A PRE-CONSTRUCTION INVENTORY AND WILDLIFE MANAGEMENT PLAN FOR A FLOOD CONTROL IMPOUNDMENT IN CLARK COUNTY, WISCONSIN

by

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ABSTRACT

A pre-construction inventory of physical-chemical characteristics, plant communities, and animal taxa was conducted on the 655.9 ha Poplar River Watershed Area (PRWA) located in Clark County, Wisconsin, from May 1975 through May 1977. The inventory collected base information from the site of the proposed 117.8 ha PRWA flood control impoundment.

Brick Creek, the major source of water for the proposed PRWA impoundment, is an intermittent stream; major stream discharge occurs in the spring and secondarily in the fall. The proposed impoundment will have a mean depth of 1.25 m, a mean annual flushing rate of 5.2/year, a 12 percent mean annual evaporation loss of mean stream inflow, and a drainage to impoundment ratio of 27:1.

The impoundment will likely be eutrophic. A low siltation rate is indicated, but undecomposed vegetation, resulting from rooted aquatics, could be an important factor in the impoundment filling time. Waters in Brick Creek are characterized by moderately low specific conductance values, a circumneutral pH, and alkalinity and hardness values considered soft. A game fishery is precluded from Brick Creek and the proposed impoundment by temporary low dissolved oxygen concentrations and high water temperatures; winter fish-kills are expected in the impoundment. Nitrogen and phosphorus loading is sufficient for algal blooms to occur, and to support extensive stands

of emergent vegetation. Chemical concentrations in Brick Creek were similar at the PRWA dam site and below the Owen dam, and in ground water. Coliform bacteria in Brick Creek could exceed maximum permissible counts for swimming beaches in the PRWA impoundment.

Upland and aquatic vegetation was analyzed; a cover type map was constructed for the entire PRWA. Seventy taxa of aquatic macroinvertebrates were collected in stream riffles; a biotic index indicated "good" water quality. At least 19 species of fish occur in Brick Creek, and 9 species of herps on the PRWA. The redside dace (Clinostomus elongatus) and the bullfrog (Rana catesbieana) were present, and are classified as on "watch status" and "changing status," respectively, by the Wisconsin Endangered Species Committee. Use of the area by spring breeding waterfowl was minimal. Woodcock were common during spring 1976. A total of 107 species of birds and 29 species of mammals were known to be present. The arctic shrew (Sorex arcticus), an uncommon Wisconsin mammal, was the most abundant mammal in the small mammal census. Few species of waterfowl and shorebirds were present, and wetland associated mammals were poorly distributed because of meager amounts of surface water on the PRWA.

A 10-year wildlife management plan, emphasizing waterfowl production, was developed.

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INTRODUCTION

Major consideration of wildlife habitat improvement has not been included historically in the pre-construction planning of flood control impoundments in Wisconsin. Similarly, the pre- to post-construction changes in wildlife populations and species diversity resulting from such impoundment construction have not been documented.

This thesis presents base information collected from May 1975 through May 1977 on pre-construction conditions and presents a wildlife management plan for the "Poplar River Watershed Area" (PRWA), a multi-purpose water control structure in Clark County, Wisconsin. The impoundment is designed primarily to provide flood protection for the city of Owen. The management plan and design of the wildlife structures are functional and research oriented.

The objectives of this study were to: (1) monitor some of the physical and chemical parameters of the PRWA, (2) inventory the plant communities and animal species present on the PRWA, and (3) prepare a 10-year wildlife management plan for the PRWA which would emphaisze waterfowl production.

Federal assistance for construction of the impoundment is provided under authority of Public Law 83-566 (Water Protection and Flood Prevention Act). The Clark County Soil and Water Conservation District (Clark County SWCD) owns the land, is the contracting agency, and will be responsible for operation and maintenance. Construction costs are shared between the Soil Conservation Service (SCS), Clark County SWCD and the city of Owen. The SCS provides technical assistance through the Clark County SWCD. The funding for management practices outlined in this plan will come from the Clark County Board through the Clark County SWCD.

A draft-copy of the wildlife management plan contained herein was supplied to the Clark County SCS office; portions of the plan have been implemented.

Measurements in this paper are presented in metric units to facilitate post-construction comparisons by the scientific community. Equivalent English units are also provided in the INTRODUCTION section. The MANAGEMENT RECOMMENDATIONS section is presented in English units to facilitate the implementation of recommended management practices by government agencies who have yet to adopt the metric system. An English-metric conversion table is presented in Appendix A.

For the following taxonomic groups, nomenclature conforms to: plants (Gleason 1954), aquatic macroinvertebrates (Hilsenhoff 1975; Pennak 1953), fish (Bailey et al. 1970), herptiles (Conant 1958), birds (Morony et al. 1975), and mammals (Jones et al. 1973).

Study Area

The 3,122.3 ha (7,712 a) Poplar River Watershed (PRW) is located in NE central Wisconsin and includes the area designated as the PRWA (Fig. 1A). The 655.9 ha

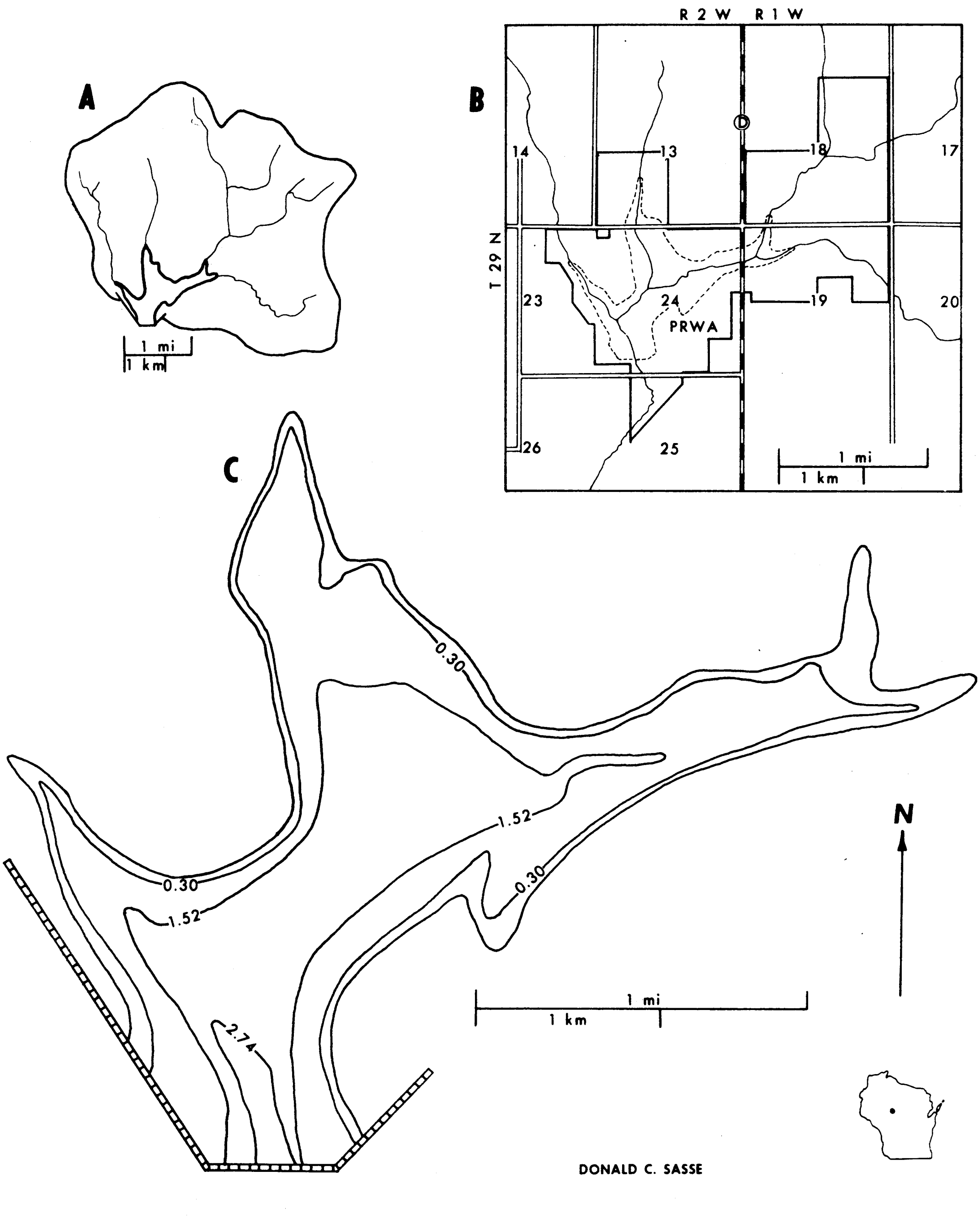


Fig. 1. A. Poplar River Watershed, B. Poplar River Watershed Area (PRWA), and C. depth contours (m) of the proposed PRWA impoundment.

(1,620 a) PRWA is located in Sections 18 and 19 of Hoard Township, R-1-W, T-29-N, and in Sections 13, 23, 24, and 25 of Hixon Township, R-2-W, T-29-N, Clark County, Wisconsin. The PRWA includes the land owned by the Clark County SWCD and the 129.6 ha (320 a) located in the east ½ of Section 18, Hoard Township, R-1-W, T-29-N, which are owned by the Clark County Hospital (Fig. 1B). The 117.8 ha (291 a) proposed PRWA impoundment is designed to hold a water level at 384.4 m (1,261 ft) of elevation (Fig. 1C).

Bedrock on the PRWA consists of Upper Cambrian sandstones and Precambrian igneous rocks overlain by thick deposits of Pleistocene glacial drift, which is predominantly till. The surface soils are primarily silt loams originating from wind-blown silts overlying the glacial deposits. The flood plains are mainly alluvial, and uplands are primarily Withee and Marshfield silt loams which are poorly drained. Topography of the area grades from nearly level to gently sloping. The growing season averages 138 days and average annual precipitation 838.2 mm (33 in) (Akeley 1974).

The major source of water for the proposed PRWA impoundment is Brick Creek, which flows through the watershed in a southerly direction to the Poplar River. Brick Creek is an intermittent stream with portions drying up in mid- to late summer.

The watershed is located just north of the Curtis Tension Zone (Curtis 1959) commonly used to denote north-south limitations in the range of flora and fauna in Wisconsin. Current land use is predominantly agriculture with small interspersed woodland blocks. County highway "D" bisects the PRWA and additional town roads, located on section lines, provide easy access to the area.

METHODS

Watershed Hydrology and Morphometry

Precipitation records from April 1975 through May 1977 were obtained from the University of Wisconsin Experimental Station at Marshfield, located 50 km southeast of the study area. These data were compared with the previous 30-year monthly means from that station to determine any deviations from the expected precipitation values.

Stream inflow in Brick Creek was measured at the site of the proposed dam, with a Gurley Current Meter and the surface float method (Ward 1967). The surface float method consisted of floating an orange down the middle of a 7 m interval of stream for ten trials to obtain an average inflow value. The two methods were compared and a correction made for the surface float values from a regression analysis of 18 paired surface float and Gurley Current Meter values between 0.028 and 0.708 m^3/second (m^3/s). Stream inflow was measured during and immediately after major precipitation periods.

Stream temperature was recorded with a constant-recording thermograph located 255 m below the proposed dam site, from 11 June through 10 November 1975, and from 13 April through 3 August 1976.

The area of impoundment within each contour was determined by polar planimeter; calculations are based on a stable water level of 384.35 m of elevation. The volume of water within each area of contour of depth and the volume of the total impoundment, were based on the mean depth in each area of contour of depth of the impoundment (Hutchinson 1957).

Pan evaporation records were obtained from the University of Wisconsin State Experimental Farm, Marshfield, Wisconsin. The annual impoundment evaporation loss was calculated as recommended for the NE-central region of Wisconsin by the Environmental Science Services Administration (1970). Annual impoundment evaporation loss was considered to be equivalent to 76 percent of the pan evaporation loss per unit area for the months May through October. This value was then considered to represent 79 percent of the total annual impoundment evaporation. The remaining 21 percent annual evaporation loss was divided among the months November through April. Mean annual impoundment evaporation loss was calculated from the pan evaporation records for the 35 year period 1939 through 1974.

Monthly stream inflow was calculated for dates on which stream flow was gauged. Inflow for periods between these dates was then extrapolated from these data and precipitation records.

Monthly stream inflow volumes of Brick Creek were adjusted by using linear regression with respective volumes reported for the Jump River at Sheldon, Rusk County, and the Black River at Neillsville, Clark County, for the dates June 1975 through May 1976. The monthly stream flow of the two rivers for the 1-year period were compared with their respective monthly means for the previous 60-year period, and the percent difference calculated.

The monthly percent difference for each of the two rivers was averaged for each month; the resulting mean percent differences were used to adjust the June 1975 through May 1976 volumes of Brick Creek and to calculate its mean stream inflow for each month.

The annual flushing rate (annual stream inflow/ impoundment volume) was calculated for the years June 1975 through May 1976, and June 1976 through May 1977. The drainage area/impoundment area ratio was also calculated.

Water Quality

"Grab" water samples were taken by immersing a water sample bottle 10 cm below the surface in mid-stream. Thirty water samples were taken at the site of the proposed PRWA dam from 13 May 1975 through 7 April 1977. Four additional water samples were taken below the dam in Owen on 24 August 1975, 31 March 1976, and 14 March and 6 April 1977. Two ground water samples were taken at the PRWA dam site on 15 October and 5 November 1976.

Stream inflow and stream temperature were measured and recorded at the time water samples were taken. Water chemical analyses of these water samples were conducted by the Environmental Task Force Laboratory at the University of Wisconsin - Stevens Point. The following parameters were determined from the water samples: suspended solids, specific conductance, pH, alkalinity (bromocresol green-methyl red), total hardness Ca^{++}hardness, 5-day biological oxygen demand (B.O.D.$_5$), dissolved oxygen (D.O.), total reactive phosphorus (non-filtered samples by Stannous Chloride method), total phosphorus (Stannous Chloride method following persulfate digestion), NH_4 (ammonia nitrogen), NO_3-NO_2 (nitrate and nitrite nitrogen), Kjeldajl nitrogen, and fecal coliform bacterial counts (American Public Health Association 1976).

The monthly suspended solids, nitrogen, and phosphorus loading were calculated by averaging their respective concentrations in water samples within like runoff periods of each month. Average concentrations of these materials and inflow were used to calculate each type of loading during each like inflow period. Period loadings were summed to obtain annual loading rates.

Vegetation

Vascular aquatic vegetation was determined 4 September 1976, by the line-intercept technique (Cox 1967, Muller-Domois and Ellenberg 1974). Stream transects were selected randomly at 1- to 50-m intervals within the proposed impoundment basin with the initial point at, and moving upstream from, the proposed dam site. Transects traversed the stream at right angles to the centerline; all species intercepted in each vertical stratum of the transect were recorded to the nearest cm. Only that vegetation which was present within the stream banks was recorded. Strata were defined as: (1) combined submergent-floating, and (2) emergent. The dominance, relative dominance, frequency, relative frequency, and importance value (relative dominance plus relative frequency) were calculated according to the formulas given in Cox (1967). A specimen of each recorded species was collected and placed in the University of Wisconsin - Stevens Point herbarium.

Terrestrial cover type boundaries on the PRWA were determined from aerial photographs and verified on the ground. The stratum rank method (Lindsey et al. 1961) was used to determine dominant plant species within the three strata (canopy, shrub layer and ground layer) of each cover type.

Stream Substrate

The physical and vegetative substrate of Brick Creek were mapped using a plane table and alidade. Physical substrate was determined by subjective visual estimate on 24 June 1976; particle definitions conform to Cummins (1962). Beds of aquatic vegetation were recorded by dominant taxa on 28 July 1976. The area of physical and vegetative substrate were determined by polar planimeter from the resulting map.

Aquatic Macroinvertebrates

Benthic macroinvertebrates were collected in the center of riffles with a Surber square-foot bottom sampler (0.093 m^2 with a bag of 750 um mesh opening) (Welch 1948). Ten samples were taken 215 m above and 1 km below the proposed PRWA dam on 16 April, 19 May, and 18 June 1976. A 75-m buffer area was maintained between the road (section 24-25 line) and the first sample point to avoid atypical habitats which occur below bridges (Mackenthun 1966).

Macroinvertebrate samples were preserved in 70 percent isopropyl alcohol in the field, sorted in the laboratory and identified with the aid of keys by Hilsenhoff (1975), Pennak (1953) and Eddy and Hodson (1961).

An "index of similarity" was calculated for the upstream and downstream sample areas based on taxa present in samples collected in 1976 (Odum 1950, 1971).

A biotic index (B.I.) following that of Hilsenhoff (1977), was modified to include all aquatic arthropods present in each Surber sample collected on 18 June 1976. Values assigned to taxa not listed by Hilsenhoff (pers. comm.: Gerald Z. Jacobi, 1978, University of Wisconsin - Stevens Point) are recorded in Appendix B.

Macroinvertebrate volumes were determined with the syringe volumetric measuring device described by Meyers and Peterka (1974). Macroinvertebrates were removed from the alcohol preservative, soaked in water for at least 30 minutes, blotted dry for 30 seconds and volumes determined in the volumetric apparatus to the nearest 0.01 ml. Invertebrate samples were stored in preservative for at least 12 months before making volumetric measurements. Uncertainty and variation associated with organisms shrinkage in preservative (Leonard 1939) and weight gain or loss which varies with taxa, physical condition, and duration in preservatives (Howmiller 1972; Stanford 1973) precluded application of a correction factor to volumetric measurements. Volumes can be converted to biomass using the specific gravity of 1.05 (Hynes and Coleman 1968).

Fish

Fish were collected by electro-fishing, dip netting, and seining. A back-pack shocker was used for electro-fishing on 26 June 1975. The shocker had a pulsed direct current, square waves at 100 Hertz and a 10 percent duty cycle, and was set on the high voltage back pack output of 325 volts direct current at 1 amp. The census area extended from 245 m below, to 65 m above the proposed PRWA dam site. A dip-net was used to make casual fish captures above and below the proposed PRWA dam site during August 1975. A seine with 4.69 mm diameter openings was used below the proposed dam site on 18 June 1976, and within the proposed PRWA impoundment basin on 15 August 1976. Representative specimens were preserved and placed in the University of Wisconsin - Stevens Point museum.

Amphibians and Reptiles

Amphibians and reptiles were identified by their calls and by direct sightings. Species were recorded by casual observations made during other routine wildlife censuses from May 1975 through December 1976.

Waterfowl Breeding Pair Counts

Waterfowl breeding pair counts were conducted by walking a 4.5 km-transect of Brick Creek. Counts were conducted during two periods (1) early May (1-15) for mallards (Anas platyrhynchos), and (2) late May (16-31) for blue-winged teal (A. discors) and renesting mallards (Hammond 1959). Four counts were made in 10 days during each of the two periods (Dzubin 1969). Counts were begun at sunrise and continued for about three hours. Isolated pairs, lone males, or groups of two to five males present in the same area for three of the four counts in a 10-day period were considered to represent resident breeding pairs.

Woodcock Singing-Ground Survey

Woodcock (Philohela minor) singing-grounds were located and recorded (Bureau of Sport Fisheries and Wildlife 1973). The survey was conducted between 25 April and 15 May 1976, and began 10 to 30 minutes after sunset (depending on light intensity), it was conducted when temperatures were above 22° C, the wind was less than 7.44 km/hr, and it was not raining or snowing. A 6.45-km vehicle transect was driven through the PRWA with 2-minute listening stops at 0.65-km intervals, for a total of 10 stops per transect. Singing grounds were plotted on a map to avoid counting the same woodcock at two different stops on a given transect.

Ruffed Grouse Drumming Counts

Drumming male ruffed grouse (Bonasa umbellus) were located and enumerated from listening points and by systematically searching for droppings to identify drumming logs (Gullion 1966) during the period 15 April through 15 May 1976. Listening points were at 0.4-km intervals or less, for 10-minute periods in suitable habitat. Listening was begun 30 minutes before sunrise and continued for 2 hours on days when weather conditions were suitable. Additional checks were made for drumming grouse in late afternoon and evening. Drumming logs were marked with plastic flagging.

All Birds

Singing male birds were counted while I walked a 5.1-km line-transect and made 3-minute stops at 100-m intervals (Robbins 1966; New 1972); transect routes were reversed on each count. Transects were conducted from 30 minutes after sunrise until 1000 hrs (Stewart and Kantrud 1972) during the period 20 through 27 May 1976. I traversed grassland, marsh, shrub and forest cover types on my transects. Species identifications were made from bird songs, and visual observations made with 7 x 50 mm binoculars. Transects were censused when weather conditions conformed to criteria used by Stewart and Kantrud (1972). The relative abundance was determined from the number of each species counted per km of transect, 0.0 through 0.5 - rare, 0.6 through 1.0 - uncommon, 1.1 through 2.5 - common, and more than 2.5 - abundant.

Mammals

Small mammal snap-trapping and pit-fall can trapping were conducted 3 July through 18 August 1976, for 5-day periods at each location as recommended by Shadowen (1963). Four cover types were trapped: (1) grass-forb, (2) marsh, (3) shrub, and (4) aspen forest.

Trap stations were spaced 2.5 paces apart (about 3.8 m) on line transects with trap type distribution as shown in Fig. 2. Pit-fall traps consisted of 1-gallon cans buried flush with the surface of the ground. Victor-mouse, Museum special, and Victor-rat snap traps were baited with a mixture of equal parts of peanut butter, rolled oats, raisins, and bacon grease; pit-fall traps were not baited.

Traps were checked each day at sunrise, and the number of set and sprung traps recorded. A correction was made for sprung traps by counting half of them as set (including traps capturing a specimen), on the assumption that each trap was sprung for one half of the trapping interval (Nelson and Clark 1973). The total corrected number of set traps was used to calculate a capture index.

The trapping index was divided into two parts: (1) a snap-trap capture index (SCI), and (2) a pit-fall trap capture index (PCI). A SCI and PCI were necessary to separate the single captures of snap-traps from the multiple captures of pit-fall traps.

Specimens were placed in the University of Wisconsin - Stevens Point Museum. Mammals detected during other wildlife censuses were recorded.

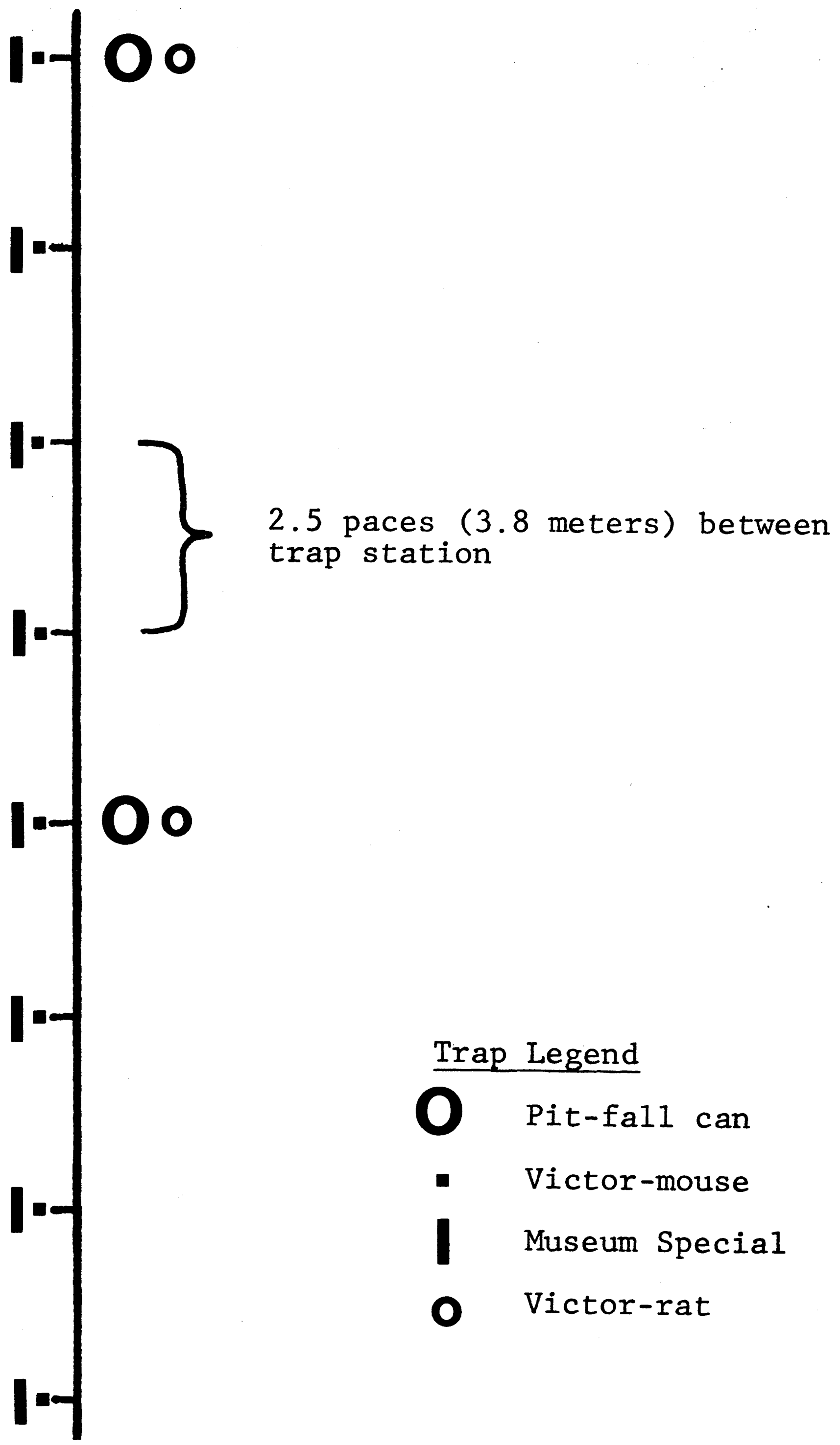


Fig. 2. Deployment and types of traps on the Poplar River Watershed Area small mammal census.

RESULTS AND DISCUSSION

Watershed Hydrology and Morphometry

An examination of hydrologic and morphometric data from the PRWA shows that the impoundment will fill.

Precipitation for the 14-month period April 1975 through May 1976 was above average. A total of 1,130.8 mm of precipitation fell during the period which was 174.5 mm above the 956.3 mm mean of the previous 30 years, although a t-test did not indicate a significant difference ($P > 0.85$) (Appendix C). Except for the summer, precipitation was above the mean of the previous 30 years for all seasons of the year, but not significantly so, spring ($P > 0.29$), fall ($P > 0.72$), winter ($P > 0.87$), and spring ($P > 0.19$). During the summer season 298.2 mm of precipitation fell which was 3.6 mm below the 301.8 mm mean of the previous 30 years for the seasons, but the difference was not significant ($P > 0.04$).

Conversely, precipitation for the 12-month period June 1976 through May 1977 was below average. A total of 404.4 mm of precipitation fell during the period which was 387.6 mm below the 792.0 mm mean of the previous 30 years, but not significantly so ($P > 0.93$) (Appendix D). Precipitation within each season of this 12-month period was less than the season means of the previous 30 years. The 127.0 mm of precipitation which fell during the spring was 38.1 mm below the 165.1 mm mean of the previous 30 years, and was significantly different ($P > 0.99$). There were no significant differences within the summer ($P > 0.49$), fall ($P > 0.84$), or winter seasons ($P > 0.14$), and the previous 30-year period.

The average precipitation value over the 2-year period, June 1975 through May 1977, closely approximated the means of the previous 30 years. Annual precipitation for the two 1-year periods were 1,131.8 mm and 404.4 mm, with a mean difference of -106.4 mm when compared with the annual precipitation means for the previous 30 years.

Stream inflow rates over the 12-month period June 1975 through May 1976 ranged from less than 0.028 m^3 per second (m^3/s) during mid-summer, to an over-the-bank flood estimated at 4.520 m^3/s following a storm in late November 1975 (Appendix E). Inflow rates in the fall, September through October 1975, and spring, April through May 1976, typically ranged from 1 to 4.6 m^3/s. Stream inflow rates during summer, June through August 1975, and winter, December 1975 through March 1976, reached low inflow rates of less than 0.028 m^3/s. Stream inflow was less than 0.028 m^3/s from June through July 1976. A drought caused a no-flow period from early August 1976 through February 1977. Above average precipitation in March 1977, which was twice the mean of the previous 30-year period, together with an early snow melt, re-established a spring stream inflow of 0.054 to 0.636 m^3/s.

Temperature highs in Brick Creek were well below the tolerance limit for benthic organisms, which is close to

50^{o} C for a "balanced population structure" (U.S. Federal Water Pollution Control Administration 1967). Recorded highs in mean weekly stream temperatures were 25^{o} C in 1975 and 27^{o} C in 1976 (Fig. 3, Appendix F). The moderately warm temperatures which already occur in Brick Creek could be increased as a result of warmer water from the impoundment outflow. Higher stream temperatures could alter the stream benthos community as well as associated benthic-dependent members of the food chain.

Construction of the PRWA dam will produce a shallow impoundment with a mean depth of 1.25 m (Fig. 1C). Impoundment contour intervals of depth constitute the following percentage of the total 117.8 ha surface area: 0 to 0.30 m, 16.2 percent; 0.30 to 1.52 m, 46.7 percent; 1.52 to 2.74 m, 34.9 percent; and 2.74 m plus, 2.2 percent. A total of 62.9 percent is within the 0 to 1.52 m depth range. The maximum depth will be 3.35 m. The volume of water in the impoundment will be 1,488,000 m^3.

Precipitation trends and stream discharge rates show that the majority of stream inflow occurs in the spring and secondly in the early fall (Fig. 4 and Table 1). Monthly stream inflow for the impoundment basin during the two-year period of June 1975 through May 1977 ranged from zero during the drought in the fall of 1976 to 2,389,000 m^3 during April 1976.

