, these small salamanders were unable to negotiate the steep cement curbs of the road and were trapped on the road surface. Of these trapped animals, some were killed by cars, some survived until the following day and were dessicated by the sun, and some walked along the gutter and into the grated storm sewer traps that open along the curbs. Once in these drop-flow devices, they were washed into the storm sewer main running beneath the road and out of the study area via the Moses Creek storm sewer system.

Frogs and Toads

I observed 6 anuran species on the study area Mar 1977-Mar 1979 (Table 8). The only species that I could not confirm as present was the green frog (Rana clamitans). I found no green frogs incidentally or while searching for spring choruses, when they would have been conspicuous.

Frog and toad breeding areas expanded with the increased water coverage in the wetlands in 1978. Toad breeding areas expanded in size but there were no choruses in completely new areas (Fig. 5). Toads were relatively unselective in their choice of breeding habitat, and often were found singing in very small and temporary puddles. Toads often called from such sites individually, and at considerable distances from major breeding choruses. The incidence of individual, lone calling males also increased in 1978.

The only breeding Ranid on the study area was the wood frog. This frog's breeding area occupied a much larger portion of the available wetland habitat during 1978 when the wetlands were reflooded (Fig. 5). The largest breeding area in 1978 occurred on an area that had been drained during 1977, just west of Michigan Ave.

No wood frog breeding areas were found east of Michigan Ave. during either year, although apparently similar habitat existed on both sides of the roadway in 1978. Adult wood frogs were observed during their breeding season and during late summer in the extreme northern and northeastern portions of the study area both years, but the lack of breeding choruses in these areas suggests that they did not breed there. There were wood frog breeding choruses north of the study area.

Leopard frogs were first observed on the study area in late Sep 1978. At this time leopard frogs were uncommon, but occasionally were observed on or near Michigan Ave. during rainy evenings. Leopard frogs were reported to inhabit the area in 1974 (Warzyn Engineering Service Co., Inc. 1974, Strand and Associates, Inc. 1974) before the wetlands

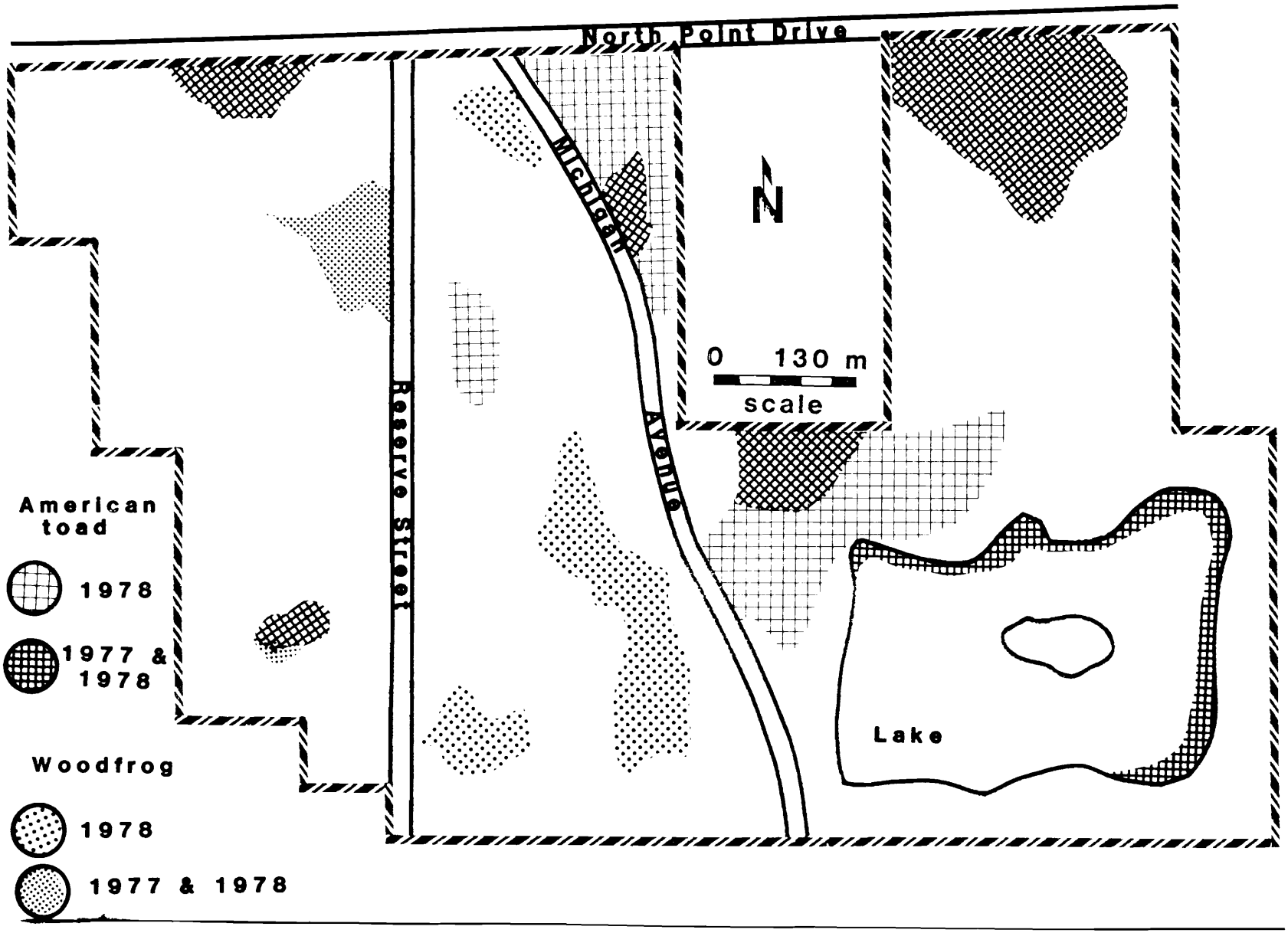


Figure 5. Portion of the study area used by breeding American toads and wood frogs, 1977 and 1978.

had been drained. The drainage of the wetlands in 1975 evidently rendered them unsuitable for leopard frog reproduction. The damming of the storm sewer inlets in 1978, with the associated reflooding, apparently reversed this condition. Leopard frogs disperse widely throughout non-wetland habitats after the late spring breeding season, but require marshy habitat for reproduction.

There were 3 species of tree frogs (Hylidae) resident on the study area (Table 8). Chorus frogs and spring peepers were common and widespread throughout the study area, while the gray treefrogs were less abundant, but widely distributed. Choruses of gray treefrogs were small, usually consisting of 6 or fewer singing males, while choruses of chorus frogs and spring peepers were large. Gray treefrogs rarely were observed except during the breeding season, Apr-May.

Gray treefrogs are arboreal and require standing water only for reproduction (Behler and King 1979). For this reason they probably were less affected by changes in the wetland water levels that occurred 1977-1978. Also, they confined their breeding activity to relatively dependable water sources, even in 1978 when large water areas were available (Fig. 6). Like toads, gray treefrogs found some of the shallow lakeshore zone suitable breeding habitat both years.

Breeding grounds of spring peepers expanded also (Fig. 6), but less so than those of chorus frogs. In 1978, spring peepers abandoned a breeding area used in 1977. Increased water levels at the abandoned site probably created water depths that were excessive for successful peeper reproduction. Male peepers generally selected bare earth or

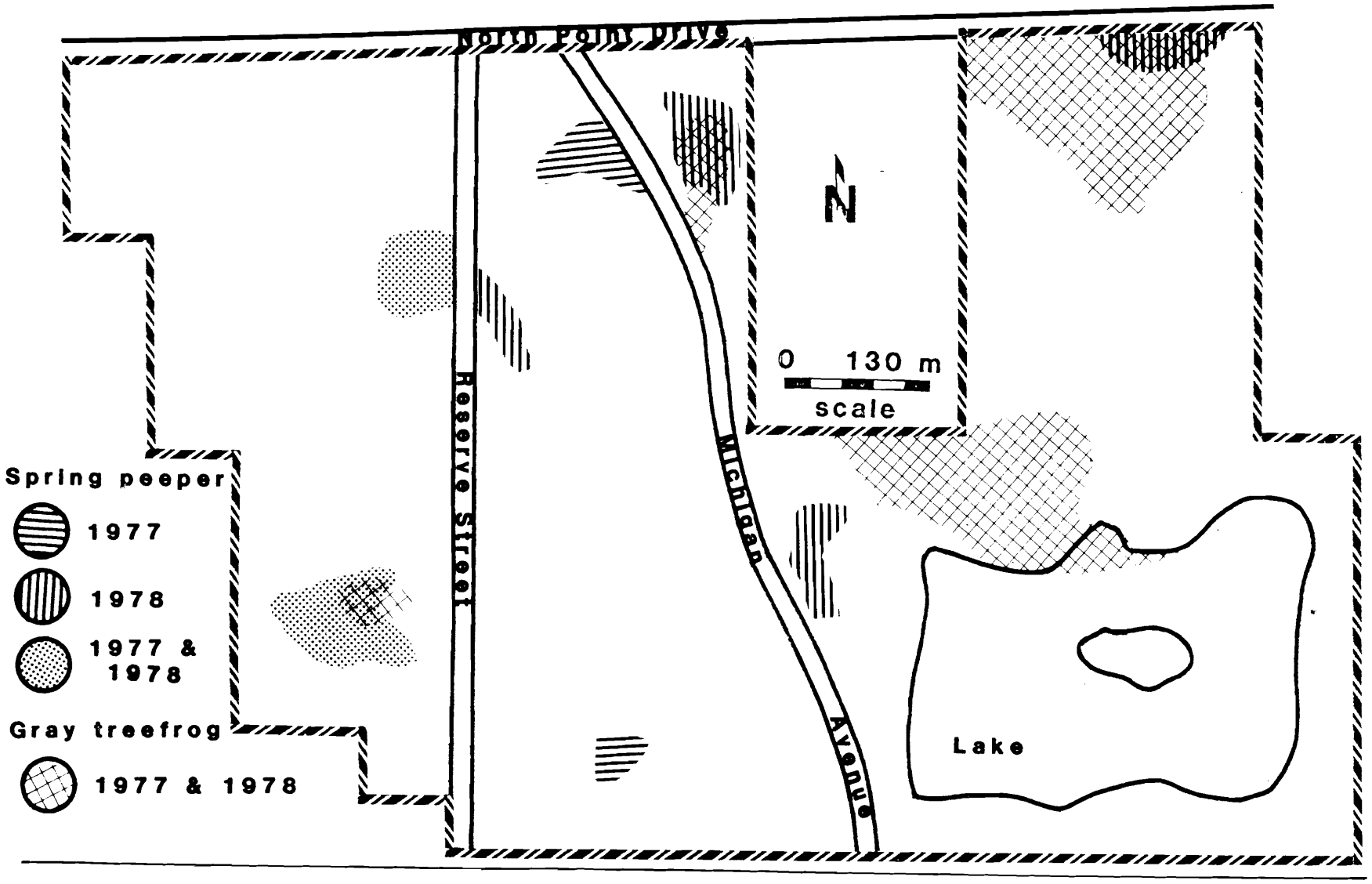


Figure 6. Portion of the study area used by gray treefrogs and spring peepers, 1977 and 1978.

herbaceous vegetation slightly above water level to call from. The increased wetland water levels in 1978 inundated such sites in the area abandoned in 1978.

Chorus sizes and relative intensity during breeding seasons indicated that chorus frogs were the most abundant anuran on the study area (Fig. 7). In 1978 the breeding areas of this species had expanded to include much of the available sheet water on the area.

Like salamanders, toads were observed to become trapped by the Michigan Ave. curb and gutter. Toad entrapment was observed as early in the study as July 1977, shortly after the curb was installed and even before the blacktop was laid. Toads were subject to entrapment throughout the warm months and during daylight hours. Although toads were found in the sewer traps, most apparently were crushed by cars.

Wood frogs, another species adversely affected by the Michigan Ave. curb and gutter arrangement, suffered the heaviest mortality on the road. Like salamanders, wood frogs became trapped on the roadway during the evening hours, particularly during periods of rain. On these occasions, wood frogs jumped onto the road and were unable to escape. This situation was most pronounced during Sep-Oct., the season when wood frogs presumably migrate from summer to winter habitat. The winter habitat of wood frogs on the study area is unknown.

On 2 Oct 1978, during a light evening rain shower, I toe-clipped 20 wood frogs I found on the road between 2000 and 2100. At 0600 on 3 Oct before daylight and traffic on Michigan Ave. developed, I collected and examined all frogs on the roadway. One unmarked, live wood frog was found; all others were dead. Of all 28 frogs collected,

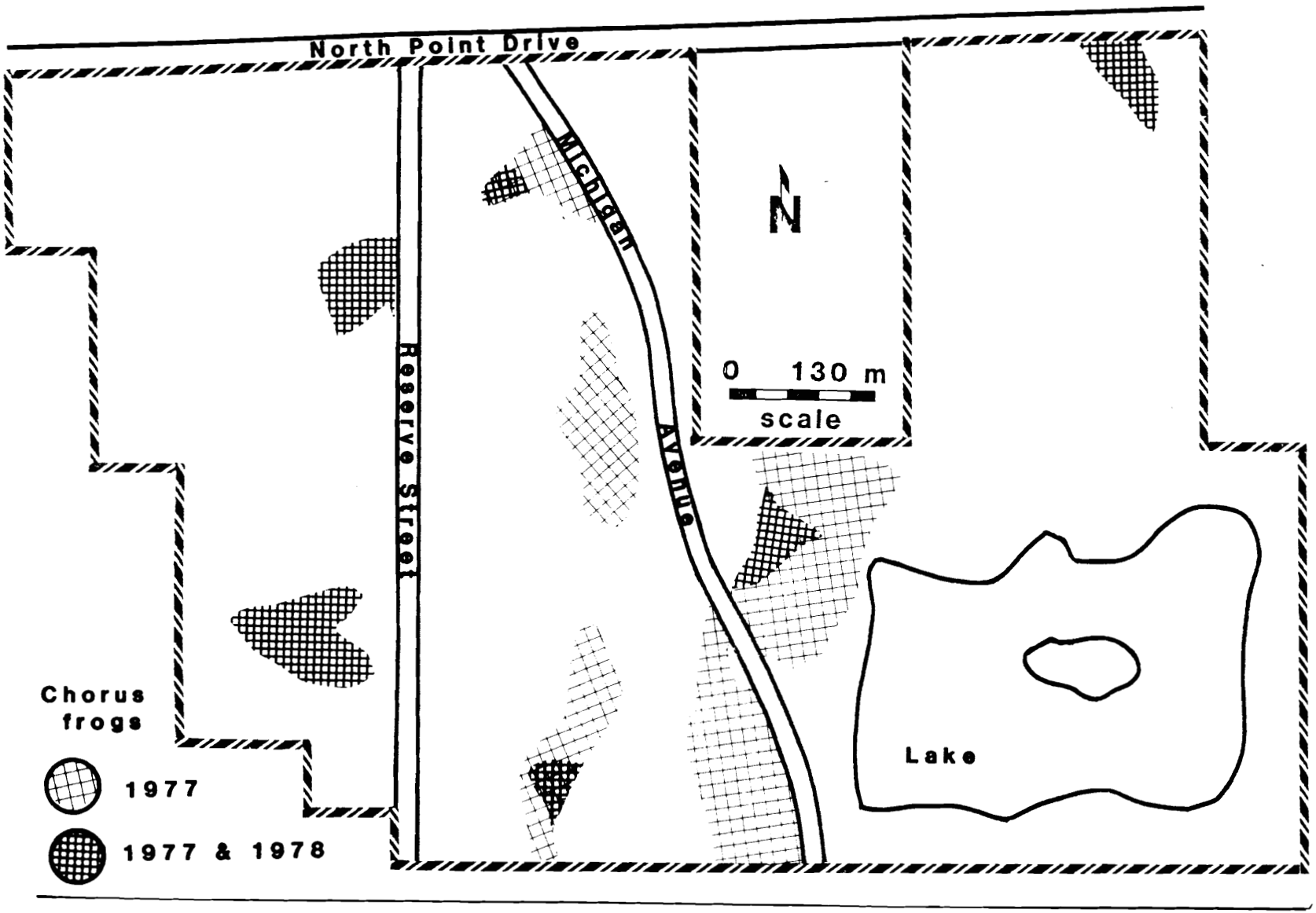


Figure 7. Portion of the study area used by breeding chorus frogs, 1977 and 1978.

