ECOLOGICAL FACTORS INFLUENCING WATERFOWL PRODUCTION ON THREE IMPOUNDMENTS IN CENTRAL WISCONSIN

by

Eric C. Nelson

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APPROVED BY THE GRADUATE COMMITTEE OF:

R. K. Anderson

Dr. Raymond K. Anderson
Professor of Wildlife

Lyle E. Nauman

Dr. Lyle E. Nauman
Associate Professor of Wildlife

Gerald Z. Jacobi

Dr. Gerald Z. Jacobi
Associate Professor of Water Resources - Limnology

ABSTRACT

Waterfowl productivity and breeding ecology were studied on three publically-owned impoundments in southern Wood County, Wisconsin in 1975 and 1976. Production of near flight-aged young was less than one third of that previously reported for Wisconsin's high production area (Horicon Marsh) in the southeast section of the state. Low waterfowl production is a product of poor quality habitat on the study areas. Organic soils are acidic, not well decomposed, and have low nutrient contents, except for phosphorus which probably occurs in an unavailable form. Waters are soft, slightly acidic, have low dissolved solid concentrations, and are moderately fertile. Succession is advanced on all study areas and the impoundments do not have sufficient interspersion of emergent vegetation and open water. Surface and benthic aquatic invertebrate populations are comparatively low throughout the breeding season and are probably inadequate to meet the high protein requirements of more breeding hens and developing ducklings. Potential upland nesting habitat is inadequate, particularly for blue-winged teal (*Anas discors*), on all study areas. Nest predator activity is not excessively high.

Duck production is higher on J-Flowage and WC-North, where a generally higher quality habitat prevails, than on WC-South. Water quality is better, plant succession is not as advanced, and invertebrate food sources are greater on these areas than on WC-South. Emergent species composition in WC-South is essentially a spikerush (*Eleocharis palustris*) monotype; J-Flowage and WC-North contain suitable mixtures. Submergent vegetation is sparse on WC-South; J-Flowage and WC-North have dense stands of coontail (*Ceratophyllum demersum*) or water weed (*Anacharis canadensis*).

Differences in hydrologic characters of the wetlands account for variation in quality. Habitat management practices are recommended.

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Thanks to John Peterka, North Dakota State University, for loaning an invertebrate volumetric measuring device. Byron Shaw and Richard Stevens of the Environmental Task Force Laboratory, UW-Stevens Point, generously provided laboratory space and manpower for water quality analyses. Computer analyses were possible only with help from Fred Hilpert, UW-Stevens Point. William Hilsenhoff, UW-Madison, assisted with invertebrate identification.

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INTRODUCTION

Knowledge of waterfowl breeding ecology on wetlands throughout southern Wood County, Wisconsin is incomplete. Waterfowl production in this central Wisconsin area is only one third of that produced in southeastern Wisconsin, the state's highest duck production region (Jahn and Hunt, 1964; March et al, 1973). The purpose of this study was to determine the ecological factors that influence low waterfowl productivity on three publically-owned waterfowl impoundments in Wood County.

Major portions of the mallards (*Anas platyrhynchos*), wood ducks (*Aix sponsa*), and blue-winged teal (*Anas discors*) harvested in Wisconsin are produced in the state (March et al, 1973). The maintenance and conservation of Wisconsin's breeding duck population (to the benefit of all types of human endeavor) is increasingly more dependent upon supplying more breeding habitat through wetland management. Development and management of state-owned, artificial wetlands could produce the equivalent of Wisconsin's better-quality natural wetlands, and thereby, increase total production estimates by 50 percent (March et al, 1973). This study can assist public agencies in their selection of wetlands to be managed for breeding ducks.

The study was orginated by the Wisconsin Department of Natural Resources (WDNR) and the College of Natural Resources, University of Wisconsin - Stevens Point (UW-Stevens Point). Support was provided by the WDNR through Pittman-Robertson research funds.

Field work was conducted from April 1975 to August 1976 in cooperation with Guy Baldassarre, a fellow graduate student at UW-Stevens Point. I will refer to his evaluation of three study impoundments located near my project areas.