Stream inflow trends correlated with precipitation throughout the two years of the study. Annual inflow from

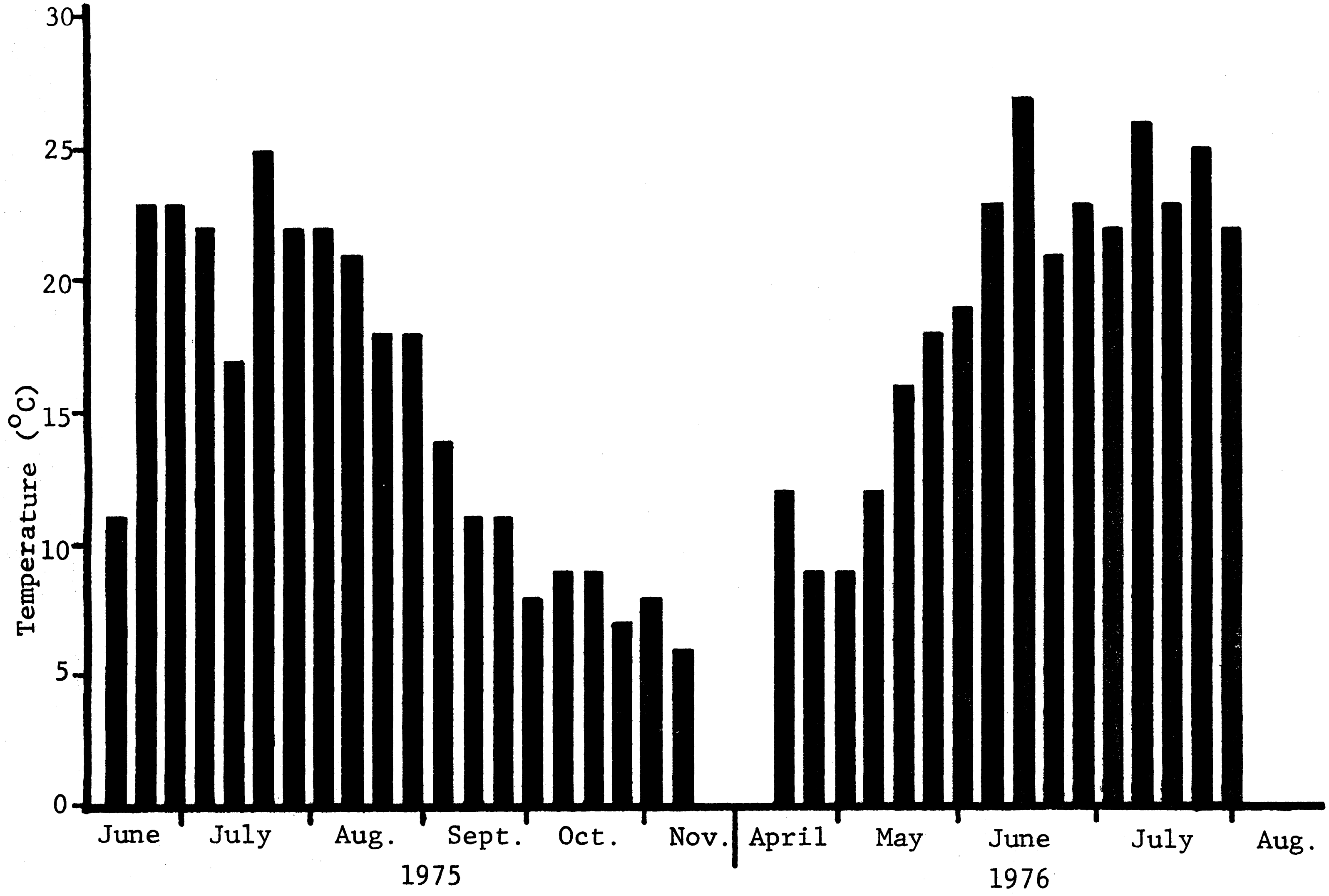


Fig. 3. Mean of weekly water temperatures in Brick Creek, Poplar River Watershed Area, 11 June through 10 November 1975 and 13 April through 3 August 1976.

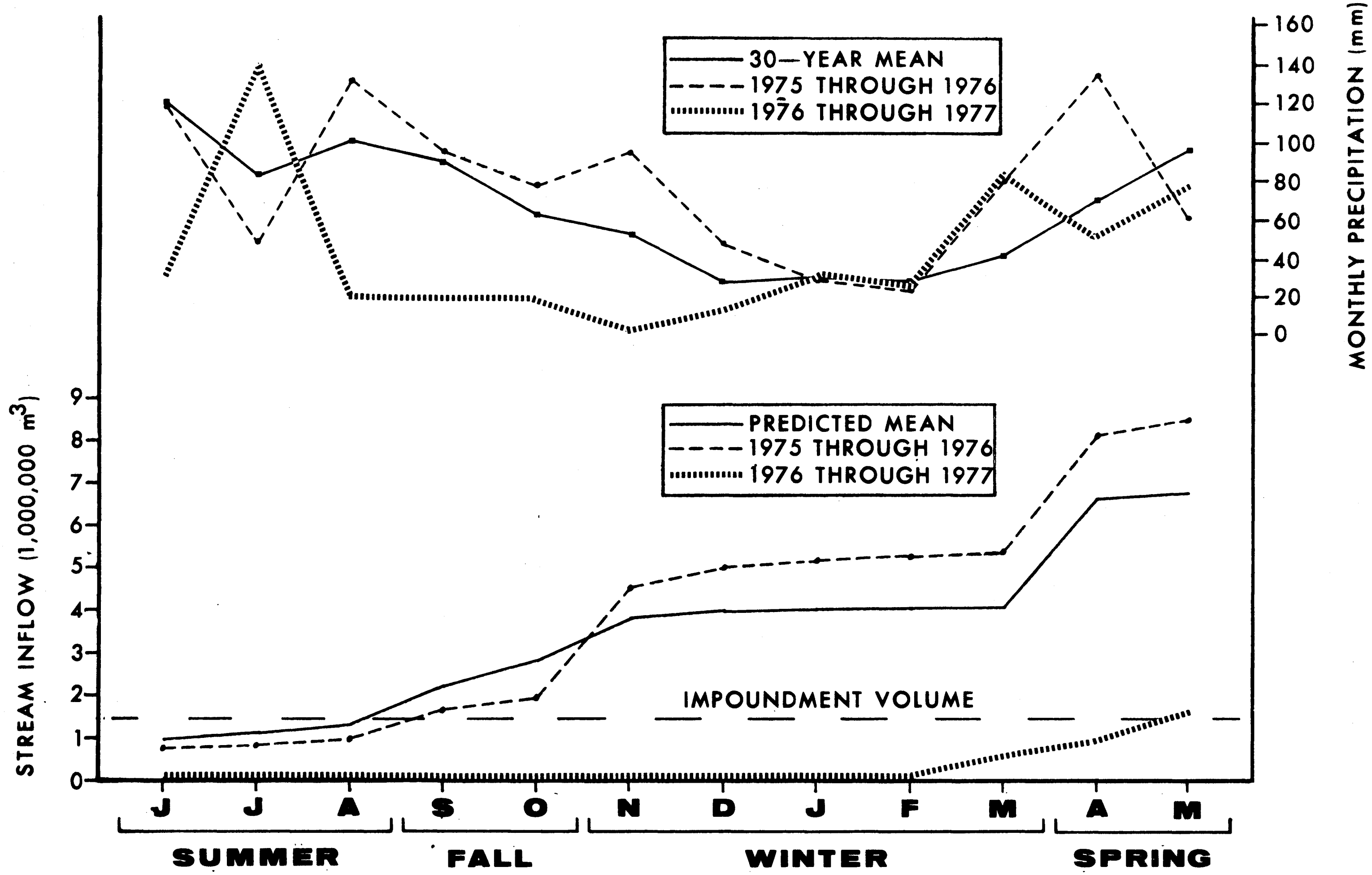


Fig. 4. Precipitation and cumulative stream flow data for Brick Creek at the site of the proposed Poplar River Watershed Area dam, June 1975 through May 1977.

Table 1. Measured and predicted monthly stream inflow (m^3) for Brick Creek as compared with volumes adjusted for the calculated evaporation loss from the proposed Poplar River Watershed Area impoundment, June 1975 through May 1977.

	Stream inflow		
Month	1975-76	1976-77	Predicted mean
June	723,000 (586,000)[a]	35,000 (b)	951,000 (807,000)
July	78,000 (-95,000)	14,000 (b)	195,000 (38,000)
August	143,000 (-10,000)	6,000 (b)	164,000 (25,000)
September	764,000 (669,000)	0 (-117,000)	955,000 (856,000)
October	167,000 (92,000)	0 (55,000)	464,000 (398,000)
November	2,684,000 (2,654,000)	0 (b)	987,000 (959,000)
December	494,000 (464,000)	0 (b)	214,000 (186,000)
January	75,000 (45,000)	0 (b)	52,000 (24,000)
February	69,000 (39,000)	0 (b)	33,000 (5,000)
March	109,000 (79,000)	479,000 (b)	48,000 (20,000)
April	2,839,000 (2,809,000)	356,000 (b)	2,605,000 (2,577,000)
May	350,000 (b)	742,000 (b)	1,094,000 (960,000)
Totals:	8,495,000 (7,332,000)[c]	1,570,000 (b)	7,762,000 (6,855,000)

[a] Inflow minus evaporation.

[b] Evaporation records not available.

[c] Does not include evaporation loss for May 1976.

June 1975 through May 1976 would have produced 8,495,000 m^3 per year. Conversely, inflow in the drought year of June 1976 through May 1977 would only have been 1,570,000 m^3 per year.

Stream flow was uniform throughout the Clark County region. Three streams were compared, the Jump River located 50 km northwest of the PRWA, the Black River located 45 km south of the PRWA, and Brick Creek on the PRWA. There was a good correlation between the Jump River and Black River (r^2 = 91.6), however, there was a poor correlation between the Jump River and Brick Creek (r^2 = 47.6), and the Black River and Brick Creek (r^2 = 24.7) for the 12-month period June 1975 through May 1976 (U.S. Geological Survey Water - Supply 1950-1959; U.S. Geological Survey Data 1960-1976) (Appendix G). The greatest flow variability occurred in the months of March and April. When these months were excluded from the correlation, monthly discharge trends for the remaining 10-month period were similar between the Jump River and the Black Rivers (r^2 = 96.9), the Jump River and Brick Creek (r^2 = 95.0), and the Black River and Brick Creek (r^2 = 94.9). An examination of the March and April hydrographs for the Jump River, Black River and Brick Creek did not show a recognizable pattern of peak flows and so prevented a hydrographic reconstruction for the two months. As the best alternative estimate, the mean monthly percent difference between the mean flow of the Jump River and the

Black River were used to predict the inflow for Brick Creek for March and April 1976. Variability in March and April flow of the three streams may have been a product of some of my measurements on Brick Creek occurring between peak flow periods, regional differences in snowfall and subsequent snowmelt, soil type and the resulting percolation rates, and land use as it affects runoff rates. The predicted mean inflow for Brick Creek is 7,762,000 m^3/year.

Evaporation and transpiration will cause a moderate loss of annual impoundment inflow. The calculated evaporation loss for the 11 month period June 1975 through April 1976 is 10 percent of the inflow for the period (Appendix H). Evaporation records for the period May 1976 through May 1977 were incomplete. The predicted mean annual evaporation loss for the impoundment is 907,000 m^3 or 12 percent of the mean annual inflow. This figure compares relatively well with the original estimate of 1,119,000 m^3 per year (Akeley 1974). Emergent-floating aquatic vegetation and terrestrial phreatophytes adjacent to the impoundment could also produce a transpiration loss not unlike that lost through evaporation. The transpiration loss was not calculated because future species composition, distribution, and density is unknown.

Annual flushing rates are moderate for the impoundment basin. The annual flushing rates were 5.7 for June 1975 through May 1976, 1.2 for June 1976 through May 1977 and 5.2 for the predicted mean inflow. Above normal (18 percent) precipitation from April 1975 through May 1976, and below normal (42 percent) precipitation from June 1976 through May 1977 influenced the range (5.7 to 1.2) in flushing rates. The mean annual flushing rate minus evaporation was 4.6, which is adequate to fill the impoundment during all but extreem drought years.

The drainage area/impoundment area ratio is 27. It is a measure of potential nutrient leaching from the drainage area to the impoundment. When compared to ratios for other Wisconsin lakes, it indicates an intermediate ratio for the PRW.

Water Quality

An examination of water quality indicates a highly fertile impoundment.

Average water chemical values in Brick Creek for spring 1976, a year of above normal precipitation, are more representative of a normal year because values for spring 1977 were preceeded by an atypical 6-month no-flow (drought) period (Table 2 and Appendix I).

Data indicates a low siltation rate for the impoundment. Suspended solids averaged 5.76 mg/l for the spring of 1976 indicating a low siltation rate. Sediment inflow of 5.17 kg/ha of drainage area is also low (Fig. 5 and Table 3). Cummulative monthly sediments are probably less than shown because the November 1975 value of 1.92 kg/ha/mo reflect a month of abnormally high stream inflow and the data do not consider the transfer of sediment via stream outflow. Sediment transfer in the outflow was not calculated because

Table 2. Mean water quality parameters for Brick Creek, from 13 May 1975 through 6 April 1977.[a]

Parameter	Spring $\bar{X}$ 1976 (n=8)	Spring $\bar{X}$ 1977 (n=4)	Spring range 1976 (n=8)	Spring range 1977 (n=4)	Annual range (1975-1977) (n=30)
Physical					
Stream discharge (m^3/s)	0.520	0.305	(0.028-1.423)	(0.054-0.636)	(0.028-4.520)
Stream temp. (^oC)	8	1	(4-16)	(0-3)	(0-19)
Susp. solids (mg/l)	5.76		(1.7-8.8)		(1.7-25.9)
Conductance (uMOHS/cm)	103	152	(76-155)	(120-197)	(61-310)
Chemical					
pH			(6.88-8.28)	(6.54-7.57)	(6.54-8.54)
Alkalinity (mg/l) as $CaCO_3$	37	22	(16-70)	(18-26)	(16-92)
Total hard. (mg/l) as $CaCO_3$	56	90	(44-80)	(70-120)	(44-154)
Ca^{++} hard. (mg/l) as $CaCO_3$	28	44	(16-48)	(30-64)	(12-80)
$B.O.D._5$ (mg/l)	1.29	5.66	(0.60-2.20)	(3.30-7.90)	(0.45-7.90)
D.O. (mg/l)	8.9	8.6	(6.9-11.0)	(8.1-9.7)	(2.2-11.0)
NH_4-N (mg/l)	0.16	0.28	(<0.04-0.39)	(0.18-0.46)	(<0.04-0.53)

Table 2. Continued.

Parameter	Spring $\bar{X}$		Spring range		Annual range
	1976 (n=8)	1977 (n=4)	1976 (n=8)	1977 (n=4)	(1975-1977) (n=30)
NO_3-NO_2-N (mg/l)	0.13	0.98	(<0.04-0.25)	(0.35-1.37)	(<0.04-1.37)
Kjeldahl-N (mg/l)	0.91	2.00	(0.75-1.12)	(1.05-2.59)	(0.25-2.59)
Total N (mg/l)[b]	1.04	2.98			
Reactive P (mg/l)	0.063	0.103	(0.015-0.151)	(0.038-0.238)	(0.015-0.435)
Total P (mg/l)	0.112	0.181	(0.056-0.243)	(0.043-0.475)	(0.038-0.560)
N:P (inorganic)[c]	16	29			
<u>Bacteriological</u>					
Coliform count (MFFC/100ml)	54	154	(<3-113)	(30-520)	(<3-5,300)

[a] Values summarized for spring (ice melt - 31 May) the major discharge period.

[b] Kjeldahl-N + NO_3 + NO_2-N.

[c] Inorganic-N (NO_3 + NO_2-N + NH_4-N):inorganic-P (reactive-P).

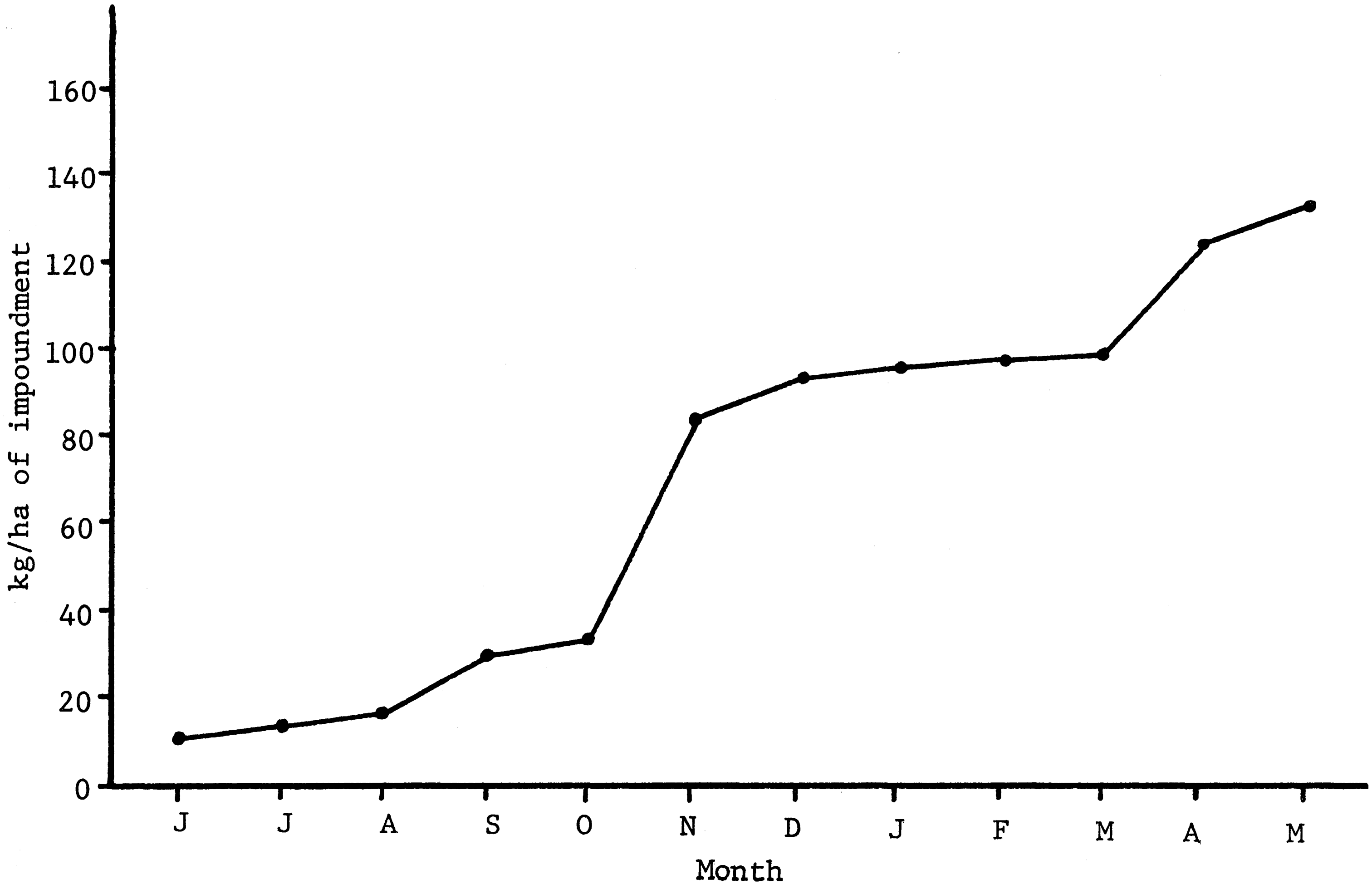


Fig. 5. Cumulative monthly sediment present in the stream inflow of Brick Creek, June 1975 through May 1976.

Table 3. Monthly sediment (kg/ha of impoundment/month) present in stream inflow of Brick Creek, June 1975 through May 1976.

Month	Monthly sediments	Cumulative monthly sediments
June	12.92	12.92
July	1.57	14.49
August	2.39	16.88
September	14.70	31.58
October	3.93	35.51
November	51.00	86.51
December	8.25	94.76
January	0.65	95.41
February	0.59	96.00
March	2.14	98.14
April	26.72	124.86
May	10.28	135.14
Total (kg/ha/yr):	135.14	

of unquantificable sediment settling and sediment-chemical reactions within the impoundment. Extrapolation of 135.14 kg/ha of impoundment/yr, assuming a bulk density of silt at 1.13 g/cc (Thompson and Troeh 1973), to the impoundment filling rate per 100 years is 38,110 m^3, and is an extremely low filling rate. This rate is 8 percent of the original gross estimate of 318,370 m^3 per 100 years (Akeley 1973). Annual impoundment filling by sediment is expected to be minimal. Rooted aquatic plants, however may be a more important factor in the filling time of the impoundment than that of sediment. The shallow nature of the impoundment will favor rooted aquatic plant growth which could add significantly to the undecomposed organic layer of the impoundment bottom and thus decrease impoundment storage capacity.

Average specific conductance values for spring 1976 averaged 103 uMOHS/cm (range: 76 to 155) and indicate a moderately low level of ionized material in the water. Values are characteristic of the west central region of Wisconsin.

The pH was circumneutral and ranged from 6.88 to 8.28 during the spring of 1976. Seasonal changes in pH values corresponded to increased photosynthesis during the summer, with the pH increasing as CO_2 was removed from water by plants. A subsequent decline in pH occurred as the photosynthetic rate decreased because of reduced light intensity, and CO_2 solubility increased as water cooled in the fall.

Alkalinity values for the PRWA indicate soft to moderately soft water conditions. Alkalinity averaged 37 mg/l as $CaCO_3$ during spring and ranged from 16 to 92 mg/l over the two year sampling period. A total alkalinity of 40 mg/l is thought to be a natural separation between hard and soft waters (Moyle 1949).

Hardness values also denote soft water conditions. During spring 1976 the total hardness and Ca^{++} hardness averaged 56 (2 year range: 16 to 92) and 28 mg/l as $CaCO_3$ (2 year range: 12 to 80), respectively. This 2:1 ratio of total hardness:Ca^{++} hardness indicates that an equal portion of calcium and other cations, presumably magnesium, were being dissolved. Variation in the range of total and Ca^{++} hardness values are a result of differing stream inflow rates. Higher hardness values were recorded during low inflow periods which were primarily from ground water, whereas low hardness values were associated with the dilution effects of high inflow rates. Hardness values reflect soft water (U.S. Environmental Protection Agency 1976). Low hardness values are characteristic of igneous rock (Hutchison 1957), the primary bedrock in the area, but may also in part be due to liming of agricultural soils in the watershed.

Low dissolved oxygen (D.O.) levels were below the minimum concentration of 5.0 mg/l required to maintain a good warm water fish population (U.S. Environmental Protection Agency 1976). Average spring 1976 5-day biological oxygen demand ($B.O.D._5$) values of 1.29 mg/l are moderate and indicate an input of organic material via runoff. An inverse relationship trend between $B.O.D._5$ and D.O. values was evident throughout the seasons. D.O. values averaged 8.9 mg/l during the spring of 1976, but ranged as low as 4.6 mg/l during the summer of 1976 and as low as 2.2 mg/l during the summer of 1976 during near drought conditions. Low D.O. concentrations may be due to anaerobic ground water which comprises the major source of water during low stream flow. Temporary low D.O. levels are sufficient to preclude a gam fishery in Brick Creek and the proposed impoundment.

Concentrations of nitrogen (N) and phosphorus (P) indicate algal blooms could occur in the impoundment. The mean spring 1976 nitrogen concentrations were 0.16, 0.13 and 0.91 mg/l, for ammonia (NH_4-N), nitrate and nitrite (NO_3-NO_2-N) and Kjeldahl-N, respectively. Mean spring phosphorus values were 0.063 and 0.112 mg/l for reactive P and total P, respectively. Lakes containing 0.3 mg/l inorganic nitrogen (NO_3-N, NO_2-N and NH_4-N) and 0.015 mg/l soluble phosphorus (reactive P) at the time of spring overturn, are capable of producing nuisance algal growths (Sawyer 1947). Concentrations in Brick Creek during spring 1976 reached these levels, inorganic nitrogen 0.29 mg/l and reactive P 0.063 mg/l. Wisconsin lakes with a mean total phosphorus concentration of more than 0.1 mg/l would have algal blooms during most of the growing season (Lueschow et al. 1970). Concentrations in Brick Creek from June 1975 through May 1976, 0.112 mg/l total phosphorus, would have exceeded this level.

The annual N and P loading rates for the PRWA impoundment for June 1975 through May 1976, appear to be above average as a result of twice the averaged precipitation during November 1975 (Table 4). Loading rates for June 1976 through May 1977 are atypical because of the drought which occurred during this period.

The technique of estimating nutrient loading has been used in a number of situations as a guide for management decisions (Vollenwider 1968; Uttormark et al. 1974; and Dillon 1975). Nutrient loading in the PRWA impoundment indicates a eutrophic impoundment. Nutrient loading figures of Uttormark et al. (1974) compared with the PRWA impoundment basin area/lake area ratio and inorganic N loss/active P loss ratio, for the 1 year period June 1975 through May 1976, illustrate nutrient loading at levels approaching a eutrophic impoundment (Fig. 6). A problem with Uttormark's et al. (1974) comparison is that it does not consider loading per volume of water as has been done by Dillon (1975). Total P loading to the PRWA impoundment places it in a eutrophic classification. Phosphorus concentrations approached levels characteristic of advanced eutrophication in lakes (Dillon 1975) for the year June 1976 through May 1977 (Fig. 7). The year June 1976 through May 1977 received below normal precipitation and was abnormal.

The N:P ratio in Brick Creek is 16:1, and shows that

Table 4. Nitrogen and phosphorus loading (kg/ha of impoundment) in the proposed Poplar River Watershed Area impoundment, June 1975 through May 1977.

Month	1975-1976		1976-1977	
	N[a]	P[b]	N[a]	P[b]
June	0.003 (0.062)	0.002 (0.007)	0.000 (0.002)	0.000 (0.001)
July	0.000 (0.001)	0.001 (0.001)	0.000 (0.000)	0.000 (0.000)
August	0.003 (0.004)	0.001 (0.002)	0.000 (0.000)	0.000 (0.000)
September	0.003 (0.090)	0.002 (0.004)	c	c
October	0.001 (0.004)	0.001 (0.001)	c	c
November	0.026 (0.326)	0.014 (0.028)	c	c
December	0.005 (0.052)	0.002 (0.004)	c	c
January	0.003 (0.004)	0.000 (0.000)	c	c
February	0.003 (0.006)	0.000 (0.000)	c	c
March	0.003 (0.009)	0.001 (0.001)	0.036 (0.087)	0.004 (0.008)
April	0.046 (0.144)	0.005 (0.011)	0.010 (0.023)	0.001 (0.001)
May	0.004 (0.019)	0.001 (0.002)	0.020 (0.046)	0.002 (0.003)
Totals: (kg/ha/yr)	0.100 (0.721)	0.030 (0.061)	0.066 (0.158)	0.007 (0.013)

[a] Inorganic N
(Total N)

[b] Reactive P
(Total P)

[c] No flow due to drought.

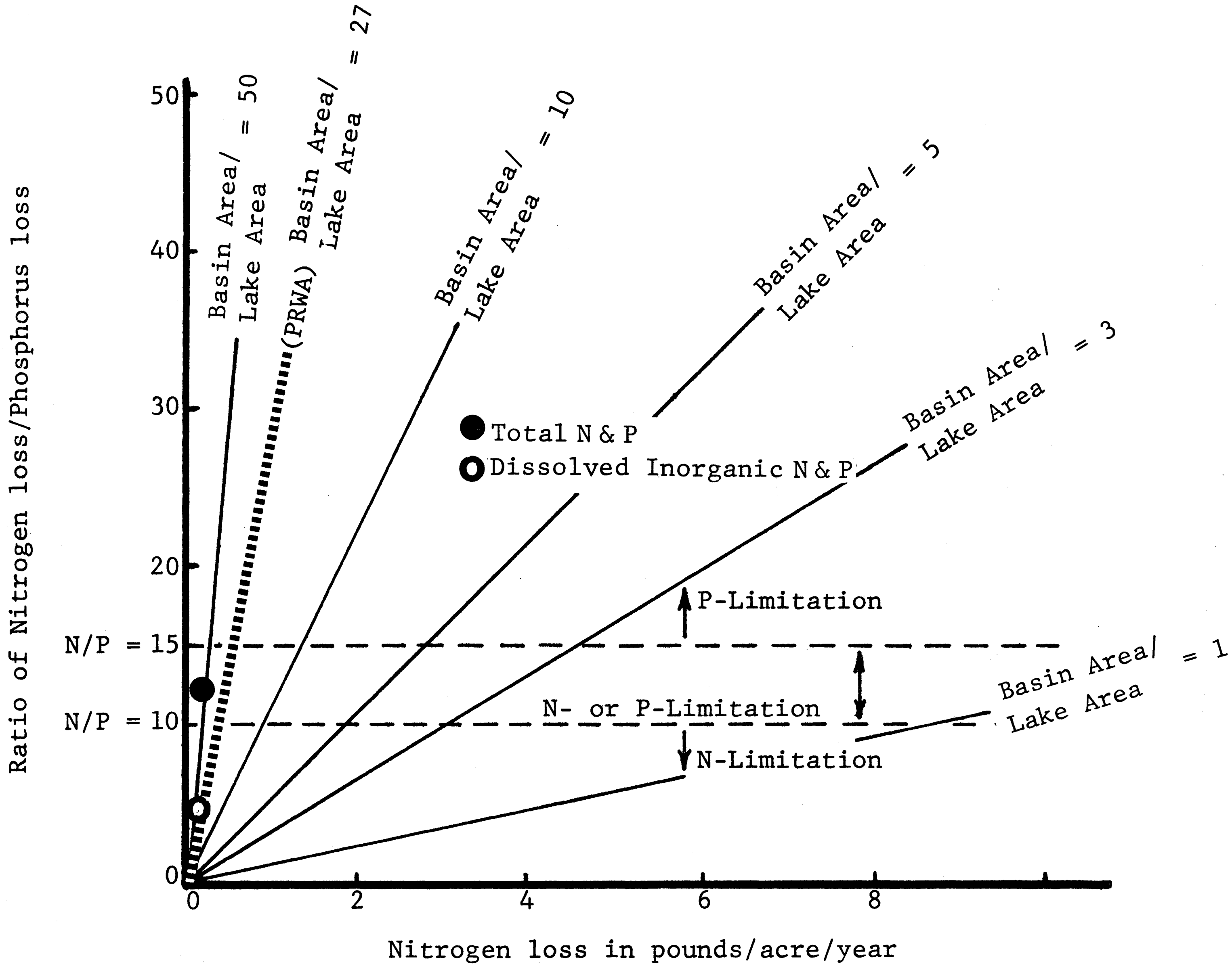


Fig. 6. Nutrient coefficients for the Poplar River Watershed Area (PRWA) impoundment, June 1975 through May 1976, compared with Uttormark et al. (1974).