2 had been clipped, 14 had not, and 12 were undetermined because of extreme mutilation. The ratio of marked/unmarked frogs allowed an estimate of 160 frogs that had been trapped on the road during the night. By Lincoln index, I estimated that only 27 (17%) had been killed by vehicles. Because the remaining 83% were unaccounted for, I assumed they fell into the grated sewers and were washed away, similar to the salamanders, or were eaten by predators. Twice during Aug and once during Oct 1978 I observed a striped skunk (Mephitis mephitis) eating frogs on the roadway. Crows often were observed eating crushed frogs during the early morning hours.

Mammals

Small Mammals

Of the small mammals detected on the study area (Table 9), 2 were rarely observed. The meadow jumping mouse was captured twice and the red-backed vole once. Both species were found only in 1977.

Changes in small mammal abundance in undisturbed habitats (Table 10) were independent of development of the study area. The shrews present increased in abundance slightly, while the population of Peromyscus leucopus declined. Although no red-backed voles or meadow jumping mice were captured in 1978, their absence cannot be attributed to any known change in habitat due to developments. Both of these species were captured in plots 1 (savanna) and 2 (hardwoods) (Appendix A).

The installation of dams in the storm sewer inlets in 1978 caused water levels in plot 3 to be maintained at or above ground level. Plot 6 was similarly flooded in 1978 due to runoff from an expanded parking

Table 9. Mammal species observed, Mar 1977-Mar 1979.

Masked shrew (Sorex cinereus)
Arctic shrew (S. arcticus)
Short-tailed shrew (Blarina brevicauda)

Bats (Chiroptera)

Eastern cottontail (Sylvilagus floridanus)
Snowshoe hare (Lepus americanus)

Woodchuck (Marmota monax)
Eastern chipmunk (Tamias striatus)
13-lined ground squirrel (Spermophilus tridecemlineatus)
Gray squirrel (Sciurus carolinensis)
Red squirrel (Tamiasciurus hudsonicus)
Southern flying squirrel (Glaucomys volans)
Northern flying squirrel (G. sabrinus)

Beaver (Castor canadensis)

White-footed mouse (Peromyscus leucopus)
Red-backed vole (Clethrionomys gapperi)
Meadow vole (Microtus pennsylvanicus)
Muskrat (Ondatra ziebethicus)

Norway rat (Rattus norvegicus)
House mouse (Mus musculus)

Meadow jumping mouse (Zapus hudsonius)

Porcupine (Erethizon dorsatum)

Domestic dog (Canis familiaris)
Red fox (Vulpes vulpes)

Short-tailed weasel (Mustela erminea)
Long-tailed weasel (M. frenata)
Mink (M. vison)
Stripped skunk (Mephitis mephitis)
River otter[a] (Lutra canadensis)

Domestic cat (Felis domesticus)
Bobcat[b] (Felis rufus)

White-tailed deer (Odoccileus virginianus)

[a]Unconfirmed reports from several observers; uncommon in county.

[b]Unconfirmed reports from 2 observers; species rare in county, nearest known individual 40 km NW.

Table 10. Index of abundance of small mammals captured in undisturbed habitats (Plots 1, 2, 5, 7, 8), 1977 and 1978.

Species	Captures/1000 pitfall trap-nights		Captures/1000 snap-trap trap-nights	
	1977	1978	1977	1978
Blarina brevicauda	8.8	0.0	2.7	9.2
Sorex cinereus	0.0	11.1	16.3	11.8
Peromyscus leucopus	0.0	0.0	54.3	18.3
Zapus hudsonius	0.0	0.0	2.7	0.0
Microtus pennsylvanicus	0.0	0.0	1.4	0.0
Clethrionomys gapperi	0.0	0.0	2.7	0.0

lot and from the devegetation of the area west of the study area during construction of commercial buildings. The unanticipated flooding of plot 6 precluded use of this plot as a control for comparison to re-flooding in wetland plots 3 and 4. In response to this flooding, all small mammals decreased in abundance (Table 11) except the arctic shrew. The arctic shrew evidently invaded these plots in response to the standing water. The 1975 drainage of plot 3 evidently allowed the invasion of white-footed mice which were excluded with the plot's reflooding in 1978 (Appendix A). In plot 4 (Appendix A), where the wetlands did not retain standing water, all small mammals increased in abundance.

No bats were captured on the reserve during the study. Bats were observed rarely in Apr-May and Oct 1977 and 1978, but seemed slightly more common during 1978. The small bats present probably were Myotis lucifugus, most common in the Stevens Point area.

Lagomorphs

Of the 2 lagomorphs present on the study area, only the cottontail was abundant (Appendix O). Only 1 snowshoe hare was captured during the study, and Dr. Neil Payne (CNR, UWSP) caught 1 on the area in 1975.

The trapline I route (Appendix A) was trapped only during fall 1977 (Appendix E) to avoid anticipated vandal problems in 1978, which occurred in 1977.

Cottontails were less abundant on the reserve in 1978 than in 1977 (Table 13). Juveniles composed over 80% of the cottontails captured in 1977 compared to 64% in 1978, indicating less reproduction in 1978.

Table 11. Index of abundance of small mammals in plots 3 and 6, inundated in fall 1978.

Species	Captures/1000 pitfall trap-nights		Captures/1000 snap-trap trap-nights	
	1977	1978	1977	1978
Blarina brevicauda	8.8	0.0	32.1	31.7
Sorex cinereus	17.5	51.8	19.2	2.0
S. arcticus	0.0	0.0	0.0	4.0
Peromyscus leucopus	0.0	0.0	8.5	4.0
Microtus pennsylvanicus	0.0	7.4	55.0	6.0

Table 12. Index of abundance of small mammals in plot 4, 1977 and 1978.

Species	Captures/1000 pitfall trap-nights 1977	1978	Captures/1000 snap-trap trap-nights 1977	1978
Blarina brevicauda	0.0	0.0	14.5	76.9
Sorex cinereus	55.6	155.6	21.7	6.4
Peromyscus leucopus	0.0	0.0	0.0	12.8
Microtus pennsylvanicus	0.0	0.0	101.5	141.0

Table 13. Age and sex ratios, captures/100 trap-nights (t-n), and densities of cottontail rabbits in each habitat, 1977 and 1978.

Habitat	Total captures[a]		Adults		Juveniles		Males		Females		Unknown sex		Captures/ 100 t-n		Rabbits/ha[b]	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
Mixed woods	12	13	3	5	8	7	6	5	5	7	0	0	3.4	3.6	2.9	0.8
Hardwoods	18	5	1	3	11	2	7	2	5	3	0	0	7.7	2.3	3.1	1.1
Pine	25	22	6	5	17	10	12	6	10	8	1	1	5.0	7.1	4.0	5.6
Wetland	67	21	8	7	50	11	26	7	27	11	5	0	7.0	5.6	5.6	1.0
Meadow	7	5	1	0	5	5	2	4	4	1	0	0	13.0	8.9	8.3	1.6
Savanna	30	14	6	4	13	18	10	3	9	9	0	0	9.6	5.0	2.0	1.8
Total	159	80	25	24	104	43	63	27	60	39	6	1				

[a]Some individuals were captured more than once.

[b]From Overton (1971).

Overall, the male/female ratio differed between 1977 and 1978, at 105/100 and 69/100, respectively. Cottontail densities on the study area varied from a low of 0.8/ha in mixed woods habitat in 1978 to a high of 8.3/ha in meadow habitat in 1977.

Data indicate that the restoration of the large wetland area in 1978 was detrimental to the cottontail population (Appendix O). Generally, sample sizes were too small to determine, with confidence, the effects of other developments upon the cottontail population, although in aggregate these developments apparently depressed reproduction and abundance in 1978.

Sciurids

There were 3 species of ground squirrels and 4 species of tree squirrels on the study area (Table 9), of which the gray squirrel was most abundandant. No gray squirrels were captured on trapline I (Appendix A) east of the lake, although I observed 2 juveniles there in Sep 1977.

Capture data from all traplines combined (Table 14) showed a slight increase in gray squirrel numbers on the reserve in 1978. The adult/juvenile ratio in 1977 and 1978 was 82/100 and 226/100, respectively. The higher ratio in 1978 indicates a reproductive failure or a decrease in juvenile survival in 1978. Sex ratios (M/F) were 163/100 and 133/100 in 1977 and 1978, respectively.

Based upon recaptures in 1978 of gray squirrels tagged in 1977, apparent juvenile survival was 44% and adults 30%, although dispersal rates are unknown.

Capture data from individual traplines in 1977 and 1978 (Appendix P) provide some insight to the apparent redistribution of the gray squirrel population in 1978, although sample sizes are small.

Table 14. Age and sex ratios, captures/100 trap-nights (t-n), and densities of gray squirrels in each habitat, 1977 and 1978.

Habitat	Total captures[a]		Adults		Juveniles		Males		Females		Unknown sex		Captures/ 100 t-n		Squirrels/ ha[b]	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
Mixed woods	22	20	6	8	13	4	13	6	5	6	1	0	6.3	5.6	5.5	0.6
Hardwoods	5	13	2	9	1	1	0	6	2	3	1	1	2.1	6.1	0.7	3.0
Pine	7	12	3	6	0	3	3	4	2	5	0	0	3.6	3.4	1.9	0.9
Wetland	2	2	1	1	0	0	0	0	1	1	0	0	0.4	0.5	0.1	0.2
Meadow	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Savanna	9	13	2	8	4	4	2	8	1	3	2	1	2.9	4.7	2.7	3.5
Total	45	60	14	32	17	12	18	24	11	18	4	2				

[a]Some individuals were captured more than once.

[b]From Overton (1971).

The reflooding of 16.5 ha of wetland habitat between Michigan Ave. and Reserve St. (Trapline III) evidently did not affect gray squirrels (Appendix P).

The largest increases in gray squirrel densities occurred in hardwoods, pine and savanna habitat (Table 14), especially in the area covered by trapline IV west of Reserve St. This portion of the study area was not disturbed by developments in 1978. The decline in squirrel densities in mixed woods habitat (Table 14) was most apparent between Reserve St. and Michigan Ave. on trapline III (Appendix P). This area was subjected to construction of trails.

In 1978, red squirrels were subject to capture in box traps set in trees for flying squirrels, as well as in box traps set on the ground. Because of probable differences in the relative efficiency of each trap type for red squirrels, direct comparisons of captures/ unit effort in 1977-1978 probably are not dependable. Some traplines yielded no recaptures making mark-recapture population estimates impossible. Red squirrels were restricted to habitats that contained conifers. Population densities of 0.5/ha were calculated in pine and mixed woods habitat in 1977 and 0.1/ha-0.8/ha in 1978 from traplines that permitted calculations.

Apparently, no fox squirrels (S. niger) occur on the study area, although they occur in Portage County.

Two species of flying squirrels (Table 9) were present. The northern flying squirrel had not been recorded in Portage County previously (Jackson 1961). This documentation extends the known range of this species south of the previously-known range in Wisconsin. In 770 trap-nights, 14 northern and 11 southern flying squirrels were

captured in the fall 1978. Population estimates (Overton 1965) based upon 74 captures of these squirrels were 16.5 ± 2.5 G. sabrinus and 14.0 ± 2.8 G. volans on the reserve. Captures of G. sabrinus occurred almost exclusively in pine habitat at an estimated density of 2.8/ha. G. volans was most abundant (4.2/ha) in mixed woods, but occurred in hardwood habitat also. Jackson (1961) reported densities of both species of 3-4/ha in suitable habitats.

No flying squirrel den trees were found on the reserve.

Other squirrels present (Table 9) were rarely or never captured. One woodchuck den existed on the study area near North Point Dr., east of Michigan Ave. At least 1 woodchuck was observed there until Sep 1978 when 1 was killed by a car. Whether the dead woodchuck killed was the only individual present is unknown.

Eastern chipmunks were never captured in snap traps and captured in box traps only rarely, so I made no population estimate. However, chipmunks were common throughout wooded portions of the study area. The effects of developments upon the chipmunk population are unknown, but probably minimal.

Thirteen-lined ground squirrels were present near Maria Dr. adjacent to mowed lawns. At least 1 den existed just north of Maria Dr. between Reserve St. and Michigan Ave. and contained at least 6 squirrels in Aug 1978. Of these 6, 5 were juveniles.

Mustelids

The striped skunk was the most common mustelid, and often was observed in all habitat types. All 3 skunks captured in 1977 were adults. During fall 1978, 2 adults and 4 juveniles were captured 8 times.

A single adult male badger was captured in the meadow near Reserve St. and North Point Dr. during fall 1977. There was no evidence of badgers using the area in 1978.

One juvenile short-tailed weasel was captured in wetland habitat during 1977. No long-tailed weasels were captured in 1977. In 1978, 3 weasels were captured 6 times, including 1 short-tailed weasel of each sex, and 1 adult male long-tailed weasel. The 6 captures of these weasels were widely scattered throughout the study area, but usually near or in wetlands.

No mink were captured during the study, but 2 sightings of them confirmed their use of the lake and the wetland areas. Two students reported seeing otter in the lake on 3 occasions during spring 1978. I was unable to confirm these observations and believe they were of mink. Mink were first seen on the study area at about the same time.

Miscellaneous Mammals

Two beaver were observed on the area during spring 1978, after the wetlands were reflooded. Apparently they did not establish residence, as no lodges, dens, or evidence of feeding was observed.

Muskrats rarely were observed on the study area during 1977, while the wetlands were being drained. The only 2 observations during 1977 were both of dead animals, 1 on Reserve St., and 1 on Maria Dr. With the wetlands reflooded in 1978, muskrats were common throughout the wetlands. However, their use of the lake was limited. Muskrats also were observed in Moses Creek in 1978.

I observed porcupines on 2 occasions in summer 1977, but saw none during 1978. Porcupines reach their southern range limit along the tension zone (Burt 1957).

I observed fox tracks on the reserve during Dec 1977 and saw 1 on the reserve near North Point Dr. just east of the private residences in Oct 1977.

Two bobcat sightings on the reserve were reported 1977-1979 but were not confirmed. Bobcats are rare in the county.

Domestic cats often were observed on the area, often hunting small mammals.

Domestic dogs were common on the study area. Dogs roamed freely throughout the area and sometimes were accompanied by people. Occasionally dogs were observed chasing squirrels on the area but I witnessed no kills. Dogs chased deer on the reserve throughout the study. During Mar-Apr 1977, there was little snow to restrict deer movements and make them vulnerable to dogs. In late Mar and early Apr 1979, conservation officers reported that dogs had killed at least 5 deer on the study area.

White-tailed Deer

The study area supported 8-10 deer during the summers of 1977 and 1978 (Fig. 8). The number present during winter was nearly double that of summer.

The only known reproduction on the study area was in 1977 when a 3-year old doe often was seen with 2 fawns. She was killed by a car on Michigan Ave. in Jul 1977 soon after the new road was opened. One of her fawns suffered a broken leg but was not recovered. I assume the death of the lactating doe caused the death of both fawns. No other fawns were observed during the study. One yearling buck was present on the reserve May-Aug 1977 and 1978.