STUDY AREAS

Studies were conducted on three man-made impoundments (Type IV and V wetlands; Shaw and Fredine, 1956) on two public wildlife areas in Remington Township, Wood County, Wisconsin, 2 - 8 miles (3.2 to 10.6 km) west of Babcock (Fig. 1). This central Wisconsin area is within the bed of glacial Lake Wisconsin that once covered approximately 1500 sq. mi. (3,890 sq. km.) and now consists of peat and sand marshes interspersed with upland ridges and islands. Upper Cambrian bedrock is sandstone with shale and conglomerate rock (U.S. Geological Survey, 1976); soils are Newton sands overlain with peat (Hole, et al, 1974). Vegetation is dominated by aspen-oak (Populus-Quercus) uplands, lowland brush, and sedge (Carex spp) marsh.

Cranberry culture and logging are the major commercial enterprises of the area. Regional land-use management was most intense during the early 1900s when an extensive series of ditches, dikes, and impoundments was constructed to drain the organically-rich peat soils for agricultural use. Farming failed, however, due to short growing seasons and nutrient-poor soils, and by the 1930s most of the land was abandoned. Subsequently, private individuals and the state of Wisconsin acquired these lands for wildlife and forest management. Maintenance of the drainage system has been an integral part of the state's management program.

Four management units (3 state and 1 federal), encompassing 124,838 acres (50,542 ha), have been established in this region of southern Wood and Juneau Counties; they are, 1) Sandhill Wildlife Area (9,150 acres; 3,704 ha), 2) Wood County Wildlife Area (18,500 acres; 7,490 ha), 3) Meadow Valley Wildlife Area (57,639 acres; 23,336 ha), and 4) Necedah National