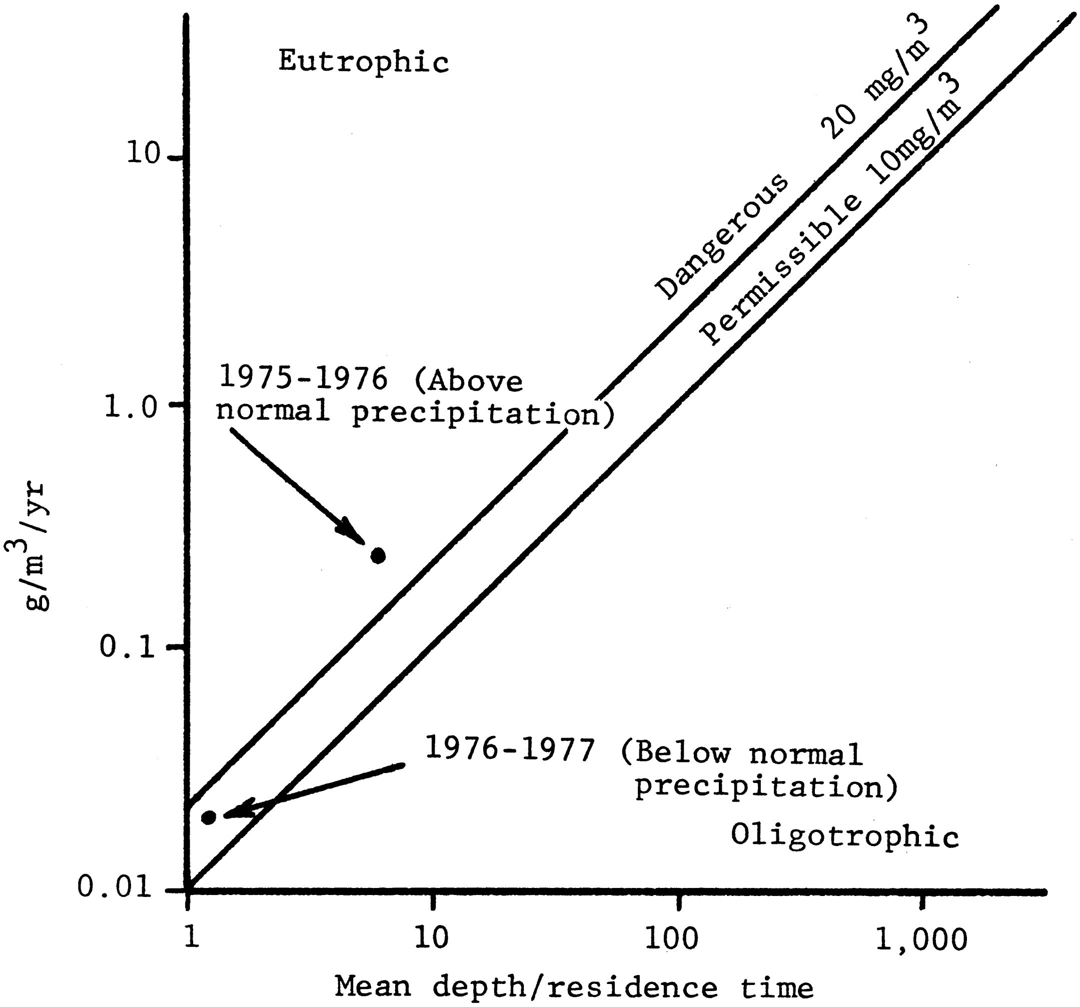


Fig. 7. Total phosphorus loading ($g/m^2/yr$) and mean depth (m)/residence time as they relate to the trophic nature of the Poplar River Watershed Area impoundment (Dillon 1975).

nitrogen would become limiting first in the N:P requirements of algae. A N:P ratio (inorganic-N:soluble-P) of 60:1 is optimal for algal growth (Gerloff and Skoog 1957). Phosphorus most commonly limits productivity (Wetzel 1975), but N can be limiting in eutrophic lakes particularly those high in P (Keeney 1972) as is anticipated in the PRWA impoundment. Nitrogen inputs from runoff via Brick Creek inflow could increase and alter this N:P ratio if significant changes in land use practices occurred, e.g., increased use of fertilizers or domestic animal wastes on agricultural lands. This nitrogen limitation is only meaningful in the absence of nitrogen fixing organisms such as blue-green algae.

Maximum rooted aquatic plant growth is obtained at nutrient concentrations below those which produce the highest growth rates of algae (Mulligan and Branowski 1969 cited by Keeney 1972). In considering the shallow nature of the impoundment and the competitive relationship between rooted aquatics and algae for nutrients and light, predictions of algal blooms and eutrophication may not hold true. The relevance of nutrient loading curves to algae populations, discussed previously, are not directly applicable to rooted aquatics. However, they do show that nutrient loading is sufficient to produce abundant rooted aquatic vegetation. Other nutrient sources for rooted aquatics and algae, wind action and the resulting upturn of sediments, could equal or exceed loading from inflow.

Fecal coliform counts during base flow periods (less than 0.142 m^3/s) ranged from less than 3 to 2,075 Membrane Filtered Fecal Coliform (MFFC)/100 ml for 1975 through 1977 (Appendix I). Counts in samples collected during runoff periods ranged from 690 MFFC/100 ml during the summer of 1976, to 5,300 MFFC/100 ml during the fall and spring periods of 1975 to 1977. The high counts of 2,075 MFFC/100 ml, recorded during the base inflow of 1976 drought represents a 6 fold increase in coliform bacteria over a 6 day period with no increase in runoff and, is atypical; the range of 70 to 170 MFFC/100 ml (summer 1976) is a more accurate reflection of base flow counts. The source of coliform bacteria is most likely domestic animal wastes from adjacent agricultural lands, although wild animal and human wastes may also contribute.

Fecal coliform bacteria could exceed maximum permissible counts for swimming beaches. Maximum permissible coliform counts (U.S. Environmental Protection Agency 1976) require that not more than 10 percent of the total samples taken during any 30 day period should exceed 400 MFFC/100 ml. This criteria would have been exceeded 16 June 1975 when the coliform count was 690 MFFC/100 ml. In addition to coliform bacteria, the possibility of extensive stands of emergent vegetation, algal blooms, a strong possibility of leech populations and "swimmers itch" (Mackenthum et al. 1964) will limit the potential for a good swimming beach on the impoundment.

Chemical and bacteriological differences between water samples (n = 4) taken at the PRWA dam site and below the Owen dam were similar, with the exception of the pH, alkalinity and D.O. which tended to be higher below the Owen dam (Appendix I). This tendency of higher concentrations for these three parameters below Owen dam is probably due to increased leaching of the substrate which increased pH and alkalinity, and agitation which increased D.O. with the downstream passage of water.

Chemical concentrations in ground water samples (n = 2) were similar to those obtained from water samples taken in Brick Creek during low base flow periods (less than 0.028 m^3/s) (Appendix I). This similarity between base flow and ground water samples is normal because ground water provides the major portion of stream flow volumes.

Vegetation

Importance values, for vegetation present in Brick Creek (Table 5), were used to determine the following ranking, in order of importance: (1) combined submergent-floating strata - pondweed (*Potamogeton amplifolius*), waterweed (*Elodea canadensis*), arrow-head (*Sagittaria* spp.), water starwort (*Callitriche palustris*), and yellow water lily (*Nuphar variegatum*), and (2) emergent strata - bur-reed (*Sparganium* - comprised of *S. chlorocarpum* and *S. eurycarpum*), arrow-head, great (softstem) bulrush (*Scirpus validus*), (rice) cut-grass (*Leersia oryzoides*), manna grass (*Glyceria grandis*), sedge (*Carex rostrata*), spike rush (*Eleocharis acicularis*), and beggars-tick (*Bidens cernua*). These

Table 5. Aquatic vegetation present in the portion of Brick Creek scheduled for inundation by the Poplar River Watershed Area impoundment, 1975.

Species	Dominance	Relative dominance	Frequency	Relative frequency	Importance Value
Submergent-Floating					
Pondweed *Potamogeton amplifolius*	8.95	44.00	28	33.34	77.34
Waterweed *Elodea canadensis*	6.83	33.54	24	28.57	62.11
Arrow-head *Sagittaria* spp.	3.51	17.23	20	23.81	41.04
Water starwort *Callitriche palustris*	0.50	2.46	8	9.52	11.98
Yellow water lily *Nuphar variegatum*	0.56	2.77	4	4.76	7.53
Totals:	20.35	100.00	84	100.00	200.00

Table 5. Continued.

Species	Dominance	Relative dominance	Frequency	Relative frequency	Importance Value
Emergent					
Bur-reed *Sparganium* spp.[a]	31.89	48.29	72	39.13	87.42
Arrow-head *Sagittaria* spp.	12.99	19.67	32	17.39	37.06
Great (softstem) bulrush *Scirpus validus*	6.59	9.97	32	17.39	27.36
(Rice) cut grass *Leersia oryzoides*	8.98	13.59	16	8.70	22.29
Manna grass *Glyceria grandis*	2.21	3.35	12	6.52	9.87
Sedge *Carex rostrata*	1.40	2.12	8	4.35	6.47
Spike rush *Eleocharis acicularis*	1.80	2.73	4	2.17	4.90
Beggar-ticks *Bidens cernua*	0.18	0.28	8	4.35	4.63
Totals:	66.04	100.00	184	100.00	200.00

[a] *Sparganium chlorocarpum* and *S. eurycarpus*.

aquatic species and others can be expected to become established in the impoundment. Other species reported in Owen pond by Akeley (1974), which may also become established in the PRWA impoundment, include coontail (Ceratophyllum demersum), floating-leaf pondweed (P. natans), water smartweed (Polygonum natans), and cattail (Typha spp.)

Cultivated lands (110.9 ha; 17 percent) are those being tilled in 1975 or 1976 (Fig. 8 and Table 6). These lands tended to be located on the well drained uplands.

Grass-forb (77.7 ha; 12 percent) are those lands no longer under cultivation, and presently dominated by grasses and/or forbs. These areas, on moderate lowlands and uplands, include old fields and areas maintained in grassland by grazing.

The sedge-meadow (18.6 ha; 3 percent) are areas dominated by sedges (Carex spp.). These areas were often maintained in a sedge-meadow form by grazing; some have scattered shrubs. They occur on semi-moist sites.

Marsh cover types (25.9 ha; 4 percent) are dominated by reed-canary grass (Phalaris arundinacea) and contain wool grass (Scirpus cyperinus) as a sub-dominant. These areas are devoid of trees, but may include a few small isolated shrubs. This cover type occurs in an area of mineral soil overlain by wet organic soil.

The shrub cover types (150.6 ha; 23 percent) are dominated by willow (Salix spp.), and frequently include alder (Alnus spp.), as a sub-dominant. Other shrubs also present

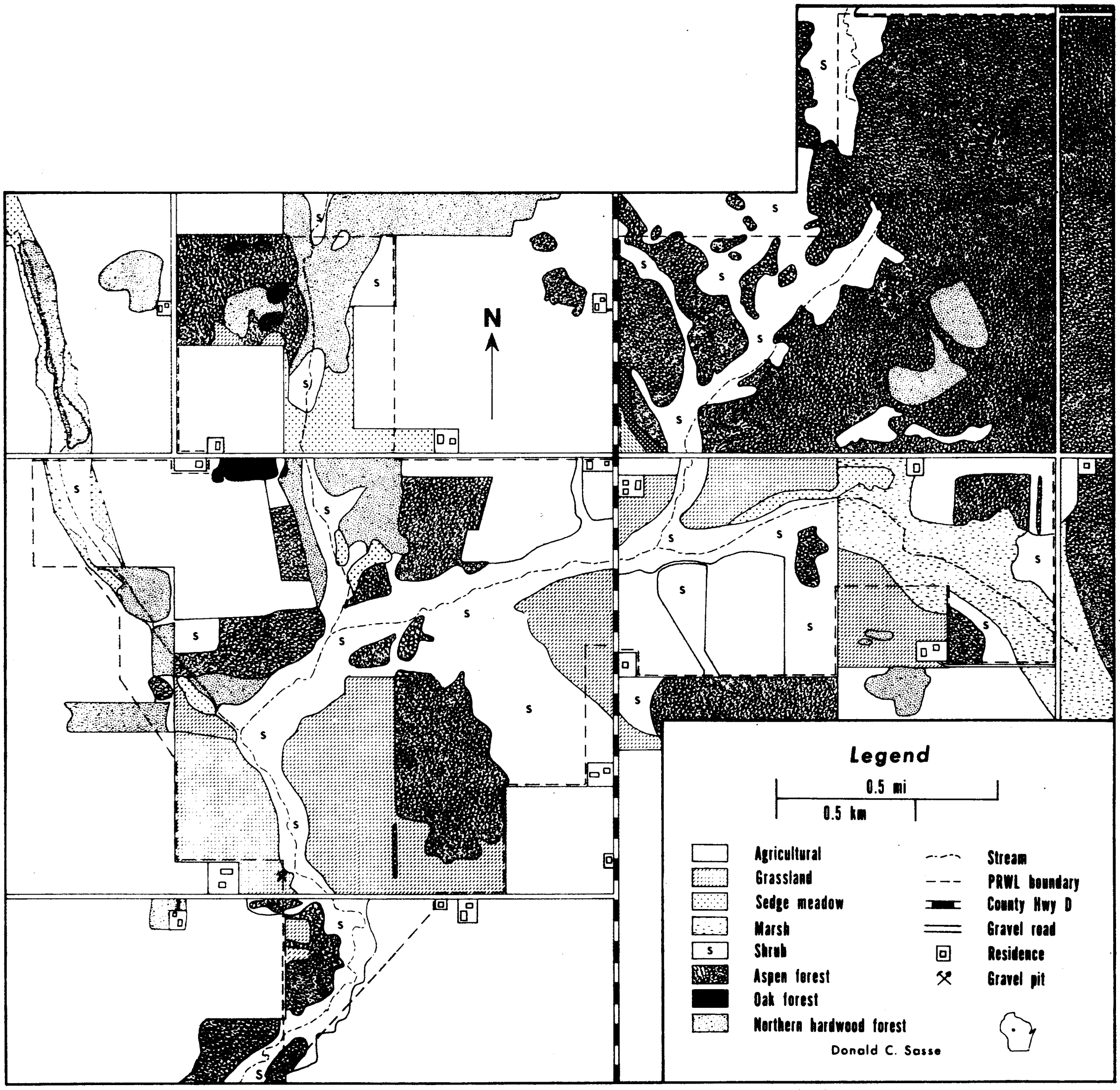


Fig. 8. Cover type map of the Poplar River Watershed Area (PRWA), 1975.

Table 6. Expected loss of cover types, present in 1975, to inundation by the Poplar River Watershed Area impoundment; expressed in ha and percent.

Vegetation covertype	Pre-construction		Inundated lands		Post-construction	
	ha	(%)	ha	(%)	ha	(%)
Cultivated	110.9	(17)	3.6	(3)	107.3	(16)
Grass-forb	77.7	(12)	21.1	(18)	56.6	(9)
Sedge-meadow	18.6	(3)	7.7	(7)	10.9	(2)
Marsh	25.9	(4)	0.0	(0)	25.9	(4)
Shrub	150.6	(23)	53.4	(45)	97.2	(15
Aspen forest	221.1	(33)	15.8	(13)	205.3	(31)
Oak forest	5.7	(1)	0.0	(0)	5.7	(1)
Northern hardwood forest	45.3	(7)	16.2	(14)	29.1	(4)
Surface water (impoundment)	0.0	(0)			117.8	(18)
Totals:	655.8	(100)	117.8	(100)	655.8	(100)

in these areas include narrow-leafed spirea (*Spirea alba*) and red-osier dogwood (*Cornus stolonifera*). A few scattered American elm (*Ulmus americana*) and swamp white oak (*Quercus bicolor*) also occur in these areas. The shrub cover type occurs along stream courses and on other wet soil sites.

Aspen forests (221.2 ha; 33 percent) are dominated by quaking aspen (*Populus tremuloides*), but frequently include subdominant hardwood species, such as red maple (*Acer rubrum*), American basswood (*Tilia americana*), American elm, white oak (*Q. alba*) and bur oak (*Q. macrocarpa*). Major shrubs occurring in the aspen forests include: raspberry and blackberry (*Rubus* spp.), narrow-leafed spirea, common hazel (*Corylus cornuta*) and willow. Aspen forests are distributed on the moderate to well drained sites.

Oak forests (5.7 ha; 1 percent) are dominated by bur oak and white oak. Quaking aspen, white ash (*Fraxinus americana*), red maple, and American elm occur as subdominant tree species. Common shrubs in this cover type include: common hazel, red-osier dogwood, and gooseberry (*Ribes* spp). This cover type occurs on the more well drained upland sites.

Northern hardwood forests (45.3 ha; 7 percent) are dominated by red maple and American basswood, and to a lesser degree by American elm, white oak, white ash, yellow birch (*Betula lutea*), and paper birch (*B. papyrifera*). Quaking aspen also occurs in these stands. Common shrubs include: common hazel as the dominant shrub, and other shrubs such as red-osier dogwood, raspberry, currents (<u>Ribes</u> spp.), and gooseberries. These forest types occur on moderately to well drained sites.

Aspen, oak, and northern hardwood forests comprise 272.1 ha (41 percent) of the total PRWA (655.8 ha). Aspen forest constitutes 81 percent of the PRWA forest area.

Construction of the 117.8 ha impoundment will inundate the following cover types: cultivated, 3.6 ha (3 percent); grass-forb, 21.1 ha (18 percent); sedge-meadow, 7.7 ha (7 percent); shrub, 53.4 ha (45 percent); aspen forest, 15.8 ha (13 percent); and northern hardwood forest, 16.2 ha (14 percent). A total of 32.0 ha (27 percent) of the proposed inundation area is forested.

The cover types present within the area proposed for inundation are common on private lands adjacent to the PRWA. A large portion of the area proposed for inundation is shrub cover type (45 percent), which can be expected to reestablish at least 25 percent of its former cover type area along the impoundment shoreline. The forested areas proposed for inundation contain little merchantable timber. The inundation of productive cultivated, grass-forb, and forested cover types would be mitigated by the creation of productive aquatic wildlife habitat.

<u>Stream Substrate</u>

The stream bed of Brick Creek at the lower-dam area, extending from the proposed dam site downstream 215 m to the road (Section 24-25 line), was 74 percent silt (Fig. 9

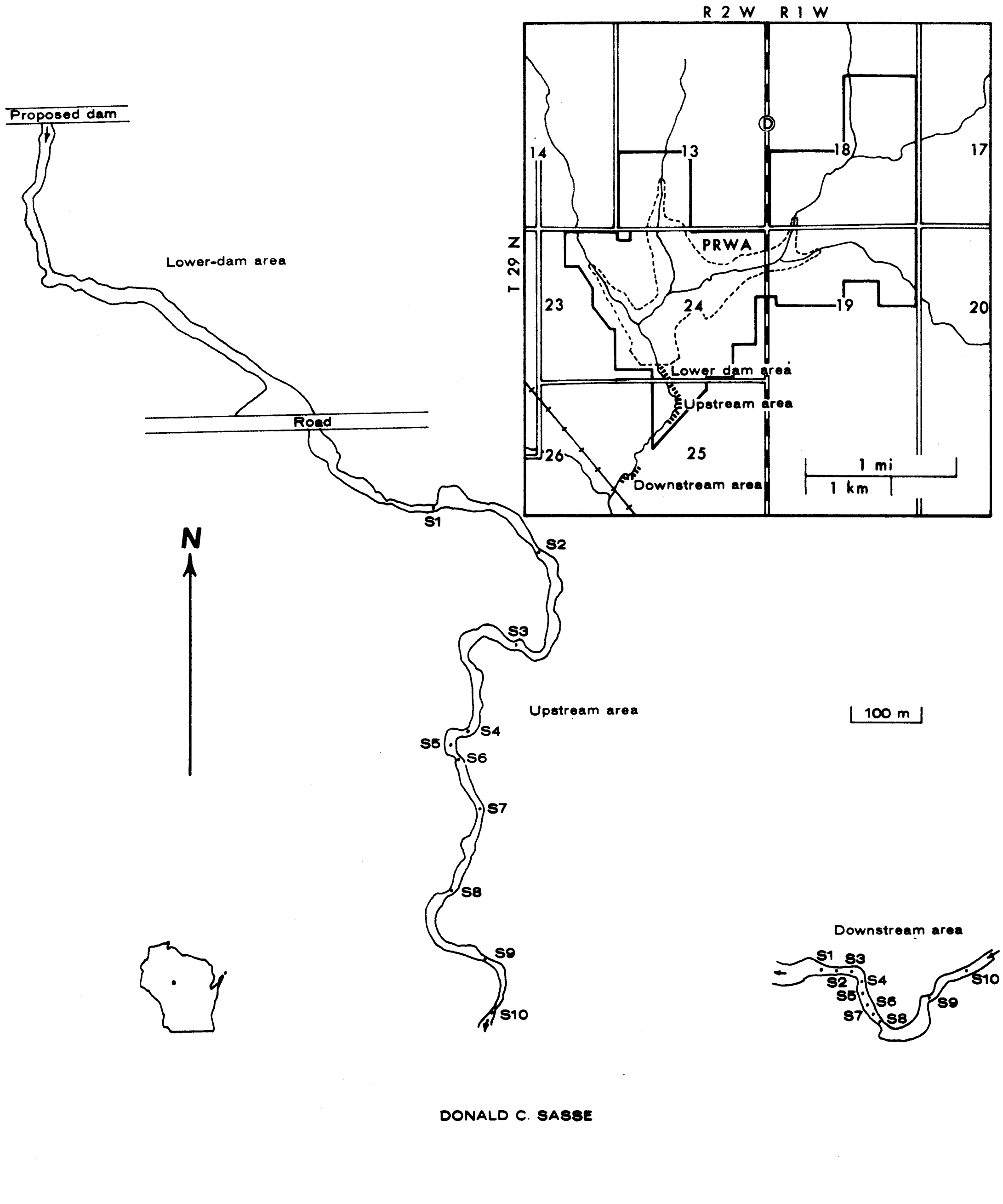


Fig. 9. Locations of the lower-dam, upstream and downstream sample areas, and Surber sample points (S) on Brick Creek, Poplar River Watershed Area (PRWA), 1976.

and Table 7). The silt deposition was probably caused by the slowing of water behind the culverts during high stream discharge periods. The sand and gravel, which constitute the remainder of the substrate (19 and 7 percent, respectively), was present upstream from the silt deposition and near the dam site.

The upstream area extends from the road (Section 24-25 line) downstream for 470 m. This area contained less silt (23 percent) and a more representative distribution of other substrate types, sand (30 percent), gravel (42 percent), and pebble (5 percent).

The lower area begins approximately 1 km below the proposed dam site and extends for 155 m downstream. Gravel was the dominant substrate (72 percent) with pebble comprising most of the remainder (25 percent).

Substrate directly affects stream productivity. A shifting sand substrate is low in macroinvertebrate production whereas rubble and gravel substrate are extremely productive (Tarzwell and Gaufin 1967). A transportation of silt, through erosion, to the highly productive substrates of gravel and pebble would fill substrate intersticies (Tarzwell and Gaufin 1967) and reduce numbers and taxa of organisms (Weber 1973). An increase in silt substrate, resulting from impoundment construction and a subsequent reduction in stream flushing, can be expected.

Aquatic vegetation (macrophytes) provided additional substrate for invertebrates. The stream bed from the dam

Table 7. Percent distribution of dominant substrate types in Brick Creek, August, 1976.

	Sample area		
	Lower-dam	Upstream	Downstream
Substrate			
Physical type (percent):[a]			
Silt	74	23	3
Sand	19	30	0
Gravel	7	42	72
Pebble	0	5	25
Totals	100	100	100
Vegetative species (percent):			
Bur-reed *Sparganium* spp.[b]	71	7	0
Great (softstem) bulrush *Scirpus validus*	17	1	8
Pondweed *Potamogeton crispis*	1	6	13
Waterweed *Elodea canadensis*	1	9	2
Miscellaneous	1	1	1
Totals	91	24	24
Distance of stream mapped (m):	215	470	155
Area of stream substrate mapped (m^2):	1,355	2,185	765

[a] Particle size according to Cummins (1962).
[b] *Sparganium chlorocarpum* and *S. eurycarpus*.

site down to the road had a 91 percent plant cover dominated by bur-reed (Sparganium spp.) and great (softstem) bulrush, 71 and 17 percent, respectively. There was a 24 percent plant coverage at the upstream and downstream areas, although the percent cover of individual plant species differed. The upstream area consisted principally of waterweed, bur-reed, and pondweed (Potamogeton crispis); 9, 7, and 6 percent, respectively. Pondweed and bulrush predominated, 13 and 8 percent, respectively, in the downstream area. An increase of instream vegetation rarely alters the composition of the fauna, but almost always results in an increased biomass (Hynes 1960). Plant coverage will probably increase, with construction of the proposed impoundment, as a result of decreased stream discharge and increased silt deposition.

Aquatic Macroinvertebrates

Aquatic macroinvertebrates, in addition to being good fish food, are good indicators of stream quality because they are sessile, relatively long lived, and sensitive to environmental change. Macroinvertebrates were sampled in riffle areas because a change in discharge most seriously affects those portions of a stream first (Stalnaker and Arnette 1976). Stream sampling efficiency is also greatest in riffles (Gaufin et al. 1965).

Seventy taxa of aquatic macroinvertebrates were collected in Brick Creek (Table 8). The riffles at the upstream and downstream sample areas had a 74 percent "index of similarity" (Odum 1950, 1971) for invertebrate taxa

Table 8. Aquatic macroinvertebrates collected from Brick Creek, 16 April, 19 May and 18 June 1976.

Plecoptera

Perlidae <u>Phasganophora</u>

Perlodidae <u>Isoperla</u>

Ephemeroptera

Heptageniidae <u>Heptagenia</u>, <u>Stenacron</u>, <u>Stenonema</u>

Baetidae <u>Baetis</u>

Leptophlebiidae

Ephemerellidae <u>Ephemerella</u>

Caenidae <u>Caenis</u>

Ephemeridae <u>Ephemera</u>

Odonata

Calopterygidae <u>Calopteryx</u>

Coenagrionidae <u>Argia</u>

Aeshnidae <u>Basiaeschna</u>

Hemiptera

Belostomatidae <u>Belostoma</u>

Trichoptera

Philopotamidae <u>Dolophilodes</u>

Polycentropodidae

Hydropsychidae <u>Cheumatopsyche</u>, <u>Hydropsyche</u>

Glossosomatidae <u>Agapetus</u>, <u>Glossosoma</u>

Hydroptiliadae <u>Agraylea</u>, <u>Ochrotrichia</u>

Phryganeidae <u>Ptilostomis</u>

Limnephilidae <u>Frenesia</u>, <u>Limnephilus</u>, <u>Onocosmoecus</u>, <u>Platycentropus</u>, <u>Pseudostenophylax</u>, <u>Pycnopsyche</u>

Table 8. Continued.

Molannidae	*Molanna*
Helicopsychidae	*Helicopsyche*
Leptoceridae	*Ceraclea*, *Triaenoides*
Megaloptera	
Sialidae	*Sialis*
Lepidoptera	
Pyralidae	*Parargyractis*
Coleoptera	
Haliplidae	*Haliplus*, *Peltodytes*
Dytiscidae	*Agabus*, *Deronectes*[a], *Hydroporus*, *Laccophilus*
Gyrinidae	*Gyrinus*
Hydrophilidae	*Berosus*
Psephenidae	*Ectopria*, *Psephenus*
Elmidae	*Dubiraphia*, *Optioservus*, *Stenelmis*
Dryopidae	*Helichus*
Diptera	
Tipulidae	*Hexatoma*, *Tipula*, *Prionocera*
Ceratapagonidae	
Chironomidae	
Simulidae	*Prosimulium*, *Simulium*
Tabanidae	*Chrysops*
Empididae	
Isopoda	
Asellidae	*Asellus*
Amphipoda	
Talitridae	*Hyalella*

Table 8. Continued.

Decapoda		
	Cambarinae	*Orconectes*
Hydracharina		
Oligochaeta		
Hirudinea		
Gastropoda		
	Amnicola, *Ferrisia*, *Helisoma*, *Physa*	
Pelecypoda		
	Sphaeridae	
	Unionidae	*Lampsilis*

[a] Hilsenhoff (1975) does not separate *Deronectes* and *Oreodytes*.

(Fig. 9). A percent-similarity of zero indicates that taxa of the areas being compared are entirely different, with no taxa in common, while a figure of greater than 50 percent indicates a relatively close similarity.

The mean Biotic Index (B.I.) of 2.15 $\pm$ 0.06 for the upstream area indicates "good" water quality with some enrichment or disturbance (Table 9). The mean B.I. for the downstream area of 2.81 $\pm$ 0.07, and the mean of 2.50 $\pm$ 0.09 for the combined upstream and downstream areas indicates "fair" water quality with moderate enrichment or disturbanc (Hilsenhoff 1977). This disparity between the mean B.I. values from the two areas is, in part, a function of the reciprocal of the index of similarity, i.e., a 26 percent difference between the two areas. Whereas taxa present at the two areas are similar, differences in the mean B.I. may be due to environmental tolerances of individual taxa and their relative abundance.

Variability was greater between B.I.'s for Brick Creek (range: 2.02 to 2.91), than between Brick Creek and Hilsenhoff's (1977) B.I. for the Poplar River. Hilsenhoff (1977) calculated a B.I. of 2.20 for a June 1973 sample taken in the Poplar River several km below its confluence with Brick Creek. The B.I.'s were calculated from June samples after streams had returned to normal flow (Hilsenhoff 1977). I was prevented from taking additional samples by the drought which extended from summer through winter of 1976.

There was no significant difference ($P < 0.05$) between

Table 9. Biotic Index by substrate for benthic macroinvertebrates collected in Surber samples from the upstream and downstream areas, Brick Creek, 18 June 1976.

Sample Site No.	Upstream area		Downstream area	
	Substrate[a]	Biotic Index[b]	Substrate	Biotic Index
1	Gravel	2.09	Pebble	2.84
2	Gravel	2.19	Pebble	2.74
3	Gravel	2.32	Gravel	2.53
4	Gravel	-	Gravel	3.04
5	Gravel	1.79	Gravel	2.66
6	Pebble	2.25	Gravel	3.29
7	Sand	2.13	Pebble	2.91
8	Gravel	2.02	Pebble	2.81
9	Sand	2.11	Gravel	2.60
10	Sand	2.41	Pebble	2.71
$\bar{x}$		2.15 ± 0.06[c]		2.81 ± 0.07
$\bar{x}$ for both areas = 2.50 ± 0.09				

[a] Dominant substrate at the sample site; particle size according to Cummins (1962).
[b] Biotic Index calculated according to Hilsenhoff (1977) and Appendix B.
[c] Mean and standard error of mean.

the B.I.'s from different substrate types at either upstream or downstream areas (student t-test). The apparent similarity of substrate types in Brick Creek may be due to small sample size and/or sample variability, because others have found low invertebrate numbers and/or biomass associated with sand substrate (Tarzwell 1938; Tebo 1955; Egglishaw 1969; and Scullin 1977).

The means of invertebrate volumes increased from 16 April through 18 June at both upstream and downstream areas (Table 10 and 11; Appendix J, K, and L). Mollusca and Decapoda volumes will be discussed separately; their volumes were not included in the total volumes because they occurred erratically, and their large volumes biased the total sample volumes. The total means of monthly volumes and standard errors at the upstream area were 4.93 ± 1.78, 5.30 ± 1.13, and 8.84 ± 2.88 for sample dates 16 April, 19 May, and 18 June 1976, respectively. Volumes at the downstream area were 7.89 ± 2.90, 8.14 ± 1.62, and 9.94 ± 0.84 for sample dates 16 April, 19 May, and 18 June 1976, respectively. This volumetric increase reflects scouring of substrates by spring flooding and subsequent relatively low mean volumes of invertebrates in April (Logan 1963; Minckley 1963; and Scullin 1977). After spring scouring, biomass increased through the summer, because of an increase in numbers and size of organisms.

The means of monthly invertebrate volumes were consistently higher in the downstream area. This may have been

Table 10. Mean volume (ml/m^2) of benthic macroinvertebrates collected in Surber samples from riffles at the upstream area in Brick Creek 16 April, 19 May, and 18 June 1976.