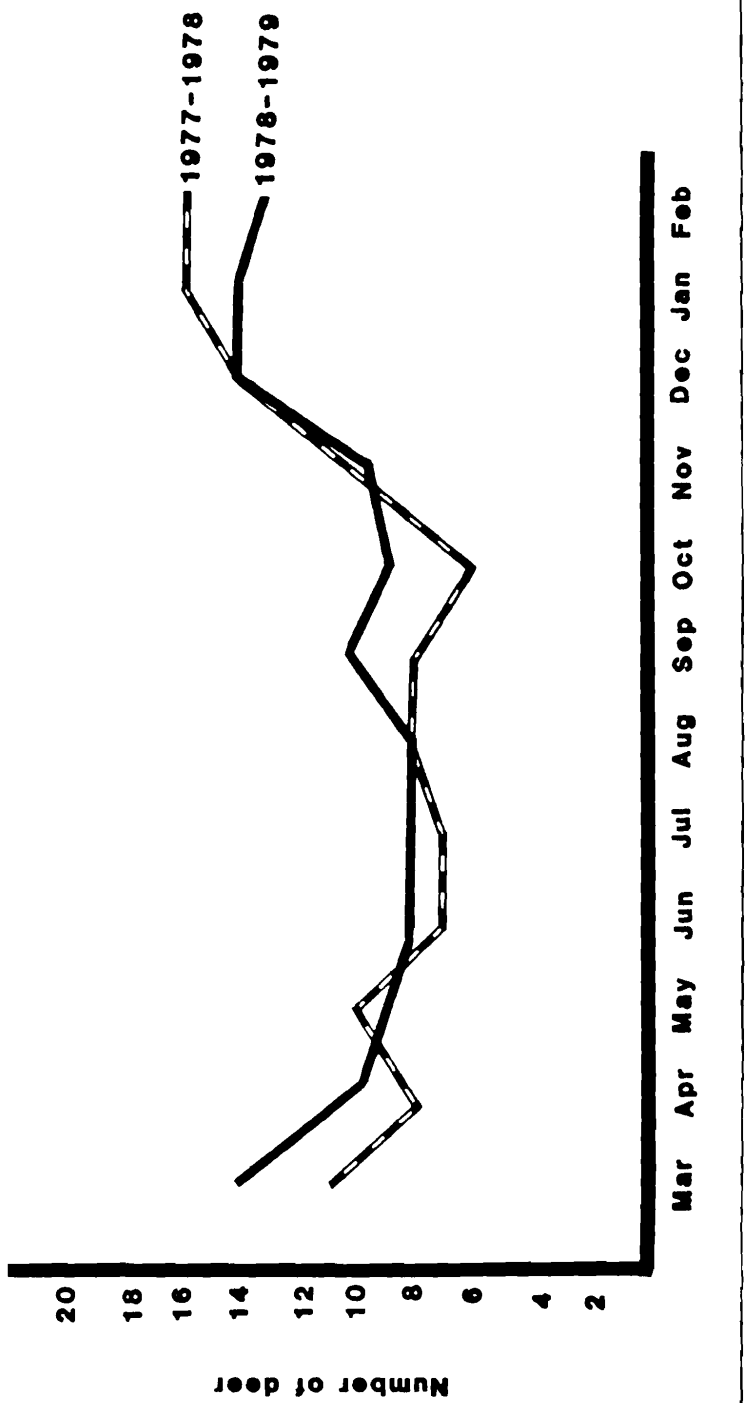


Figure 8. Number of deer present by month, Mar 1977-Mar 1979.

Radio telemetry monitoring of the 2 deer marked indicated that they spent about 95% of their time within the study area during the winter and spring months 1978. Both deer occasionally grazed on the lawns north of and adjacent to the reserve. The only unusually long movement occurred on 1 June 1978 when 3 deer, including the marked doe, left the study area and traveled 1 km south through a residential area of Stevens Point. One deer became separated from the group and was injured; police destroyed it. The remaining 2 deer returned to the study area at dusk the same day.

Private individuals fed deer from a corn pile north of the study area during winter and spring 1979, and drew 6-9 deer to the bait pile almost daily.

Mortality of deer on the area Jan 1977-Apr 1979 was attributed to, in order of importance, dogs, road kills, and poaching (bow hunting). At least 11 deer were killed on the area during the study (Table 15).

Table 15. Known mortality of deer, Mar 1977-Mar 1979.

	Causes of deer mortality							
	Dogs		Vehicles		Poaching		Total	
	1977-78	1978-79	1977-78	1978-79	1977-78	1978-79	1977-78	1978-79
Mar-May								
Number killed	0[a]	5	0	1	0	0	0	6
Percent of mean population killed	0	52	0	10	0	0	0	62
Jun-Aug								
Number killed	0	0	3	0	0	0	3	0
Percent of mean population killed	0	0	38	0	0	0	38	0
Sep-Nov								
Number killed	0	0	0	0	0	1	0	1
Percent of mean population killed	0	0	0	0	0	13	0	13
Dec-Feb								
Number killed	0	0	1[b]	0	0	0	1[b]	0
Percent of mean population killed	0	0	7	0	0	0	7	0
Total number	0	5	4	1	0	1	4	7

[a]Lack of dog predation in spring 1978 attributed to absence of crusted snow which increases deer vulnerability.

[b]Individual assumed to have been killed in Jan-Feb by a vehicle. I found the partially decayed carcass adjacent to Michigan Ave. in Apr 1978.

DISCUSSION

Birds

The spring and fall censuses provided the greatest diversity in birds on the study area (Fig. 3).

The relatively large diversity of birdlife on the study area is in part attributable to the diversity of habitats it contains (Fig. 2). Beimborn (1969) correlated the range limits of about 20% of Wisconsin's bird species with the tension zone (Fig. 1). Of the 14 species he listed, 7 are known to breed in Portage County. Of these 7, the sharp-shinned hawk, Cooper's hawk, red-breasted nuthatch, tufted titmouse, and western meadowlark were observed on the reserve during at least 1 breeding bird census.

While the construction of Michigan Ave. and the lake destroyed 4.0 and 9.7 ha of natural habitat, respectively, the construction of the lake before the study began contributed to the habitat diversity of the area by providing the only large, open, permanent body of water in the area. Fifteen bird species were observed during the study that probably would not have been present had the lake not been constructed (Table 16). These species represent nearly 10% of the bird species observed on the area during the study. In addition, the lake provided new aquatic habitat for migrants, and probably increased the abundance of species already using the area. Insectivorous birds such as the swallows, swifts, and nighthawks which commonly feed over water, and migrant waterfowl probably benefitted most from the lake construction.

My failure to confirm the presence of the long-billed marsh wren probably reflects the species' extirpation from the study area. Suitable habitat probably existed on the reserve before the wetlands were

Table 16. Bird species observed on the study area that would have not been present had the lake not been constructed.

1. Common loon
2. Horned grebe
3. Pied-billed grebe
4. Great blue heron
5. Green heron
6. American bittern
7. Pintail
8. Green-winged teal
9. Lesser scaup
10. Common goldeneye
11. Bufflehead
12. Common merganser
13. Spotted sandpiper
14. Short-billed dowitcher
15. Belted kingfisher

drained in 1975, and the wetland restoration may allow this wren to return as a breeding bird.

Spring Migrant Birds

Because of the variation in spring bird diversity in unaltered habitats, 1977 and 1978 (Fig. 3), no changes in altered habitats can be attributed to development alone. Additionally, 14 of the spring species observed only in 1978 visit central Wisconsin only on migration or as winter residents, but do not breed here. Birds often use habitats on migration that are not typical of their preferred breeding habitat. Fluctuations in the bird diversity of a given area during migrations are common, and evidently caused the difference in the number of species present during spring 1977 and 1978 on the study area.

Woodcock and Ruffed Grouse

The study area's woodcock population apparently was unchanged between 1977 and 1978, despite development between the 2 years.

Woodcock often were observed in areas from which ground vegetation had been removed and/or bare soil exposed. Woodcock used trails, the lake area, and other areas for feeding. Hale and Gregg (1976) found that such disturbed areas were highly attractive to woodcock for feeding and night roosting in northern Wisconsin. Newly disturbed areas attracted woodcock in 1978, but evidently were not important enough to increase the carrying capacity of the study area.

Ruffed grouse decreased in abundance, as indicated by the number of drumming sites abandoned between spring 1977 and spring 1978. A significant ($P < .01$) drop in the grouse population was indicated when IAs for grouse observed in all habitats were compared between years. The drop in the grouse population probably was not due to developments occurring on the area, but may have reflected a regional decline.

Summer Nesting Birds

Holmes and Sturges (1975) found that 73% of the bird species they observed during spring migration remained on their study area to breed. On the study area, 71% and 73% remained to breed in 1977 and 1978, respectively. Holmes and Sturges (1975) found that breeding bird diversity was similar in 5 consecutive years in unchanged habitats. Likewise, I found that similar diversities occurred both years in unaltered habitats.

The effect of trail construction in pine habitat was to break the monotypic pine cover. This effect was pronounced in previously-burned areas that had revegetated with even-aged jack pine.

MacArthur and MacArthur (1961) first demonstrated that foliage height diversity and "edge" are more important in regulating breeding bird diversity than the composition of plant species in the habitat. Willson (1974) found that bird species diversity was correlated with foliage height diversity, increasing with "environmental patchiness in 3 dimensions". The increase in such patchiness created new niches for exploitation. Moss (1978) found a similar correlation between structural diversity of vegetation and bird diversity in Scotland. Poorest bird diversity occurred in even-aged monoculture plantations without undergrowth, and richest diversities occurred in mixed woodland with thick understories, where vegetation was more evenly distributed between height ranges of 0.0 and 15.0 m (Moss 1978). She suggested that this correlation resulted from an increase in available niches in the structurally diverse habitat.

In response to the reflooding of wetlands in 1978, common wetland species -- catbird, yellow warbler, red-winged blackbird, grackle, goldfinch, and song sparrow -- showed the greatest increase in response to the reflooding of wetlands in 1978. Obviously, these species were most affected when the wetlands were drained in 1975.

The draining of the wetlands in 1975 killed much of the study area's wetland vegetation. In 1978, after reflooding, willows and some other wetland species seemed to recover partially and sprout new growth. This resulted in more cover during the 1978 summer breeding season than was present the previous year. Jaeger (1978) found that an increased water level in southern Wisconsin wetlands reduced the abundance of common wetland species of birds. He attributed the decrease to a reduced amount of cover as wetland vegetation was killed by the unnaturally high water levels. The drainage of the study area wetlands accomplished similar effects upon wetland vegetation and bird life, although the wetland vegetation died for lack of water rather than from too much of it.

In studying the influence of drought on red-winged blackbirds in Pennsylvania, Brenner (1966) determined that reduced water levels in their habitat reduced their reproductive success. Wetlands in the reserve were subjected to an artificial drought-type condition from 1975-1978.

Brooks (1960) compared songbird communities in 2 different successional stages of wetland habitat in Wisconsin. He found that differences in bird density and diversity were influenced by vegetation and that the willow shrub type wetland habitat supported the densest and most diverse bird populations.

The apparent lack of influence that traffic on Reserve St. had on birds before 1978 in the wetland and pine habitats is probably due to the low, dense structures of these habitats. Both habitats are dense in profile from ground level to 3 m, and to 4-5 m in pine habitats along Reserve St. This very dense vegetation probably serves as an effective barrier to the noise and visual disturbance of road traffic for birds nesting along the road. The mixed woods habitat adjacent to the road has very little understory and this sparse vegetation does not offer the birds a screen from

traffic disturbance. The open structure of the mixed woods habitat could account for the apparently detrimental influence of vehicular traffic on birds in that habitat along Reserve St.

The data are inconsistent concerning the observed effect of traffic on birds. While the removal of traffic in mixed woods along Reserve St. allowed an increase in bird abundance, the addition of vehicular traffic to mixed woods along Michigan Ave. in 1978 did not depress bird abundance.

The construction of Michigan Ave. was underway during the 1977 summer bird census and may have provided even more disturbance to breeding birds along the corridor than the 1978 vehicular traffic. The varied construction activities may have been more difficult for the birds to tolerate than traffic, to which they may become accustomed. If this were the reason for the discrepancy in the observed effect of vehicular traffic on birds in this habitat type, any negative impact of traffic along the new road would have gone undetected. No comparable breeding bird censuses were conducted along this route before construction began, so results are inconclusive.

In the wetland habitat along Michigan Ave. which was disturbed by traffic on the new road and reflooded in 1978, the net increase ($P < .001$) (Appendix K, L) in the breeding bird population was nearly identical to the increase observed in wetlands subjected only to reflooding in 1978 (Appendix H). The increase in bird abundance along Michigan Ave. was probably due to the reflooding of the wetlands alone.

These data indicate that the damage to the wetland habitat caused by drainage incidental to the road construction was more detrimental to breeding birds than the actual presence of the road and its associated vehicular traffic.

Fall Migrant Birds

The large difference in fall migrant bird diversity between 1977 and 1978 (Fig. 3) evidently was the result of differences in migration times and patterns and cannot be related to any habitat changes on the study area. The only change in habitat conditions that occurred between the 1977 and 1978 fall censuses was a slight increase in water levels and soil moisture in some portions of the wetlands. Because the 1978 increase in migrant birds occurred throughout the study area, it is unlikely the slight changes in wetland conditions contributed to the increase.

Winter Resident Birds

The large difference in winter bird diversity between 1977-1978 and 1978-1979 (Fig. 3) also was not caused by development. Evidently, the usual winter visitors bypassed central Wisconsin area during southward migration or did not arrive in the area at all during the winter of 1978-1979. There were no habitat changes between the 1977-1978 and 1978-1979 winter censuses to account for the differences in winter bird diversity.

About 10% of the species observed on the study area were considered permanent residents, and were observed during at least 1 of each census period. Holmes and Sturges (1975) reported that only 10.7% of all species they observed on their New Jersey study area maintained permanent residence, and that winter was the season of lowest bird species diversity.

Reptiles

Although most herps are inconspicuous and easy to overlook, the eastern hognose snake, northern ringneck snake, five-lined skink and wood turtle probably would have been detected if they inhabited the study area. The lack of documentations for the EIAs (Warzyn Engineering

Service Co., Inc. 1974, Strand and Associates, Inc. 1974) suggests they were never present.

The snapping turtle probably was not present at the time of the EIA preparations, before the lake was constructed. Snapping turtles are aquatic, inhabiting permanent bodies of water that contain fish as their major food source (Pell 1940, Alexander 1943). In simulated field conditions, Froese (1978) found that some form of aquatic cover was an essential habitat requirement for snapping turtles. Mud substrate or some type of obstructions, including rocks and aquatic plants, offered concealment, enhanced protection, and provided locations from which to obtain food (Froese 1978). Also, aquatic vegetation is injested directly, as are invertebrates and vertebrates associated with the vegetation. Because the lake is extremely oligotrophic, lacks aquatic vegetation, and has a sand bottom, it must be considered very marginal snapping turtle habitat.

The lake island presents the 1 location of suitable turtle nesting habitat associated with the lake. Shoreline areas, otherwise suitable, are heavily used by people who would inadvertantly trample any turtle nests present.

The marginal aquatic habitat of the study area, combined with the consistent human disturbance of the lake habitat probably will retard the establishment of viable turtle populations.

The relative importance of meadow habitat to snakes (Table 6) may be slightly exaggerated. The open, sparsely vegetated nature of this habitat enabled me to search entire meadows more quickly and thoroughly than other habitats. Also, an old well located west of Reserve St. near the edge of the meadow may serve as a hibernaculum for some of the

area's snakes. On 2 occasions in Oct 1978, 2-5 garter snakes were found in the immediate vicinity of the well, but none was observed inside. The well on the study area is similar to at least 7 other old wells in Portage County known to serve as hibernacula for garter and fox snakes, but somewhat shallower (1.3 m). This lack of depth may not provide protection from frost during years of extreme cold and little snow cover as occurred in 1977. If this well serves as a hibernaculum, the congregation of snakes in the area may have further biased the importance of meadow habitat to snakes.

Gregory (1977) reported that most red-bellied snakes were found in generally open areas such as marshes or meadows, although he found some in aspen forests. He found that smooth green snakes preferred wooded and meadow habitats adjacent to marshes.

The apparent abandonment of wetland habitats on the study area by garter snakes (Table 7) in 1978 is attributed to the flooding of these areas as a result of the dammed storm sewer inlets. The use of the wetlands by snakes increased during Sep-Oct 1978 after water in the wetlands had receded.

Although trail development had no measurable impact upon garter snake populations (Table 7), several observations seem pertinent. I occasionally found snakes basking and immobile on trails during the morning hours of my 1978 summer bird census. Because of the relatively open-canopied nature of most habitats, it is unlikely that the availability of basking sites was limiting in 1977, or that the construction of trails would have increased the carrying capacity of the study area for snakes. The use of these trails may increase the vulnerability of snakes to predation, especially from raptors. I found 2 garter snakes crushed on trails, presumably by joggers.

Amphibians

Salamanders

Generally, the damming of the storm sewers in 1978 benefitted all salamander species by expanding the area of suitable breeding habitat.

Although the woodland salamanders are not restricted to standing water for reproduction like the ambystomids, they require a moist substrate, and probably benefitted as well.

I feel that the apparent increase in populations of salamanders was real, although because they became trapped on the road, salamanders were more easily observed. Observations of blue-spotted salamanders trapped on the road indicate that they tend to follow the curb and gutter rather than try to cross the road. This behavior makes them less vulnerable to being killed by cars, but increases their chances of falling into the drop-flow structures and going undetected. Most of the salamanders on Michigan Ave. were observed on the southern 1/3 of the extension. This 300-m portion of the road passes through wetland habitat (Fig. 2).