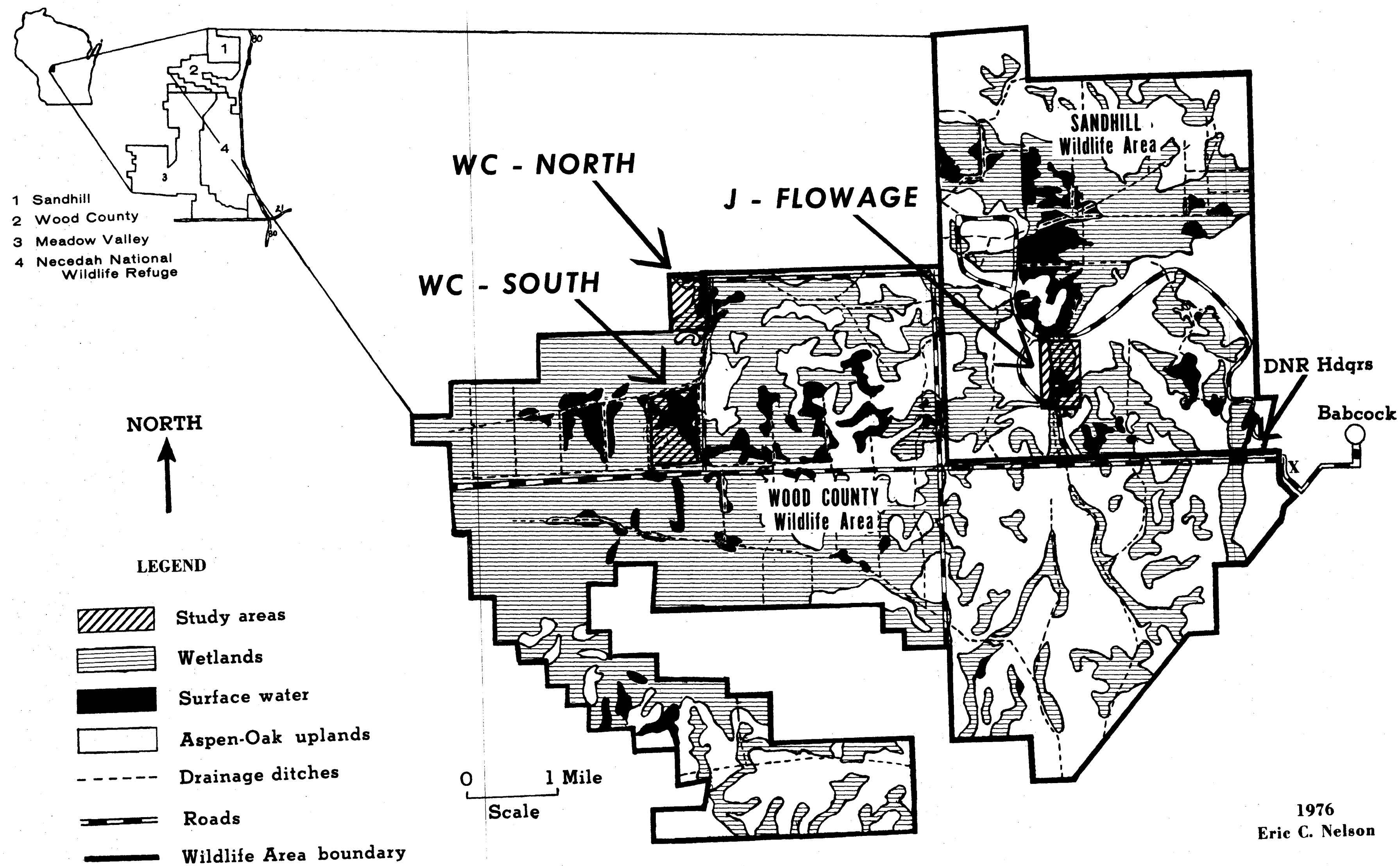

Fig. 1. Waterfowl management study impoundments, Wood County, Wisconsin.

Wildlife Refuge (39,549 acres; 16,012 ha).

The three study impoundments were: 1) J-Flowage located in the Sandhill Wildlife Area (NW¼, Sec 8, T21N, R2E), 2) Wood County-South (WC-South) in the Wood County Wildlife Area (Secs 9 and 10, T21N, R2E), and 3) Wood County-North (WC-North) also in the Wood County Wildlife Area (NW¼, Sec 3, T21N, R2E).

J-Flowage (100 acres; 40.5 ha) contains 55 acres (22 ha) of emergent vegetation and surface water; the remainder consists of willow (*Salix* spp.), sedge (*Carex*, spp.), spirea (*Spirea tomentosa*), blue-joint grass (*Calamagrostis canadensis*), and stunted cattail (*Typha*, spp.) (Fig. 2). Water flows from Galleger Flowage into J-Flowage and is directed southward by a channel running the length of the impoundment. Water control structures (high risers) are located at the north and south ends. During periods of low water flow, water is retained by three beaver (*Castor canadensis*) dams at the impoundment's north end. A dike separates the east and west sections of J-Flowage and water moves from east to west through a culvert in the dike. J-Flowage was accidentally drained 19 June 1976 and reflooded within 3 days.

WC-South is a rectangularly-shaped impoundment (308 acres; 125 ha) with ditches and a drivable dike around its perimeter (Fig. 3). Thirty percent (94 acres; 38 ha) of the impoundment consists of open water and emergent vegetation, 13 percent (41 acres; 17 ha) offsite aspen, and 60 percent (184 acres; 74 ha) is sedge meadow interspersed with willow and wool-grass bulrush (*Scirpus cyperinus*) islands. The impoundment's major water source is groundwater; incoming runoff is inhibited by the surrounding ditches. Water drainage is from south to north. WC-South was drained in August 1975 in preparation for a prescribed burn but the