	16 April			19 May			18 June		
	Sand (n = 3)[a]	Gravel (n = 6)	Pebble (n = 1)	Sand (n = 3)	Gravel (n = 6)	Pebble (n = 1)	Sand (n = 3)	Gravel (n = 5)	Pebble (n = 1)
Plecoptera			0.11		0.01 ± 0.01		0.22 ± 0.17	1.47 ± 0.73	2.64
Ephemeroptera	0.51 ± 0.15[b]	0.20 ± 0.07	0.38	0.16 ± 0.04	0.74 ± 0.12	0.49	0.64 ± 0.46	1.15 ± 0.35	0.44
Odonata							0.02 ± 0.02		
Hemiptera									
Trichoptera	0.71 ± 0.30	3.09 ± 2.40	4.18	1.22 ± 0.47	4.47 ± 0.11	1.76	0.09 ± 0.07	4.94 ± 2.23	1.74
Megaloptera								0.02 ± 0.02	0.33
Lepidoptera									
Coleoptera	0.20 ± 0.09	0.47 ± 0.28	0.11	0.22 ± 0.03	0.35 ± 0.17	0.60	0.20 ± 0.07	1.72 ± 0.88	1.43
Diptera	3.70 ± 1.03	0.89 ± 0.38	0.22	1.28 ± 1.19	1.14 ± 0.59	1.16	1.34 ± 0.37	2.78 ± 2.37	0.44
Oligochaeta				0.02 ± 0.02	0.11 ± 0.09		0.02 ± 0.02	0.01 ± 0.01	0.05
Hirudinea	0.07 ± 0.02							0.42 ± 0.20	0.33
Arachnida									
Isopoda		0.13 ± 0.15			0.05 ± 0.03		0.02 ± 0.02	0.30 ± 0.15	0.22
Amphipoda		0.01 ± 0.01			0.01 ± 0.01		0.02 ± 0.02	0.04 ± 0.01	
Mean of totals:	5.19 ± 1.20	4.79 ± 3.04	5.00	2.90 ± 0.72	6.89 ± 1.57	4.01	2.57 ± 0.14	12.85 ± 4.45	7.62
Mean total of all substrates	4.93 ± 1.78 (n = 10)			5.30 ± 1.13 (n = 10)			8.84 ± 2.88 (n = 9)		

[a] Number of samples
[b] Mean and standard error of mean.

Table 11. Mean volume (ml/m^2) of benthic macroinvertebrates collected in Surber samples from riffles at the downstream area in Brick Creek, 16 April, 19 May, and 18 June 1976.

	16 April		19 May		18 June	
	Gravel (n = 5)[a]	Pebble (n = 5)	Gravel (n = 5)	Pebble (n = 5)	Gravel (n = 5)	Pebble (n = 5)
Plecoptera		0.09 ± 0.09		0.01 ± 0.01	0.32 ± 0.10	0.66 ± 0.14
Ephemeroptera	0.28 ± 0.08[b]	0.13 ± 0.03	0.68 ± 0.52	0.48 ± 0.21	1.65 ± 0.57	3.36 ± 1.16
Odonata						
Hemiptera				0.01 ± 0.01		
Trichoptera	5.16 ± 5.09	2.39 ± 1.78	4.47 ± 2.15	5.31 ± 1.88	4.79 ± 1.58	2.51 ± 0.56
Megaloptera		0.04 ± 0.04			0.02 ± 0.01	0.02 ± 0.01
Lepidoptera						
Coleoptera	0.88 ± 0.53	0.60 ± 0.48	0.44 ± 0.13	0.95 ± 0.28	0.88 ± 0.10	0.94 ± 0.17
Diptera	2.05 ± 0.77	3.55 ± 1.58	1.37 ± 0.35	1.57 ± 0.30	1.74 ± 0.55	2.89 ± 0.51
Oligochaeta	0.03 ± 0.01		0.07 ± 0.07	0.02 ± 0.02	0.02 ± 0.01	0.01 ± 0.01
Hirudinea		0.34 ± 0.22	0.04 ± 0.04	0.02 ± 0.02	0.16 ± 0.12	0.08 ± 0.02
Arachnida					0.01 ± 0.00	
Isopoda	0.04 ± 0.02	0.47 ± 0.35	0.27 ± 0.18	0.20 ± 0.09	0.42 ± 0.26	0.53 ± 0.11
Amphipoda	0.05 ± 0.02	0.05 ± 0.04	0.22 ± 0.17	0.15 ± 0.05	0.23 ± 0.17	0.20 ± 0.04
Mean of totals:	8.50 ± 4.97	7.27 ± 3.60	7.57 ± 2.64	8.71 ± 2.19	10.08 ± 1.32	9.79 ± 1.19
Mean of all substrates:	7.89 ± 2.90 (n = 10)		8.14 ± 1.62 (n = 10)		9.94 ± 0.84 (n = 10)	

[a] Number of samples.
[b] Mean and standard error of mean.

caused by at least three factors: (1) The grazed gramanoid streamside vegetation of the lower site was more open. Braatz (1974) also found that the mean annual density of drifting organisms was higher in a meadow than in successive downstream brushy stations, and that the density of detritus produced by riparian vegetation, was positively correlated with the mean density of invertebrates. Scullin (1977) also found that numbers and biomass of benthic macroinvertebrates were consistently higher in a meadow zone and decreased in downstream brushy zones. He felt that the abundance of macroinvertebrates in the meadow was a product of a richer food base in the form of detritus for invertebrates. The greater amount of detritus downstream on the study area also contributes to the greater density of invertebrates. (2) Shrub-riparian vegetation at the upstream area would shade the stream, whereas the meadow in the downstream area would allow more solar radiation to reach the stream. Additional solar radiation would support a higher algal biomass and thus could increase stream production of invertebrates (Odum 1971). (3) Runoff containing organic materials from adjacent agricultural lands between the upstream and downstream areas, may have increased the fertility of the stream, and increased production of algae, and thus invertebrates (Bartsch and Ingram 1959).

Invertebrate taxa volumes in the stream show the presence of a diverse fauna on 16 April, 19 May, and 18 June 1976. Gaufin (1973) and Hart and Fuller (1974) recommend the consideration of a macroinvertebrate community as a whole rather than placing reliance on a single species in a given locality as an indicator of environmental change.

The presence of three principle indicator groups, Plecoptera, Ephemeroptera, and Tricoptera, in Brick Creek is indicative of good stream quality. Gaufin (1973) found these gilled forms to be "...more nearly restricted to, and comprising a larger portion of the clean water association than other groups." Mason et al. (1971) also refer to Plecoptera, Ephemeroptera, and Tricoptera as being sensitive to pollution.

Mean volumes of Plecoptera in June show that they are well established on pebble, and to a lesser extent on gravel, substrate. Plecoptera, which seldom inhabit pure sandy bottoms (Gaufin 1965), were absent from samples taken in sand substrate on the study area. Ephemeroptera were well distributed throughout all substrate types in April through June at the two areas. Tricoptera were present at volumes above those of other invertebrates, for all substrates, with the exception of 16 April at the downstream area, and on sand substrate on 19 May and 18 June. Lower volumes of Tricoptera on 16 April were probably due to the influence of substrate scouring by spring flooding (Logan 1963, Minckley 1963, and Scullin 1977). Shifting sand provides an unstable substrate and organisms such as Tricoptera are particularly vulnerable to scouring (Tebo 1955).

Diptera ranked second in the mean volume of all invertebrates and consistently, except for the April period, was the largest mean volume of organisms on sand substrate. Sand substrate was only present at the upstream area; this substrate distribution may have resulted from the major erosion of the road bed (Section 24-25 line), located above the upstream area, during past years. Scullin (1977) also reported Chironomidae (Diptera) to be the most abundant organisms on sand substrate in a brushy zone. Spring floods, and resulting substrate scouring, probably influenced April invertebrate volumes. Low mean volumes of Oligochaetes indicate pollution tolerant Diptera taxa were present in low volumes; Diptera can be present in both polluted or clean water streams, and higher volumes (Chironomidae) are frequently associated with pollution - low volumes indicate clean water taxa predominate. Mason et al. (1971) refer to Chironomidae (Diptera) and Oligochaeta as pollution tolerant.

Relatively low mean volumes of Isopoda and Amphipoda also indicate good stream quality. The presence of comparatively high mean volumes of Isopoda and Amphipoda at the downstream area are consistent with differences in the B.I. means for the two sites. Organic enrichment in runoff from agricultural lands may influence the downstream area; Isopoda and Amphipoda are capable of tolerating high levels of organic enrichment or disturbance (Hynes 1960).

Molluscs formed 9, 66, and 9 percent of the total invertebrate volume on 16 April, 19 May, and 18 June, respectively, at the upstream area (Appendix I, J, and K). The extremely high mollusc volume on 19 May (66 percent) was due to the presence of Lampsilis which constituted 64 percent of the total invertebrate volume. Molluscs at the downstream area represented 4, 8, and 13 percent of the total invertebrates on 16 April, 19 May, and 18 June, respectively. Molluscs were probably undersampled because I sampled only riffles.

Decapoda were present only in the downstream area on 18 June where they contributed to 1 percent of the total sample volume. The absence of Decapoda may be a result of their ability to evade capture, and/or my sampling only in riffles.

A decrease in environmentally sensitive species of macroinvertebrates, and an increase in the abundance of tolerant organisms, can be expected below the proposed dam after construction. The impoundment will cause a rise in water temperature, a probable reduction in the D.O. concentration, and a decrease in stream flow. A change from a lotic to lentic system, within the inundation area, will cause some lotic species to disappear and lentic species to become more abundant, but should result in an overall increase in macroinvertebrate diversity and abundance on the PRWA.

Fish

Nineteen species of fish were captured in Brick Creek

(Table 12). Seined samples were pooled because of the greater confidence placed on these samples which were taken during the drought in the summer 1976. The redside dace, which occurred in both 1975 and 1976 samples and constituted 0.5 percent of the 1976 samples, is classified as being on "watch status" (Hine et al. 1975).

A decrease in the natural diversity of fish species can be expected with the impounding of Brick Creek. Construction of the proposed impoundment is expected to eliminate the redside dace below the dam and within the inundated area. The survival of the Johnny darter (Etherstoma nigrum), Blackside darter (Percina maculata), and Iowa darter (Etherstoma exile), which are adapted to stream habitats, is doubtful because of the low D.O. concentrations and an increase in water temperature which is expected within the impoundment as well as below the outflow.

The potential for a sport fishery in the PRWA is poor. Results of morphometric, hydrologic and water chemistry analysis discussed previously, support Akeley's (1974) statement that a PRWA impoundment fishery would commonly experience winter kill and possibly summer kill conditions.

Amphibians and Reptiles

Nine species of amphibians and four species of reptiles were detected on the PRWA during the period May 1975 through December 1976 (Table 13). The bullfrog, which is currently listed as "changing status" (Hine et al. 1973), was sighted or its call noted during the spring of 1975 on two occasions,

Table 12. Species of fish captured in Brick Creek in 1975 and 1976.

Species	Electro-fishing 26 June 1975	Dip-net August 1975	Seining 18 July 1976	Seining 15 August 1976[b]	Seining Total 1976
Fathead minnow <u>Pimephales promelas</u>	X[a]		215 (28.3)[c]	170 (21.8)	385 (25.0)
White sucker <u>Catostomus commersoni</u>	X		146 (19.3)	171 (22.0)	317 (20.6)
Brook stickleback <u>Culaea inconstaus</u>	X	X	56 (7.4)	105 (13.5)	161 (10.5)
Blacknose dace <u>Rhinichthys atratulus</u>	X		45 (5.9)	86 (11.0)	131 (8.5)
Creek chub <u>Semotilus atromaculatus</u>	X		55 (7.3)	70 (9.0)	125 (8.1)
Central mudminnow <u>Umbra limi</u>	X	X	55 (7.3)	49 (6.3)	104 (6.8)
Northern redbelly dace <u>Phoxinus eos</u>	X		50 (6.6)	49 (6.3)	99 (6.4)
Pearl dace <u>Semotilus margarita</u>	X		38 (5.0)	24 (3.1)	62 (4.0)
Johnny darter <u>Etherstoma nigrum</u>	X		34 (4.5)	15 (1.9)	49 (3.2)
Blackside darter <u>Percina maculata</u>	X		32 (4.2)	5 (0.7)	37 (2.4)
Bluntnose minnow <u>Pimephales notatus</u>	X		8 (1.1)	13 (1.7)	21 (1.4)
Pumpkinseed <u>Lepomis gibbosus</u>				9 (1.2)	9 (0.6)
Redside dace <u>Clinostomus elongatus</u>	X		4 (0.5)	4 (0.5)	8 (0.5)
Iowa darter <u>Etherstoma exile</u>				4 (0.5)	4 (0.3)
Brassy minnow <u>Hybognathus hankinsoni</u>				1 (0.1)	1 (0.1)

Table 12. Continued.

Species	Electro-fishing 26 June 1975	Dip-net August 1975	Seining 18 July 1976	Seining 15 August 1976[b]	Seining Total 1976
Common shiner *Notropis cornutus*	X		2 (0.3)	1 (0.1)	3 (0.2)
Blacknose shiner *Notropis heterolepis*	X		1 (0.1)	1 (0.1)	2 (0.1)
Black bullhead *Ictalurus melas*		X		1 (0.1)	1 (0.1)
Tadpole madtom *Noturus gyrinus*		X			
Minnow fry (undetermined)			17 (2.2)	1 (0.1)	18 (1.2)
		Totals:	758 (100.0)	779 (100.0)	1,537 (100.0)

[a] X=present in sample

[b] No stream flow - available water restricted to deep holes.

[c] Percent

Table 13. Amphibians and reptiles detected on the Poplar River Watershed Area, 15 May 1975 through 31 May 1977.

Amphibians	
Red-backed salamander	*Plethodon cinereus cinereus*
Common toad	*Bufo americana americana*
Spring peeper	*Hyla crucifer crucifer*
Bullfrog	*Rana catesbeiana*
Green Frog	*Rana clamitans melanota*
Mink frog	*Rana septentrionalis*
Northern leopard frog	*Rana pipiens pipiens*
Pickrel frog	*Rana palustris*
Wood frog	*Rana sylvatica sylvatica*
Reptiles	
Common snapping turtle[a]	*Chelydra serpentina serpentina*
Blanding's turtle	*Emydoidea blandingi*
Midland painted turtle	*Chrysemys picta marginata*
Eastern garter snake	*Thamnophis sirtalis sirtalis*

[a] Sighting of hatchlings emerging from nest.

but it was not heard or seen in 1976. A poor distribution of surface waters and related wetlands appear to be limiting to many herptile species.

Herptile numbers and diversity should increase after construction of the proposed impoundment. The increase in amount and distribution of permanent shallow surface waters, will increase the habitat and food supply for many species.

Waterfowl Breeding Pair Counts

Spring waterfowl use of the PRWA was minimal. The total waterfowl breeding pair counts recorded for the PRWA were 0.9 and 1.3 pairs/km of Brick Creek in 1975 and 1976, respectively (Fig. 10). One pair of mallards and one pair of wood ducks (*Aix sponsa*) were residents on the PRWA during the late May count (16 through 25 May) in 1975. Early May counts (7 through 13 May) in 1976 revealed two pairs of mallards and 4 pairs of blue-winged teal. Late May counts (18 through 27 May) in 1975 showed one pair of blue-winged teal to be present. All surface water areas on the PRWA were censused for breeding waterfowl. Breeding waterfowl use of the PRWA is restricted by a poor distribution, and meager amount, of surface water. Construction of the proposed impoundment would create permanent surface waters and increase waterfowl habitat in the area.

Woodcock Singing Ground Survey

An average of 2.00 woodcock per 1.61 km transect, S.E. = 0.50 (Fig. 10), was recorded in four woodcock singing-ground surveys made from 30 April through 13 May 1976 (Table 14).

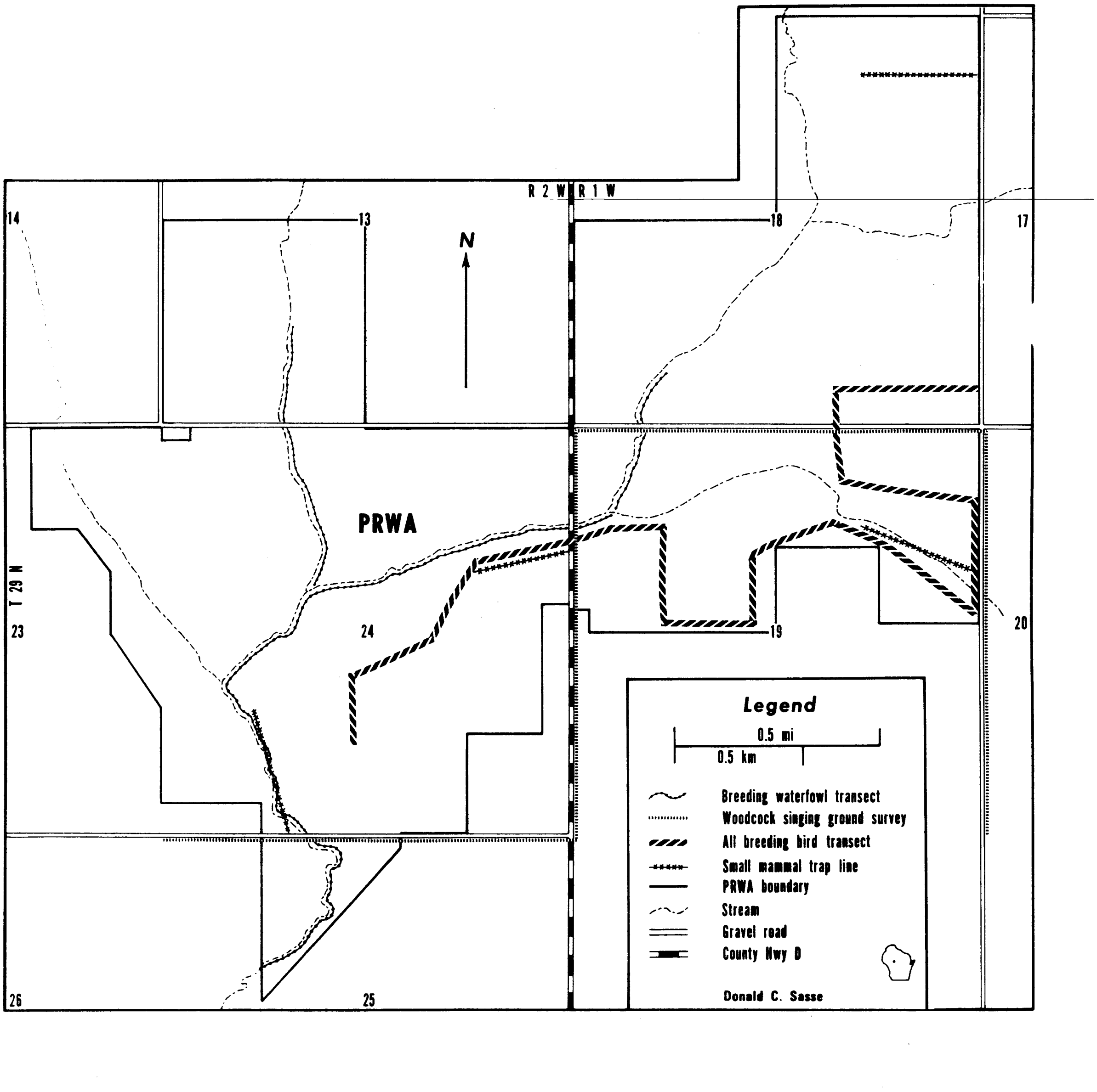


Fig. 10. Breeding waterfowl, woodcock singing ground, all breeding bird, and small mammal trap line transects on the Poplar River Watershed Area (PRWA), 1975 and 1976.

Table 14. Woodcock singing ground surveys (n = 4) conducted on the Poplar River Watershed Area, 30 April through 13 May 1976.

Date	No. of woodcock recorded in 10 stops[a]	No. of woodcock per mile
April 30	9	2.25
May 7	8	2.00
May 8	7[b]	1.75
May 13	8	2.00
	$\bar{x}$ = 8	2.00
	S.E. = 0.50	

[a] Frog vocalizations consistently limited the hearing range to 100 feet at two of the ten stops.

[b] Traffic noises limited hearing at one of the ten stops.

Traffic noises limited the hearing range at one of the transect stops on 8 May when only seven woodcock were counted. Frog vocalizations consistently limited the effective hearing range to about 30 m at two of the ten stops during each of the four transect surveys. Singing ground surveys conducted on the PRWA are not directly comparable to other regional surveys, because the PRWA survey route was more intense to detect woodcock on lands contained in, and adjacent to, the area proposed for inundation. Inundation of existing woodcock habitat by the proposed impoundment is expected to be mitigated by a natural reestablishment of shrubs along the shoreline which would increase the distribution and amount of woodcock habitat.

Ruffed Grouse Drumming Counts

Fifteen drumming ruffed grouse (one grouse/13.8 ha of forest) were present on the PRWA, excluding the 64.8 ha in the NE ¼ of Section 18, Hoard Township (Fig. 11). The NE ½ of Section 18 was not included in the survey, but would have similar ruffed grouse densities. Two of the 15 drumming grouse were in pole-stage stands of the northern hardwood forest cover type, the remainder were in the aspen forest cover type. A density of one grouse/2.4 ha in May reflects population saturation in aspen forests in Minnesota (Gullion 1976). Much of the aspen forest on the PRWA is over mature with poorly dispersed cut over areas. Four ha blocks in an interspersion of juxtaposition of 0 to 10, 10 to 20, 20 to 30 and 30 to 40 year aspen age classes,

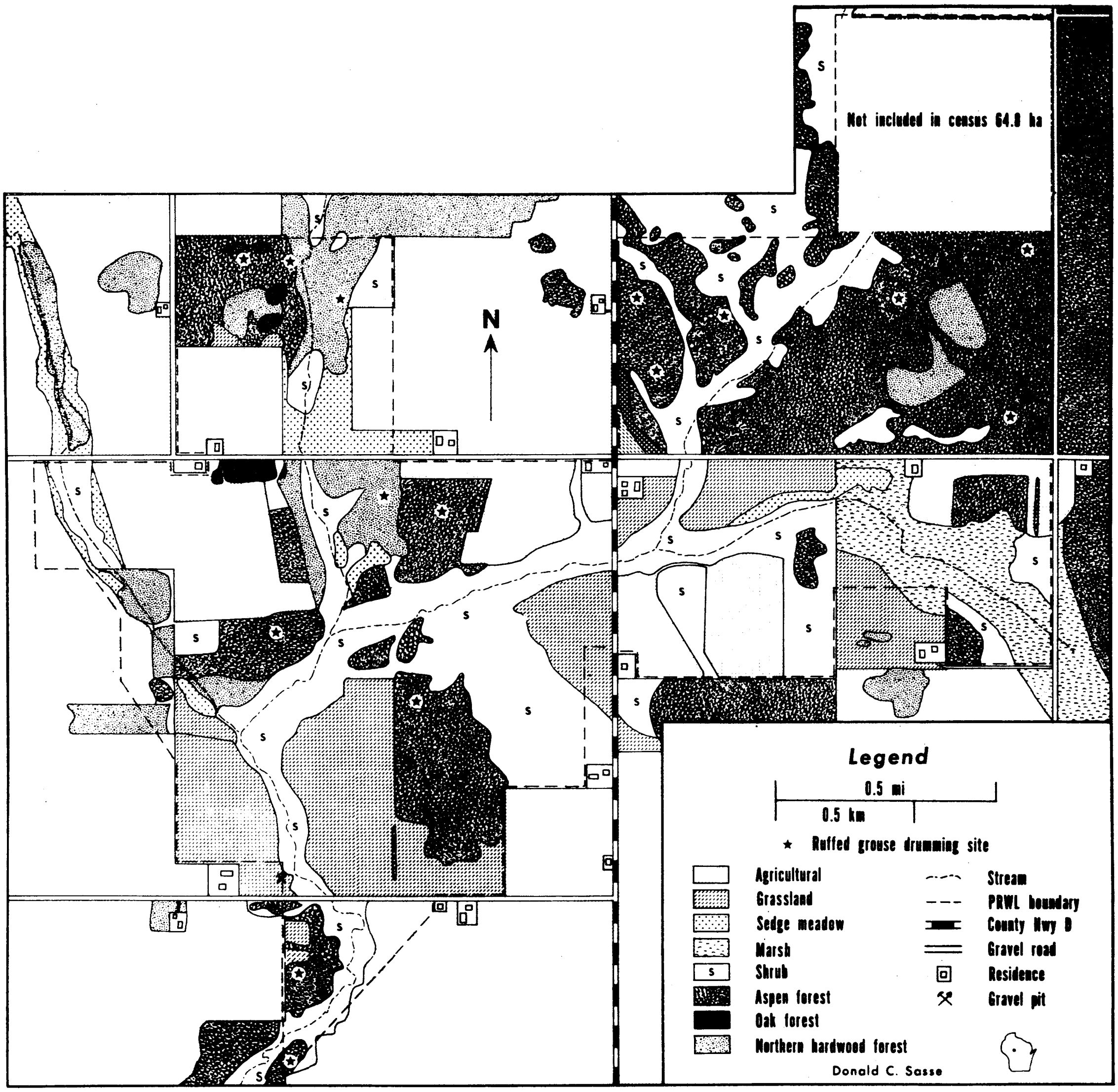


Fig. 11. Distribution of ruffed grouse drumming sites on the Poplar River Watershed Area (PRWA), 15 April through 16 May 1976.

would provide new forest openings, dense sapling stands, pole stage stands for nesting cover and mature trees for winter food (Gullion 1968).

Construction of the proposed impoundment will inundate two grouse drumming logs and reduce grouse habitat, however, the habitat loss would have a minimal effect on grouse populations in the local region because grouse habitat is abundant on private lands adjacent to the PRWA.

All Birds

From May 1975 through December 1976, 107 species of birds were detected on the PRWA (Table 15). The small number of waterfowl and shorebird species is a reflection of meager amounts of surface water, and is characteristic of the northeast-central Wisconsin region.

The relative abundance of avian breeding pairs on the 5.2 km transect (Fig. 10) conducted from 20 through 27 May 1976 in grass-forb (1.3 km), marsh (1.1 km), shrub (1.3 km) and forest cover types (1.0 km) are presented in Tables 16, 17, 18 and 19, respectively. Breeding pairs were absent from the cultivated cover type (0.5 km) because fields had been recently plowed or were in corn stubble.

Bird species counted on transects numbered 16, 9, 20, and 22 for the grass-forb, marsh, shrub, and forest cover types, respectively, excluding the cultivated cover type. The number of bird species increased with the age of terrestrial plant communities. Bird species diversity has previously been shown to be correlated with foliage height

Table 15. Birds observed, and the cover types in which each observation was made, on the Poplar River Watershed Area, 15 May 1975 through 31 December 1976. St = stream, Cu = cultivated, Ga = grass-forb, Se = sedge, Ma = marsh, Sh = shrub, As = aspen forest, Oa = oak forest, and No = northern hardwood forest.

Pied-billed grebe (Ma)
Podilymbus podiceps

Great blue heron (St,Ma)
Ardea herodias

Green heron (St,Ma)
Butorides virescens

Great egret (Ma)
Egretta albus

American bittern (St,Ga,Ma)
Botaurus lentiginosus

Canada goose (Cu,Ga)
Branta canadensis

Mallard duck (St,Ma)
Anas platyrhynchos

American black duck (St)
Anas rubripes

Green-winged teal (St)
Anas crecca

Blue-winged teal (St,Ma)
Anas discors

Wood duck (St)
Aix sponsa

Hooded merganser (St)
Mergus cucullatus

Red-tailed hawk (Ga,As)
Buteo jamaicensis

Red-shouldered hawk (As,Oa,No)
Buteo lineatus

Broad-winged hawk (Cu,Ga)
Buteo platypterus

Rough-legged hawk (Cu,Ga)
Buteo lagopus

Northern harrier (Ga,Se,Ma)
Circus cyaneus

Peregrine falcon (Ma)
Falco peregrinus

American kestrel (Cu,Ga)
Falco sparverius

Ruffed grouse (Sh,As,Oa,No)
Bonasa umbellus

Sharp-tailed grouse[a] (Cu)
Tympanuchus phasianellus

Ring-necked pheasant (Cu,Ga)
Phasianus colchicus

Sora rail (St,Se,Ma)
Porzana carolina

American coot (St)
Fulica americana

Killdeer (Cu,Ga,Sh)
Charadrius vociferus

American woodcock (Ga,Sh)
Scolopax minor

Common snipe (Se,Ma,Sh)
Gallinago gallinago

Rock dove (Cu,Ga,Sh)
Columba livia

Mourning dove (Cu,Ga,Sh,As)
Zenaida macroura

Black-billed cuckoo (Sh,As)
Coccyzus erthropthalmus

Great horned owl (No)
Bubo virginianus

Short-eared owl (Ga)
Asio flammeus

Table 15. Continued.

Common nighthawk (Cu,Ga,Se,Ma)
Chordeiles minor

Chimney swift (Cu,Ga,Se,Ma)
Chaetura pelagica

Ruby-throated hummingbird (Oa, No)
Archilochus colubris

Belted kingfisher (St)
Ceryle alcyon

Common flicker (Cu,Sh,As)
Colaptes auratus

Red-headed woodpecker (Cu,As)
Melaner erthrocephalus

Yellow-bellied sapsucker (As, No)
Sphyrapicus varius

Hairy woodpecker (As,Oa,No)
Picoides villosus

Downy woodpecker (As,No)
Picoides pubescens

Eastern kingbird (Ga,Sh)
Tyrannus tyrannus

Great crested flycatcher (As)
Myiarchus crinitus

Eastern phoebe (Oa,No)
Sayornis phoebe

Alder flycatcher (Sh)
Empidonax traillii

Least flycatcher (As,Oa,No)
Empidonax minimus

Eastern wood pewee (As,No)
Contropus virens

Horned lark (Cu,Ga)
Eremophila alpestris

Tree swallow (Cu,Ga,Se,Sh)
Tachycineta bicolor

Barn swallow (Ga,Ma)
Hirundo rustica

Cliff swallow (Cu,Ga,Se,Ma)
Petrochelidon pyrrhonota

Purple martin (Cu,Ga)
Progne subis

Blue jay (As,Oa,No)
Cyanocitta cristata

Northern raven (As,No)
Corvus corax

American crow (Ga,As,Oa,No)
Corvus brachyrhynchos

Black-capped chickadee (Sh,As Oa,No)
Parus atricapillus

White-breasted nuthatch (As, Oa)
Sitta carolinensis

Northern house wren (Cu)
Troglodytes aedon

Sedge wren (Ga,Ma,Sh)
Cistothorus platensis

Gray catbird (Sh,As)
Dumetella carolinensis

Brown thrasher (Ga,Sh)
Toxostoma rufum

American robin (Cu,Ga,Sh,As, Oa,No)
Turdus migratorius

Wood thrush (As,No)
Hylocichla mustelina

Veery (As,Oa,No)
Hylocichla fuscescens

Golden-crowned kinglet (As, No)
Regulus satrapa

Table 15. Continued.