Frogs and Toads

The small influx of leopard frogs during fall 1978 may indicate that the study area is within spring-fall migration distance of an existing population, and that these frogs may re-establish a breeding population if conditions remain suitable.

The reflooding of the wetlands in 1978 attracted wood frogs west of Michigan Ave. only, although there was similar habitat east of the road. This suggests that the road may present a barrier to wood frogs, and that it prevented them from reaching and colonizing suitable

breeding habitat. The mortality of wood frogs on Michigan Ave. probably interferes with fall migration.

The mortality of toads on Michigan Ave. is probably as great as that of wood frogs because toads are as common, and vulnerable throughout the warm months. However, their mortality is less noticeable because their annual mortality is not concentrated during several weeks in the fall, as it is for wood frogs.

If traditional breeding areas of vulnerable amphibians are permanently separated from their other seasonal habitats, the populations cannot be expected to thrive. In the case of the wood frog, an invasion from the wetlands north of North Point Dr. would be necessary to re-establish a breeding population east of Michigan Ave.

Toads, blue-spotted salamanders, and red-backed salamanders may be similarly affected by the road's impassability.

Leopard frogs often were killed by cars on Michigan Ave., but were not trapped by the curb because of their greater jumping ability. The hylids present on the reserve were not found on the new road. Although they may have been killed and overlooked because of their small size, they would not become trapped because of their ability to climb the curbs.

The insects attracted to the lights along Michigan Ave. may cause toads and frogs to approach the road in response to abnormally high prey densities. If so, it is likely that the lights cause these animals to become trapped on the road and present a constant hazard to these animals throughout the warm months.

Mammals

Small Mammals

Small mammal trap plots 1 and 2 represented typical habitat for the

red-backed vole and meadow jumping mouse captured in 1977, Plot 1 (Appendix A) was an open oak savanna, a habitat preferred by Zapus in Minnesota's prairie transition zone (Iverson et al. 1967). This transition zone is similar to the Curtis tension zone (Curtis 1959) in Wisconsin in which Schmeeckle Reserve lies. Iverson et al. (1967) found that red-backed voles are more non-selective in the transition zone than elsewhere in its range in Minnesota. Quimbey (1951) reported non-selectivity of habitats for Zapus also.

Plot 2 yielded the only red-backed vole captured on the study area. Iverson et al. (1967) found that these voles preferred habitats similar to those preferred by Peromyscus leucopus in the Minnesota transition zone. Peromyscus was the most common species in plot 2 in 1977 and 1978 (Appendix A).

Although red-backed voles and meadow jumping mice are rare on the study area, their future probably is secure unless the savanna and hardwood habitats are disturbed. The 1977-1979 development did not affect the areas in which these species were captured. Gunderson (1959) found that red-backed voles prefer rotting stumps, logs and loose forest litter. Similar debris was characteristic of plot 2.

Although arctic shrews reportedly were present on the study area during fall 1974 (Warzyn Engineering Service Co., Inc. 1974, Strand and Associates, Inc. 1974), none was captured during 1977. Because arctic shrews prefer very moist habitats (Getz 1961), the drainage of the reserve wetlands in 1975 probably eliminated arctic shrew habitat. The 1978 reflooding of plot 3 evidently allowed recolonization. Plot 6, similarly flooded, also attracted arctic shrews. Although soil moisture

is beneficial to shrews in general (Getz 1961), the severe flooding of plots 3 and 6 apparently displaced masked shrews and reduced the abundance of short-tailed shrews.

White-footed mice prefer forested habitats (Burt 1957). Wetzel (1958) and Hirth (1959) found that white-footed mice may occur in early successional stages, but that population size increases as succession advances. This preference of these mice for wooded habitats was attributed to the structural difference between grasslands and forest habitats (MCloskey and LaJoie 1975). Their preference for more complex habitat structure usually prevents extensive overlap with meadow voles. Also, interspecific interaction between these 2 species further serves to displace white-footed mice from meadow vole habitat (Bowker and Pearson 1975). Meadow voles prefer a moist habitat with a dense grassy ground cover (Getz 1960). The 1978 flooding of plots 3 and 6 eliminated white-footed mice from habitat typical of meadow voles. Blem and Blem (1975) found that white-footed mice successfully inhabit bottomlands subject to flooding only if flooding is not severe. White-footed mice increased in abundance in plot 4 where flooding was not severe.

Bat populations probably will increase on the study area if the wetlands are allowed to retain water and as the lake matures. These areas will produce more insects in time and greater prey densities may attract more bats. Roosting sites probably are not limiting on the study area.

Lagomorphs

The southern range limit of snowshoe hares in Wisconsin (Burt 1957) corresponds to the Curtis tension zone (Curtis 1959) which passes through

Portage County. Snowshoe hares are more common in extreme northern Portage County, but very rare on the study area.

Cottontail densities of 0.8-8.3/ha were within the range reported by other workers. Edwards and Eberhardt (1967) reported density estimates of 2.1/ha in unconfined plots and up to 5.9/ha in fenced areas, although they felt their estimates were low. Lord (1963) reported Illinois cottontail densities of 3.1-8.0/ha. Rose (1977) considered cottontail densities of 2.5-4.0/ha low in Illinois, and densities of over 4.5/ha high.

Cottontails were affected primarily by the reflooding of the wetlands in 1978. The decrease in rabbit densities in 1978 (Table 13) in wetland habitat was in response to habitat lost to flooding. Because the wetlands comprise such a high percentage of the available habitat (Table 1), and its population contained a high percentage of juveniles in 1977 (Table 13), the high production in the wetlands probably overflowed into surrounding habitat types that year. With the wetlands reflooded in 1978, the major cottontail production area was adversely affected and caused lower cottontail densities throughout the study area (Table 13).

Sciurids

Gray squirrel densities were low in all habitat types (Table 14). Mosby (1969) reported gray squirrel densities as high as 14/ha in unexploited woodlot populations. Although limited poaching occurred on the study area, the harvest probably was minimal, and the gray squirrel population was practically unexploited.

The slight increase in the study area's gray squirrel population apparently occurred in areas undisturbed by development in 1978, resulting in a change in distribution of squirrels. Because the wetland

habitat contained so few squirrels (Table 14), it is unlikely the re-flooding in 1978 affected the population. Nevertheless, the area between Michigan Ave. and Reserve St. (trapline III) was nearly devoid of squirrels in 1978 (Appendix P). The presence of trails in the wooded habitats increased human disturbance there and may have caused emigration out of that area. If such movement occurred, it helps explain the corresponding increases in squirrel abundance elsewhere in the study area in 1978. Two adult squirrels trapped west of Michigan Ave. on trapline III in 1977 were recaptured in the undisturbed trapline II area east of Michigan Ave. (Appendix A) in 1978.

West of Reserve St., the trapline IV area (Appendix A), the gray squirrel population apparently dropped, as reflected by captures/100 trap-nights, although the population density in 1977 (Appendix P) was based upon only 1 recapture. Over 50% of the gray squirrels captured on trapline IV in 1978 had been captured in 1977 on traplines III and IV. This, again, suggests that squirrels abandoned the trapline III area (Appendix A) which was disturbed by human use of trails in 1978 in favor of undisturbed habitats.

The increased adult/juvenile ratio in 1978 indicates a poor reproductive year. If a low availability of nutritious foods, especially mast, had caused the apparent low reproduction in 1978 (Smith and Barkalow 1967), it would have affected the entire study area rather than the area only between Reserve St. and Michigan Ave.

Red squirrel densities on the study area were low (0.1-0.8/ha). Rusch and Reeder (1978) reported densities of 0.86-2.64/ha in Alberta

jack pine habitat. Kemp and Keith (1970) found densities of 0.10-0.56, also in Alberta, and Layne (1954) found densities of 0.25-0.75/ha in New York.

Red squirrels concentrated during winters in dense stands of young white pine, near North Point Dr. west of Reserve St., and centrally on the study area just east of Reserve St. There was evidence of extensive use of the pine seeds as a food source by red squirrels in these areas. Development had not damaged these pine stands from 1977 to 1979. The extensive use red squirrels made of these pine stands suggests that these stands are important to red squirrel survival.

The coexistence of the northern and southern flying squirrels on the study area was unknown before 1977. The northern species prefers coniferous habitats while the southern species is less specific in its habitat requirements (Burt 1957). The southern range limit of the northern flying squirrel in Wisconsin (Burt 1957, Jackson 1961) corresponds to the tension zone (Curtis 1959).

Jackson (1961) and others have noted that each species congregates in communal den trees during the winter months. No such den trees were identified for either species, although 2 individuals were observed to retreat to a single ground den when released from traps. If the flying squirrels use communal den trees, as few as 2-4 trees may contain the entire population during the winter months. Destruction of these den trees through development would jeopardize the future of the flying squirrel populations on the study area.

Mustelids

The more frequent observation of skunks in 1978 may have resulted from immigration. The wooded habitat west of the study area along U.S. Business Route 51 was developed, probably displacing any skunks living there.

The occurrance of mink on the study area in 1978 is attributed to the increased water levels as a result of the dammed storm sewers which attracted muskrats, a preferred prey of mink. Mink probably inhabited the area before 1977 when the wetlands were drained.

The apparent increase in both weasels and mink in 1978 may have been partly in response to the general increase in small mammals, serving as prey, throughout large portions of the wetlands that year.

Miscellaneous Mammals

Muskrats dug no burrows in the lake banks, although I often observed them in the area in 1978. The soft sand of the banks and berm probably would not permit tunneling. Aquatic vegetation, typical of muskrat habitat, especially cattails (Typha latifolia) was absent. The muskrat population is expected to increase if the wetlands are allowed to retain water.

The incidence of beaver on the study area in 1978 was due to the increased water levels after the storm sewers were dammed. The beaver probably were dispersing young and did not remain. Moses Creek (Fig. 2) provides a travel corridor for beaver to the study area from wetlands north of North Point Dr.

Porcupines are not abundant in Portage County, but occur in the northern portions of the county. Porcupines can be expected to occur in the study area occasionally unless development north and northeast

of the study area eliminates wooded habitats. Their presence depends partly upon their ability to immigrate from the north.

Likewise, fox enter the reserve from the north and northeast and will occur occasionally until development eliminates these travel corridors.

I found no evidence of raccoons (Procyon lotor) on the study area, although they occur in Portage County. Den sites for raccoons are scarce on the study area and no dependable food supply exists. The densest concentrations of raccoons in the Stevens Point area occur in riparian habitat along the Wisconsin River and its tributaries, habitat quite different than that in the study area.

White-tailed Deer

The increased deer population during the fall and winter months began with the movement of deer into the study area from north of the study area during the rut (Oct). The immigrant deer remained on the area Dec-Mar because of the excellent winter shelter provided by young, dense jack pine stands, as well as the availability of winter browse in the study area. Both of these conditions are a result of fires.

The undeveloped property north of the study area, and the UWSP property adjacent to North Point Dr. not included within the Schmeeckle Reserve boundary are critical to the deer herd during all seasons. Because these undeveloped areas are relatively undisturbed by people and recreational developments, they provide the most-used bedding and fawning areas and allow deer easy access to escape cover north of North Point Dr. These areas, along with the 4 ha of adjacent private land, provide the route of seasonal migration from the north and an escape route when deer are harassed, and therefore deserve protection if the herd is to be maintained on the study area.

Additionally, if the habitat north of North Point Dr. is damaged, the study area will be isolated, deer movement will be restricted, and deer will abandon the area eventually; the source for replacement of deer killed by cars, dogs and poachers probably will be lost. In view of the continuing development, it is unlikely that reproduction on the study area alone can keep pace with mortality.

The impact of roads on deer mortality was compensated for by immigration from the north from 1977 to 1979. The reflooding of the wetlands removed some habitat that deer used, but did not present a barrier to their movements.

The construction of trails encouraged increased use of the area by people. People, and their pets, are responsible for harassment of deer throughout the year and probably prevent does from rearing fawns on the area. Harassment by people at other times of the year probably is not important, except when dogs chase and kill deer Mar-Apr. Dog predation would occur regardless of the presence of trails on the reserve.

RECOMMENDATIONS

Management

The proposed management recommendations are designed to preserve wildlife diversity and abundance through habitat protection, while encouraging educational use of Schmeeckle Reserve.

The study area has been subjected to numerous physical alterations that have reduced its value as a natural outdoor laboratory and teaching tool. Overuse and misuse of the area by students and others have compromised the area's educational value even further. Finally, Schmeeckle Reserve has suffered from a lack of comprehensive management with clear policy objectives.

The following management recommendations are aimed principally at wildlife populations, but will help preserve Schmeeckle Reserve in its natural state for many purposes.

1. Recommendation. Establish a committee including, but not limited to CNR and Biology Department faculty members to make policy decisions regarding the management of Schmeeckle Reserve, and to formulate long-range management objectives.

Justification. The CNR and Biology Department currently, and historically have made the greatest educational use of the study area. The Schmeeckle Reserve study area is well-suited and convenient for use in teaching classes in botany, soils, forestry, water, plant and animal ecology, wildlife, and interpretation. It is the natural features of Schmeeckle Reserve that enable its use for these purposes. Further, the policy behind the management affects the very qualities of the area that make it so valuable as a teaching tool.

The UWSP objective to provide a first priority on teaching requires educational use of the study area as its primary use. The departments dependent on Schmeeckle Reserve for these purposes should have the opportunity to preserve and/or restore it for these purposes.

A detailed proposal defining structure and line of authority should be drafted and voted upon by concerned faculty members. This group's function as the committee should be to provide direction in Schmeeckle Reserve's management. The committee should be responsible to the UWSP administration through the dean, CNR.

2. Recommendation. Hire a full-time biologist as manager of Schmeeckle Reserve.

Justification. The manager would implement management plans developed jointly with the committee, and serve as a day-to-day manager of Schmeeckle Reserve in the field. The manager would inform committee members of problems requiring resolution, and provide input to the policy decisions of the committee.

The manager would be directly responsible to the committee for management decisions made in the field.

The manager position requires a biologist to evaluate changing conditions of plant and animal communities, submit informative reports, and coordinate educational and research activities, while maintaining a natural environment rather than a park.

The biologist should have a strong background in plant and animal identification, and experience in plant and animal censuses and analysis of biological data to coordinate the biological education and research.

Responsibility. Schmeeckle Reserve Management Committee, UWSP.

3. Recommendation. Eliminate the road-based storm sewer inlets on the Michigan Ave. extension and North Point Dr., and replace them with appropriately sized culverts to curtail wetland drainage and restore natural water levels and flow patterns on the Schmeeckle Reserve. Justification. This study has shown that the wetland drainage associated with these wetland draining structures was detrimental to the diversity and abundance of wildlife on Schmeeckle Reserve. In time this drainage will allow accelerated succession on the wetland areas and further reduce wildlife populations through habitat loss.

The storm sewer dams installed in 1978 should be maintained until the permanent structural corrections are completed. The dams are effective in raising water levels within most of Schmeeckle Reserve's wetlands, but water levels are not maintained at pre-1975 levels, nor do the dams allow water to flow in a natural pattern. Further, these dams are frequently removed by vandals and are difficult to maintain. Proper operation of these dams would require a constant and careful surveillance of water levels and coverage, and frequent elevation changes to more closely simulate natural wetland conditions. No water level control is possible with the current structures.

The Michigan Ave. EIA (Strand and Associates, Inc. 1974) specified that culverts be placed beneath the roadbed to mitigate wetland damage associated with the extension construction, and to permit natural water flow within the area. Legal action concerning this non-compliance may be necessary.

Responsibility. UWSP, City of Stevens Point, State of Wisconsin.

4. Recommendation. Remove the curbs of Michigan Ave. and North Point

Dr. within and adjacent to Schmeeckle Reserve, and replace with a curb of shallower, more sloped design.

Justification. The curb in place is too steep to allow cross movement by most of Schmeeckle Reserve's amphibian species. This barrier to movement may eventually result in the extirpation of some species throughout portions of the Schmeeckle Reserve. A shallower curb design is available and would serve the intended purpose of the curb structure while allowing freedom of amphibian movement. Without curb entrapment, the massive mortality observed in 1978 would not have occurred. The length of time amphibians would be trapped on the roadway would be reduced, lessening the frequency of vehicle-killed amphibians, and the curb would no longer function as a drift fence which causes amphibians to fall into the roadway's drop-flow sewers.

Responsibility. UWSP, City of Stevens Point.