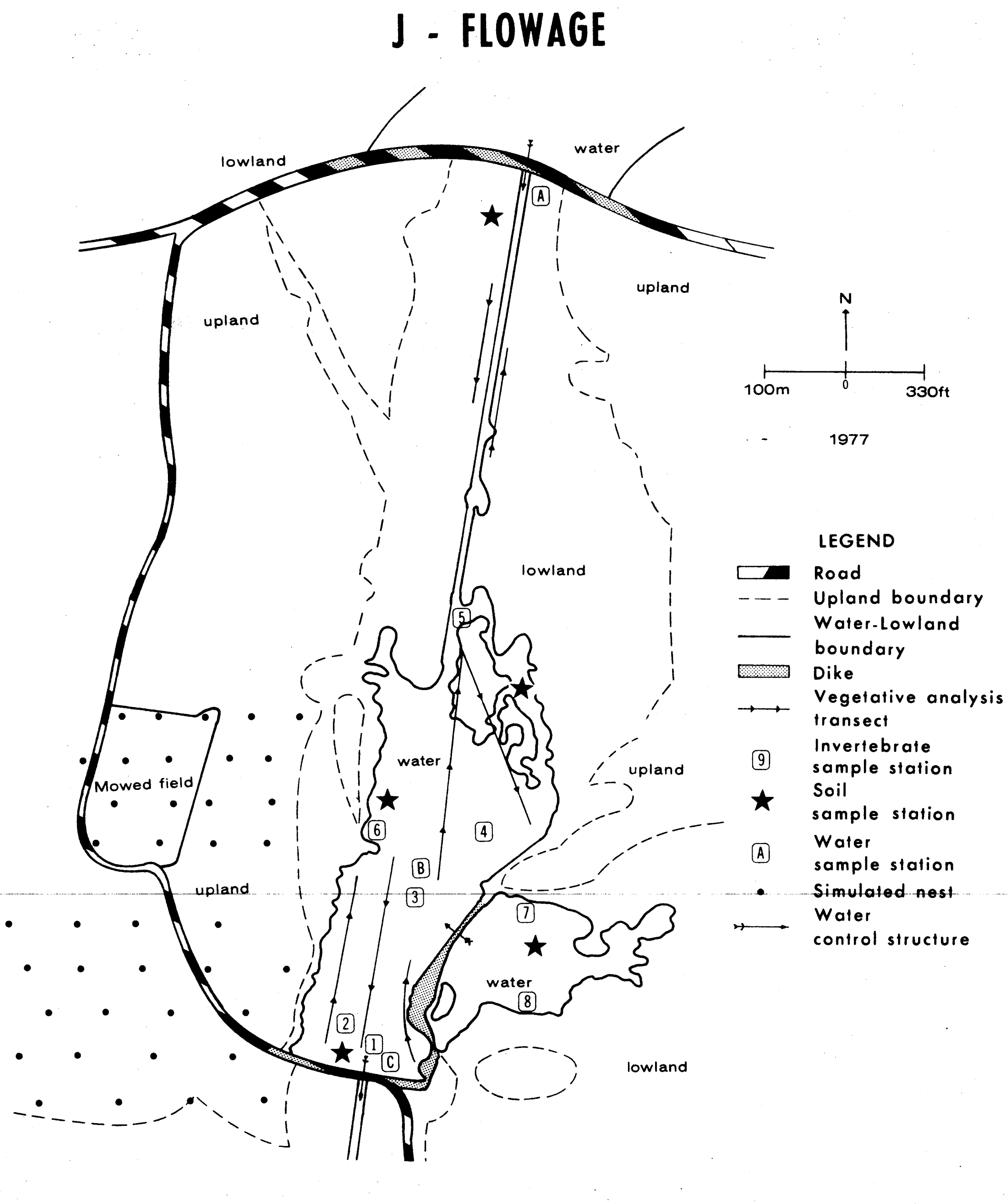

Fig. 2. Locations of sampling stations, vegetation transects, and simulated nests on and near J-Flowage, Sandhill Wildlife Area, Wood County, Wisconsin.