Ruby-crowned kinglet (Sh)
Regulus calendula

Ceadar waxwing (As,Oa,No)
Bombycilla cedrorum

Northern shrike (Sh,As)
Lanius excubitor

European starling (Cu,Ga,Sh)
Sturnus vulgaris

Red-eyed vireo (As,No)
Vireo olivaceus

Warbling vireo (As,No)
Vireo gilvus

Nashville warbler (As)
Vermivora ruficapilla

Yellow warbler (Sh)
Dendroica petechia

Yellow-rumped warbler (As,Oa, No)
Dendroica coronata

Blackburnian warbler (As,No)
Dendroica fusca

Chestnut-sided warbler (As,No)
Dendroica pensylvanica

Ovenbird (As,Oa,No)
Seivrus aurocapillus

Common yellowthroat (Sh,As)
Geothlypis trichas

Wilson's warbler (As)
Wilsonia pusilla

American redstart (Oa)
Setophaga ruticilla

House sparrow (Cu,Ga,Sh)
Passer domesticus

Bobolink (Cu,Ga)
Dolichonyx oryzivorus

Eastern meadowlark (Cu,Ga)
Sturnella magna

Red-winged blackbird (Cu,Ga, Se,Ma,Sh)
Agelaius phoeniceus

Northern oriole (Sh,As)
Icterus galbula

Brewer's blackbird (Sh)
Euphagus cyanocephalus

Common grackle (Cu,Ga,Ma,Sh, As)
Quiscalus quiscula

Brown-headed cowbird (Cu,Ga, Se,Ma,Sh,As)
Molothrus ater

Scarlet tanager (As,Oa)
Piranga olivacea

Northern cardinal (Sh,As,Oa No)
Cardinalis cardinalis

Rose-breasted grosbeak (As,Oa, No)
Pheucticus ludovicianus

Indigo bunting (As,Oa)
Passerina cyanea

Evening grosbeak (As,Oa,No)
Coccothraustes vespertina

Purple finch (Oa)
Carpodacus purpureus

Common redpoll (Sh,As,No)
Acanthis flammea

American goldfinch (Ma,Sh)
Carduelis tristis

Rufous-sided towhee (Sh)
Pipilo erthrophthalmus

Savannah sparrow (Ga)
Ammodramus sandwichensis

Table 15. Continued.

Grasshopper sparrow (Ga) *Ammodramus savannarum*
Vesper sparrow (Ga) *Pooecetes gramineus*
Northern junco (Cu,Ga,Sh,As,No) *Junco hyemalis*
Chipping sparrow (Cu,Sh) *Spizella passerina*
White-crowned sparrow (Sh) *Zonotrichia leucophrys*
White-throated sparrow (Sh,As) *Zonotrichia albicollis*
Fox sparrow (Sh,As) *Zonotrichia iliaca*
Song sparrow (Cu,Ga,Se,Ma,Sh) *Zonotrichia melodia*
Snow bunting (Cu,Ga) *Plectrophenax nivalis*

[a] Sighted by Soil Conservation Service personnel.

Table 16. Relative abundance of avian breeding pairs in the grass-forb cover type of the Poplar River Watershed Area, 20 through 27 May 1976.

Species	Relative abundance
American bittern[a] Botaurus lentiginosus	Rare
Killdeer Charadrius vociferus	Uncommon
Rock dove[a] Columba livia	Rare
Mourning dove[a] Zenaida macroura	Rare
Eastern kingbird[a] Tyrannus tyrannus	Rare
Barn swallow[a] Hirundo rustica	Rare
American crow[a] Corvus brachyrhynchos	Rare
Sedge wren Clistothorus platensis	Abundant
Bobolink Dolichonyx oryzivorus	Rare
Eastern meadowlark Sturnella magna	Rare
Common grackle[a] Quiscalus quiscula	Uncommon
Brown-headed cowbird Molothrus ater	Common
Savannah sparrow Ammodramus sandwichensis	Common
Grasshopper sparrow Ammodramus savannarum	Common
Vesper sparrow Pooecetes gramineus	Rare

Table 16. Continued.

Species	Relative abundance
Song sparrow *Zonotrichia melodia*	Abundant

[a] Assumed to be a breeding resident of an adjacent cover type.

Table 17. Relative abundance of avian breeding pairs in the marsh cover type of the Poplar River Watershed Area, 20 through 27 May 1976.

Species	Relative abundance
American bittern *Botaurus lentiginosus*	Common
Mallard *Anas platyrhynchos*	Rare
Common snipe *Gallinago gallinago*	Rare
Sedge wren *Cistothorus platensis*	Abundant
Red-winged blackbird *Agelaius phoeniceus*	Abundant
American goldfinch *Carduelis tristis*	Common
Barn swallow[a] *Hirundo rustica*	Rare
Common grackle[a] *Quiscalus quiscula*	Rare
Song sparrow *Zonotrichia melodia*	Common

[a] Assumed to be a breeding resident of an adjacent cover type.

Table 18. Relative abundance of avian breeding pairs in the shrub cover type of the Poplar River Watershed Area, 20 through 27 May 1976.

Species	Relative abundance
American bittern[a] *Botaurus lentiginosus*	Rare
Mallard[a] *Anas platyrhynchos*	Uncommon
Northern harrier *Circus cyaneus*	Rare
Killdeer[a] *Charadrius vociferus*	Rare
Common snipe[a] *Gallinago gallinago*	Rare
Rock dove[a] *Columba livia*	Common
Eastern kingbird *Tyrannus tyrannus*	Rare
Barn swallow[a] *Hirundo rustica*	Common
Sedge wren *Cistothorus paltensis*	Common
Gray catbird *Dumetella carolinensis*	Common
American robin *Turdus migratorius*	Rare
Yellow warbler *Dendroica petechia*	Common
Common yellowthroat *Geothlypis trichas*	Rare
Red-winged blackbird *Agelaius phoeniceus*	Abundant
Northern oriole *Icterus galbula*	Rare

Table 18. Continued.

Species	Relative abundance
Brewer's blackbird[a] *Euphagus cyanocephalus*	Uncommon
Brown-headed cowbird *Molothrus ater*	Abundant
American goldfinch *Carduelis tristis*	Rare
White-crowned sparrow *Zonotrichia leucophrys*	Abundant
Song sparrow *Zonotrichia melodia*	Abundant

[a] Assumed to be a breeding resident of an adjacent cover type.

Table 19. Relative abundance of avian breeding pairs in the forest cover type of the Poplar River Watershed Area, 20 through 27 May 1976.

Species	Relative abundance
Red-shouldered hawk *Buteo lineatus*	Rare
Ruffed grouse *Bonasa umbellus*	Common
Mourning dove *Zenaida macroura*	Common
Common flicker *Colaptes auratus*	Rare
Yellow-bellied sapsucker *Sphyrapicus varius*	Rare
Downy woodpecker *Picoides pubescens*	Common
Great crested flycatcher *Myiarchus crinitus*	Rare
Least flycatcher *Empidonax minimus*	Uncommon
Blue jay *Cyanocitta cristata*	Abundant
Black-capped chickadee *Parus atricapillus*	Uncommon
American crow *Corvus brachyrhynchos*	Abundant
American robin *Turdus migratorius*	Rare
Wood thrush *Hylocichla mustelina*	Common
Veery *Hylocichla fuscescens*	Abundant
Red-eyed vireo *Vireo olivaceus*	Rare

Table 19. Continued,

Species	Relative abundance
Blackburnian warbler *Dendroica fusca*	Rare
Chestnut-sided warbler *Dendroica pensylvanica*	Common
Ovenbird *Seiurus aurocapillus*	Uncommon
Common yellowthroat *Geothlypis trichas*	Common
Common grackle *Quiscalus quiscula*	Uncommon
Brown-headed cowbird *Molothrus ater*	Rare
Rose-breasted grosbeak *Pheucticus ludovicianus*	Abundant

diversity (Wilson 1974). The lower number of species recorded in the marsh (9) as compared to the grass-forb (6) or shrub (20) cover types of the PRWA, is believed to be due to the lack of foliage height diversity and the lack of surface water in the marsh during the nesting season.

The avian habitat which would be inundated by the proposed impoundment, which are also common habitat on adjacent private lands, would be mitigated by the creation of wetland habitat which is currently marginal within the region. Establishing new wetland habitat in the area will increase the abundance and diversity of associated avian species.

Mammals

Twenty-nine taxa of mammals were detected on the PRWA from 15 May 1975 through 31 May 1976 (Table 20). The small mammal censuses, snap-trap capture index (SCI) and pit-fall capture index (PCI), were conducted 17 through 22 July in the grass-forb, 30 July through 4 August in the marsh, 6 through 11 July in the shrub, and 12 through 17 August in the forest cover types during 1976 at locations shown in Fig. 10.

Small mammal densities were remarkably similar, except in the shrub cover type (SCI = 8.30), throughout the summer - SCI = 10.31, 10.28, and 10.26 in the grass-forb, marsh, and forest cover type, respectively (Table 21). The mammal densities in the shrub cover type were probably lower because it was the first cover type trapped in the season, 6 through 11 July, and rodent densities had not yet increased to those

Table 20. Mammals detected on the Poplar River Watershed Area, 15 May 1975 through 31 May 1977.

Masked shrew
Sorex cinereus[a]

Water shrew
Sorex palustris[a]

Arctic shrew
Sorex arcticus[a]

Pygmy shrew
Microsorex hoyi[a]

Short-tailed shrew
Blarina brevicauda[a]

Star-nosed mole
Condylura cristata[a]

Eastern cottontail
Sylvilagus floridanus

Snowshoe hare
Lepus americanus

Eastern chipmunk
Tamias striatus[a]

Woodchuck
Marmota monax

Gray squirrel
Sciurus carolinensis

Red squirrel
Tamiasciurus hudsonicus

Northern flying squirrel
Glaucomys sabrinus[a]

Beaver
Castor canadensis

White-footed mouse
Peromyscus leucopus[a]

Gapper's red-backed mouse
Clethrionomys gapperi[a]

Meadow vole
Microtus pennsylvanicus[a]

Muskrat
Ondatara zibethicus

Black rat
Rattus rattus[a]

House mouse
Mus musculus[a]

Meadow jumping mouse
Zapus hudsonius[a]

Fox
Spp.[b]

Raccoon
Procyon lotor

Ermine
Mustela erminea[a]

Long-tailed weasel
Mustela frenata[a]

Mink
Mustela vison

Striped skunk
Mephitis mephitis

River otter
Lontra canadensis

White-tailed deer
Odocoileus virginianus

[a] Specimen placed in the University of Wisconsin - Stevens Point museum.

[b] Identification based on tracks, either red fox (*Vulpes vulpes*) or gray fox (*Urocyon cinereoargenteus*).

Table 21. Small mammal snap-trap and pit-fall trap index on the Poplar River Watershed Area, 6 through 17 August 1976; captures per 100 trap nights.

Species	Cover type			
	Grass-forb (17 to 22 July)[a]	Marsh (30 July to 4 August)	Shrub (6 to 11 July)	Forest (12 to 17 August)
Masked shrew *Sorex cinereus*	1.96[b] (5.33)[c]	0.41 (2.18)	0.86 (2.00)	4.93 (5.00)
Water shrew *Sorex palustris*			0.24	
Arctic shrew *Sorex arcticus*	2.45 (11.05)	5.57 (22.76)	3.63 (22.06)	
Pygmy shrew *Microsorex hoyi*			0.12	0.33
Short-tailed shrew *Blarina brevicauda*	0.16 (1.33)	1.35	0.48	2.20 (9.00)
Star-nosed mole *Condulura cristata*		0.28		
White-footed mouse *Peromyscus leucopus*	0.21		0.24	2.49
Gapper's red-backed mouse *Clethrionomys gapperi*				0.31
Meadow vole *Microtus pennsylvanicus*	5.53	2.41 (1.00)	2.61	

Table 21. Continued.

Species	Cover type: Grass-forb (17 to 22 July)[a]	Marsh (30 July to 4 August)	Shrub (6 to 11 July)	Forest (12 to 17 August)
House mouse *Mus musculus*		0.12		
Meadow jumping mouse *Zapus hudsonius*		0.14	0.12	
Totals:	10.31 (17.71)	10.28 (25.94)	8.30 (24.06)	10.26 (14.00)
Total trap nites:	519.0 (67)	723.0 (91)	613.5 (72)	679.0 (85)

[a] Trapping period.

[b] Snap-trap capture index (see METHODS section).

[c] Pit-fall trap capture index (see METHODS section).

indicated later in the summer.

Shrews were most abundant in the cover types in which soil moisture was high. The PCI captured almost exclusively shrews; Nellis et al. (1974) also found pit-fall traps more efficient, than snap-traps, in capturing shrews. Shrew densities were highest in the lowland marsh (PCI = 25.94) and shrub (PCI = 24.06) cover types, compared to the upland grass-forb (PCI = 17.71) and forest (PCI = 14.00) cover types. High soil moisture levels insure high humidity in shrew tunnels and are, along with temperature, important factors influencing shrew distribution (Getz 1961).

The meadow vole (Microtus pennsylvanicus) was the most abundant mammal in the grass-forb cover type (SCI = 5.53), and was followed by the arctic shrew (SCI = 1.96). The white-footed mouse (Peromyscus leucopus) and the short-tailed shrew (Blarina brevicauda) were also present, but at low densities (SCI = 0.21 and 0.16, respectively). The diversity of small mammal species found in the grass-forb cover type was similar to that found in grasslands in Minnesota in which the meadow vole was also the most abundant small mammal (Iverson et al. 1967). The arctic shrew which was abundant on the PRWA, was an exception to Iverson's et al. (1967) species diversity list.

The arctic shrew was the dominant mammal in the marsh cover type (SCI = 5.57), followed by the meadow vole (SCI = 2.41), short-tailed shrew (SCI = 1.35), masked shrew (SCI = 0.41), and star-nosed mole (Condylura cristata) (SCI = 0.28).

The meadow jumping mouse (Zapus hudsonius) and the house mouse (Mus musculus) were less abundant (SCI = 0.14 and 0.12, respectively).

The arctic shrew (SCI = 3.63) ranked first in the shrub cover type, followed by the meadow vole (SCI = 2.61), masked shrew (SCI = 0.86), short-tailed shrew (SCI = 0.48), water shrew (Sorex palustris) (SCI = 0.24), white-footed mouse (SCI = 0.24), pygmy shrew (Microsorew hoyi) (SCI = 0.12), and meadow jumping mouse (SCI = 0.12).

The arctic shrew was considerably more abundant when compared to the ratio of pygmy, water, and masked shrews inhabiting the PRWA. The average ratio, in the marsh and shrub cover types of the PRWA, was ten arctic shrews to one masked shrew compared with the 0.04:1 ratio thought to exist in Wisconsin (Jackson 1961). Jackson (1961) also felt that arctic shrews are five times more numerous than are pygmy or water shrews. The ratio of the water shrew to the pygmy shrew (2:1) was similar on the PRWA. However, the ratio of the arctic shrew to the water shrew, and the ratio of the arctic shrew to the pygmy shrew (15:1 and 30:1, respectively) were considerably higher on the PRWA than the ratios indicated by Jackson (1961).

The arctic shrew was present on the PRWA at an abnormally high density. This shrew accounted for 62, 88, and 92 percent of the small mammals in the grass-forb, marsh, and shrub cover types, respectively. The abundance of the arctic shrew in the grass-forb cover type on the PRWA is atypical, and may indicate arctic shrew dispersal from overcrowded preferred habitat, marsh and shrub cover types, to less favorable habitat. Jackson (1961) stated that the normal habitat of the arctic shrew is wet wooded swamps or willow-alder marshes.

The arctic shrew was also more abundant than the meadow vole in the marsh and shrub cover types of the PRWA. Clough (1963) studied a small mammal population in a marsh-shrub habitat near Madison, Wisconsin and found that the meadow vole was the most common small mammal, with the masked shrew second and the arctic shrew third. This difference between the PRWA and Clough (1963) in the ranking of the arctic shrew, to the meadow vole and masked shrew, supports the supposition that arctic shrew densities were abnormally high on the PRWA.

The water shrew and star-nosed mole were present in restricted habitats. The water shrew was present in portions of the shrub cover type along Brick Creek. This shrew is nearly aquatic and inhabits partially wooded areas near surface waters; northern Clark County is the southern most part of its range in Wisconsin (Jackson 1961). The star-nosed mole was present in low densities in the marsh cover type of the PRWA. This mole prefers muck, humus, or lightly sandy soil (Jackson 1961). The silt soils of the PRWA uplands probably restrict it to the organic soils present in the wet lowlands.

The masked and short-tailed shrews were the principal mammals, and were present in equal abundance in the forest cover type. The masked and short-tailed shrews ranked first and second, respectively, in the SCI, but were inversely ranked in the PCI. The white-footed mouse ranked second (SCI = 2.49), followed by the short-tailed shrew (SCI = 2.20), pygmy shrew (SCI = 0.33) and Gapper's red-backed mouse (Clethrionomys gapperi) (SCI = 0.31). Arctic shrews were not captured in the forest cover type.

The pygmy shrew was present in shrub and forest cover types in low numbers. Long (1972) stated that pygmy shrews are not taken frequently but have been found in a variety of habitats and usually within 30 m or less of water. Surface water was absent in the forest cover type, but was present in the shrub cover type which the pygmy shrew inhabited.

The masked shrew and short-tailed shrew occurred in all four cover types, but the meadow jumping mouse was found only in the marsh and shrub cover types. Iverson et al. (1967) found these three species in habitats ranging from grassland to continuous forest in Minnesota. The meadow jumping mouse may have been absent from the grass-forb and forest cover types because these upland areas were too dry. Jackson (1961) stated that this mouse is found in a variety of habitats, but usually in moist grassy situations, and often near surface water.

The white-footed mouse and Gapper's red-backed mouse were abundant in the forest cover type. The white-footed mouse was found in all cover types with the exception of the marsh cover type; it was most abundant in the forested cover type. Jackson (1961) reported similar white-footed mouse habitat preferences ranging from forested to brushy cover types. Gapper's red-backed mouse was abundant, but present only in the forested cover type on the PRWA. Jackson (1961) reported similar habitat preference for this mouse.

The species composition of non-flying small mammals (bats were not collected) on the PRWA, is similar to that reported for Clark and Taylor counties by Schmidt (1931), Jackson (1961), and Clark (1972). The following small mammals were found by these authors, but were not detected on the PRWA: least chipmunk (Eutamias minimus), thirteen-lined ground squirrel (Spermophilus tridecemlineatus), Franklin's ground squirrel (Spermophilus franklini), southern flying squirrel (Glaucomys volans), deer mouse (Peromyscus maniculatus), pine mouse (Pitymys pinetorum), southern bog lemming (Synaptomys cooperi), and woodland jumping mouse (Napaeozapus insignis). These species were not detected on the PRWA because of habitat deficiency, or perhaps because of their secretive habits, reduced susceptibility to trapping or occurrence at low densities.

Burrowing mammals, e.g., badger (Taxidea taxus) and the thirteen-lined ground squirrel, were not observed on the PRWA and were either rare or absent. Silt soils, level topography, and a high ground water table on the PRWA may be a limiting factor for burrowing mammals. Woodchuck (Marmota monax) and striped skunk (Mephitis mephitis) dens on the PRWA were associated primarily with the foundations of old buildings.

The eastern chipmunk (Tamias striatus) was common in the forest cover type. Gray squirrels (Sciurus carolinensis) were observed only in or adjacent to the oak cover type. The sparse distribution of mast and lack of suitable nest cavities probably limit squirrel abundance. The red squirrel (Tamiasciurus hudsonicus) and the northern flying squirrel were more widely distributed, than the gray squirrel, throughout the forest cover types.

Eastern cottontail (Sylvilagus floridanus) and snowshoe hare (Lepus americanus) were well distributed throughout the PRWA. The hare was particularly abundant in the shrub and aspen forest cover types.

Furbearer abundance was low. Muskrats (Ondatra zibethicus) were present, but sparsely distributed and were often concentrated in deep pools below bridges during midsummer because of the intermittent nature of Brick Creek. A lack of surface water in the marsh proper, also limited muskrat distribution. Mink (Mustela vison) and weasel-ermine (Mustela spp.) sign was frequently present along Brick Creek and in the marsh. Beaver (Castor canadensis) cuttings and otter (Lontra canadensis) tracks were observed only once along Brick Creek - these species are infrequent visitors to the PRWA. Raccoon (Procyon lotor) sign was common, and fox tracks were observed infrequently during the winter.

White-tailed deer (Odocoileus virginianus) were commonly observed on the PRWA during all seasons of the year except winter when they were rare.

Small mammals provide a prey base for raptors, canids, and other predatory animals. Inundation of cover types by the proposed impoundment will decrease the small mammal prey base, but the loss would be mitigated by a major increase in habitat for furbearers and other wetland associated mammals.

Conclusion

The construction of the proposed PRWA impoundment will increase the present sparse regional distribution of wetlands and should increase species diversity. The construction of the impoundment will create a wetland unit in a region of Wisconsin where there is a poor distribution of surface waters. Establishment of wetlands is unique when compared to the current national trend toward wetland filling or drainage. Unique species confined to a lotic environment, such as the redside dace, would be negatively affected by an impoundment. However, losses would be mitigated by benefits afforded to other wildlife, such as the bullfrog. Wildlife associated with surface waters are expected to show a dramatic increase in diversity and production. Implementation of wildlife management practices will help to maintain a high level of diversity and production on the area.

MANAGEMENT RECOMMENDATIONS (10-Year Plan)

Land use recommendations are based on soil type, present land use, and the habitat requirements of various species of wildlife. Management recommendations are grouped according to habitat types (units). Recommendations within management units, where applicable, are presented in the following sequence: Recommendations - (what to do), Justification - (why do it), Timing - (when to do it), Locations - (where to do it), Methods - (how to do it), and Costs - (1978 projected costs).

Unit I: Surface Water

WATER LEVEL FLUCTUATIONS

Recommendations:

1. Draw water levels down for 1 year, after the impoundment has been filled for 5 years.
2. Plant reed canary grass on the exposed substrate during the summer of the drawdown.

Justification:

A 15 May to 1 March drawdown to the 1,256 ft elevation line will expose 63 percent of the impoundment substrate (Fig. 1C). The 1 March through 31 May mean inflow, with allowance for evaporation loss is 2,907 acre-feet (A-ft) and will be sufficient to refill the impoundment (Table 1).

Periodic draw-downs will not interfere with flood control priority. Organic matter builds up within a stable water regime as a result of incomplete decomposition caused by low bacterial activity under anaerobic conditions (Ruttner 1953). This accumulation of organic matter would reduce the storage capacity of the impoundment for flood control. Soil aeration, after drawdown, accelerates the rate of bacterial decomposition of accumulated organic materials (Cook and Powers 1956) and would help maintain a maximum storage capacity for flood control.

An impoundment draw-down will also arrest aquatic succession and should increase waterfowl productivity. Waterfowl use of impoundments can be expected to reach a peak in the first few years after flooding and then decline after 4 or 5 years (Hartman 1949; MacNamara 1957; Kadlec 1962; Harris and Marshall 1963). At the age of 5 to 6 years an impoundment reaches a stage approaching the lower values of alkalinity and specific conductance found in natural waters. The successional stage of vegetation which develops under these conditions is low quality waterfowl food. Desirable food plants, such as pondweeds and other submerged and floating species, are displaced by cattails and sedges. The number of invertebrate taxa also decreases, and undesirable taxa become more numerous (Whitman 1976). After the impoundment has been filled for 5 years, draw-down and soil drying will set back succession to a stage similar to that of early, more productive years.

Soil nutrient release during draw-downs can be maximized by planting terrestrial plant species which maximize biomass production and have various photosynthetic efficiencies. Broadcasting reed canary grass on exposed mudflats that result from the drawdown, will augment the volunteer plant species. This increased plant growth will increase detritus when flooded, and thereby maximize invertebrate production for waterfowl. Invertebrates are important in waterfowl diets because of the protein they supply to laying hens, moulting adults, and young broods (Sugden 1973; Swanson and Meyer 1973; Whitman 1973; Krapu 1974; Swanson et al. 1974).

Outbreaks of botulism are a potential problem because of some key ecological conditions. The shallow nature of the impoundment and intermittent stream inflow during summer, are characteristic of the PRWA. The shallow water edges of mudflats are favorite loafing and feeding places for waterfowl. A decrease in the water level through the summer could kill aquatic macroinvertebrates and fish which would then provide the medium for the growth of the bacteria *Clostridium botulinium*. Dead invertebrates and maggots from dead fish infected with this anaerobe contain a toxin which, when ingested by waterfowl, can cause botulism poisoning. Botulism poisoning can be controlled by raising the water level to temporarily disperse waterfowl to other areas. However, the inflow of Brick Creek would be insufficient to substantially increase the water level of the PRWA impoundment as a botulism control measure.

Timing:

Start the draw-down on 15 May and begin refilling on the following 1 March. Seed canary grass during the summer while the exposed substrate is still wet.

Methods:

Broadcast canary grass seed on exposed mud flats at a rate of 6 lb/A. Do not seed areas which have live trees on them because shade will inhibit seed germination and growth. Canary grass seed may be purchased from Waupaca Farm and Garden, 214 Water Street, Waupaca, Wisconsin 54981.

Costs:

Canary grass seed: $4.70/lb, at 6 lbs/A, for 75 A	$ 2,115.00
Labor: $5.00/man hour, at 1 A/hour, for 75 A	375.00
Total cost:	$ 2,490.00

NESTING ISLANDS

Recommendations:

1. Construct 7 nesting islands, 25 ft in diameter, and dispersed throughout the impoundment as indicated in Fig. 12. Seed islands to grasses.
2. Maintain islands in a gramanoid plant successional stage by prescribed burning.
3. Give excavation and deployment of level ditching and potholes priority over construction of nesting islands.

Justification:

Islands have been used by nesting waterfowl in areas which lack suitable nest-habitat and suffer high nest predation (Hammond and Mann 1956; Duebbert 1966; Young 1968;

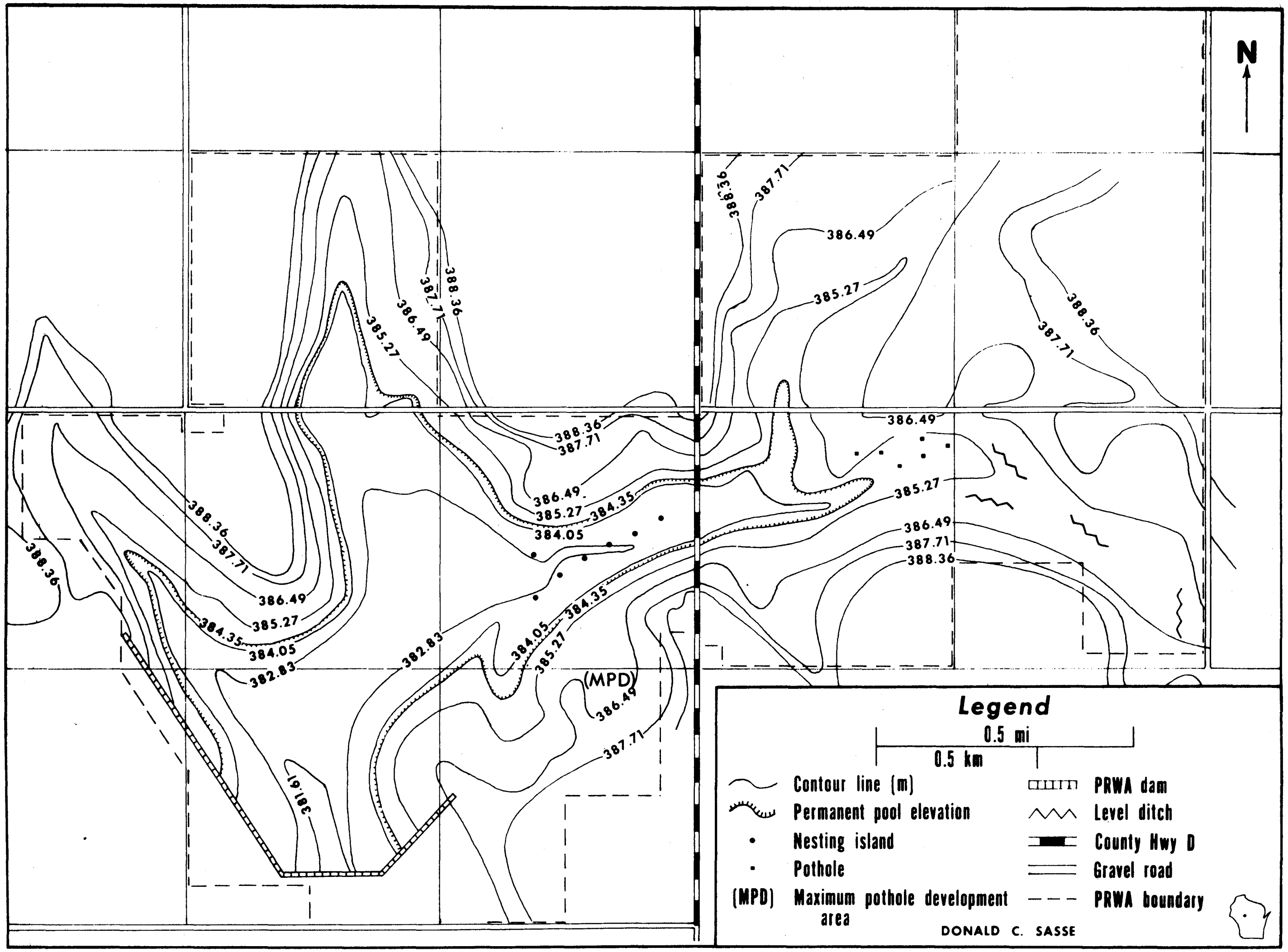


Fig. 12. Topography of the Poplar River Watershed Area (PRWA), 1976.

Linde 1969; Mathisen 1969; Vermeer 1970). The proposed islands are designed to provide loafing areas, nesting habitat and research opportunities. Similar islands have received little use by nesting waterfowl in other parts of Wisconsin (pers. comm.: Dick Hunt, 1975, WDNR).

Advantages of nesting islands include: (1) reduction in disturbance of nesting waterfowl by mammals, (2) increased capacity for territorial occupancy resulting from the high ratio of water-land edge land mass, and (3) close proximity to water, food, loafing (or lookout sites), and nesting cover (Hammond and Mann 1956).

A narrow, shallow shelf on the windward side (west) of each island will allow emergent vegetation to become established and thus help protect the island from erosion and provide cover for waterfowl. Monitor the islands annually for erosion. The installation of log booms or riprap may be required to further protect them from erosion during early spring prior to vegetation emergence.

Timing:

Construct islands prior to filling the impoundment. Seed islands after their construction and while the soil is still moist. If construction is delayed until late fall, begin seeding after ground-thaw in the spring. Conduct prescribed burning on islands in May-June; begin the first burn in 1980.