5. Recommendation. Preserve natural plant communities by minimizing development of Schmeeckle Reserve.

Justification. Further recreational developments, excluding the completion of boardwalks on developed trails, will encroach upon already-shrinking habitats within the reserve and encourage increased unregulated human use which further damages plant communities. The further construction of recreational facilities within Schmeeckle Reserve is unnecessary, as a large portion of the UWSP campus has been devoted to recreation. Schmeeckle Reserve is the only area on campus suited for outdoor educational use by the CNR and the Biology Department. The proposed exercise trails and other facilities would further damage the only campus natural area.

Responsibility. Manager, Schmeeckle Reserve Management Committee.

6. Recommendation. Extend the Schmeeckle Reserve boundaries to include the portion of the study area that extends to North Point Dr., east of the private residences (Fig. 2), the area north of the parking lot at Reserve St. and Maria Dr., and the southern 4 ha of privately-owned land on North Point Dr., as proposed already.

Justification. The area east of Michigan Ave. on North Point Dr. contains the best representative savanna community on the area, containing open grassland and oak as a result of previous fires. This area is relatively remote and undisturbed by human activities. This savanna area and the private land are especially critical to the maintenance of Schmeeckle Reserve's deer herd, as they comprise most of the important fawning habitat during the spring, and valuable feeding and bedding habitat throughout the year. Because these areas are relatively unvisited by humans, they serve as important escape cover when deer are harassed. These areas also serve as the major corridor between Schmeeckle Reserve and the more extensive habitat north of North Point Dr.

The other area recommended for inclusion, west of Reserve St., is primarily wetlands, including the only sedge meadow in the area. The area also contains a small but semi-permanent pond which provides habitat for a variety of aquatic vertebrates and invertebrates. This wetland area provides the only dependable summer and fall water sources for birds and mammals west of the north campus lake.

Responsibility. UWSP, State of Wisconsin.

7. Recommendation. Allow and encourage the Reserve St. roadbed to revegetate, and restrict trail development to narrow widths on the route that has been disturbed already.

Justification. Roadways, utility corridors, and other unnatural open strips provide a barrier to the movements of small forest mammals and subject animals in these corridors to predation. The present gravel surface of the roadway provides no cover for protection of animals attempting to cross the road. This surface may have to be broken to allow revegetation. Any trail development along this route should be confined to the area already disturbed to prevent encroachment on undisturbed habitats adjacent to the roadway. Narrow trails through the new vegetation will encourage free movement of small mammals and serve to restrict human movement into undisturbed areas. Under no circumstances should the route be mowed.

Responsibility. Manager, Schmeeckle Reserve Management Committee.

8. Recommendation. Discourage incompatible developments adjacent to Schmeeckle Reserve.

Justification. The integrity of the Schmeeckle Reserve's plant and animal communities is dependent upon surrounding habitats, in part, for diversity. Golf course development north of North Point Dr. would destroy an annually-used nest site of the red-shouldered hawk, until recently considered threatened in Wisconsin, but a regular visitor to the study area. Extensive development may result in the loss of the Schmeeckle Reserve deer herd also, if all available escape cover is eliminated.

Development east of the lake will destroy the grassland habitat of the area, and cause the loss of bird species such as nesting mallards, teal, harrier, kestrel, meadowlarks, and several sparrows and other species.

Surrounding development should be influenced by planning input from university sources. Without this university contribution, surrounding development will reduce the effective size of the reserve, creating an insular type of situation. Such islands, by biogeographic principles, lose species diversity as they lose inhabitable area (MacArthur and Wilson, 1967). Animals that require large home ranges or that are sensitive to human disturbance will be displaced, and species that can tolerate the new urbanized environment will become more numerous (Engel and Payne 1979).

Responsibility. Manager, Schmeeckle Reserve Management Committee, UWSP, UWSP Foundation, Inc., City of Stevens Point, Town of Hull, Portage County.

9. Recommendation. To resolve conflicts, establish use priority on the Schmeeckle Reserve as follows: 1) UWSP natural science classes, 2) natural science research through the UWSP by students and faculty, 3) outdoor education programs of UWSP, 4) environmental education programs other than regular UWSP classes, 5) UWSP organized physical education classes, and 6) informal recreational use by students and the public.

Justification. CNR/Biology classes and research are given priority because Schmeeckle Reserve represents a valuable and easily accessible outdoor laboratory for the activities not available elsewhere within walking distance of the campus. Additionally, such use of the area can be controlled to prevent damage to the natural environment when conducted by faculty personnel, and it contributes data useful in the management of Schmeeckle Reserve.

Environmental education class-type pursuits other than regular courses are similarly suited to Schmeeckle Reserve, but they do not contribute to the understanding of the area through systematic collection of biological data.

Organized physical education pursuits, with the possible exception of boating classes, can be conducted elsewhere on the UWSP campus. These activities will not damage the environment of the reserve nor disrupt more important activities if they are properly planned. These activities contribute nothing to the knowledge of the reserve.

Informal recreational use should be permitted and encouraged when and where such use will not interfere with previously mentioned activities. These types of activities are recognized as important to the overall educational experience provided by the university. It is stressed that Schmeeckle Reserve is an outdoor laboratory, not a park. Responsibility. Manager, Schmeeckle Reserve Management Committee.

10. Recommendation. Restrict consumptive uses (removal) of Schmeeckle Reserve's natural resources. Resources not threatened by removal may be collected for educational purposes.

Justification. This recommendation would prohibit non-educational removal of resources from Schmeeckle Reserve including, but not limited to firewood, birch trees, wildflowers, wildlife, soils, and geologic materials. Such removal has been extreme in the past due to lack of regulations and enforcement, and has adversely affected Schmeeckle Reserve's plant and animal life. Birch trees have been cut and stripped to such an extent that they have been virtually eliminated from many parts of the reserve. Dead wood has been removed in great quantities by

groups with chainsaws. This dead vegetation provides a source of food and cover for a variety of vertebrate and invertebrate species, as well as nutrients for plant life. Poaching continues on Schmeeckle Reserve on a limited basis, regardless of existing regulations, due to a lack of enforcement. Amphibians often are removed from the area by students for possession as pets, and willow twigs and wildflowers often are collected by individuals.

This recommendation would not prevent plant collections, small mammal trapping, or other removal for educational purposes in conjunction with bonafide UWSP classes or research projects.
Responsibility. Manager, Schmeeckle Reserve Management Committee.

11. Recommendation. Restrict informal recreational use to hours, places, and activities that will protect the environment of Schmeeckle Reserve.
Justification. Informal recreational use has been responsible for the most damage to Schmeeckle Reserve with the exception of physical changes by construction. Restrictions should limit activities to trails and other designated areas to prevent compaction of soils throughout the area and damage to plant communities by trampling. Fires, except when prescribed by the manager and Schmeeckle Reserve Management Committee, should be prevented. Fires have been numerous in the history of the area and are a potential threat during many of the warm months, especially when wetlands are allowed to drain. While natural fires may occur, unplanned wildfires as a result of carelessness are undesirable. Pets should not be allowed on the area. Cats use the area and compete with natural predators on the area. Dogs kill small mammals and birds as well, and harass deer. These domestic animals should be considered a nuisance and be removed from Schmeeckle Reserve whenever observed.

Responsibility. Manager, Schmeeckle Reserve Management Committee.

12. Recommendation. Incorporate use regulations adopted for Schmeeckle Reserve into the City of Stevens Point local ordinances to allow enforcement, prosecution, and provide deterrent penalties.
Justification. Regulations to control human use of Schmeeckle Reserve will not be effective unless there is an adequate mechanism for enforcement of the regulations. Schmeeckle Reserve regulations should be adopted as city ordinances. UWSP regulations apply only to students and not to the general community. Also, ordinance status would allow enforcement by city police and provide for penalties. Strict enforcement of these rules will preserve the area and establish a more desirable pattern of use by recreationists. Other universities have successfully established nondamaging patterns of use within natural areas and arboretums by initial strict enforcement and vigorous prosecution.
Responsibility. UWSP, City of Stevens Point.

13. Recommendation. Eliminate the flow of polluted runoff water from commercially-developed areas west of Schmeeckle Reserve.
Justification. These pollutants are drawn through Schmeeckle Reserve's wetlands and drained by the Michigan Ave. storm sewer system. Accumulated sediments and pollutants in the wetlands eventually will impact natural vegetation and wildlife diversity by eliminating susceptible species.
Responsibility. UWSP

Research

General

The following research recommendations were formulated to enhance the value of Schmeeckle Reserve as an educational tool and provide

biological data on which to base sound management decisions for the preservation of wildlife and other natural features of the reserve.

1. Recommendation. Establish a permanent grid system on Schmeeckle Reserve by installing permanent plot markers throughout the area.
Justification. Many biological studies through various UWSP classes and student groups have been conducted on Schmeeckle Reserve. Because these studies used various versions of base maps of varying scale and accuracy, the use of data collected and the replication of studies are difficult. There needs to be a standard method of study area definition if diverse biological investigations are to be coordinated and used.

The proposed grid system will allow accurate study area location and delineation by all students and faculty. Precise study area designations will enable successive studies by classes and allow data comparisons with previous studies.
Responsibility. Manager, Schmeeckle Reserve Management Committee.

2. Recommendation. Encourage and coordinate educational activities and research projects on Schmeeckle Reserve.
Justification. The many studies conducted on the reserve have provided a large and diverse data base. Data from these studies are not as useful as they could be for making management decisions because of the inconsistencies in their methods of collection. Specific data collection methods should be established for each discipline (e.g. vegetation sampling, small mammal censuses, bird censuses, etc.) for use on the reserve. By directing the effort of students toward investigating relevant questions, their efforts can provide information useful in the management of Schmeeckle Reserve, as well as provide field work training.

Although many classes and student groups (e.g. student chapter of The Wildlife Society, student chapter of Society of American Foresters) use Schmeeckle Reserve for at least some projects and assignments, the area could support a much greater educational use with increased benefits to the students and the reserve. Class and research projects should be conducted on Schmeeckle Reserve whenever the resources allow, rather than on off-campus locations, particularly in light of travel restrictions due to high fuel costs. In the past, unrestricted human use of Schmeeckle Reserve has discouraged its educational use.

Responsibility. Manager, UWSP faculty.

3. Recommendation. Compile and computerize the storage of all biological data gathered on Schmeeckle Reserve through classwork, group, and individual research projects.

Justification. Systematic collection of biological data gathered on the reserve using the grid system will enable computer storage of this data over long time periods. This data will be readily available for educational uses by students and faculty in a usable form. Collection and storage of this data over time will permit long-term studies of vegetational succession and population trends. Such studies are rarely pursued due to the long number of years required for data collection. If faculty will coordinate the student research performed each year with this comprehensive storage system, long-term studies will be possible.

Such a biological storage/retrieval system would expand the usual university-conducted studies of 2-3 years to a much longer time span.

Responsibility. Manager, Schmeeckle Reserve Management Committee, UWSP faculty, UWSP.

Specific

1. Map and monitor plant communities and compile a complete plant species list for Schmeeckle Reserve.
2. Continue annual wildlife population censuses on Schmeeckle Reserve as directed by the manager.
3. Conduct water quality analyses within Schmeeckle Reserve.
4. Determine the locations of winter denning sites for Glaucomys spp. on Schmeeckle Reserve.
5. Continue to monitor the mortality of amphibians on Michigan Ave. within Schmeeckle Reserve.
6. Monitor fish populations in the lake.
7. Monitor the growth and succession of the lake.
8. Locate, number, and map the locations of nest boxes placed on the reserve in 1977-1978 and monitor their use.
9. Monitor habitat changes on Schmeeckle Reserve.

LITERATURE CITED

Alexander, M.M. 1943. Food habits of the snapping turtle in Connecticut. J. Wildl. Manage. 7:278-282.

Barger, N.R., R.H. Lound, and S.D. Robbins, Jr. 1975. Wisconsin birds: a checklist with migration graphs. Wisconsin Soc. for Ornith., Inc., Loganville. 32 pp.

Behler, J.L., and F.W. King. 1979. The Audubon Society field guide to North American reptiles and amphibians. Alfred A. Knopf, New York. 719 pp.

Beimborn, D. 1969. Bird species and the tension zone. Passen. Pigeon 31:49-51.

Blem, L.B., and C.R. Blem. 1975. The effect of flooding and the length of residency in the white-footed mouse, Peromyscus leucopus. Amer. Midl. Nat. 94:232-236.

Bowker, L.S., and P.G. Pearson. 1975. Habitat ordination and interspecific interaction of Microtus pennsylvanicus and Peromyscus leucopus. Amer. Midl. Nat. 94:491-496.

Brenner, F.J. 1966. The influence of drought on reproduction in a breeding population of red-winged blackbirds. Amer. Midl. Nat. 76:201-210.

Brooks, W.S. 1960. Songbird communities of two marsh habitats. Passen. Pigeon 22:111-125.

Bull, J., and J. Farrand, Jr. 1977. The Audubon Society field guide to North American birds (eastern region). Alfred A. Knopf, New York. 775 pp.

Burt, W.H. 1957. Mammals of the Great Lakes Region. Univ. Michigan Press, Ann Arbor. 246 pp.

Cagle, F.R. 1939. A system of marking turtles for future identification. Copeia 1939:170-173.

Chandler, S.R., B. Bruun, and H.S. Zim. 1966. Birds of North America. Golden Press, New York. 340 pp.

Collins, J.T., J.E. Juheey, J.L. Knight, and H.M. Smith. 1978. Standard common and current scientific names for the North American amphibians and reptiles. Misc. Pub., Herpet. Circ. 7. Society for the Study of Amphibians and Reptiles. Lawrence, Kansas. 36 pp.

Conant, R. 1975. A field guide to reptiles and amphibians of eastern North America. Houghton Mifflin Co., Boston. 429 pp.

Curtis, J.T. 1959. The vegetation of Wisconsin. Univ. Wisconsin Press, Madison. 608 pp.

_____, and R.P. McIntosh. 1951. An upland forest continuum in the prairie-forest border of Wisconsin. Ecology 32:476-496.

Davis, D.E. 1942. A new census method applied to Cuban birds. Ecology 23:370-376.

Dumas, P.C. 1950. Habitat distribution of breeding birds in southwestern Washington. Condor 52:232-237.

Edwards, W.R., and L.L. Eberhardt. 1967. Estimating cottontail abundance from live-trapping data. J. Wildl. Manage. 31:87-96.

Engel, T.C., and N.F. Payne. 1979. Wildlife in the small city. Trans. Annual Conf. on Small City and Regional Communities 2:269-273.

Finley, R.W. 1965. Geography of Wisconsin. College Printing and Typing Co., Inc., Madison. 321 pp.

Froese, A.D. 1978. Habitat preferences of the common snapping turtle, Chelydra s. serpentina. J. Herpet. 12:53-58.

Getz, L.L. 1960. A population study of the vole, Microtus pennsylvanicus. Amer. Midl. Nat. 64:392-405.

_____. 1961. Factors influencing the local distribution of shrews. Amer. Midl. Nat. 65:67-88.

Greene, C.W. 1935. The distribution of Wisconsin fishes. Wisconsin Conserv. Comm., Madison. 235 pp.

Gregory, P.T. 1977. Life history observations on three species of snakes in Manitoba. Can. Field-Nat. 91:19-27.

Griggs, R.F. 1914. Observations on the behavior of some species on the edges of their range. Bull. Torrey Bot. Club. 41:25-49.

Gromme, O.J. 1963. Birds of Wisconsin. Univ. Wisconsin Press, Madison. 223 pp.

Gunderson, H.F. 1959. Red-backed vole habitat studies in central Minnesota. J. Mammal. 40:405-412.

Hale, J.B., and L.E. Gregg. 1976. Woodcock use of clearcut aspen areas in Wisconsin. Wildl. Soc. Bull. 4:111-115.

Hirth, H.F. 1959. Small mammals in old field succession. Ecology 40:417-425.

Holmes, R.T., and F.W. Sturges. 1975. Bird community dynamics and energetics in a northern hardwoods ecosystem. J. Anim. Ecol. 44:175-200.

Iverson, S.L., R.W. Seabloom, and J.M. Hnatiuk. 1967. Small mammal distributions across the prairies-forest transition of Minnesota and North Dakota. Amer. Midl. Nat. 78:188-197.

Jaeger, M.J. 1978. Breeding bird distributions and vegetation structure at the Columbia Generating Station. Proc. Joint Conf. on Sensing and Environ. Pollutants 4:181-183.

Jackson, H.H.T. 1961. Mammals of Wisconsin. Univ. Wisconsin Press, Madison. 504 pp.