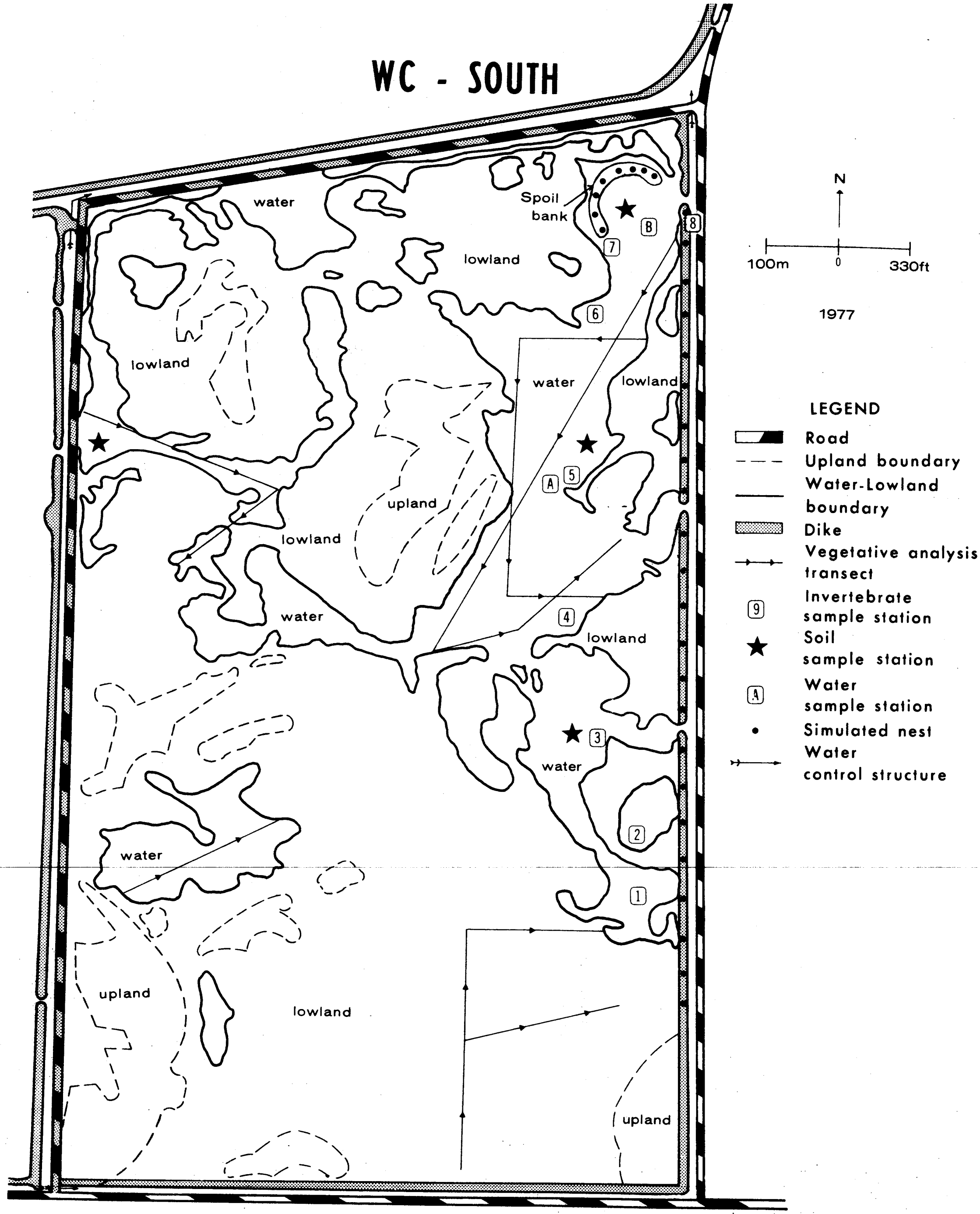

Fig. 3. Locations of sampling stations, vegetation transects, and simulated nests on WC-South, Wood County Wildlife Area, Wood County, Wisconsin.

burn was not completed because of wet weather.

The third study area, WC-North is 152 acres (62 ha) in size and is bordered by ditches and dikes on its north, south, and east sides. Access roads accompany the east and north dikes (Fig. 4). Water flows from south to north and enters WC-North through openings in the south dike and at the impoundment's northwest corner. One third (50 acres; 20 ha) of the study area is aspen-oak upland, 30 percent (46 acres; 19 ha) is combinations of sedge, willow, and/or wool-grass bulrush, and 36 percent (56 acres; 23 ha) is covered by surface water interspersed with emergent vegetation.

METHODS AND MATERIALS

WATERFOWL CENSUSES

Waterfowl were censused by truck and on foot along specified routes between 20 April and 15 June 1975 and 1 April and 15 June 1976. Two types of censuses were used. The first determined dates of arrival, peak numbers, and departure of migrant waterfowl by conducting counts on 4- to 6-day intervals throughout the census periods. The second census determined the number of breeding pairs. Each study area was censused four times during a 7- to 10-day interval (4-in-10 count) when most of the early nesting species were laying or incubating eggs (Dzubin, 1969). An identical census was conducted when late nesting species were in these reproductive stages. Early 4-in-10 counts were conducted 21 April to 2 May 1975, and 24 April to 3 May 1976; late counts were made 27 May to 5 June 1975, and 17 May to 24 May 1976. Variation in yearly phenology accounted for the difference in the late count, time intervals.