Methods:

Construct islands with a bulldozer according to the dimensions given in Fig. 13. Seed islands with a 1:1 ratio of canary grass and rye (Secale cereale), or a mixture of other suitable grasses, at a rate of 6 lbs/A. Maintain island vegetation in a gramanoid form by prescribed burning. Maintain a 4 year prescribed burning rotation on the islands; burn 1 or 2 islands annually.

Costs:

Island construction: $1.15/yd^3$, at 952 yds^3 per island, for 7 islands	$ 7,665.00
Seeding and mulching of islands: 0.45 A	390.00
Maintenance: prescribed burning on 1 or 2 islands annually at $50 per year for 6 years	300.00
Total costs:	$ 8,355.00

WOOD DUCK MANAGEMENT

Recommendations:

1. Erect 20 wood duck nest boxes, in 4 clusters containing 5 boxes each, with predator deterring modifications. Disperse the clusters as shown in Fig. 14.
2. Conduct annual maintenance of nest boxes.

Justification:

Suitable nesting cavities do not exist on the PRWA for wood ducks. The factors most limiting to wood duck production are the lack of suitable nesting cavities, predation, and interspecies competition for available cavities. Wood duck nesting boxes can effectively increase wood duck production, especially where the number of natural cavities is limiting (Bellrose et al. 1964; McGilvrey 1966; Jones and

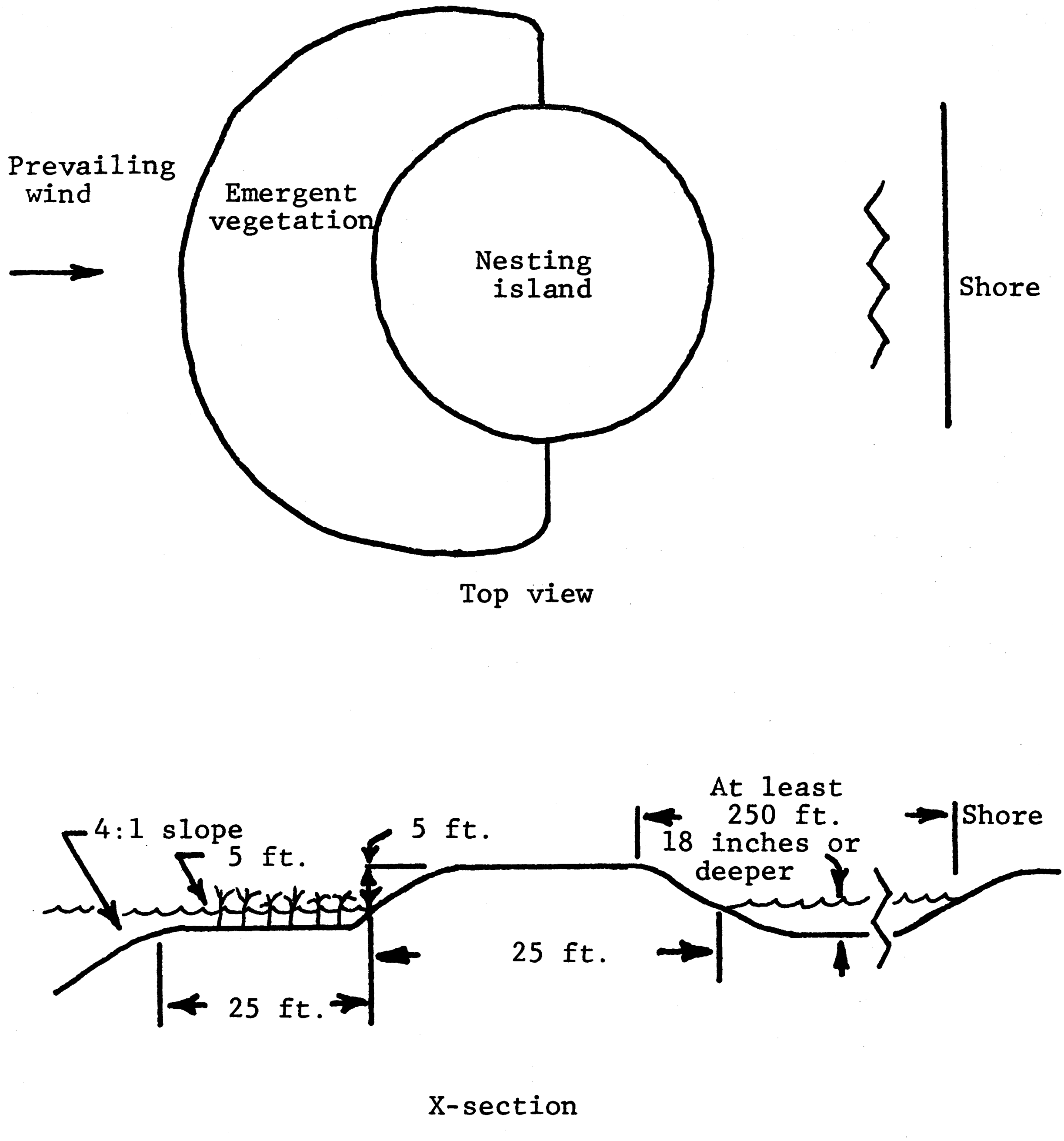


Fig. 13. Dimensions of waterfowl nesting islands for the Poplar River Watershed Area impoundment. Dimensions assume a permanent water level of 1,261.0 ft. of elevation.

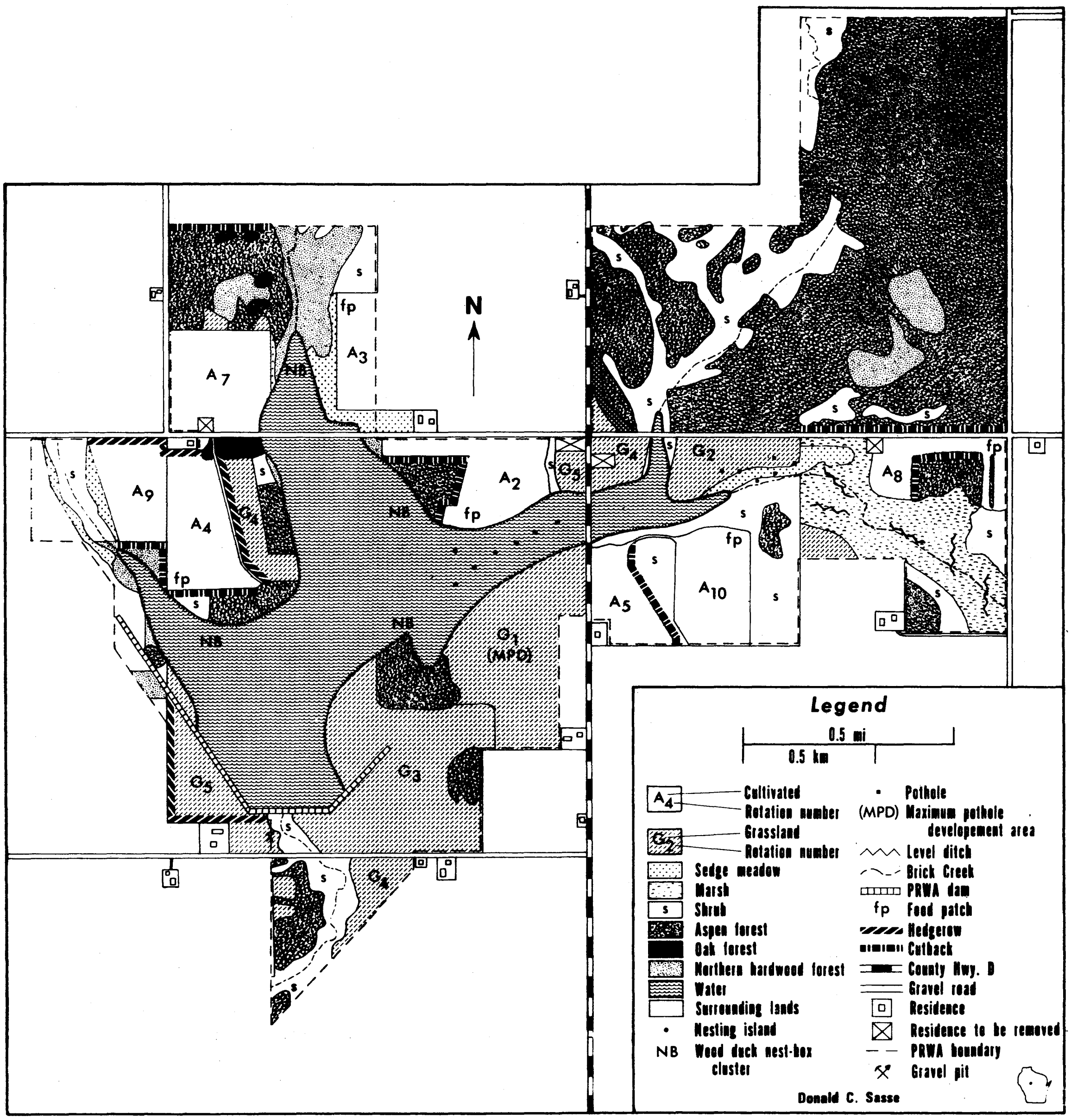


Fig. 14. Wildlife management practices for the Poplar River Watershed Area (PRWA), 1976.

Leopold 1967; Hester and Dermid 1973; Beshears 1974). Management to increase wood duck production consists primarily of providing predator-proof nesting boxes in habitat where insufficient numbers of natural nesting cavities are available and/or nest predation is severe. A minimum of one usable cavity per 5 A of woodlands is necessary for wood ducks, and additional cavities would be desirable (McGilvrey 1966; Beshears 1974).

The advantages of nesting boxes over natural cavities are: (1) they are easily visible, therefore easily found by ducks, (2) if well constructed, they last longer than natural cavities, which are generally short-lived, (3) they can be more effectively protected against predation, and (4) ducklings are spared the hazards of a long, overland journey if the boxes are placed near permanent water (Grice and Rogers 1965).

Plastic nest boxes are cheaper, when man-hours are figured into the cost of construction of wood boxes. In addition they are rot proof, light weight, their construction facilitates easy cleaning, and the outside surface is smooth enough to inhibit climbing predators. Cylinderical metal, and presumably plastic, houses afford greater protection than wooden houses; however, they are widely accepted by wood ducks only when: (1) there is a high density of breeding wood ducks, (2) the breeding population is expanding, or (3) a local population is conditioned to nesting in houses (Bellrose et al. 1964). A high density of nesting wood ducks is not present on the PRWA, and therefore 20 wooden nesting boxes are initially recommended. Install plastic boxes in later years to provide additional nesting sites as broods hatch, migrate, and return to their natal nesting area.

Annual nest box maintenance is necessary to maximize wood duck production. Boxes may become unserviceable because of accumulated nest refuse or wind damage.

Nesting requirements for wood ducks will be met with the erection of nest boxes. The impoundment will meet the other production requirements of wood ducks and other waterfowl. The distribution of impoundment water depths, potential emergent vegetative cover, and nutrient concentrations should provide optimum conditions for waterfowl breeding pairs and brood rearing.

Timing:

Erect nest boxes in early spring 1978, and begin annual nest box maintenance in early spring 1979.

Locations:

Determine locations for mounting individual boxes within each cluster in the field.

Methods:

Mount nest boxes 4 to 5 ft above the high water mark. Space boxes at 150 to 300 ft intervals within each cluster, and with a minimum of 600 ft between clusters. Erect boxes in shaded areas to deter starlings from nesting in them. Mount boxes over water on trees; an inverted cone shield of sheet metal will be necessary to deter climbing predators. For large trees, a metal band at least 50 inches long and wide enough to overlap around the tree, will effectively guard against predation. Place 4 inches of fresh sawdust in each box for nesting material. Instructions for construction of wooden wood duck nest boxes are presented in McGilvrey (1966), Giles (1971), and Beshears (1974). Dimensions and description of the attachment of a second starling nest box to the wood duck nest boxes, which deter starlings from nesting in the wood duck nest boxes, are presented in Grabill (1977). Plastic wood duck boxes may be purchased under the brand name "The Tom Tubbs Wood Duck Box" from the Minnesota Waterfowl Association, Inc., P.O. Box 72, Albert Lea, Minnesota 56007.

Maintain an excess of 50 to 100 percent more nest boxes than are used by nesting wood ducks, e.g., when 10 of the initial 20 boxes are used, erect additional boxes.

Do not consider erection of nest boxes unless provisions are made for their maintenance and for predator deterring structures. Inspect nest boxes annually prior to ice melt, to repair damaged boxes, clean out debris, and insert fresh sawdust.

If wood duck use of the impoundment is low for the first 2 years, consider relocating wild broods of wood ducks from other wildlife areas. Capen et al. (1974) describes the transplant procedure, in which wild hen wood ducks are captured with their broods in nest boxes. Broods and wing clipped hens are then moved and released from a slow release box.

Costs:

Materials:	Lumber, at $5.00/box, for 20 boxes ..	$ 100.00
	Sheet metal predator guards: at $3.00/guard, for 20 boxes	60.00
	Erection hardware and nails: at $1.00/box, for 20 boxes	20.00
Labor:	Construction, $5.00/man hour, 0.75 hour/box, for 20 boxes	100.00
	Erection, $5.00/man hour, 0.75 hour/box, for 20 boxes	75.00
	Maintenance, $5.00/man hour, 0.5 hour/box, for 20 boxes annually, for 8 years	400.00
	Total costs:	$ 755.00

NESTING PLATFORMS

Recommendations:

1. Erect nesting platforms for great blue herons and double crested cormorant (*Phalacrocorax auritus*) if a nesting tradition becomes established on the PRWA.

Justification:

Trees located within the inundated area will provide initial sites for heron and cormorant nesting after flooding. Functional nesting sites will decrease after 8 to 10 years, as trees die and are blown over. The erection of nesting platforms at this time will maintain nesting habitat.

Timing and Location:

Examine functional nesting sites in 1986 and erect suitable nesting platforms where needed.

Methods:

Contact the Wisconsin Department of Natural Resources for current methods. Research on nest platform construction and use is continuing at this time.

Costs:

Materials:	6 nesting platforms on one 35 ft telephone pole	$ 106.00
Labor:	construction of 6 nesting platforms, equipment rental, and erection of the pole	89.00
	Total costs:	$ 195.00

Unit II: Marsh

LEVEL DITCHING

Recommendations:

1. Excavate 5 level ditches for a total of 3,500 ft of ditching, according to the dimensions in Fig. 15; disperse them as shown in Fig. 12 and 14.
2. Broadcast the spoil and leave a 12 ft berm between the ditch and the spoil.
3. Seed the spoil in grasses.

Justification:

Level ditching has been used as a wildlife management technique to improve semi-dry wetland habitat in Wisconsin for waterfowl and furbearers (Anderson 1948; Linde 1969).

Some of the values realized from level ditching that are applicable to the PRWA include: (1) to improve the distribution of water in marshes having dense, unbroken stands of vegetation, (2) provide open water for waterfowl courtship and brood rearing, and (3) establish, increase or maintain aquatic food and cover plants for waterfowl (Atlantic Flyway Council 1972). The deep water of the ditches also makes it possible for muskrats to obtain food despite thick ice, provides protection from freeze-outs, maintains conditions during summer drought periods, and thus increases the muskrat population (Anderson 1948; Mathiak 1953).

Ditches should zig-zag at 100 ft intervals to increase the visual isolation of waterfowl breeding pairs and thereby increase their density.

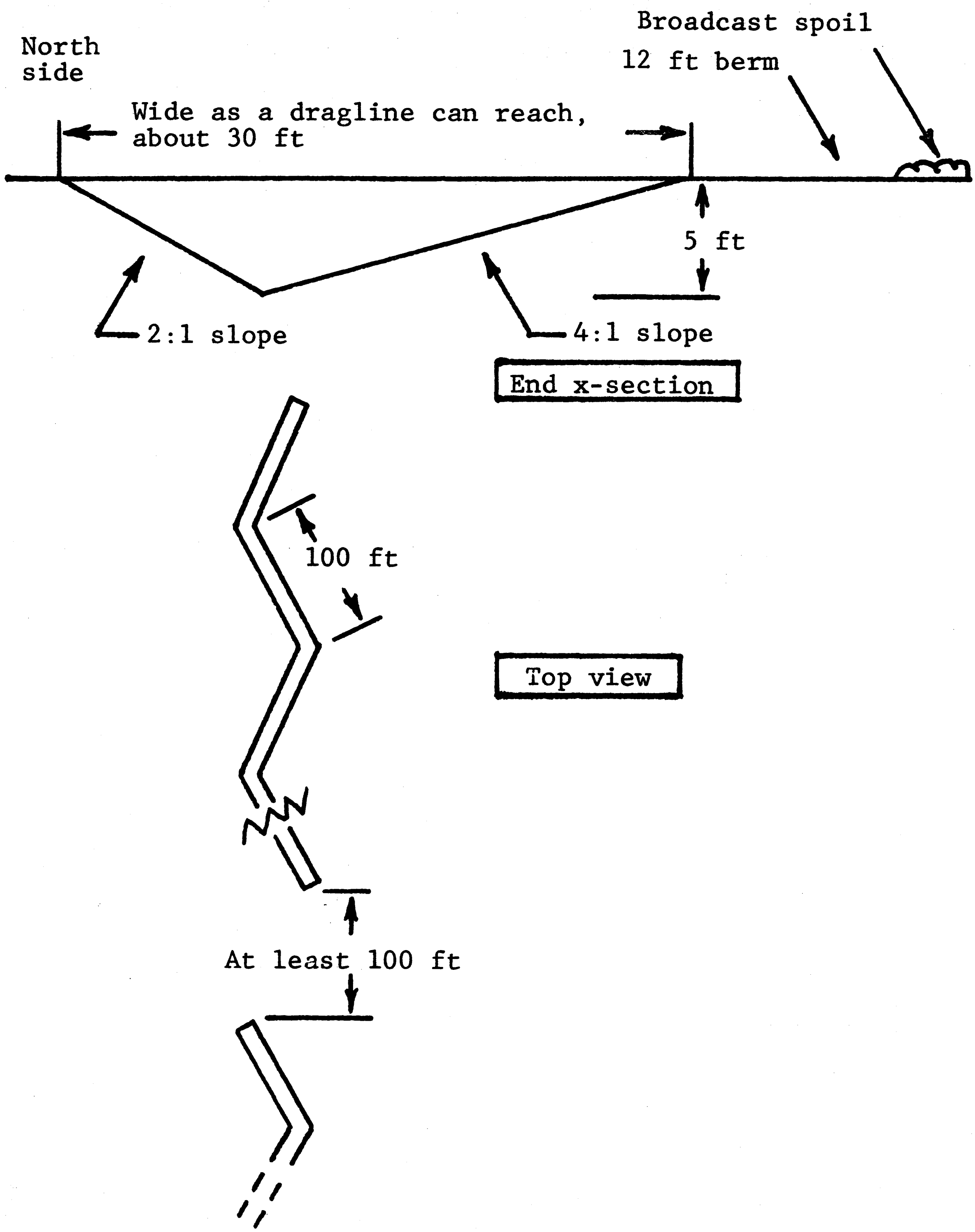


Fig. 15. Level ditching specifications for the Poplar River Watershed Area.

Broadcast the spoil to avoid creating a spoil bank which would result in a "predator sink" for nesting waterfowl. Waterfowl tend to nest on spoilbanks and thus become easy prey. A spoil bank would also draw nesting waterfowl away from more desirable nesting areas which are established to reduce predation (see Unit III: Grasslands). Broadcasting the spoil with a berm, helps to increase the longevity of the ditches by decreasing the siltation from erosion and muskrat tunneling in spoil banks.

Timing:

Construct ditches during the fall of 1976, and seed broadcast spoil while the soil is still moist.

Locations:

Construct level ditches in the northern ½ of Section 19 (Fig. 1B, 12, and 14).

Methods:

Dredging is the most economical method of constructing ditches (Linde 1969). Complete all excavation, requiring the use of a dragline, at one time to reduce the cost.

The 100 ft zig-zag interval is optimum, a 300 ft interval is maximum. Space parallel ditches 200 ft apart if a modification from the arrangement in Fig. 12 and 14 is necessary (Linde 1969).

Seed the spoil area with equal parts of canary grass and rye at the rate of 6 lbs/A following excavation.

Costs:

Excavation: \$1.08/yd^3, for 9,700 yds^3 for

3,500 ft of ditching .... $ 10,480.00

Spoil re-vegetation: $41,00/A for seed, fertilizer and their application, for 5.6 A 230.00

Total costs: $ 10,710.00

POTHOLES

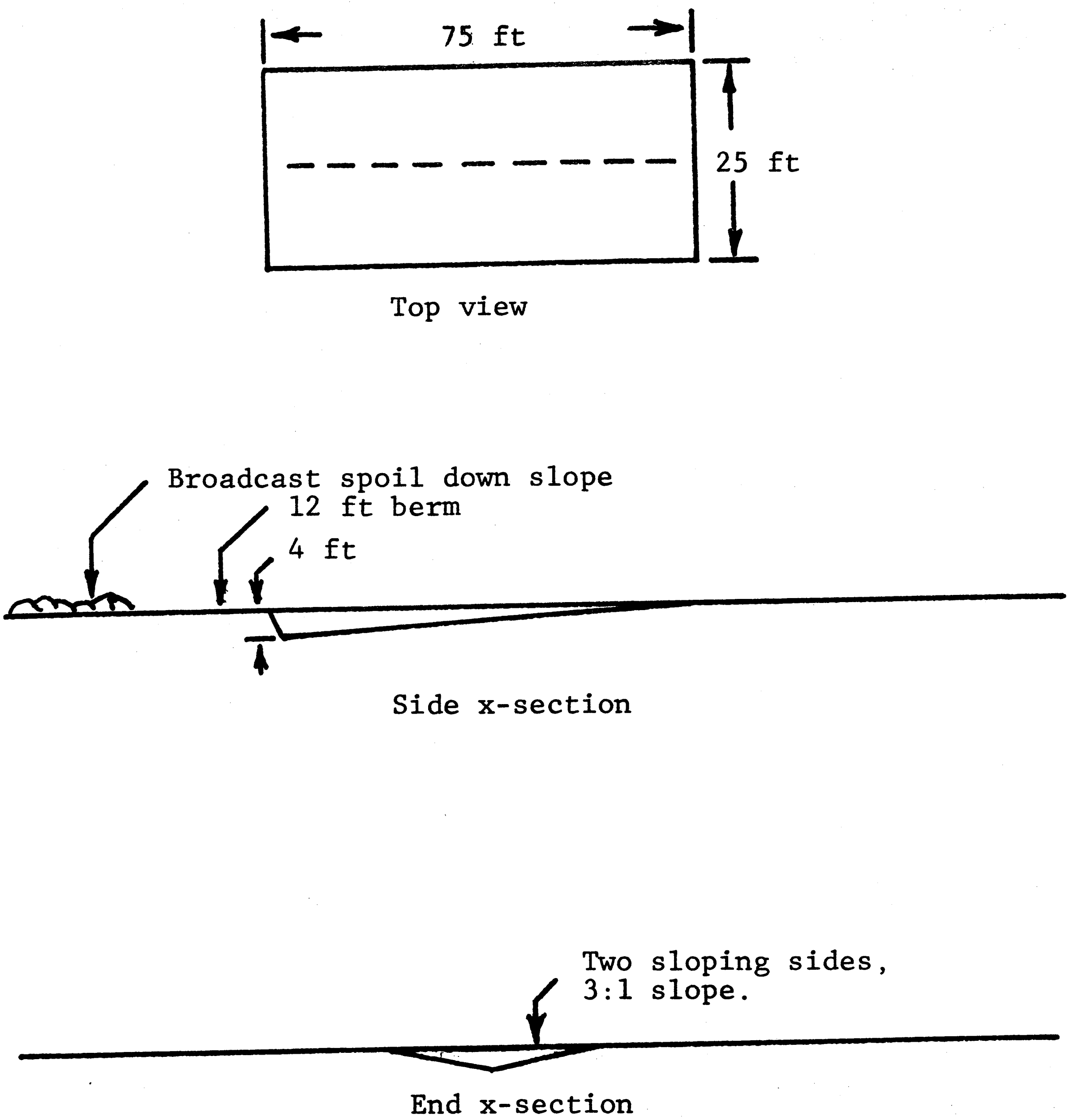
Recommendations:

1. Excavate the maximum number of runoff potholes (about 17) at designated locations in Fig. 12 and 14, according to the dimensions and recommended spacing in Fig. 16.
2. Broadcast spoil down slope and leave a 12 ft berm between the pothole and spoil.
3. Seed broadcast spoil in grasses.
4. Construct two loafing logs (4-ft logs, 6 to 12 inches in diameter), fasten together and anchor them in the center of each pothole.

Justification:

Potholes will increase potential waterfowl breeding pair territories in the watershed area by increasing the number of visually isolated areas used by waterfowl for loafing areas and courtship (Linde 1969; Hoffman 1970; Evrard 1975). Pothole sites are located in, or adjoining, the recommended grassland nesting blocks (Unit III: Grasslands), to provide a close proximity of waterfowl courtship and nesting areas.

Hammond and Lacy (1959) state that the optimum size for potholes is 20 to 25 ft wide and 40 to 75 ft long



Maintain a 200 ft distance between potholes.

Fig. 16. Specifications for potholes on the Poplar River Watershed Area.

providing a water surface area of 500 to 2,000 ft^2. A greater proportional increase in use was found with an increase in size within the above dimensions. They recommended a depth of 4 ft, and that potholes have one or two sloping edges so that dabblers could use the bottom foods. Broadcast spoil down slope to increase the volume of water retained in the potholes, and reduce waterfowl nest predation on spoil banks. A berm will reduce siltation into potholes and increase their life span.

Wedge-shaped bottoms afford a shallow edge for puddle ducks in spite of fluctuations in water level and concomitantly provide a maximum surface area of water during drought periods (Linde 1969).

Excavation of potholes in existing grassland waterways and natural drainage depressions will reduce the costs. The present grassland waterways are approximately 2 ft deeper than the surrounding field.

Timing:

Excavate potholes concurrent with level ditching in the fall 1976. Seed the spoil while the soil is still moist.

Locations:

Excavate a maximum number of potholes (approximately 11) according to recommended spacing in the natural depressions and drainage systems in the NE ¼ of the SE ¼ of Section 24, and 6 potholes in grassland waterways present in the NE ¼ of the NW ¼ of Section 18 (Fig. 1B, 12, and 14).

Methods:

Excavate potholes with a dragline.

Costs:

Excavation:	Section 24 (maximum pothole development area) $\$1.08/yd^3$, at 71 yd^3/pothole, for an estimated 11 potholes	$ 844.00
	Section 18, $\$1.08/yd^3$, at 38 yd^3/pothole, for 6 potholes	246.00
Spoil re-vegetation:	$41.00/A for seed, fertilizer, and their application, for 3 A	123.00
Loafing logs:	Construction and placement, at $5.00/man hour, at 1 hour/pothole, and $1.00 for hardware/pothole, for 17 potholes	102.00
	Total costs:	$ 1,315.00

Unit III: Agricultural Land

GRASSLANDS - WATERFOWL NESTING COVER

Recommendations:

1. Establish permanent grassland blocks, of 40 to 160 A, adjacent to the impoundment and marsh, for waterfowl nesting cover (Fig. 14).
2. Seed designated fields, not currently in grasses (22 A), to switch grass (Panicum varigatum) to establish permanent grasslands.
3. Implement a 5-year rotation prescribed burning program to reduce woody shrubs in the grasslands.
4. Prohibit or tightly control grazing on grasslands.

Justification:

The value of large blocks of grassland areas for waterfowl nesting has been well documented. Idle 40 to 160 A stands of cool-season, introduced grasses in combination with legumes produced maximum numbers of upland nesting ducks in north-central South Dakota (Duebbert and Kantrud 1974). There was a 79 percent hatching success on Cropland Adjustment Programs (CAP) land versus 30 percent on diversified agricultural land in South Dakota. The dense vegetation of CAP lands is believed to have impeded the travel of mammalian predators, thus reducing predation (Duebbert 1969).

Switch grass is recommended over other grass species because it forms dense residual cover and lodges less easily. It requires 3 to 4 years to become established (pers. comm.: Bill Woehler, 1976 WDNR).

Prescribed burning is an economical and effective tool, frequently used by game managers in Wisconsin to: (1) reduce the dead herbaceous material and clean up trees and brush, (2) establish and maintain nesting areas for waterfowl by bringing about a grass-forb successional stage, and (3) produce open areas that will provide better spring grazing for geese (Linde 1969).

Uncontrolled grazing has been shown to be detrimental to waterfowl nesting success throughout waterfowl range in North America (Bue et al. 1952; Glover 1956; Burgess et al. 1965; Kirsch 1969; Gjersing 1975; and Hilliard 1974). Grazing causes a reduction in residual cover, which is needed for waterfowl nesting, through trampling and consumption. Light grazing is an alternative to no grazing; it can be allowed at one animal unit/6.7 A/day during the period 1 July (Bennett 1937; Glover 1956) through 15 August. Terminate grazing on or before 15 August to permit vegetation re-growth, and to provide residual for waterfowl nest cover, for the following spring.

Timing:

Seed switch grass between 15 May and 10 June (late May is best) 1978. Mow fields, which are planted in switch grass, in mid-July to reduce competing weeds. Begin the rotational burning sequence in 1979 and proceed on an annual cycle according to the field numbers in Fig. 14. Conduct prescribed burns in early April after snow melt and when climatic conditions are conducive to burning.

Locations:

The areas requiring seeding to switch grass include the 16 A in the NW ¼ of Section 24 (G_4), 3 A in the NE ¼ of Section 24 (G_5), and 3 A in the NW ¼ of Section 19 (G_4) (Fig. 1B and 14).

Methods:

Prepare the switch grass seed bed and seed the same day. Switch grass, which gains an increased growth advantage the later in the spring the seed bed is prepared and the sooner after seed bed preparation seeds are planted, has a longer germination period than most weeds. Plant seed 0.5 inches deep at the rate of 6 lb/A with a conventional grain drill using the small box; and use metering recommended for alfalfa. It may be necessary to mow areas planted in switch grass the first year, because other plants may hinder its growth. Mow with a rotary mower set at a height of 8 inches. It may be necessary to mow again in late summer, depending upon the extent of weed growth (pers. comm.: Bill Woehler, 1976, WDNR).

Burn with a strip-head fire (Brown and Davis 1973). Set head fires in strips, 25 to 100 ft wide, so that each strip burns with the wind into the previous burned strip. Contact a Department of Natural Resources Wildlife manager about climatic restrictions for burning and necessary equipment.

Costs:

Soil preparation and seeding: plowing, disking, harrowing and grain drilling, at \$20.56/A for 22 A .... \$ 452.00

Mowing: \$4.30/A, for 22 A, 1 treatment 95.00

Seed: \$4.50/lb, at 6 lb/A, for 22 A 594.00

Prescribed burning: \$2.50/A, including installation of fire lines, transportation and movement of fires supression equipment. Average annual cost = \$125.00, for 8 years 1,000.00

Total costs: \$ 2,141.00

CROP ROTATION AND FOOD PATCHES

Recommendations:

1. Begin a 10-year crop rotation on designated cultivated lands (Fig. 14). Crop rotation by years are: 1 through 2 - corn (*Zea mays*), 3 - oats (*Avena fatua*), 4 through 5 - hay, and 6 through 10 - idle, do not cut old hay (Table 22).
2. Seed hay in smooth brome (*Bromus inermis*) and alfalfa (*Medicago sativa*); permit two harvests per year.
3. Direct sharecroppers to plant wildlife food patches, four 5-A patches at least 300 ft wide, in corn annually.
4. If a nucleus of sharp-tailed grouse become established, consider additional food patches of buckwheat (*Fagopyrum esculentum*) and rye.