Jones, J.K., Jr., D.C. Carter, and H.H. Genoways. 1975. Revised checklist of North American mammals north of Mexico. Occas. Pap. 28(7), Museum, Texas Tech. Univ. Lubbock. 14 pp.

Kemp, G.A., and L.B. Keith. 1970. Dynamics and regulation of red squirrel (Tamiasciurus hudsonicus) populations. Ecology 51:763-779.

Kendeigh, S.C. 1944. Measurement of bird populations. Ecolog. Monogr. 14:67-106.

Layne, J.N. 1954. The biology of the red squirrel, Tamiasciurus hudsonicus loquax (Bangs), in central New York. Ecolog. Monogr. 24:227-267.

Lord, R.D., Jr. 1963. The cottontail rabbit in Illinois. Illinois Dept. Cons. Tech. Bull. No. 3. Southern Illinois Univ. Press, Carbondale. 94 pp.

MacArthur, R.H., and E.O. Wilson. 1967. The theory of island biogeography. Princeton Univ. Press.203 pp.

MacArthur, R.H., and J.W. MacArthur. 1961. On bird species diversity. Ecology 42:594-598.

MacLeod, C.F., and J.L. Lethiecq. 1963. A comparison of two trapping procedures for Sorex cinereus. J. Mammal. 44:277-278.

Martin, L. 1965. The physical geography of Wisconsin. Univ. Wisconsin Press, Madison. 657 pp.

MCloskey, R.T., and D.T. LaJoie. 1975. Determinants of local distribution and abundance in white-footed mice. Ecology 56:467-472.

Mosby, H.S. 1955. Live trapping objectionable animals. Virginia Polytechnic Inst. Agr. Ext. Serv. Circ. 667, Blacksburg, 4 pp.

_____ 1969. The influence of hunting on the population dynamics of a woodlot gray squirrel population. J. Wildl. Manage. 33:59-73.

Moss, D. 1978. Diversity of woodland song-bird populations. J. Anim. Ecol. 47:521-527.

Odum, E.P. 1950. Bird populations of the Highland (North Carolina) Plateau in relation to plant succession and avian invasion. Ecology 3:587-606.

Overton, W.S. 1965. A modification of the Schnabel estimator to account for removal of animals from the population. J. Wildl. Manage. 29:392-395.

_____. 1971. Estimating the numbers of animals in wild populations. Pp. 403-455 IN R.H. Giles, Jr. (ed). Wildlife management techniques. Wildl. Soc., Washington.

Pell, S.M. 1940. Notes on the food habits of the common snapping turtle. Copeia 1940:131.

Quimby, D.C. 1951. The life history and ecology of the jumping mouse Zapus hudsonius. Ecolog. Monogr. 21:61-95.

Robbins, C.S. 1970. Recommendations for an international standard for a mapping method in bird census work. Audubon Field Notes 24:723-726.

Rose, G.B. 1977. Mortality rates of tagged adult cottontail rabbits. J. Wildl. Manage. 41:511-514.

Rusch, D.A., and W.G. Reeder. 1978. Population ecology of Alberta red squirrels. Ecology 59:400-420.

Schnabel, Z.E. 1938. Estimation of the total fish population in a lake. Amer. Math. Monthly. 45:348-352.

Smith, N.B., and F.S. Barkalow, Jr. 1967. Precocious breeding in the gray squirrel. J. Mammal. 48:328-330.

Strand, J.A., and Associates, Inc. 1974. Michigan Avenue Extension, Stevens Point, Wisconsin. Madison. 126 pp.

Taber, R.D., and I.M. Cowan. 1971. Capturing and marking wild animals. Pp. 227-317 IN R.H. Giles, Jr. (ed). Wildlife management techniques. Wildl. Soc., Washington.

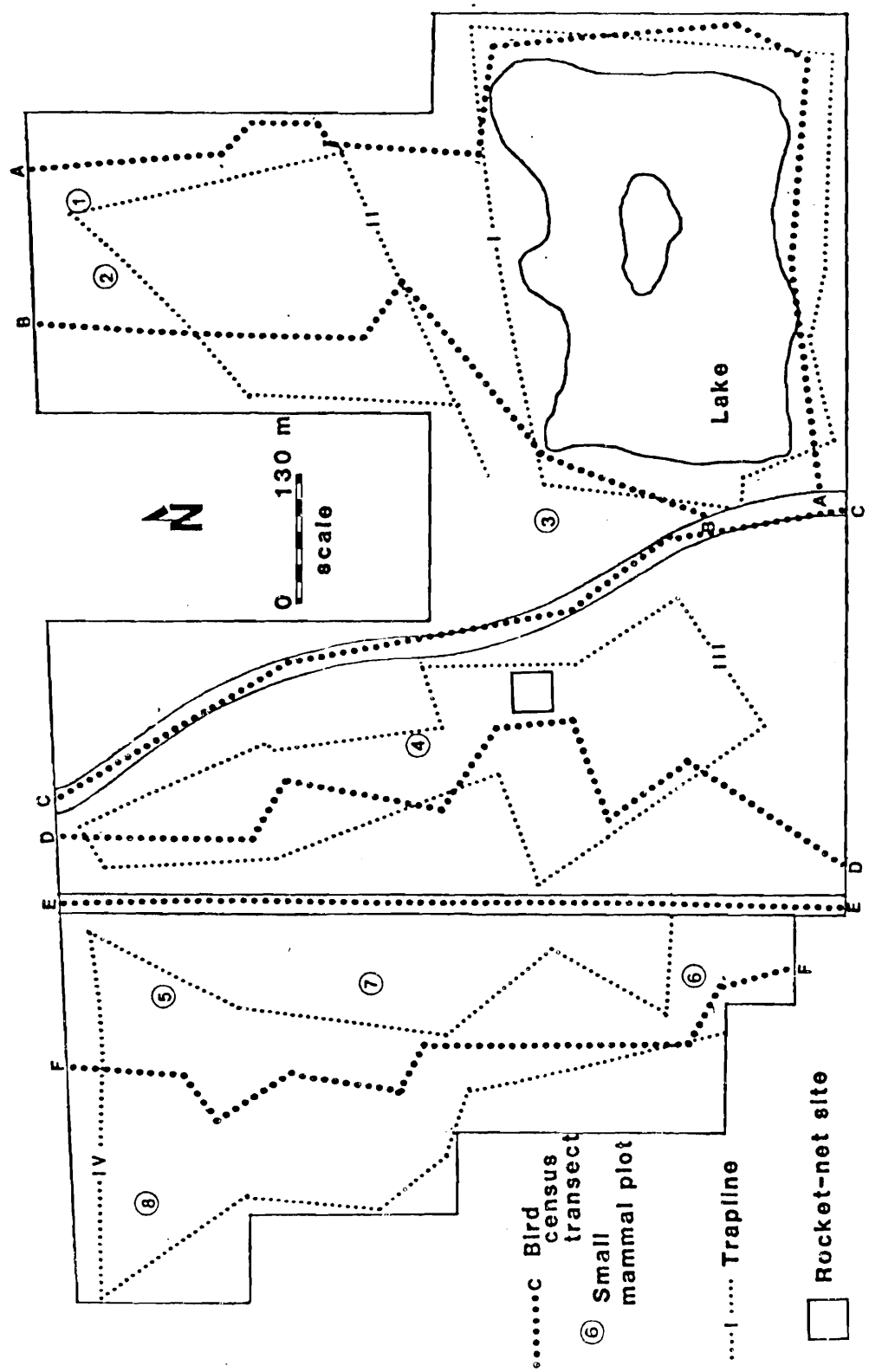
Warbach, O. 1958. Bird populations in relation to changes in land use. J. Wildl. Manage. 22:23-28.

Warzyn Engineering Service Co., Inc. 1974. Lake construction Maria Drive at Michigan Avenue, Stevens Point, Wisconsin. Madison. 41 pp.

Wetzel, R.M. 1958. Mammalian succession on midwestern floodplains. Ecology. 39:262-271.

Willson, M.F. 1974. Avian community organization and habitat structure. Ecology. 55:1017-1029.

APPENDICES



Appendix A. Location of bird census transects, traplines, small mammal plots, and deer bait/rocket-net site used to census vertebrates on Schmeeckle Reserve, Mar 1977-Mar 1978.

Appendix B. Census points on all bird census transects (A-F) grouped by habitat and various developments in 1978.

1978 Development	Habitat					
	Wetland	Mixed woods	Pine	Hardwoods	Meadows	Savanna
Trails	A/1-4,6-9	A/5,11 D/1,2	A/10,12 B/11 D/3,6,7,9	None	D/4,5	None
Flooding	B/12,13 D/11,12	None	F/8-10	None	None	None
Michigan Avenue and Flooding	C/1-4	None	None	None	None	None
Reserve St. Closure	E/1,2	E/3,5-7	E/4,8	None	None	None
Michigan Avenue	None	C/5-7	C/8	None	None	None
No Development	B/8 F/11	B/9,10 F/3-5	F/1,6,7	A/13 B/1,2,7,8 D/10	F/2	A/14-17 B/3-6

Appendix C. Number of census points used to compute IA for each breeding bird species in habitats affected by various developments.

Development	Habitat	No. Census Points
Trail construction	Wetland	8
	Mixed woods	4
	Pine	7
	Meadow	2
Flooding	Wetland	4
	Pine	2
Traffic, flooding	Wetland	4
Traffic removal	Wetland	2
	Mixed woods	4
	Pine	2
Addition of traffic	Mixed woods	3
	Pine	1
No change	Wetland	2
	Mixed woods	5
	Pine	3
	Hardwoods	6
	Meadow	1
	Savanna	8

Appendix D. Dates small mammals were trapped in each plot (Appendix A), number of traps deployed, and number of trap-nights compiled during each census period, 1977 and 1978.

	Small Mammal Plot Number							
	1		2		3		4	
	1977	1978	1977	1978	1977	1978	1977	1978
Census dates	10/2-4	10/11-13	10/6-8	10/14-16	9/28-30	10/18-20	10/11-13	10/22-24
No. pitfall traps	12	15	12	15	13	15	12	15
No. snap traps	56	70	50	70	64	70	42	52
No. pitfall trap-nights	36	45	36	45	39	45	36	45
No. snap-trap trap-nights	112	209	150	195	191	210	138	156

Appendix D. Continued.

	Small Mammal Plot Number							
	5[a]		6		7		8	
	1977	1978	1977	1978	1977	1978	1977	1978
Census dates	10/9-11		10/4-6	10/28-30	9/30-10/2	10/31-11/2	10/12-14	11/3-5
No. pitfall traps	13		13	15	13	15	9	15
No. snap-traps	46		47	46	53	60	58	60
No. pitfall trap-nights	36		39	45	39	45	27	45
No. snap-trap trap-nights	144		139	138	157	180	173	180

[a]Plot 5 was not trapped in 1978 because workmen regularly were working in the meadow with heavy equipment, and an unknown student was trapping the area.

Appendix E. Wooden box trap trap-nights compiled in each habitat along traplines I-IV (Appendix A), 1977 and 1978.

	Trap line							
	I[a]		II		III		IV	
Habitat	1977	1978	1977	1978	1977	1978	1977	1978
Mixed woods	0	0	0	0	168	116	180	243
Hardwood	0	0	155	126	56	36	24	52
Pine	200	0	0	0	140	102	156	208
Wetland	500	0	150	120	294	216	18	39
Meadow	0	0	0	0	42	30	12	26
Savanna	0	0	295	239	0	0	18	39
Total	700	0	600	485	700	500	408	607

[a]Plot I was not trapped in 1978.

Appendix F. Comparison of bird abundance between 1977 and 1978 in habitats unchanged by development between the 2 breeding bird censuses.

	Wetland habitat	
	Index of abundance	
Species	1977	1978
Cooper's hawk	0.000	0.063
Mourning dove	0.000	0.177
Common flicker	0.063	0.000
Yellow-bellied sapsucker	0.063	0.000
Great-crested flycatcher	0.000	0.250
Tree swallow	0.125	0.000
Blue jay	0.063	0.395
American crow	0.000	0.125
Black-capped chickadee	0.375	0.000
Northern house wren	0.000	0.125
Gray catbird	0.063	0.188
American robin	0.217	0.000
Cedar waxwing	0.000	0.063
European starling	0.000	0.063
Yellow warbler	0.063	0.000
Ovenbird	0.063	0.063
Common yellowtnroat	0.250	0.250
House sparrow	0.000	0.125
Red-winged blackbird	0.177	0.313
Northern oriole	0.063	0.000
Common grackle	0.089	0.125

Appendix F. Continued.

Wetland habitat (continued)

Species	Index of abundance 1977	1978
Brown-headed cowbird	0.089	0.395
Rose-breasted grosbeak	0.188	0.000
American goldfinch	0.063	0.063
Song sparrow	0.405	0.433

Appendix F. Continued.

Mixed woods habitat		
	Index of abundance	
Species	1977	1978
Common flicker	0.075	0.025
Pileated woodpecker	0.050	0.000
Hairy woodpecker	0.050	0.025
Downy woodpecker	0.050	0.025
Eastern phoebe	0.100	0.000
Least flycatcher	0.125	0.000
Eastern pewee	0.100	0.200
Blue jay	0.260	0.075
American crow	0.184	0.075
Black-capped chickadee	0.000	0.100
White-breasted nuthatch	0.000	0.025
American robin	0.229	0.270
Red-eyed vireos	0.071	0.000
Warbling vireo	0.050	0.000
Black-and-white warbler	0.050	0.000
Yellow warbler	0.000	0.025
Ovenbird	0.000	0.225
Red-winged blackbird	0.000	0.050
Brown-headed cowbird	0.132	0.125
Northern cardinal	0.000	0.125
Rose-breasted grosbeak	0.050	0.000
Indigo bunting	0.050	0.255
American goldfinch	0.075	0.050
Rufous-sided towhee	0.000	0.025
Chipping sparrow	0.000	0.050
Song sparrow	0.050	0.025

Appendix F. Continued.

Species	Pine habitat Index of abundance 1977	1978
Common flicker	0.042	0.000
Downy woodpecker	0.125	0.042
Eastern kingbird	0.125	0.083
Great-crested flycatcher	0.000	0.125
Eastern pewee	0.250	0.208
Tree swallow	0.083	0.102
Blue jay	0.349	0.292
American crow	0.118	0.331
Black-capped chickadee	0.102	0.339
White-breasted nuthatch	0.000	0.083
Red-breasted nuthatch	0.000	0.042
American robin	0.083	0.553
Veery	0.083	0.042
Solitary vireo	0.083	0.000
Ovenbird	0.000	0.125
Common yellowthroat	0.083	0.000
Common grackle	0.000	0.083
Brown-headed cowbird	0.204	0.000
Northern cardinal	0.167	0.000
Rose-breasted grosbeak	0.083	0.000
Indigo bunting	0.083	0.083
Grasshopper sparrow	0.042	0.000
Lark sparrow	0.125	0.000
Field sparrow	0.000	0.042
White-throated sparrow	0.000	0.042

Appendix F. Continued.

Species	Hardwoods habitat Index of abundance 1977	1978
Northern goshawk	0.042	0.000
Broad-winged hawk	0.000	0.042
Ruffed grouse	0.186	0.021
Killdeer	0.000	0.042
Common flicker	0.000	0.042
Hairy woodpecker	0.000	0.042
Downy woodpecker	0.042	0.042
Great-crested flycatcher	0.000	0.083
Eastern pewee	0.000	0.021
Purple martin	0.042	0.063
Blue jay	0.167	0.125
American crow	0.063	0.260
Black-capped chickadee	0.063	0.000
Tufted titmouse	0.021	0.000
Northern house wren	0.000	0.021
Gray catbird	0.063	0.063
Brown thrasher	0.000	0.051
American robin	0.167	0.146
Wood thrush	0.042	0.000
Veery	0.165	0.125
Black-and-white warbler	0.000	0.021
Yellow warbler	0.042	0.021
Ovenbird	0.188	0.312
Common yellowthroat	0.000	0.083

Appendix F. Continued.

Hardwoods habitat (continued)

Species	Index of abundance 1977	1978
Red-winged blackbird	0.088	0.042
Common grackle	0.000	0.042
Brown-headed cowbird	0.104	0.169
Rose-breasted grosbeak	0.167	0.063
Indigo bunting	0.000	0.021
American goldfinch	0.081	0.063
Rufous-sided towhee	0.021	0.042
Field sparrow	0.188	0.021
Song sparrow	0.177	0.125

Appendix F. Continued.