The exact locations of pairs, lone males, and groups of 2 to 5 males

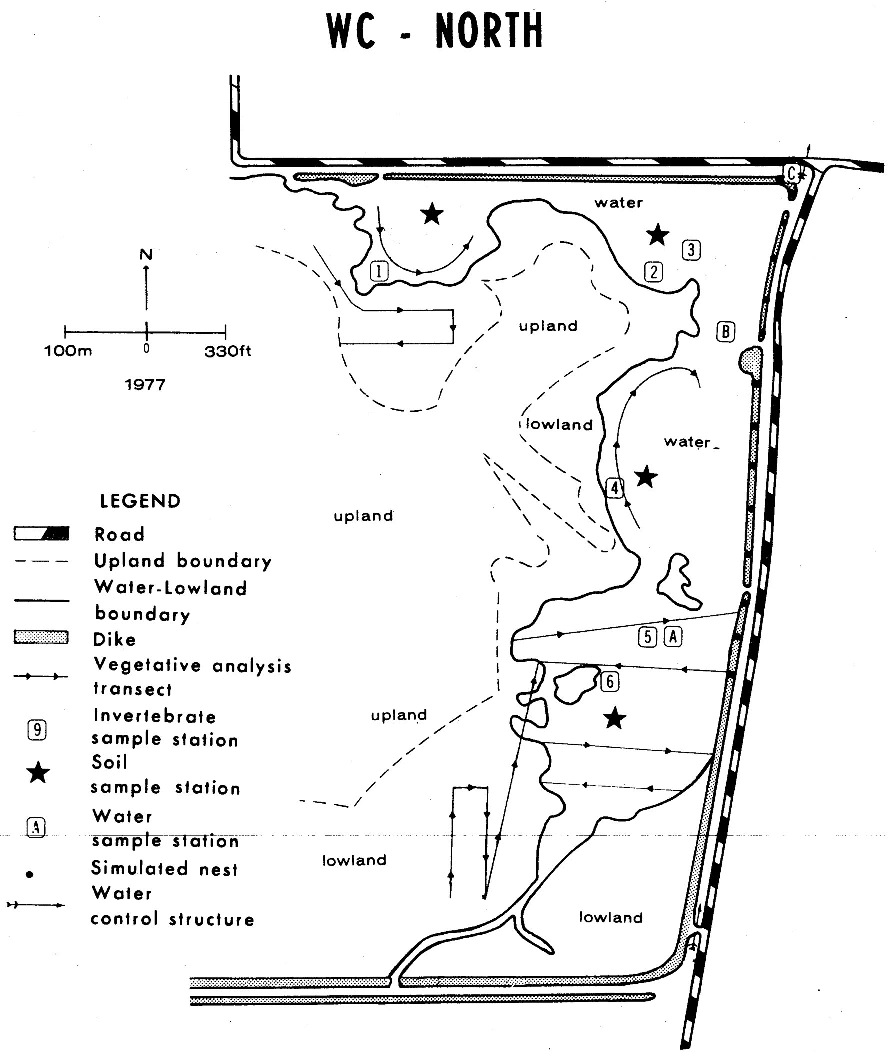

Fig. 4. Locations of sampling stations, vegetation transects, and simulated nests on WC-North, Wood County Wildlife Area, Wood County, Wisconsin.

were recorded on base maps of each impoundment. Pairs and males appearing in similar locales on 3 or more days of the 4-in-10 counts were classified as resident breeding pairs or "indicated pairs" (Dzubin, 1969) of the study area. Counts were conducted from early morning to mid-day in 1975, and in early morning only in 1976.

BROOD COUNTS AND PRODUCTION ESTIMATES

Brood counts in 1975 were few and sporadic; no production estimate was made for that year.

A total of 21 brood counts were made from 31 May to 23 July 1976. Counts were made during a 2-hour period just after sunrise or prior to sunset, and were alternated each day. Each impoundment was counted on a 5- to 8-day rotation. Incidental brood observations were also recorded. Ducklings were aged according to Gollop and Marshall (1954). Repeated brood observations allowed me to distinguish individual broods (based upon their size, age, and relative locations on the marsh) and classify them as residents or transients. I assumed a brood was a resident if it was observed two or more times; transient broods were those seen only once.

Duck production was estimated from the number and size of observed Class II and older broods. The estimate is presented as a numeric range; its upper (maximum) range limit included all Class II and older broods observed one or more times, thus including both residents and transients; the lower range limit includes resident broods only.

NEST SEARCH

Searches for waterfowl nests were conducted in late May and early June of 1975 and 1976. In 1975, a crew of 5 people, moving abreast and one chain (20 meters) apart, searched the periphery of WC-South and J-Flowage. In 1976, the distance between crew members was shortened to 15 feet (5 meters) and each member used a stick to beat the vegetation. The peripheries of all three study areas were searched in 1976. All searches were conducted between 1000 and 1600 hours, Central Daylight Savings Time.