Justification:

A 10-year crop rotation is desirable in maintaining soil fertility and is in keeping with sound agricultural

Table 22. Ten-year crop rotation, 1977 through 1986, according to their designated crop-field numbers for the Poplar River Watershed Area. Additional land acquisitions may be incorporated into the blank spaces.

Crop	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Corn	-- No.10	23[a] No.9	22 No.8	11 No.7	40 No.6	-- No.5	19 No.4	29 No.3	11 No.2	26 No.1
Corn	26 No.1	-- No.10	23 No.9	22 No.8	11 No.7	40 No.6	-- No.5	19 No.4	29 No.3	11 No.2
Oats	11 No.2	26 No.1	-- No.10	23 No.9	22 No.8	11 No.7	40 No.6	-- No.5	19 No.4	29 No.3
Hay	29 No.3	11 No.2	26 No.1	-- No.10	23 No.9	22 No.8	11 No.7	40 No.6	-- No.5	19 No.4
Hay	19 No.4	29 No.3	11 No.2	26 No.1	-- No.10	23 No.9	22 No.8	11 No.7	40 No.6	-- No.5
Old hay[b]	-- No.5	19 No.4	29 No.3	11 No.2	26 No.1	-- No.10	23 No.9	22 No.8	11 No.7	40 No.6
Old hay[b]	40 No.6	-- No.5	19 No.4	29 No.3	11 No.2	26 No.1	-- No.10	23 No.9	22 No.8	11 No.7
Old hay[b]	11 No.7	40 No.6	-- No.5	19 No.4	29 No.3	11 No.2	26 No.1	-- No.10	23 No.9	22 No.8
Old hay[b]	22 No.8	11 No.7	40 No.6	-- No.5	19 No.4	29 No.3	11 No.2	26 No.1	-- No.10	23 No.9
Old hay[b]	23 No.9	22 No.8	11 No.7	40 No.6	-- No.5	19 No.4	29 No.3	11 No.2	26 No.1	-- No.10

[a] Acres
[b] Idle, do not cut old hay.

practices. Fields in crop rotation will supplement food patches and nest areas for wildlife. Maintain the same relative acreages of each crop annually to insure stability of wildlife food sources and nesting cover.

Food patches are located near the impoundment to serve as fall food for waterfowl, away from roads to decrease disturbance to wildlife, and near shrub covertypes which provide winter cover for pheasants and other wildlife. It is best to maintain food patches in corn each year because: (1) better weed control can be exerted over these low lying sites, (2) better control of invading woody shrubs can be maintained, and (3) more food will be available for wildlife, than would be provided by low growing crops, during the critical winter period. Food-patches, in strips, less than 300 ft wide, become filled with drifting snow and thus are unavailable for wildlife.

SCS personnel sighted three sharp-tailed grouse on the PRWA during the winter of 1975-76; current grouse numbers are unknown. Sharp-tailed grouse needs are met in this plan, with the exception of additional food patches if future grouse censuses show a breeding population to be present (Edminster 1954).

Timing:

Plant food patches and other designated crops each spring. Begin the annual crop dispersion of the 10-year crop rotation in 1977 (Table 22).

Locations:

Locations of food patches and cultivated lands are shown in Fig. 14.

Methods:

Plant hay fields in smooth brome at the rate of 10 lb/A in combination with alfalfa at 12 lb/A. Do not cut idle old hay in years 6 through 10 of the rotation, allow natural vegetation to encroach for additional nesting cover. Negotiate sharecropping agreements on an individual basis. Closely monitor sharecropper compliance with proper rotation sequence and timing.

Costs:

Use returns from sharecropping agreements to pay for administrative costs (contracts), food patches, and other management practices	\$ 0.00
Total costs:	\$ 0.00

HEDGEROWS AND CUTBACKS

Recommendations:

1. Plant 0.75 miles of hedgerow in designated areas (Fig. 14). Establish hedgerows contiguous with forest areas or shrub cover types.
2. Establish 1.7 miles of cutback along the forest field margins in designated areas (Fig. 14).
3. Maintain hedgerows and cutbacks by cutting out trees over 30 ft in height, except mast and fruit bearing trees, as they appear.

Justification:

Hedgerows and cutbacks provide food, cover, nesting areas, and travel lanes for a variety of wildlife (e.g., song birds, game birds, and cottontail rabbits). Hedgerows and cutbacks will increase the distribution of shrubs on the watershed lands and increase the production of associated wildlife.

Plowing and disking hedgerow sites, prior to planting, results in increased soil moisture loss and decreased seedling survival. Plant one species in several consecutive holes to promote cross pollination. Conifer species, which maintain their lower limbs next to the ground at maturity, provide winter cover. Grass strips on each side of the hedgerow provide animal nest habitat.

Timing:

Plant hedgerows and establish cutbacks in the spring of 1978. Permit cutting of trees, to establish cutbacks, to commence immediately.

Methods:

Plant seedlings with a tractor-drawn tree planter; modify the tree planter by removing the scalper. Do not disk or plow the site prior to planting. Mount a sprayer on the back of the planter to spray Simazine or Princep herbicide, according to the mixture shown on the table, for a 1 ft width on each side of each row. Plant four rows, a row of shrubs on each side and two center rows of trees, and leave a 10 ft wide grass strip on each side of the hedgerow.

Space trees 6 ft apart and shrubs 3 ft apart within rows, and leave 6 ft between rows of trees and 4.5 ft between tree-shrub rows. Plant one species in up to 25 successive holes. Place three shrub stems in each hole. Plant an equal ration in each group of the following, or other appropriate, species: (1) shrubs -- silky dogwood (*Cornus amomum*), gray dogwood (*C. femina*), mixed crab (*Pyrus* spp.), and nine-bark (*Physocarpus* spp.), and (2) trees -- white spruce (*Picea glauca*) and northern white-ceader (*Thuja occidentalis*), all available from the Wisconsin Department of Natural Resources nursery (pers. comm.: Thomas Meier, 1978, WDNR).

Establish cutbacks, 50 ft wide is optimum and 25 ft wide is minimum, by issuing permits to local residents to cut out trees for firewood.

Costs:

Tree and shrub seedlings: free for use on county lands	$ 0.00
Planter rental: free for use on county lands	0.00
Tractor rental: $48.00/mile of hedgerow, for 0.75 miles	36.00
Herbicide treatment: $5.00/mile, for 0.75 miles	4.00
Labor: $5.00/man hour, for a 4 man crew consisting of 1 driver, 1 planter, and 2 men sorting seedlings for the planter,	

at $160.00/mile, for 0.75 miles	120.00
Cutback cutting permits: cost of permits to be paid by the individuals who cut and remove the wood	0.00
Total costs:	$ 160.00

Unit IV: Shrub Communities

Recommendations:

1. Maintain existing communities for wildlife cover and nesting areas, except for the maximum pothole development area (Fig. 14). Convert this area of scattered willow to grassland by burning (see Unit III: Grassland).
2. Prevent shrub communities from spreading into new areas with the exception of hedgerows and cutbacks.

Justification:

The distribution of the shrub communities on the PRWA is such that it could be incorporated into a scattered wetlands program as described by Gates (1970). Gates states that these shrub-swamp areas are used by pheasants for winter cover, and that cottontail rabbit and white-tailed deer tend to overlap pheasants with regard to woody cover preference during heavy snow. Life requirements of pheasants will be met on the PRWA with this management plan. Food patches and nesting habitat are located within the necessary radius of the shrub cover.

Shrub communities are long lived and characteristically encroach into grass and pastured lands. Life expectancy of large shrub communities of up to 3,000 A in size is more than 50 years. Tree invasion occurs slowly around the periphery and after 20 years, some trees may over-top the shrubs. Land management is more easily and more economically attained through the prevention of succession than by reversing it (Curtis 1959).

Timing, Location and Methods:

Remove trees over 30 ft in height, except for mast or fruit bearing trees, as they appear in shrub communities (Fig. 14). Issue permits to local residents to cut trees for firewood.

Costs:

Cutting permits: Permit costs to be paid

by local residents .... $ 0.00

Total costs: $ 0.00

Unit V: Forested Lands

FLOODED FOREST LAND

Recommendations:

1. Do not cut trees within the area that will be flooded by the proposed impoundment.

Justification:

Trees, left standing within the area proposed for inundation will provide potential nesting sites for great blue herons and double-crested cormorants. Existing standing tree species include scattered large elm, and some young aspen and other hardwood species.

Locations:

Forested areas are shown in Fig. 14.

GENERAL FOREST MANAGEMENT GUIDELINES

Recommendations:

1. Contact a Department of Natural Resource forester to mark and layout timber compartments within the constraints of the following guide lines:
   - A. Maintain mast (oak) and fruit bearing (e.g., cherry (*Prunus* spp.) trees.
   - B. Maintain all live and dead snags in forest cover types. A distribution of at least two snags/A is preferred.
   - C. Maintain den trees at a ratio of at least two den trees/A in each forest cover type.
   - D. Establish a 40-year rotation of clear cutting 4 to 10 A compartments of aspen forest, on a

10-year cycle. Design cutting compartments in a fashion that will maximize the juxtaposition of 0 to 10-, 10 to 20-, 20 to 30-, and 30 to 40-year age classes. See Gullion (1968) for details.

E. Establish permanent 0.1 to 2.0 A openings spaced 330 ft apart, and from the forest edge, in all northern hardwood cover types.

Justification:

Mast and fruit trees provide valuable food for wildlife. Oak is the most prevalent mast tree on the PRWA, but it is limited in numbers and distribution. Existing and potential food values of acorns to wildlife (deer, squirrel, and wood ducks) makes oak tree maintenance a necessity (Martin et al. 1951). Similar rationale applies to fruit trees. Mast trees that are allowed to live past maturity will provide cavities for wood ducks, squirrels, and other cavity-dwelling wildlife.

Snags provide feeding sites for woodpeckers and other insectivorus birds, and hunting perches for raptors. Snags, which last about 30 years, have the potential of becoming den trees (Gale et al. 1973).

High intensity den-tree management for gray squirrels should include at least two dens, suitable for winter shelter and litter rearing, /A. This recommendation compensates for interspecies competition for, and inadequate distribution of, den sites (Sanderson 1975). Sanderson also recommends leaving two den trees per 5 A, preferably in ½ to 1 A clumps of trees, in regeneration cuts.

Coordination of forest and wildlife management is the most economical way to affect a significant portion of the ruffed grouse range. This will add to the attractiveness of grouse habitat and not noticeably increase forest management work load or expense (Multon 1968). The juxtaposition of aspen age classes will accommodate the maximum density of grouse and increase the production of other wildlife in the area (Gullion 1968).

Forest openings are a necessary component of forest-wildlife habitat (Larson 1967). Herbaceous plants found in openings are important in the summer diet of deer (Torgerson and Pfander 1971). Similarly, deer activity was found by McCaffery and Creed (1969) to be higher in northern hardwoods with grassy openings than in closed stands of northern hardwoods without openings. They recommend maintaining 3 to 5 percent of the forest in permanent openings for optimum forest game range.

Timing:

Initiate a forest management program in the fall 1978.

Locations:

Forested cover types are shown in Fig. 14.

Unit VI: General Management Recommendations

Closed Areas and Public Access

Recommendations:

1. Close the portions of the PRWA in Sections 24 and 13 to waterfowl hunting.
2. Prohibit the use of outboard motors on the impoundment.
3. Prohibit the use of all terrain-vehicles (ATV's), motor bikes and snowmobiles, except that snowmobiles could be permitted on marked trails.

Justification:

Closing the area to waterfowl hunting will: (1) protect local waterfowl and draw in waterfowl from surrounding areas, (2) prevent waterfowl from being "burned out" the first day of hunting season, (3) de-emphasize the harvest aspect and emphasize the production aspect of waterfowl management, (4) avoid a negative public response to closing the area at a later date, after a hunting and access tradition have become established, (5) induce more local land owners to construct potholes on their private lands in hopes of attracting waterfowl, and (6) give many non-hunters an opportunity to view and enjoy the aesthetic qualities of waterfowl. Waterfowl need to be considered as a resource for all recreational users of the area.

Outboard motor noise would detrimentally disturb waterfowl and other wildlife, and have a negative influence on the aesthetic value of the impoundment. The nature of the impoundment makes outboard motor boat travel impractical and unnecessary because: (1) of the shallow nature of the impoundment; aquatic vegetation will seriously impede motor boat travel, (2) motor boat travel produces a wake which would increase erosion of nesting islands, and (3) the size of the area is such that it is easily accessible by rowing or paddling.

Restrict ATV's and motor bikes to existing roadways because of the potential disturbance to wildlife, damage to habitat, and the accessibility of the area by foot travel.

Prohibit snowmobile traffic on grassland and marsh areas where snowmobile impact on vegetation would be most severe. A reduction in nesting cover on grassland and marsh areas as a result of snowmobile traffic could adversely affect the production of waterfowl and other grassland nesting wildlife. Snowmobile travel could be permitted on the existing trail through the forested area in Section 18. The trail through this area would increase the edge effect and cause a minimum of habitat destruction. This trail could also be used for hiking, nature and wildlife census trails during other seasons of the year.

<u>Timing</u>:

Post signs for the closed area, prohibiting motor boats on the impoundment, and prohibiting ATV's and snowmobiles (except snowmobiles on marked trails) on the PRWA in the summer 1978. Erect signs designating snowmobile trails in the fall 1978.

Locations and Methods:

Post signs at 150 ft intervals around the periphery of, and at access points to, Sections 24 and 12 denoting them as closed areas. Post the PRWA to prohibit the operation of ATV's, motor bikes, and snowmobiles, except on marked snowmobile trails.

Costs:

Posting: labor, signs and steel posts	$ 2,750.00
Total costs:	$ 2,750.00

Periodic Review and Revision

Review and revise this management plant as new information becomes available.

Wildlife Management Time Table 1976 Through 1986

1976

Fall — Construct and seed seven small nesting islands.

Fall — Excavate 3,500 ft of level ditching and seed the spoil.

Fall — Excavate 17 potholes, seed the spoil, and place loafing logs.

1977

Spring — Prepare and complete contracts for share-cropping agreements and food patches.

1978

Spring — Erect 20 wood duck nest boxes.

Spring — Prepare the seed bed and seed switch grass on 22 A.

Spring — Plant 0.75 miles of hedgerow.

Summer — Erect signs for posting the closed area and prohibiting snowmobiles (except on trails), ATV's, motorbikes and outboard motors.

Summer — Issue permits to residents to cut trees in the 1.7 miles of cutback.

Fall — Post signs to designate the snowmobile trail in Section 18.

Fall — Initiate a forest management program.

1979

Spring — Check wood duck nest boxes and complete necessary maintenance, this will be an annual event.

Spring — Burn designated grassland blocks, this will be an annual event.

1980

Spring — Burn grassland on 1 or 2 islands, this will be an annual event.

<u>1983</u>

<u>Spring</u> Conduct partial impoundment drawdown after ice out, and seed the wet substrate.

<u>1984</u>

<u>Spring</u> Reflood impoundment.

<u>1986</u>

<u>Spring</u> Inventory suitable nesting sites for heron and cormorant on the impoundment, and erect nesting platform if necessary.

Total Wildlife Management Costs 1976 Through 1986

Construction and seeding of seven waterfowl nesting islands	$ 8,055.00
Prescribed burning to reduce woody shrub encroachment on nesting islands for 6 years	300.00
Materials, construction and erection of 20 wood duck nest boxes	355.00
Annual maintenance of wood duck nest boxes for 8 years	400.00
Excavation of 3,500 ft of level ditching and seeding of the spoil	10,710.00
Excavation of 17 potholes, seeding of spoil, and placement of loafing logs	1,315.00
Prepare the seed bed and seed switchgrass on 22 A	1,141.00
Annual grassland burning costs for 8 years	1,000.00
Planting 0.75 miles of hedgerow	160.00
Labor, signs, and posts for posting the closed area, prohibiting snowmobiles (except on trails), ATV's, motorbikes, and outboard motors	2,750.00
One heron-cormorant nest structure with 6 platforms	195.00
Partial impoundment drawdown and seeding of the exposed substrate in reed canary grass	2,490.00
Contingency	3,000.00
Total	$ 31,871.00

Research Recommendations

1. Conduct a post-construction inventory of the impoundment area, 2 years after filling, to determine changes in species diversity and abundance.
2. Add herbacious materials to potholes, to increase substrate for macroinvertebrates, and then monitor waterfowl use.
3. Test loafing-structures in level ditches for potential increase in waterfowl use.
4. Test the effectiveness of a variety of terrestrial plant species to take up nutrients from the exposed substrate after water level drawdown of the impoundment. Determine animal use of these plant species after refilling.

LITERATURE CITED

Akeley, R.W. 1974. Poplar River Watershed, Clark and Taylor Counties, Wisconsin - final environmental impact statement. USDA, Soil Cons. Ser., Madison. 82pp.

American Public Health Association. 1976. Standard methods for the examination of water and waterwaste. 14th ed., Amer. Public Health Assoc., Amer. Water Works Assoc. and Water Pollut. Control Fed., New York. 1193pp.

Anderson, W.L. 1948. Level ditching to improve muskrat marshes. J. Wildl. Manage. 12:172-176.

Atlantic Flyway Council. 1972. Techniques handbook of waterfowl habitat development and management. The Atlantic Flyway Council, Bethany Beach, Delaware. 218pp.

Bailey, R.M., J.E. Fitch, E.S. Herald, E.A. Lachner, C.C. Lindsey, C.R. Robins, and W.B. Scott. 1970. A list of common and scientific names of fishes from the United States and Canada. 3nd ed., Amer. Fish. Soc. Spec. Publ. No. 6, Amer. Fish. Soc., Washington, D.C. 150pp.

Bartsch, A.F., and W.M. Ingram. 1959. Stream life and the pollution environment. Public Works. 90:104-110.

Bellrose, F.G., K.L. Johnson, and T.U. Meyers. 1964. Relative values of natural cavities and nesting houses for wood ducks. J. Wildl. Manage. 28(4):661-676.

Bennett, L.J. 1937. Grazing in relation to the nesting of the blue-winged teal. Trans. N. Amer. Wildl. Conf. 2:393-387.

Beshears, W.W., Jr. 1974. Wood ducks in Alabama. Alabama Dept. of Cons. and Nat. Resour. Spec. Rep. No. 4. 15pp.

Braatz, D.A. 1974. Invertebrate drift in a central Wisconsin brook trout stream. M.S. Thesis. Univ. of Wisconsin - Stevens Point. 63pp.

Brown, A.A., and K.P. Davis. 1973. Forest fire control and use. 2nd ed., McGraw-Hill Book Co., New York. 686pp.

Bue, I.G., L. Blankenship, and W.H. Marshall. 1952. The relationship of grazing practices to waterfowl breeding populations and production on stock ponds in western South Dakota. Trans. N. Am. Wildl. Conf. 17:396-414.

Bureau of Sport Fisheries and Wildlife. 1973. Woodcock singing-ground survey instructions. Bur. Sport Fish. and Wildl., Office of Migratory Bird Manage. (mimeo.). 4pp.

Burgess, H.W., H.H. Prince, and D.L. Trauger. 1965. Blue-winged teal nesting success as related to land use. J. Wildl. Manage. 29(1):89-95.

Capen, D.E., W.J. Crenshaw, and M.W. Coulter. 1974. Establishing breeding populations of wood ducks by relocating wild broods. J. Wildl. Manage. 38(2):253-256.

Clark, T.W. 1972. An ecological survey of the mammals of north central Wisconsin. Univ. Wis., Stevens Point Mus. Nat. Hist. Faunal & Floral Rept. No. 8. 37pp.

Clough, G.C. 1963. Biology of the arctic shrew, Sorex arcticus. Amer. Midl. Nat. 69(1):69-81.

Conant, R. 1958. A field guide to the reptiles and amphibians of the United States and Canada east of the 100th meridian. Houghton Mifflin Co., Boston. 366pp.

Cook, A.H., and C.F. Powers. 1958. Early biochemical changes in the soil and waters of artificially created marshes in New York. N.Y. Fish Game J. 5:9-65.

Cox, G.W. 1967. Laboratory manual of general ecology. WM. C. Brown Co. Publishers, Dubuque, Iowa. 165pp.

Cummins, K.W. 1962. An evaluation of some techniques for the collection and analysis of benthic samples with special emphasis on lotic waters. Amer. Midl. Nat. 67(2):477-504.

Curtis, J.T. 1959. The vegetation of Wisconsin. Univ. of Wisconsin Press, Madison. 657pp.

Dillon, P.J. 1975. The phosphorus budget of Cameron Lake, Ontario: the importance of flushing rate to the degree of eutrophy of lakes. Limnol. and Oceanogr. 20(1):28-39.

Duebbert, H.F. 1966. Island nesting of the gadwall in North Dakota. Wilson Bull. 78(1):12-25.

_______. 1969. High nest density and hatching success of ducks on South Dakota CAP land. Trans. N. Am. Wildl. Nat. Resour. Conf. 34:218-219.

_______, and H.A. Kantrud. 1974. Upland duck nesting related to land use and predator reduction. J. Wildl. Manage. 38(2):257-265.

Dzubin, A. 1969. Assessing breeding populations of ducks by ground counts. pp. 178-230, In: Saskatoon Wetlands Seminar, Can. Wildl. Ser. Rep. Ser. No. 6, Ottawa. 262pp.

Eddy, S., and A.C. Hodson. 1961. Taxonomic keys to the common animals of the north central states exclusive of the parasitic worms, insects and birds. Burgess Publishing Co., Minneapolis. 162pp.

Edminster, F.C. 1954. American game birds of field and forest: their habits, ecology and management. Charles Scribner's Sons, New York. 490pp.

Egglishaw, H.J. 1969. The distribution of benthic invertebrates on substrata in fast-flowing streams. J. Anim. Ecol. 38:19-33.

Environmental Sciences Services Administration. 1970. Climatology and meteorology. Appendix C, In: Upper Mississippi River comprehensive basin study. Prepared by U.S. Army Eng. Dist., St. Louis, Env. Sci. Ser. Admin., for UMRCBS Coord. Com., Vol. 3.

Evrard, J.O. 1975. Waterfowl use of dug ponds in Northwestern Wisconsin. Wildl. Soc. Bull. 3(1):13-18.

Gale, R.M., W.F. Kelley, and J.A. Lorenzana. 1973. Snag management. No. 1. Coordination guidelines for wildlife habitats. USDA, For. Serv., Calif. Region. 13pp.

Gates, J.M. 1970. Recommendations for a scattered wetlands program of pheasant habitat preservation in southwest Wisconsin. Wis. Dept. Nat. Resour. Tech. Bull. No. 63. 23pp.

Gaufin, A.R. 1965. Environmental requirements of Plecoptera. pp. 107-110. In: Biological problems in water pollution, Third Seminar, 1962. U.S. Dept. HEW, Public Health Ser., Div. of Water Supply and Pollut. Cont., Cincinnnati, Ohio. 424pp.

_______. 1973. Use of aquatic invertebrates in the assessment of water quality, p. 96-116. In: Cairns, J.C., Jr. and K.L. Dickson (eds.), Biological methods for the assessment of water quality. Amer. Soc. for Testing and Materials, Philadelphia. 256pp.

Gerloff, G., and F. Skoog. 1957. Nitrogen as a limiting factor for the growth of Microytis aeruginosa in southern Wisconsin lakes. Ecology. 38(4):556-561.

Getz, L.L. 1961. Factors influencing the local distribution of shrews. Amer. Midl. Nat. 65(1):67-88.

Giles, R.H. 1971. Wildlife management techniques. The Wildl. Soc., Washington, D.C. 623pp.

Gjersing, F.H. 1975. Waterfowl production in relation to rest-rotation grazing. J. Range Manage. 28(1):37-42.

Gleason, H.A. 1952. The new Britton and Brown illustrated flora of the northeastern United States and adjacent Canada. Hafner Press, New York. 3 Vol.

Glover, F.A. 1956. Nesting and production of blue-winged teal (Anas discors Linnaeus) in northwest Iowa. J. Wildl. Manage. 20(1):28-46.

Grabill, B.A. 1977. Reducing starling use of wood duck boxes. Wildl. Soc. Bull. 5(2):69-70.

Grice, D., and J.P. Rogers. 1965. The wood duck in Massachusetts. Mass. Div. Fish. Game, P-R Rep., Proj. W-19-R. 96pp.

Gullion, G.W. 1966. The use of drumming behavior in ruffed grouse population studies. J. Wildl. Manage. 30(4): 717-729.

_______. 1968. Recommendations for management of ruffed grouse habitat in northern Minnesota. Minn. Dept. of Fish Game Inf. Leafl. No. 100. 3pp.

_______. 1976. Reevaluation of "activity clustering" by male grouse. Auk. 93(1):192-193.

Hammond, M.C. 1959. Waterfowl breeding population census techniques. Bur. Sport Fish. and Wildl. (mimeo.). 19pp.

_______, and C.H. Lacy. 1959. Artificial potholes and ditches as waterfowl habitat. Presented at the 21st Midwest Wildl. Conf., Minneapolis (mimeo.). 11pp.

_______, and G.E. Mann. 1956. Waterfowl nesting islands. J. Wildl. Manage. 20(4):345-352.

Harris, S.W., and W.R. Marshall. 1963. Ecology of water-level manipulation on a northern marsh. Ecology. 44(2):331-343.

Hart, C.W., Jr., and S.L.H. Fuller, eds. 1974. Pollution ecology of freshwater invertebrates. Academic Press, New York. 389pp.

Hartman, G.F. 1949. Management of central Wisconsin flowages. Wis. Conserv. Bull. 14(4):19-22.

Hester, F.E., and J. Dermid. 1973. The world of the wood duck. J.P. Lippincott Co., New York. 160pp.

Hilliard, M.A. 1974. The effects of regulated livestock grazing on waterfowl production. Utah Div. of Wildl. Res. Publ. No. 74-8. 96pp.

Hilsenhoff, W.L. 1975. Aquatic insects of Wisconsin. Wis. Dept. Nat. Res. Tech. Bull. No. 89. 53pp.

_______. 1977. Use of arthropods to evaluate water quality of streams. Wis. Dept. Nat. Resour. Tech. Bull. No. 100. 15pp.

Hine, R.L., L.M. Christenson, C.E. Germain, J.B. Hale, F.H. King and C.W. Threinen. 1973. Endangered animals in Wisconsin. Wis. Dept. Nat. Resour., Endangered Species Com., Madison. 28pp.

_______, R.F. Nicotera, L.M. Christenson, C.E. Germain, J.B. Hale, H.E. Hettrick, B. Less, and L.A. Posekany. 1975. Endangered animals in Wisconsin. Wis. Dept. Nat. Resour., Endangered Species Com., Madison (mimeo.). 10pp.

Hoffman, R.H. 1970. Waterfowl utilization of ponds blasted at Delta Marsh, Manitoba. J. Wildl. Manage. 34(3): 586-594.

Howmiller, R.W. 1972. Effects of preservatives on weights of some common macrobenthic invertebrates. Trans. Am. Fish. Soc. 101(4):743-746.

Hutchinson, G.E. 1957. A treatise on limnology. John Wiley and Sons, Inc., New York. Vol. 1. 1015pp.

Hynes, H.B.N. 1960. The biology of polluted waters. Liverpool Univ. Press, Liverpool. 202pp.

_______, and M.J. Coleman. 1968. A simple method of assessing the annual production of stream benthos. Limnol. and Oceanogr. 13(4):569-573.

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

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

Jones, J.K., Jr., D.C. Carter, and H.H. Genoways. 1973. Checklist of North American mammals north of Mexico. Texas Tech. Univ. Occas. Pap. No. 12. 14pp.

Jones, R.E., and A.S. Leopold. 1967. Nesting interference in a dense population of wood ducks. J. Wildl. Manage. 31(2):221-228.

Kadlec, J.A. 1962. The effects of a drawdown on a waterfowl impoundment. Ecology. 43(2):267-281.

Keeney, D.R. 1972. The fate of nitrogen in aquatic systems. Literature Rev. No. 3, Water Resour. Cent., Univ. of Wis., Madison. 59pp.

Kirsch, L.M. 1969. Waterfowl production in relation to grazing. J. Wildl. Manage. 33(4):821-828.

Krapu, G.L. 1974. Feeding ecology of pintail hens during reproduction. Auk. 91(2):278-290.

Larson, J.S. 1967. Forests, wildlife, and habitat management--a critical examination of practice and need. U.S. For. Serv. Res. Paper SE-30. Asheville, NC. 28pp.

Leonard, J.W. 1939. Comments on the adequacy of accepted stream bottom sampling techniques. Trans. N.A. Wildl. Conf. 4:288-295.

Linde, A.F. 1969. Techniques for wetland management. Wis. Dept. of Nat. Resour. Res. Rep. No. 45. 156pp.

Lindsey, A.A., R.O. Petty, D.K. Sterling, and W. Van Asdall. 1961. Vegetation and environment along the Wabash and Tippecanoe Rivers. Ecol. Monogr. 31(2):105-156.

Logan, S.M. 1963. Winter observations on bottom organisms and trout in Bridger Creek, Montana. Trans. Amer. Fish. Soc. 92:140-145.

Long, C.A. 1972. Notes on habitat preference and reproduction in pigmy shrews, Microsorex. Can. Field-Nat. 86:155-160.

Mackenthun, K.M. 1966. Biological evaluation of polluted streams. J. Water Pollut. Contr. Fed. 38(2):241-247.

_______, W.M. Ingram, and R. Porges. 1964. Limnological aspects of recreational lakes. U.S. Dept. of HEW, Public Health Serv., Div. of Water Supply and Pollut. Control. Public Health Serv. Publ. No. 1167. 176pp.

MacNamara, L.G. 1957. Potentials of small waterfowl areas. Trans. N. Am. Wildl. and Nat. Resour. Conf. 22:92-96.

Martin, A.C., H.S. Zim, and A.L. Nelson. 1951. American wildlife and plants: a guide to wildlife food habits. Dover Publ. Inc., New York. 500pp.

Mason, W.T., Jr., P.A. Lewis, and J.B. Anderson. 1971. Macroinvertebrate collections and water quality monitoring in the Ohio River Basin 1963-1967. Office of Tech. Programs, Ohio Basin Region and Analytical Quality Cont. Lab., Water Quality Office, Environ. Protect. Agen., Cincinnati, Ohio. 52pp.

Mathiak, H.A. 1953. Experimental level ditching for muskrat management. Wis. Conserv. Dept. Tech. Bull. No. 5. 35pp.

Mathisen, J.E. 1969. Use of man-made nesting islands as nesting sites of the Common Loon. Wilson Bull. 81(3):331.