Savanna habitat		
	Index of abundance	
Species	1977	1978
Northern goshawk	0.047	0.000
Sharp-shinned hawk	0.016	0.000
Red-tailed hawk	0.016	0.000
Broad-winged hawk	0.000	0.031
Ruffed grouse	0.094	0.016
Barred owl	0.000	0.016
Common flicker	0.031	0.000
Yellow-bellied sapsucker	0.061	0.000
Hairy woodpecker	0.000	0.016
Downy woodpecker	0.047	0.016
Eastern kingbird	0.000	0.016
Great-crested flycatcher	0.000	0.063
Eastern pewee	0.000	0.078
Purple martin	0.000	0.022
Blue jay	0.094	0.117
American crow	0.148	0.125
Black-capped chickadee	0.264	0.241
Tufted titmouse	0.031	0.000
Gray catbird	0.047	0.000
Brown thrasher	0.000	0.016
American robin	0.125	0.172
Veery	0.078	0.031
Cedar waxwing	0.000	0.016
Yellow warbler	0.000	0.047

Appendix F. Continued.

Savanna habitat (continued)		
	Index of abundance	
Species	1977	1978
Ovenbird	0.125	0.296
Common yellowthroat	0.000	0.063
Northern cardinal	0.000	0.016
Rose-breasted grosbeak	0.031	0.000
Indigo bunting	0.063	0.133
American goldfinch	0.203	0.109
Rufous-sided towhee	0.000	0.094
Grasshopper sparrow	0.016	0.016
Field sparrow	0.203	0.234
Song sparrow	0.109	0.094

Appendix F. Continued.

Species	Meadow habitat Index of abundance 1977	1978
Blue jay	0.000	0.125
American crow	0.217	0.500
Black-capped chickadee	0.177	0.125
White-breasted nuthatch	0.000	0.484
Gray catbird	0.250	0.250
American robin	0.250	0.375
Common yellowthroat	0.000	0.125
Northern oriole	0.354	0.000
Common grackle	0.306	0.000
Brown-headed cowbird	0.484	0.217
Northern cardinal	0.000	0.250
Indigo bunting	0.306	0.395
American goldfinch	0.250	0.000
Grasshopper sparrow	0.125	0.000
Song sparrow	0.000	0.125

Appendix G. Comparison of 1977 and 1978 bird abundance in habitats altered by trail construction between the 2 censuses.

	Pine habitat	
	Index of abundance	
Species	1977	1978
Wood duck	0.071	0.000
Northern goshawk	0.018	0.000
Broad-winged hawk	0.000	0.018
Killdeer	0.116	0.051
Spotted sandpiper	0.069	0.105
Barred owl	0.018	0.000
Chimney swift	0.036	0.000
Common flicker	0.116	0.125
Downy woodpecker	0.071	0.018
Great-crested flycatcher	0.000	0.125
Eastern phoebe	0.054	0.054
Tree swallow	0.036	0.071
Purple martin	0.180	0.018
Blue jay	0.160	0.277
American crow	0.079	0.394
Black-capped chickadee	0.082	0.179
White-breasted nuthatch	0.000	0.036
Northern house wren	0.000	0.018
Gray catbird	0.000	0.054
American robin	0.295	0.363
Wood thrush	0.036	0.000
Veery	0.107	0.089
Warbling vireo	0.018	0.018

Appendix G. Continued.

Pine habitat (continued)

Species	Index of abundance 1977	1978
Yellow warbler	0.062	0.054
Common yellowthroat	0.000	0.018
Ovenbird	0.200	0.125
Red-winged blackbird	0.054	0.018
Northern oriole	0.000	0.107
Common grackle	0.054	0.071
Brown-headed cowbird	0.054	0.142
Northern cardinal	0.036	0.071
Rose-breasted grosbeak	0.054	0.071
Indigo bunting	0.000	0.018
American goldfinch	0.089	0.018
Rufous-sided towhee	0.071	0.089
Chipping sparrow	0.036	0.036
White-throated sparrow	0.000	0.018
Song sparrow	0.160	0.241

Appendix G. Continued.

Mixed woods habitat		
	Index of abundance	
Species	1977	1978
Mallard	0.000	0.031
Broad-winged hawk	0.000	0.031
Killdeer	0.388	0.203
Spotted sandpiper	0.031	0.286
Mourning dove	0.063	0.156
Chimney swift	0.031	0.154
Belted kingfisher	0.000	0.031
Yellow-bellied sapsucker	0.063	0.000
Hairy woodpecker	0.063	0.000
Downy woodpecker	0.000	0.031
Eastern kingbird	0.156	0.000
Great-crested flycatcher	0.000	0.094
Tree swallow	0.094	0.125
Bank swallow	0.000	0.031
Purple martin	0.089	0.177
Blue jay	0.370	0.156
American crow	0.108	0.496
Black-capped chickadee	0.000	0.296
White-breasted nuthatch	0.000	0.031
Northern house wren	0.000	0.125
Gray catbird	0.000	0.125
Brown thrasher	0.094	0.000
American robin	0.203	0.265
Veery	0.108	0.094

Appendix G. Continued.

Mixed woods habitat (continued)

Species	Index of abundance 1977	1978
European starling	0.000	0.063
Warbling vireo	0.031	0.000
Yellow warbler	0.000	0.031
Ovenbird	0.171	0.063
Common yellowthroat	0.000	0.031
House sparrow	0.031	0.077
Western meadowlark	0.031	0.031
Northern oriole	0.000	0.171
Common grackle	0.125	0.707
Brown-headed cowbird	0.031	0.000
Rose-breasted grosbeak	0.000	0.063
Indigo bunting	0.063	0.000
Rufous-sided towhee	0.063	0.031
Song sparrow	0.234	0.171

Appendix G. Continued.

Species	Wetland habitat Index of abundance 1977	1978
Great blue heron	0.000	0.031
Green heron	0.000	0.078
American bittern	0.000	0.016
Mallard	0.000	0.016
Northern goshawk	0.016	0.000
Broad-winged hawk	0.000	0.016
Killdeer	0.670	0.410
Spotted sandpiper	0.164	0.187
American woodcock	0.078	0.063
Common snipe	0.016	0.063
Mourning dove	0.070	0.099
Common nighthawk	0.000	0.045
Chimney swift	0.022	0.198
Belted kingfisher	0.000	0.016
Common flicker	0.031	0.047
Hairy woodpecker	0.000	0.031
Eastern kingbird	0.016	0.000
Great-crested flycatcher	0.000	0.063
Tree swallow	0.133	0.360
Barn swallow	0.000	0.143
Purple martin	0.171	0.178
Blue jay	0.335	0.255
American crow	0.272	0.398
Black-capped chickadee	0.063	0.031

Appendix G. Continued.

Wetland habitat (continued)		
	Index of abundance	
Species	1977	1978
Northern house wren	0.086	0.125
Gray catbird	0.484	0.397
Brown thrasher	0.031	0.000
American robin	0.406	0.435
Veery	0.180	0.031
Cedar waxwing	0.044	0.000
European starling	0.063	0.078
Warbling vireo	0.000	0.063
Yellow warbler	0.031	0.047
House sparrow	0.016	0.054
Western meadowlark	0.031	0.000
Red-winged blackbird	0.117	0.000
Northern oriole	0.031	0.109
Common grackle	0.109	0.337
Brown-headed cowbird	0.295	0.284
Rose-breasted grosbeak	0.180	0.374
Indigo bunting	0.000	0.078
American goldfinch	0.109	0.031
Rufous-sided towhee	0.000	0.078
Savanna sparrow	0.109	0.066
Chipping sparrow	0.101	0.086
Field sparrow	0.011	0.094
Song sparrow	0.850	0.902

Appendix G. Continued.

	Meadow habitat	
	Index of abundance	
Species	1977	1978
Hairy woodpecker	0.000	0.125
Great crested flycatcher	0.000	0.125
Tree swallow	0.063	0.125
Blue jay	0.125	0.125
American crow	0.188	0.125
Black-capped chickadee	0.000	0.280
White-breasted nuthatch	0.000	0.063
Gray catbird	0.063	0.000
American robin	0.000	0.125
Wood thrush	0.063	0.000
Warbling vireo	0.125	0.000
Ovenbird	0.250	0.063
Common yellowthroat	0.000	0.125
Common grackle	0.063	0.000
Brown-headed cowbird	0.000	0.250
Northern cardinal	0.000	0.063
Rose-breasted grosbeak	0.125	0.063
Indigo bunting	0.063	0.125
Rufous-sided towhee	0.125	0.063
Chipping sparrow	0.000	0.125
Song sparrow	0.000	0.063

Appendix H. Comparison of 1977 and 1978 bird abundance in habitats subjected to flooding in 1978.

Pine habitat		
	Index of abundance	
Species	1977	1978
Ruffed grouse	0.000	0.059
Mourning dove	0.059	0.000
Eastern pewee	0.083	0.125
Blue jay	0.144	0.264
American crow	0.042	0.312
Black-capped chickadee	0.000	0.167
White-breasted nuthatch	0.000	0.042
Northern house wren	0.000	0.083
Gray catbird	0.228	0.125
American robin	0.167	0.125
Veery	0.000	0.042
European starling	0.000	0.042
Ovenbird	0.125	0.125
Red-winged blackbird	0.270	0.144
Northern oriole	0.000	0.042
Brown-headed cowbird	0.125	0.042
Northern cardinal	0.000	0.038
Rose-breasted grosbeak	0.083	0.083
Chipping sparrow	0.000	0.042
Song sparrow	0.204	0.000

Appendix H. Continued.

Species	Wetland habitat Index of abundance 1977	1978
Green heron	0.000	0.031
American bittern	0.000	0.031
Mallard	0.000	0.031
Killdeer	0.140	0.250
Hairy woodpecker	0.234	0.031
Tree swallow	0.000	0.219
Mourning dove	0.000	0.185
Common flicker	0.000	0.031
Blue jay	0.000	0.031
American crow	0.000	0.250
Black-capped chickadee	0.000	0.089
Gray catbird	0.094	0.478
American robin	0.313	0.390
Veery	0.031	0.094
Cedar waxwing	0.000	0.031
European starling	0.031	0.094
Yellow warbler	0.219	0.644
Pine warbler	0.063	0.000
Common yellowthroat	0.000	0.094
House sparrow	0.031	0.000
Red-winged blackbird	0.286	0.895
Northern oriole	0.000	0.125
Common grackle	0.031	0.188
Brown-headed cowbird	0.077	0.125
Northern cardinal	0.000	0.031

Appendix H. Continued.

Wetland habitat (continued)		
	Index of abundance	
Species	1977	1978
Rose-breasted grosbeak	0.031	0.484
Indigo bunting	0.000	0.031
American goldfinch	0.140	0.451
White-throated sparrow	0.000	0.044
Song sparrow	0.459	1.013

Appendix I. Comparison of 1977 and 1978 bird abundance in habitats subjected to removal of vehicular traffic disturbance before the 1978 census.

Wetland habitat		
	Index of abundance	
Species	1977	1978
Northern goshawk	0.063	0.000
Killdeer	0.177	0.250
American woodcock	0.250	0.000
Mourning dove	0.089	0.000
Common flicker	0.000	0.250
Eastern kingbird	0.000	0.177
Least flycatcher	0.125	0.000
Tree swallow	0.342	0.000
Purple martin	0.125	0.188
Blue jay	0.000	0.063
American crow	0.125	0.773
Black-capped chickadee	0.125	0.000
Gray catbird	0.500	0.405
Brown thrasher	0.000	0.188
American robin	0.250	0.375
Veery	0.063	0.125
European starling	0.153	0.342
Yellow warbler	0.280	0.688
Ovenbird	0.063	0.000
Common yellowthroat	0.188	0.125
House sparrow	0.188	0.242
Red-winged blackbird	1.083	0.685
Northern oriole	0.063	0.125

Appendix I. Continued.

Species	Wetland habitat (continued) Index of abundance 1977	1978
Common grackle	0.496	0.375
Brown-headed cowbird	0.523	0.815
Rose-breasted grosbeak	0.375	0.563
Indigo bunting	0.188	0.438
American goldfinch	0.342	0.563
Rufous-sided towhee	0.125	0.250
Song sparrow	0.726	0.839

Appendix I. Continued.

Pine habitat		
	Index of abundance	
Species	1977	1978
Red-tailed hawk	0.000	0.063
Mourning dove	0.063	0.000
Great horned owl	0.000	0.063
Common flicker	0.125	0.125
Pileated woodpecker	0.000	0.063
Eastern kingbird	0.586	0.063
Great-crested flycatcher	0.000	0.280
Least flycatcher	0.000	0.063
Eastern pewee	0.000	0.250
Tree swallow	0.000	0.063
Purple martin	0.067	0.000
Blue jay	0.242	0.500
American crow	0.125	0.661
Black-capped chickadee	0.343	0.198
White-breasted nuthatch	0.000	0.125
Gray catbird	0.089	0.313
American robin	0.250	0.496
Veery	0.089	0.063
Yellow warbler	0.000	0.063
Common yellowthroat	0.313	0.313
Red-winged blackbird	0.343	0.063
Common grackle	0.000	0.250
Brown-headed cowbird	0.331	0.593
Northern cardinal	0.125	0.063

Appendix I. Continued.

Pine habitat (continued)

Species	Index of abundance 1977	1978
Rose-breasted grosbeak	0.125	0.063
Indigo bunting	0.188	0.153
Chipping sparrow	0.000	0.313
Field sparrow	0.000	0.063
Song sparrow	0.313	0.250

Appendix I. Continued.

Species	Mixed woods habitat Index of abundance 1977	1978
Great blue heron	0.000	0.031
Green heron	0.000	0.063
Mallard	0.000	0.031
Wood duck	0.000	0.031
Killdeer	0.000	0.063
Mourning dove	0.063	0.000
Great horned owl	0.000	0.031
Barred owl	0.063	0.000
Common flicker	0.000	0.217
Hairy woodpecker	0.063	0.000
Downy woodpecker	0.000	0.156
Great-crested flycatcher	0.000	0.188
Least flycatcher	0.000	0.063
Eastern pewee	0.063	0.156
Tree swallow	0.000	0.121
Purple martin	0.031	0.063
Blue jay	0.156	0.383
American crow	0.286	0.718
Black-capped chickadee	0.077	0.219
White-breasted nuthatch	0.000	0.156
Gray catbird	0.140	0.125
Brown thrasher	0.044	0.000
American robin	0.515	0.499
Wood thrush	0.063	0.000
Veery	0.094	0.219

Appendix I. Continued.

Mixed woods habitat (continued)

Species	Index of abundance 1977	1978
Red-eyed vireo	0.063	0.000
Yellow warbler	0.000	0.125
Ovenbird	0.156	0.031
Common yellowthroat	0.125	0.063
Red-winged blackbird	0.125	0.400
Common grackle	0.031	0.000
Brown-headed cowbird	0.383	0.541
Northern cardinal	0.000	0.031
Rose-breasted grosbeak	0.031	0.250
Indigo bunting	0.000	0.250
American goldfinch	0.031	0.000
Grasshopper sparrow	0.031	0.000
Chipping sparrow	0.000	0.063
Field sparrow	0.000	0.063
Song sparrow	0.063	0.440

Appendix J. Comparison of 1977 and 1978 bird abundance in habitats disturbed by the presence of vehicular traffic in 1978.

Species	Mixed woods habitat Index of abundance 1977	1978
Sharp-shinned hawk	0.042	0.000
Mourning dove	0.000	0.144
Common flicker	0.125	0.083
Great-crested flycatcher	0.000	0.292
Eastern phoebe	0.208	0.208
Least flycatcher	0.102	0.000
Blue jay	0.186	0.000
American crow	0.250	0.520
Black-capped chickadee	0.382	0.161
Northern house wren	0.000	0.042
American robin	0.208	0.456
Veery	0.167	0.000
Yellow warbler	0.083	0.167
Ovenbird	0.125	0.000
Common yellowthroat	0.000	0.167
Red-winged blackbird	0.000	0.102
Common grackle	0.000	0.208
Brown-headed cowbird	0.445	0.764
Northern cardinal	0.042	0.000
Rose-breasted grosbeak	0.167	0.125
Indigo bunting	0.000	0.083
American goldfinch	0.000	0.042
Rufous-sided towhee	0.250	0.458
Field sparrow	0.000	0.125
Song sparrow	0.167	0.458

Appendix J. Continued.

Species	Pine habitat Index of abundance 1977	1978
Northern goshawk	0.125	0.000
Mourning dove	0.375	0.000
Common flicker	0.000	0.125
Hairy woodpecker	0.250	0.000
Downy woodpecker	0.000	0.125
Eastern kingbird	0.500	0.000
Great-crested flycatcher	0.000	0.685
Eastern phoebe	0.000	0.125
Tree swallow	0.000	0.125
Blue jay	0.000	0.500
American crow	0.375	0.625
Black-capped chickadee	0.125	0.750
American robin	0.000	0.025
Wood thrush	0.125	0.000
Veery	0.125	0.177
Cedar waxwing	0.000	0.125
Northern oriole	0.000	0.250
Common grackle	0.000	0.125
Brown-headed cowbird	0.000	0.125
Rose-breasted grosbeak	0.375	0.000
Indigo bunting	0.250	0.000
American goldfinch	0.125	0.000
Rufous-sided towhee	0.250	0.000
Chipping sparrow	0.250	0.000
Song sparrow	0.000	0.125

Appendix K. Comparison of 1977 and 1978 bird abundance in wetland habitat flooded and exposed to vehicular traffic disturbance in 1978.

Species	Wetland habitat Index of abundance 1977	1978
Green heron	0.000	0.063
Mallard	0.000	0.031
Ruffed grouse	0.000	0.054
Killdeer	0.221	0.555
Spotted sandpiper	0.031	0.063
American woodcock	0.000	0.125
Common snipe	0.000	0.031
Mourning dove	0.000	0.153
Common flicker	0.171	0.063
Hairy woodpecker	0.000	0.031
Downy woodpecker	0.000	0.094
Eastern kingbird	0.063	0.063
Great-crested flycatcher	0.000	0.063
Eastern phoebe	0.125	0.063
Least flycatcher	0.044	0.031
Tree swallow	0.077	0.319
Purple martin	0.000	0.031
Blue jay	0.281	0.208
American crow	0.094	0.656
Black-capped chickadee	0.370	0.063
Northern house wren	0.250	0.293
Gray catbird	0.359	0.625
American robin	0.280	0.482

Appendix K. Continued.

Wetland habitat (continued)		
	Index of abundance	
Species	1977	1978
Veery	0.171	0.573
Cedar waxwing	0.000	0.089
European starling	0.000	0.089
Warbling vireo	0.000	0.031
Yellow warbler	0.031	0.405
Ovenbird	0.031	0.000
Common yellowthroat	0.031	0.344
Red-winged blackbird	0.296	1.083
Northern oriole	0.063	0.185
Common grackle	0.094	0.496
Brown-headed cowbird	0.706	0.696
Northern cardinal	0.063	0.000
Rose-breasted grosbeak	0.406	0.545
Indigo bunting	0.000	0.188
American goldfinch	0.265	0.419
Rufous-sided towhee	0.063	0.063
Chipping sparrow	0.000	0.031
White-throated sparrow	0.031	0.031
Swamp sparrow	0.000	0.031
Song sparrow	1.013	1.487

Appendix L. Statistics of matched T-tests for indicies of bird abundance in Appendices G-L.

Appendix	Habitat	Degrees of Freedom	Test (T) Statistic	Standard Deviation	P
G	Wetland	23	0.990	0.161	0.3319
G	Mixed woods	23	0.049	0.096	0.0611
G	Pine woods	23	0.541	0.143	0.5937
G	Hardwoods	31	0.227	0.073	0.8216
G	Savanna	32	0.783	0.054	0.4392
G	Meadow	13	0.270	0.241	0.7912
H	Mixed woods	36	1.530	0.120	0.1345
H	Pine	33	2.345	0.071	0.0245[a]
H	Wetland	45	1.736	0.090	0.0893
H	Meadow	19	1.429	0.119	0.1685
I	Pine	18	0.790	0.105	0.4395
I	Wetland	28	4.135	0.186	0.0003[b]
J	Mixed woods	38	3,853	0.127	0.0004[b]
J	Pine	27	1.705	0.203	0.0993
J	Wetland	28	1.535	0.216	0.1355
K	Mixed woods	23	2.061	0.161	0.0502
K	Pine	23	0.650	0.304	0.5219
L	Wetland	40	4.030	0.200	0.0002[b]

[a]Significant at $P < .05$
[b]Significant at $P < .001$

Appendix M. Relative abundance[a] of bird species observed during 1977 and 1978 fall bird censuses.

Species	1977	1978
Horned grebe	-	Uncommon
Great blue heron	b	Rare
Green heron	-	Rare
Canada goose	b	b
Mallard	Common	Common
Black duck	-	Rare
Green-winged teal	-	Rare
Blue-winged teal	Common	Common
Lesser scaup	-	Rare
Common goldeneye	-	Uncommon
Bufflehead	Common	Common
Turkey vulture	b	b
Northern goshawk	Rare	-
Sharp-shinned hawk	-	Rare
Cooper's hawk	Uncommon	Rare
Red-tailed hawk	Common	Common
Broad-winged hawk	Uncommon	Common
Rough-legged hawk	Rare	Rare
Bald eagle	b	b
Osprey	-	Rare
Merlin	-	Rare
American kestrel	-	Rare
Ruffed grouse	Common	Rare
Ring-necked pheasant	Rare	-

Appendix M. Continued.

Species	1977	1978
American coot	-	Rare
Killdeer	Common	Uncommon
Spotted sandpiper	Uncommon	Common
American woodcock	Common	Common
Common snipe	Rare	Uncommon
Short-billed dowitcher	-	Rare
Herring gull	Rare	Rare
Mourning dove	Abundant	Common
Common screech owl	Uncommon	-
Great-horned owl	-	Rare
Barred owl	Uncommon	Rare
Whip-poor-will	Rare	Rare
Common nighthawk	Common	Common
Chimney swift	Uncommon	Uncommon
Belted kingfisher	Uncommon	Common
Common flicker	Common	Uncommon
Pileated woodpecker	Uncommon	Uncommon
Red-bellied woodpecker	Rare	-
Hairy woodpecker	Uncommon	Uncommon
Downy woodpecker	Common	Common
Eastern kingbird	Rare	-
Great-crested flycatcher	-	Uncommon
Eastern phoebe	Rare	Rare
Willow flycatcher	Rare	-
Least flycatcher	-	Rare

Appendix M. Continued

Species	1977	1978
Eastern peewee	-	Rare
Horned lark	-	Rare
Tree swallow	Common	Common
Bank swallow	-	Rare
Barn swallow	-	Common
Purple martin	Rare	Uncommon
Blue jay	Abundant	Abundant
Northern raven	Rare	Rare
American crow	Abundant	Abundant
Black-capped chickadee	Common	Common
Boreal chickadee	Rare	-
Tufted titmouse	Rare	-
White-breasted nuthatch	Common	Common
Red-breasted nuthatch	Uncommon	Uncommon
Brown creeper	-	Rare
Northern house wren	Rare	Rare
Gray catbird	Common	Common
Brown thrasher	Rare	Rare
American robin	Common	Common
Wood thrush	-	Rare
Swainson's thrush	Rare	Rare
Veery	-	Rare
Eastern bluebird	-	Rare
Golden-crowned kinglet	-	Uncommon
Ruby-crowned kinglet	Rare	Rare

Appendix M. Continued

Species	1977	1978
Cedar waxwing	Uncommon	Uncommon
European starling	Common	Common
Yellow-throated vireo	-	Rare
Solitary vireo	-	Rare
Red-eyed vireo	Uncommon	Rare
Philadelphia vireo	-	Rare
Warbling vireo	Rare	Uncommon
Black and white warbler	-	Rare
Tennessee warbler	-	Uncommon
Nashville warbler	-	Rare
Yellow warbler	Rare	-
Magnolia warbler	-	Uncommon
Cape May warbler	-	Rare
Black-throated blue warbler	-	Rare
Blackburnian warbler	-	Rare
Chestnut-sided warbler	-	Uncommon
Bay-breasted warbler	-	Rare
Blackpoll warbler	-	Rare
Pine warbler	-	Rare
Ovenbird	Rare	Rare
Kentucky warbler	-	Rare
Common yellowthroat	Uncommon	Uncommon
Canada warbler	Rare	Uncommon
American redstart	-	Uncommon
House sparrow	Common	Common

Appendix M. Continued

Species	1977	1978
Eastern meadowlark	Uncommon	Rare
Western meadowlark	Common	Uncommon
Red-winged blackbird	Abundant	Abundant
Northern oriole	-	Uncommon
Brewer's blackbird	-	Rare
Common grackle	Abundant	Abundant
Brown-headed cowbird	Rare	Uncommon
Scarlet tanager	-	Rare
Northern cardinal	Uncommon	Uncommon
Rose-breasted grosbeak	Common	Common
Indigo bunting	-	Common
American goldfinch	Common	Common
Rufous-sided towhee	Rare	-
Savanna sparrow	Rare	Rare
Northern junco	Uncommon	Common
Chipping sparrow	Rare	Uncommon
Clay-colored sparrow	Rare	Rare
White-throated sparrow	Uncommon	Common
Fox sparrow	-	Common
Swamp sparrow	Uncommon	Uncommon
Song sparrow	Common	Common

[a]Abundant - multiple individuals observed on each visit.
Common - 1 or more individuals observed on nearly every visit.
Uncommon - individuals observed on less than half the visits.
Rare - species observed only once or twice during census season.

[b]Observed flying over the north campus study area, use of the area not evident.

Appendix N. Relative abundance[a] of bird species observed during 1978 and 1979 winter bird censuses.

Species	1978	1979
Mallard	Rare	-
Sharp-shinned hawk	Rare	Rare
Cooper's hawk	-	Rare
Red-tailed hawk	Rare	Rare
Rough-legged hawk	Rare	Rare
American kestrel	Rare	-
Ruffed grouse	Common	Rare
Mourning dove	Rare	Rare
Great-horned owl	Uncommon	-
Barred owl	-	Uncommon
Pileated woodpecker	Uncommon	Uncommon
Red-bellied woodpecker	Rare	-
Hairy woodpecker	Uncommon	Rare
Downy woodpecker	Common	Common
Horned lark	Rare	-
Blue jay	Abundant	Common
Northern raven	Rare	-
American crow	Abundant	Abundant
Black-capped chickadee	Abundant	Abundant
White-breasted nuthatch	Common	Common
Brown creeper	Rare	Rare
Golden-crowned kinglet	Rare	Uncommon
Red-breasted nuthatch	Rare	Rare

Appendix N. Continued

Species	1978	1979
Cedar waxwing	Rare	Uncommon
Northern shrike	Uncommon	Rare
European starling	Common	Common
House sparrow	Common	Common
Northern cardinal	Uncommon	Uncommon
Evening grosbeak	Abundant	-
Purple finch	Rare	-
Pine grosbeak	Uncommon	-
Hoary redpoll	Rare	-
Common redpoll	Common	-
Pine siskin	Abundant	-
American goldfinch	Common	Abundant
Red crossbill	Rare	-
Northern junco	Uncommon	Common
American tree sparrow	-	Rare
Snow bunting	Rare	-

[a]Abundant - multiple individuals observed on each visit.
Common - 1 or more individuals observed on nearly every visit.
Uncommon - individuals observed on less than half the visits.
Rare - species observed only once or twice during census season.

Appendix O. Age and sex ratios, captures/100 trap-nights (t-n), and population estimates of cottontail rabbits along traplines I-IV, 1977 and 1978.

Trapline/Year	Habitat	Captures	Adult/Juv.	Male/Female	Captures/ 100 t-n	Estimated[a] Population	Rabbits/ha.
I/1977	Pine	9	75/100	200/100	4.5	14	4.8
I/1977	Wetland	32	8/100	167/100	6.4	52	8.8
II/1977	Hardwoods	13	b	100/100	8.4	6	1.7
II/1977	Wetland	5	100/100	100/100	3.5	4	3.0
II/1977	Savanna	28	55/100	143/100	9.5	15	2.0
II/1978	Hardwoods	1	b	b	0.8	1	0.3
II/1978	Wetland	5	67/100	150/100	4.2	7	5.2
II/1978	Savanna	12	43/100	43/100	5.0	14	1.9
III/1977	Mixed woods	8	40/100	75/100	4.8	20	2.9
III/1977	Hardwoods	3	50/100	b	5.4	9	6.5
III/1977	Pine	10	11/100	150/100	7.1	29	6.0
III/1977	Wetland	30	17/100	56/100	10.2	78	4.7
III/1977	Meadow	7	20/100	50/100	16.7	17	8.3
III/1978	Mixed woods	7	50/100	100/100	5.2	5	0.7
III/1978	Hardwoods	1	b	133/100	2.7	1	0.7
III/1978	Pine	9	33/100	133/100	7.8	6	1.2
III/1978	Wetland	15	50/100	50/100	5.6	10	0.6
III/1978	Meadow	3	b	b	10.0	2	1.0

Appendix O. Continued

Trapling/Year	Habitat	Captures	Adult/Juv.	Male/Female	Captures/ 100 t-n	Estimated[a] Population	Rabbits/ha.
IV/1977	Mixed woods	4	33/100	300/100	2.2	c	c
IV/1977	Hardwoods	2	b	100/100	8.3	c	c
IV/1977	Pine	6	50/100	50/100	3.8	c	c
IV/1977	Wetland	0	b	b	0.0	c	c
IV/1977	Meadow	0	b	b	0.0	c	c
IV/1977	Savanna	2	b	75/100	11.1	c	c
IV/1978	Mixed woods	6	100/100	50/100	2.5	7	0.8
IV/1978	Hardwoods	3	200/100	50/100	5.8	4	5.1
IV/1978	Pine	13	75/100	40/100	6.3	9	1.4
IV/1978	Wetland	1	b	b	2.6	1	1.0
IV/1978	Meadow	2	b	100/100	7.7	3	2.5
IV/1978	Savanna	2	100/100	b	5.1	2	1.3

[a]Estimates based upon recaptures (Schnabel 1938).

[b]One or more cohort unrepresented, no calculation possible.

[c]No recaptures occurred on trapline IV, 1977.

Appendix P. Age and sex ratios, captures/100 trap-nights (t-n), and population estimates of gray squirrels along traplines II-IV, 1977 and 1978.

Trapling/Year	Habitat	Captures	Adults/Juv.	Male/Female	Captures/ 100 t-n	Estimated[a] Population	Squirrels/ha.
II/1977	Hardwoods	5	200/100	b	3.2	4	1.1
II/1977	Wetland	0	b	b	0.0	0	0.0
II/1977	Savanna	6	200/100	100/100	2.0	5	0.7
II/1978	Hardwoods	5	b	50/100	4.0	12	3.4
II/1978	Wetland	1	b	b	0.8	3	2.2
II/1978	Savanna	10	350/100	300/100	4.2	28	3.8
III/1977	Mixed woods	10	250/100	600/100	6.0	11	1.6
III/1977	Hardwoods	0	b	b	0.0	0	0.0
III/1977	Pine	3	b	b	2.1	3	0.6
III/1977	Wetland	2	b	b	0.7	2	0.1
III/1978	Mixed woods	2	b	b	1.7	2	0.1
III/1978	Hardwoods	0	b	b	0.0	0	0.0
III/1978	Pine	0	b	b	0.0	0	0.0
III/1978	Wetland	1	b	b	0.5	1	0.0

Appendix P. Continued.

Trapline/Year	Habitat	Captures	Adults/Juv.	Male/Female	Captures/ 100 t-n	Estimated[a] Population	Squirrels/ha.
IV/1977	Mixed woods	12	9/100	175/100	6.7	75	8.6
IV/1977	Hardwoods	0	b	b	0.0	0	0.0
IV/1977	Pine	4	b	b	2.6	19	2.9
IV/1977	Swamp	0	b	b	0.0	0	0.0
IV/1977	Meadow	0	b	b	0.0	0	0.0
IV/1977	Savanna	3	b	100/100	16.7	19	11.7
IV/1978	Mixed woods	18	175/100	120/100	7.4	9	1.0
IV/1978	Hardwoods	8	500/100	500/100	15.4	5	6.3
IV/1978	Pine	12	200/100	80/100	5.8	7	1.1
IV/1978	Swamp	0	b	b	0.0	0	0.0
IV/1978	Meadow	0	b	b	0.0	0	0.0
IV/1978	Savanna	3	50/100	200/100	7.7	3	1.9

[a]Estimate based upon recaptures (Schnabel 1938).

[b]One or more cohort unrepresented, no calculation possible.