McCaffery, K.R., and W.A. Creed. 1969. Significance of forest openings to deer in northern Wisconsin. Wis. Dept. Nat. Resour. Tech. Bull. No. 44. 104pp.

McGilvrey,F.B. 1966. A guide to wood duck production habitat requirements. Bur. Sport Fish. and Wildl. Resour. Publ. No. 60. 32pp.

Meyers, G.L., and J.J. Perterka. 1974. A syringe volumetric measuring device. J. Fish. Res. Board Can. 31:1160-1161.

Minckley, W.L. 1963. The ecology of a spring stream, Doe Run, Meade County, Kentucky. Wildl. Monogr. No. 11. 124pp.

Morony, J.J., W.J. Bork, and J. Farrd. 1975. Reference list of the birds of the world. Dept. of Ornithol. Am. Mus. of Nat. Hist. 207pp.

Moulton, J.C. 1968. Ruffed grouse habitat requirements and management opportunities. Wis. Dept. Nat. Resour. Res. Rep. No. 36. 32pp.

Moyle, J.B. 1949. Some indices of lake productivity. Trans. Am. Fish. Soc. 76:322-334.

Muller-Dombois, D., and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley & Sons, New York. 547pp.

Mulligan, H.F., and A. Baranowski. 1969. Growth of phytoplankton and vascular aquatic plants at different nutrient levels. Verh. Int. Verein. Limnol. 17:802-810.

Nellis, C.H., C.J. Terry, and R.D. Taber. 1974. A conical pitfall trap for small mammals. Northwest Sci. 48(2):102-104.

Nelson, L., Jr., and F.W. Clark. 1973. Correction for sprung traps in catch/effort calculations of trapping results. J. Mammal. 54(1):295-298.

New, T. 1972. A non-game bird survey in Indiana on selected portions of natural and channeled streams in the Kankakee and Elkhart River Basins. Paper presented at the 1972 Midwest Wildl. Conf., Des Moines, Iowa. 10pp.

Odum, E.P. 1950. Bird populations of the Highlands (North Carolina) Plateau in relation to plant succession and avian invasion. Ecology. 31:587-605.

_______. 1971. Fundamentals of ecology. W.B. Saunders Co., Philadelphia. 574pp.

Pennak, R.W. 1953. Freshwater invertebrates of the United States. Ronald Press, New York. 769pp.

Robbins, S. 1966. Wisconsin's summer bird count: 1961-1965. Passenger Pigeon. 28(2):47-62.

Ruttner, F. 1953. Fundamentals of limnology. Univ. of Toronto Press, Toronto. 295pp.

Sanderson, H.R. 1975. Den-tree management for gray squirrels. Wildl. Soc. Bull. 3(3):125-131.

Sawyer, C.N. 1947. Fertilization of lakes by agricultural and urban drainage. J. New England Water Works Assoc. 61(2):109-127.

Schmidt, F.J.W. 1931. Mammals of western Clark County, Wisconsin. J. Mammal. 12(2):99-117.

Scullin, T.J. 1977. Benthos in brushy and meadow habitats of a central Wisconsin trout stream. M.S. Thesis. Univ. of Wis., Stevens Point. 61pp.

Shadowen, H.E. 1963. A live-trap study of small mammals in Louisiana. J. Mammal. 44(1):103-108.

Stalnaker, C.B., and J.L. Arnette. 1976. Methodologies for determining instream flows for fish and other aquatic life, pp. 89-138. In: Stalnaker, C.B., and J.L. Arnette (eds.). Methodologies for the determination of stream resource flow requirements: an assessment. Prepared for the U.S. Fish and Wildl. Serv., Office of Biol. Serv., Western Water Allocation, by Utah State Univ., Logan. 199pp.

Stanford, J.A. 1973. A centrifuge method for determining live weights of aquatic insect larva, with a note on weight loss in preservative. Ecology. 54(2):449-451.

Stewart, R.E., and H.A. Kantrud. 1972. Population estimates of breeding birds in North Dakota. Auk. 89(4):766-788.

Sugden, L.G. 1973. Feeding ecology of pintail, gadwall, American widgeon, and lesser scaup ducklings in southern Alberta. Can. Wildl. Serv. Rep. Ser. No. 24. 43pp.

Swanson, G.A., and M.I. Meyer. 1973. The role of invertebrates in the feeding ecology of Anatidae during the breeding season. The Waterfowl Habitat Manage. Symp., Moncton, N.B. July 30-Aug. 1, 1973:143-178.

_______, M.I. Meyer, and J.R. Serie. 1974. Feeding ecology of breeding blue-winged teal. J. Wildl. Manage. 38(3):396-407.

Tarzwell, C.M. 1938. Factors influencing fish food and fish production in southwestern streams. Trans. Am. Fish. Soc. 67:246-255.

_______, and A.R. Gaufin. 1967. Some important biological effects of pollution often disregarded in stream surveys. pp. 21-31. In: Biology of Water Pollution. USDI Fed. Water Pollut. Contr. Admin. 290pp.

Tebo, L.B., Jr. 1955. Effects of siltation, resulting from improper logging, on the bottom fauna in a small trout stream in the southern Appalachians. Prog. Fish-Cult. 17:64-70.

Thompson, L.M., and F.R. Troeh. 1973. Soil and soil fertility. McGraw-Hill Book Co., New York. 495pp.

Torgerson, O., and W.H. Pfander. 1971. Cellulose digestibility and chemical composition of Missouri deer foods. J. Wildl. Manage. 35:221-231.

U.S. Environmental Protection Agency. 1976. Quality criteria for water. U.S. Envir. Prot. Agen. (Pre-publ. copy), July. 501pp.

U.S. Federal Water Pollution Control Administration. 1967. Temperature and aquatic life. Lab. Invest. No. 6. Tech. Advisory and Invest. Branch, Tech. Ser. Prog., U.S. Fed. Water Pollut. Cont. Admin., USDI, Cincinnati, Ohio. 151pp.

U.S. Geological Survey Water Data. 1960-1976. Water Resources data for Wisconsin. (Published yearly) U.S. Geological Surv. Madison.

U.S. Geology Survey Water - Supply. 1950-1959. Surface water supply of the United States. (Published periodically) U.S. Gov. Printing Office, Washington, D.C.

Uttormark, P.D., J.D. Chapin, and K.M. Green. 1974. Estimating nutrient loading of lakes from non-point sources. Water Resour. Cent., Univ. of Wis., Madison. Environ. Protect. Agen.-660/3-74-020. 112pp.

Vermeer, K. 1970. Some aspects of the nesting of ducks on islands in Lake Newell, Alberta. J. Wildl. Manage. 34(1):126-129.

Vollenweider, R.A. 1968. Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication. Pub. N. DAS/CSI/68.27, Organ. for Econ. Co-op. and Dev., Directorate for Sci. Affaris, Paris, France.

Ward, R.C. 1967. Principles of hydrology. McGraw-Hill Publ. Co. Ltd., Maidenhead, England. 403pp.

Weber, C.I. (ed.). 1973. Macroinvertebrates, 38pp. In: Biological field and laboratory methods for measuring the quality of surface waters and effluents. Program Element 1BA027, EPA-670/4-73-001, Nat. Environ. Res. Cen. Office of Res. and Development, U.S. Environ. Protect. Agen., Cincinnati, Ohio.

Welch, P.S. 1948. Limnological methods. McGraw-Hill, New York. 381pp.

Wetzel, R.G. 1975. Limnology. W.B. Saunders Co., Philadelphia. 743pp.

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

Young, C.M. 1968. Island nesting of ducks in northern Ontario. Can. Field-Nat. 82(3):209-212.

Whitman, W.R. 1973. Controlled water-level impoundments for waterfowl. The Waterfowl Habitat Manage. Symp., Moncton, N.B. July 30-Aug. 1, 1973:201-207.

_______. 1976. Impoundments for waterfowl. Can. Wildl. Serv. Occas. Pap. No. 22. 22pp.

Appendix A. Measurement conversion factors.

Unit		Metric equivalent
mile (mi)	=	1.609 kilometers (km)
yard (yd)	=	0.914 meters (m)
foot (ft)	=	0.305 meters (m)
inch (in)	=	2.540 centimeters (cm)
inch (in)	=	25.40 milimeters (mm)
inch (in)	=	25,400 microns (um)
acre (a)	=	0.405 hectares (ha)
acre feet (a ft)	=	1,230.508 cubic meters (m^3)
cubic feet (ft^3)	=	0.836 cubic meters (m^3)
pound (lb)	=	0.373 kilogram (kg)
ounce (oz)	=	28.349 grams (g)
^{o}Fahrenheit (^{o}F)	(-32, 5/9 X remainder)	^{o}Centigrade (^{o}C)

or

Unit		English equivalent
kilometer (km)	=	0.62 miles (mi)
meter (m)	=	1.094 yards (yd)
meter (m)	=	3.281 feet (ft)
centimeter (cm)	=	0.39 inches (in)
milimeter (mm)	=	0.04 inches (in)
micron (um)	=	(0.000039) inches (in)
hectare (ha)	=	2.47 acres (a)
cubic meter (m^3)	=	(0.0008) acre feet (a ft)
cubic meter (m^3)	=	1.31 cubic feet (ft^3)
kilogram (kg)	=	(2.2046) pounds (lb)
grams (g)	=	0.035 ounces (oz)
^{o}Centigrade (^{o}C)	(X 9/5, +32)	^{o}Fahrenheit (^{o}F)

Appendix B. Values assigned to arthropod taxa not found in Hilsenhoff (1977) for calculating a biotic index (pers. comm.: Gerald Z. Jacobi, 1978, University of Wisconsin - Stevens Point).

Plecoptera

Isoperla 0

Ephemeroptera

Heptagenia 2, *Stenonema* 1.5, Leptophlebiidae 2

Hemiptera

Belostoma 3

Trichoptera

Polycentripodidae 2, *Agrapetus* 1, *Agraylea* 2, *Ptilostomis* 1, *Frenesia* 1.5, *Pseudostenophylax* 1

Lepidoptera

Parargyractis 1

Coleoptera

Haliplus 2, *Peltodytes* 2, *Deronectes* 2[a], *Hydroporus* 2 *Laccophilus* 2, *Berosus* 2, *Dubiraphia* 3, *Optioservus* (adult) 1, *Stenelemis* (adult) 2

Diptera

Prionocera 2, Ceratapagonidae 2, Chironomidae 2[b], *Simulium* 2

---

[a] Hilsenhoff (1975) does not separate *Deronectes* and *Oreodytes*.

[b] Assigned value based on associated organisms. Usually 2 except when amphipods, isopods, and oligochaets are present in high numbers.

Appendix C. Precipitation records (mm) from the University of Wisconsin-State Farm Experimental Station, Marshfield, Wisconsin, April 1975 through May 1976 compared with the previous 30-year monthly means.

Year	Month	30-year monthly mean	Precipitation for the month	Deviation from the monthly mean	Deviation for the season
1975	April	67.1	115.8	+48.7	Spring +31.6
	May	96.3	79.2	-17.1	
	June	120.4	119.6	- 0.8	
	July	81.8	46.7	-35.1	Summer -3.7
	August	99.6	131.8	+32.2	
	September	88.6	94.0	+ 5.4	Fall +20.6
	October	61.0	76.2	+15.2	
	November	51.8	95.0	+43.2	
	December	26.9	46.5	+19.6	
1976	January	29.7	28.2	- 1.5	Winter +95.2
	February	26.9	22.1	- 4.8	
	March	41.1	79.8	+38.7	
	April	68.8	134.6	+65.8	Spring +30.7
	May	96.3	61.2	-35.1	
Totals:		956.3	1130.7	+174.4	+174.4

Appendix D. Precipitation records (mm) from the University of Wisconsin-State Farm Experimental Station, Marshfield, Wisconsin, June 1976 through May 1977 compared with the previous 30-year monthly means.

Year	Month	30-year monthly mean	Precipitation for the month	Deviation from the monthly mean	Deviation for the season
1976	June	120.4	29.0	-91.4	
	July	81.8	139.7	+57.9	Summer -115.1
	August	99.6	18.0	-81.6	
	September	88.6	17.5	-71.1	Fall -113.1
	October	61.0	19.0	-42.0	
	November	51.8	0.5	-51.3	
	December	26.9	12.4	-14.5	
1977	January	30.5	11.4	-19.1	Winter -44.4
	February	25.1	23.6	- 1.5	
	March	41.1	83.1	+42.0	
	April	68.8	50.0	-18.8	Spring -38.1
	May	96.3	77.0	-19.3	
Totals:		791.9	481.2	-310.7	-310.7

Appendix E. Stream discharge from Brick Creek in cubic meters per second at the site of the proposed Poplar River Watershed Area dam, 20 May 1975 through 6 April 1977.

Date	Orange float method[a]	Gurley current meter[a]
1975 Monitoring of stream discharge was begun after the spring runoff period.		
May 20	0.068	0.071[b]
21	0.056	0.059[b]
26	0.232	0.240[b]
27	0.113	0.119[b]
28	0.045	0.048[b]
29	0.082	0.085[b]
31	0.110	0.116[b]
June 1	0.056	0.060[b]
9	<0.028	<0.028[b]
12	0.062	0.065[b]
16	0.520	0.537[b]
21	0.542	0.559[b]
22	0.195	0.203[b]
25	0.065	0.068[b]
27	0.393	0.404[b]
28	0.212	0.220[b]
July 7	0.065	0.068[b]
9	<0.028	<0.028
12	0.031	0.034[b]
14	<0.026	<0.028
22	0.045	0.048[b]

Appendix E. Continued.

Date		Orange float method[a]	Gurley current meter[a]
From 25 July through 22 August, stream discharge was less than 0.028 m^3/s.			
August	23	0.028	0.031
	31	0.141	0.147[b]
September	7	0.308	0.319[b]
	15	0.105	0.121
	21	0.958	0.924
	28	0.071	0.175
October	13	0.031	0.034[b]
	19	<0.028	<0.028
	28	0.048	0.045
November	5	0.034	0.034
	12	0.311	0.158
	21	(Flooded - 4.520)[c]	
December	22	(Ice - 0.028)[c]	
<u>1976</u>			
January	22	(Ice - 0.028)[c]	
February	23	(Ice - 0.028)[c]	
March	22	(Ice - 0.028)[c]	
	31	(Ice - 0.056)[c]	
April	6	(Ice - 0.339, beginning of runoff from snow melt)[c]	
	13	1.164	1.065
	16	0.339	0.331

Appendix E. Continued.

Date		Orange float method[a]	Gurley current meter[a]
	20	1.237	1.424
	27	0.528	0.627
	30	0.218	0.234
May	4	0.172	0.167
	7	0.138	0.133
	11	0.678	0.062
	13	0.056	0.054
	17	0.531	0.613
	19	0.218	0.229
	21	0.085	0.090
	25	<0.028	<0.028
June	1	<0.028	<0.028
	14		0.014
	18		0.014
	19		0.014
	23		0.014
	28		0.014
August	5		None
	11		0.017
	27		None

Stream flow stopped from 27 August 1976 to ice melt in March 1977.

Appendix E. Continued.

Date		Orange float method[a]	Gurley current meter[a]
1977			
March	3		
	5		0.113[c]
	14		0.636
	22		0.054
	28		0.220
April	6		0.311

[a] Cubic meters/second (m^3/s).

[b] Estimated Gurley Meter reading based on a correction factor applied to the corresponding Orange Float value. The correction factor was determined from 18 paired Orange Float-Gurley Meter values, between 0.028 and 7.008 m^3/s (r=0.98).

[c] Ice or extreme flooding prevented instrument metering. Visually estimated based on familiarity with stream discharge.

Appendix F. Mean of weekly temperatures (°C) of Brick Creek, 11 June through 10 November 1975 and from 13 April through 8 June 1976.

1975

11 through 18 June	11
18 through 25 June	23
25 June through 2 July	23
2 through 9 July	22
9 through 16 July	17
16 through 23 July	25
23 through 30 July	22
30 July through 6 August	22
6 through 13 August	21
13 through 20 August	18
24 through 31 August	18
1 through 8 September	14
8 through 15 September	11
16 through 23 September	11
30 September through 6 October	8
6 through 13 October	9
13 through 20 October	9
20 through 27 October	7
27 October through 3 November	8
3 through 10 November	6

1976

The first increase in stream temperature was noted on 6 April 1976, when the stream temperature was 3°C at 1030.

Appendix F. Continued.

13 through 20 April	13
20 through 27 April	9
27 April through 4 May	9
4 through 11 May	13
11 through 18 May	16
18 through 25 May	18
25 May through 1 June	19
1 through 8 June	23
8 through 15 June	27
15 through 22 June	21
22 through 29 June	23
29 June through 6 July	22
6 through 13 July	26
13 through 20 July	23
20 through 27 July	25
27 July through 3 August	22

Appendix G. The monthly sums of daily stream discharge measurements (cubic meters/second), June 1975 through May 1976, and monthly means of the previous 60 years from the Jump River at Sheldon, Rusk County, and the Black River at Neillsville, Clark County, Wisconsin (U.S. Geological Survey Water-Supply 1950-59; U.S. Geological Survey Data 1960-76).

Month	Jump River	Black River
June	462 (600)[a]	500 (663)
July	98 (248)	110 (269)
August	101 (1,937)	234 (190)
September	312 (341)	318 (464)
October	134 (334)	95 (289)
November	916 (340)	1,061 (386)
December	319 (143)	367 (153)
January	152 (84)	103 (95)
February	169 (69)	133 (79)
March	1,414 (627)	2,351 (1,033)
April	1,763 (1,547)	1,832 (1,742)
May	234 (816)	269 (773)

[a] Mean of the preceeding 60 years for the month.

Appendix H. Pan evaporation data from the University of Wisconsin-State Experimental Station, Marshfield, Wisconsin, April 1975 through October 1976.

Month	Pan evaporation (mm per month)
1975	
May	147.3
June	153.7
July	193.5
August	171.7
September	106.7
October	84.6
1976[a]	
September	130.8
October	61.5

[a] Evaporation records not available for May to August 1976.

Appendix I. Water quality analysis of water samples taken from Brick Creek on the Poplar River Watershed Area (PRWA), at the Owen dam, and from ground water on the PRWA, 13 May 1975 through 6 April 1977.

Date	Stream[a] Discharge	Temp °C	Suspended[b] Solids	Cond uMOHS	pH	Alk[b]	Total[b] Hard	Ca^{++}[b] Hard	BOD[b]	DO[b]	Reactive[b] P	Total[b] P	NH_4[b] N	NO_3-NO_2[b] N	Kjeldahl[b] N	Fecal[c] Coli.
1975																
May 13		13	7.0	126	6.6	44	56	34			0.060	0.173	<0.04	<0.04		
May 21	0.059	19	1.8	150	6.9	61	70	42	2.85		0.225	0.310	<0.04	<0.04		175
June 2	0.059	16	6.9	142	7.3	62	74	44	1.60		0.210	0.212	<0.04	<0.04	1.30	70
June 9	<0.028	16	3.5	161	7.50	90	92	60			0.170	0.560	<0.04	<0.04	1.65	
June 12	0.065	12	6.0	160	7.55	80	94	48	1.55		0.163	0.540	<0.04	<0.04	1.02	
June 16	0.537	12	4.0	88	7.05	64	72	30	2.05	6.4	0.044	0.172	<0.04	<0.04	1.75	690
July 14	<0.028	13	4.7	175	7.30	82	84	42		5.4	0.108	0.144	<0.04	<0.04	0.81	70
Aug 24	0.031	19	3.9	183	7.21	40	154	30		4.6	0.155	0.252	0.25	0.11	0.32	100
Aug 24[e]		21	4.2	171	7.16	56	146	42		5.1	0.088	0.138	0.21	0.40	1.68	20
Sept 15	0.121	11		124	7.48	42	70	38	2.75	9.1	0.062	0.100	<0.04	<0.04	2.38	60
Oct 29	0.045	5	5.5	185	8.54	58	80	50		11.4	0.054	0.082	<0.04	<0.04	0.46	5
Nov 21	4.520[d]	0				16	102	16			0.107	0.210				5,300
Dec 22	0.028[d]	0	1.7	160	7.10	62	128	58	0.45	8.6	0.048	0.073	<0.04	0.25	0.88	60
1976																
Jan 22	0.028[d]	0	25.9	310	7.10	82	146	54	0.90	8.2	0.082	0.083	0.28	0.46	0.74	5

Appendix I. Continued.

Date	Stream[a] Discharge	Temp °C	Suspended[b] Solids	Cond uMOHS	pH	Alk[b]	Total[b] Hard	Ca^{++}[b] Hard	BOD[b]	DO[b]	Reactive[b] P	Total[b] P	NH_4[b] N	NO_3-NO_2[b] N	Kjeldahl[b] N	Fecal[c] Coli.
Feb 23	0.028[d]	0	2.0	160	6.83	56	142	42	2.50	6.4	0.066	0.079	0.53	0.42	1.44	104
March 22	0.028[d]	0	3.1	85	6.71	26	98	12		9.0	0.159	0.212	0.14	0.42	1.54	74
March 31	0.056	0	6.1	61	6.80	18	70	12		10.4	0.041	0.125	0.35	0.25		53
March 31[e]		0	9.3	73	6.89	18	92	14		11.0	0.048	0.156	0.11	0.11		190
April 6	0.339[d]	4		76	6.88	16	58	16	0.60	9.6	0.015	0.056	<0.04	<0.04	0.81	<10
April 13	1.065	4	2.5	91	7.59	28	60	26	0.70	10.5	0.029	0.075	<0.04	<0.04	0.63	<3
April 20	1.42	9	1.7	85	8.02	24	60	22	1.75	6.9	0.046	0.101	0.35	0.18	1.16	8
April 27	0.528	6	6.95	77	7.16	34	76	26	0.60	11.0	0.061	0.086	0.39	0.25	1.02	10
May 4	0.172	4	5.5	138	8.28	36	44	30	1.25	9.5	0.050	0.067	0.14	0.18	0.93	86
May 11	0.068	10	6.8	117	7.41	52	54	34	2.20	8.5	0.082	0.124	0.04	0.07	0.84	113
May 17	0.531	9	8.1	85	7.36	36	44	26	1.65	7.4	0.071	0.148	0.18	0.14	1.12	
May 26	<0.028	16	8.8	155	7.41	70	80	48	1.60	7.6	0.151	0.243	0.11	0.11	0.75	102
June 14	<0.028	19	10.5	180	7.42	92	100	52		2.2	0.204	0.239	<0.04	<0.04	0.91	354
July 20	<0.028	19	7.10	133	7.18	52	78	62	2.00	5.2	0.121	0.199	0.26	0.07	0.42	2,075
Oct 15[f]		9		169	6.91	68	114	76	0.70		0.031	0.037	0.14	0.10	0.210	
Nov 5[f]		8	6.2	172	7.15	72	114	80		7.9	0.021	0.021	0.18	.25	0.18	

Appendix I. Continued.

Date	Stream[a] Discharge	Temp °C	Suspended[b] Solids	Cond uMOHS	pH	Alk[b]	Total[b] Hard	Ca^{++}[b] Hard	BOD[b]	DO[b]	Reactive[b] P	Total[b] P	NH_4[b] N	NO_3-NO_2[b] N	Kjeldahl[b] N	Fecal[c] Coli.
1977																
March 14	0.636	0		138	6.54	26	76	30	5.80	8.4	0.238	0.475	0.18	1.37	2.56	520
March 14[e]		0		134	6.70	28	72	30	5.60	10.2	0.435	0.518	0.49	1.16	2.06	95
March 22	0.054	0		197	7.57	26	120	64		8.1	0.038	0.043	0.46	1.33	2.59	10
March 28	0.220	3		120	7.00	20	94	40	7.90	8.3	0.068	0.129	0.24	0.88	1.82	55
April 6	0.311	2				18	70	42	3.30	9.7	0.070	0.076	0.25	0.35	1.05	30
April 6[e]		2				20	70	40	2.20	11.2	0.072	0.128	0.21	0.42	1.51	50

[a] Cubic meters/second.

[b] mg per liter.

[c] MFFC/100 ml.

[d] Ice or extreme flooding prevented instrument metering. Visually estimated based on familiarity with stream discharge.

[e] Water sample taken below the dam in Owen.

[f] Ground water sample taken at the proposed Poplar River Watershed Dam Site.

Appendix J. Volume (ml/m^2) of benthic macroinvertebrates collected in Surber samples from the upstream and downstream areas in Brick Creek, 16 April 1976.

	Upstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Plecoptera						0.11				
Ephemeroptera	0.05	0.16	0.33	0.22	0.44	0.38	0.33		0.38	0.82
Odonata										
Hemiptera										
Trichoptera	1.21	15.07	1.10	0.18		4.18	1.04	0.99	0.99	0.11
Megaloptera										
Lepidoptera										
Coleoptera	0.22	1.87	0.22	0.11	0.11	0.11	0.38	0.27	0.11	0.11
Diptera	0.16	2.69	0.93	0.93	0.38	0.22	5.72	0.27	2.31	3.08
Oligochaeta										
Hirudinea							0.11		0.05	0.05
Arachnidia										
Isopoda	0.11	0.11		0.11	0.44					
Amphipoda		0.05								

Appendix J. Continued.

	Upstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Decapoda										
Gastropoda		0.27	0.22						0.55	1.21
Pelecypoda	0.05			0.11					0.22	2.53

	Downstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Plecoptera										0.44
Ephemeroptera	0.11	0.05	0.38	0.44	0.44	0.11	0.22	0.16	0.05	0.11
Odonata										
Hemiptera										
Trichoptera	0.55	1.43		0.20	0.05	0.05	0.44	0.05	25.52	9.46
Megaloptera										0.22
Lepidoptera										
Coleoptera	0.22		0.05	0.05		2.47	0.16	0.11	1.81	2.53
Diptera	7.15	2.36	0.93	1.65	2.31	4.89	0.60	0.16	0.49	7.48

Appendix J. Continued.

	Downstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Oligochaeta					0.05	0.05			0.05	
Hirudinea		0.05						1.10		0.55
Arachnidia										
Isopoda	0.11	0.11	0.06	0.11	0.05		0.05	0.22		1.87
Amphipoda			0.05	0.05	0.05	0.11		0.05		0.22
Decapoda										
Gastropoda	0.11	0.05	0.05		0.05		0.05		0.05	2.97
Pelecypoda		0.05								

Appendix K. Volume (ml/m^2) of benthic macroinvertebrates collected in Surber samples from the upstream and downstream areas in Brick Creek, 19 May 1976.

	Upstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Plecoptera				0.05						
Ephemeroptera	0.44	1.10	0.66	1.04	0.82	0.49	0.11	0.38	0.11	0.27
Odonata										
Hemiptera										
Trichoptera	0.27	5.28	5.22	7.04	6.93	1.76	0.44	2.09	1.15	2.08
Megaloptera										
Lepidoptera										
Coleoptera	0.05	1.04	0.11	0.22	0.71	0.60	0.22		0.16	0.27
Diptera	0.22	0.27	0.11	3.46	0.33	0.16	1.04	2.47	1.15	1.65
Oligochaeta				0.55	0.11		0.05			
Hirudinea										
Arachnidia										
Isopoda	0.05	0.22			0.05					
Amphipoda			0.05							

Appendix K. Continued.

	Upstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Decapoda										
Gastropoda		0.44		0.22			0.05	0.05	0.11	0.11
Pelecypoda	0.05	99			0.88				0.22	

	Downstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Plecoptera		0.05								
Ephemeroptera	0.16	0.16	0.11	0.49	2.75	0.05	0.71	1.21		0.16
Odonata										
Hemiptera							0.05			
Trichoptera	1.70	9.18	3.83	12.87	1.15	1.87	1.10	4.34	2.64	10.23
Megaloptera										
Lepidoptera										
Coleoptera	0.38	1.59	0.05	0.77	0.22	0.49	0.27	0.99	0.66	1.54
Diptera	2.31	2.20	2.53	1.65	0.44	1.32	0.71	1.32	0.93	1.32

Appendix K. Continued.

	Downstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Oligochaeta	0.11		0.33							
Hirudinea		0.11		0.22						
Arachnidia										
Isopoda	0.11	0.55	0.11	0.99	0.22	0.05	0.05	0.05		0.11
Amphipoda	0.33	0.11	0.11	0.88	0.11		0.05	0.22		0.05
Decapoda										
Gastropoda	0.11	0.05	0.22	3.08	0.11		0.33	1.21	0.22	0.11
Pelecypoda		0.77	0.05	0.05	0.05	0.11		0.33		0.11

Appendix L. Volume (ml/m^2) of benthic macroinvertebrates collected in Surber samples from the upstream and downstream areas in Brick Creek, 18 June 1976.

	Upstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Plecoptera	4.29	1.21	0.33	-	1.21	2.64	0.55	0.33		0.11
Ephemeroptera	1.98	1.87	1.21	-	0.27	0.44	0.49	0.44	0.16	1.26
Odonata				-			0.05			
Hemiptera				-						
Trichoptera	13.32	3.68	5.17	-	0.71	1.74	0.05	1.81		0.22
Megaloptera			0.11	-						0.05
Lepidoptera				-		0.33				
Coleoptera	5.11	1.65	0.88	-	0.71	1.43	0.16	0.27	0.11	0.33
Diptera	0.27	0.49	12.26	-	0.38	0.44	1.21	0.49	2.03	0.77
Oligochaeta			0.05	-		0.05	0.05			
Hirudinea	0.66	1.10	0.22	-		0.33		0.11		
Arachnidia				-						
Isopoda	0.11	0.77	0.05	-	0.55	0.22	0.05			
Amphipoda	0.05	0.05	0.05	-				0.05		0.05

Appendix L. Continued.

	Upstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Decapoda				-						1.21
Gastropoda	1.21	0.55	1.54	-		0.99	0.05	0.49	0.33	0.11
Pelecypoda	1.32		0.44	-	0.22	0.11		0.05	0.05	0.33

	Downstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Plecoptera	0.66	0.44	0.16	0.55		0.44	0.55	0.44	0.44	1.21
Ephemeroptera	4.40	1.54	0.93	2.58	3.41	0.88	7.04	3.46	0.44	0.38
Odonata										
Hemiptera										
Trichoptera	1.15	3.85	2.14	6.05	1.98	10.39	1.26	3.52	3.41	2.75
Megaloptera			0.05	0.05				0.05		0.05
Lepidoptera										
Coleoptera	1.21	1.04	0.60	0.99	0.77	0.82	0.27	1.21	1.21	0.99
Diptera	3.19	4.18	3.79	1.15	2.03	0.82	3.30	2.69	0.93	1.10

Appendix L. Continued.

	Downstream area									
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Oligochaeta			0.05						0.05	0.05
Hirudinea	0.05	0.11	0.05	0.05	0.66	0.05	0.11			0.11
Arachnidia				0.05						
Isopoda	0.22	0.33	0.22	1.43	0.33		0.66	0.66	0.11	0.77
Amphipoda	0.33	0.11	0.05	0.88			0.11	0.22	0.22	0.22
Decapoda										
Gastropoda			0.33	0.11	2.20	0.33	0.60	1.54	3.24	0.71
Pelecypoda						0.05	0.05	5.61		0.22