SIMULATED NEST PREDATOR SURVEY

Simulated nests were exposed to predation for 21 days from 6 June to 27 June 1975, and from 20 May to 10 June 1976. (The 1975 study was initiated approximately 15 days past the peak nesting period because of logistical problems in obtaining eggs.) These studies were conducted in four habitats: 1) dikes, 2) a recently (1974) constructed nesting island or spoil bank, 3) an oak upland, and 4) a mowed field (Figs. 2, 3, 4). Thirty simulated nests were placed in dike and nesting island habitat in 1975; 85 nests were placed within the four habitats in 1976.

Field techniques followed those of Hammond (1966), with two exceptions: 1) mallard eggs were used instead of chicken eggs, and 2) the extent of vegetative cover at the nest site was determined by using a height-density pole (Robel et al, 1970). Vegetative analysis was made two days prior to egg placement and only in 1976.

Simulated nests were placed at 165-ft (50 m) intervals along dikes and on the spoil bank, and at 200-ft (60 m) intervals in the oak upland and mowed field. Single-egg nests were used in 1975. In 1976, both single- and triple-egg nests were used; single-egg nests were placed on the spoil bank, and nests of 1 and 3 eggs were alternately placed on the dike, oak upland, and mowed field habitats. The simulated nests were checked after 3 weeks of exposure in 1975, and at weekly intervals for 3 weeks in 1976.

Predator species were determined by examination of the size and shape of the broken egg shell fragments and the degree of disturbance in and around the nest (Duebbert, 1970). A nest was considered destroyed if one or more eggs were either broken by a predator, or missing.

SOILS ANALYSIS

Composite soil samples from each flowage were collected 5 August 1975 and frozen until analyzed on 17 November 1975. Each composite consisted of subsamples from 5 locations (2, 3-in. (7.6 cm) cores/location) dispersed throughout an impoundment (Figs. 2, 3, 4). The core sampling device was a 2-ft by 2-in. (61 cm x 5 cm) plastic tube attached to a 4-ft (1.3 m) frame equipped with a rubber stopper for plugging one end of the tube (unpublished, designed by John Beule and Tom Janisch, Wisconsin Department of Natural Resources, Box D, Horicon, Wis. 53032). The tube was plunged into the soil, cutting a core as it entered, and then plugged by the stopper on its open end to create an air lock above the core. The core was retained without soil loss as the tube was extracted from the substrate, and deposited into a collecting bucket.

The Soil and Plant Analysis Laboratory, Department of Soil Sciences, University of Wisconsin, Extension, Madison, Wisconsin analyzed soil samples for several trace elements, NO_3N, pH, and determined percent sand, silt, clay, and organic matter.

WATER QUALITY ANALYSIS

Impoundment waters were analyzed chemically and physically for general water quality and fertility. Samples were collected biweekly from May to August 1975, and April to August 1976. Monthly samples were collected from September 1975 to March 1976. Water was sampled from the inflow, middle, and outflow points of J-Flowage; from the middle and outflow points of WC-South, and from 2 midpoints and the outflow of WC-North (Figs. 2, 3, 4). All samples were taken within 2 feet (60 cm) of the surface with a horizontal Van Dorn water bottle, transferred to appropriate containers, cooled, and analyzed within 24 hours after sampling. Color, temperature, and pH (using a Beckman portable pH meter) were determined in the field. Further analyses were conducted in the Environmental Task Force Laboratory, University of Wisconsin - Stevens Point. Properties tested, and the corresponding methods of analysis were as follows: dissolved oxygen (DO) content (Winkler method); CO_2 content (nomograph, APHA, 1971:91); total alkalinity (bromecresol-green-methyl-red titration); specific conductance (Lectro Mho-meter); and turbidity (Hach Model 2100 Turbidimeter).

Detailed analyses (APHA, 1971) of composite, biweekly, water samples from each impoundment were conducted between 31 March and 23 June 1976. Samples were analyzed for BOD, nitrogen, and phosphorus (NO_2N-NO_3N, NH_4N, Kjeldahl N, Ortho P, and Total P).

Annual and seasonal mean values of water quality data were tested for significant differences between sample points within each impoundment, and between sample points of all impoundments (analysis of variance, simple randomized design).

Water levels were measured at water control structures in each study area on 2 to 7 day intervals. Measurements were read on the inflow and outflow tubes of J-Flowage, and on the outflow tube of WC-South. Water levels of WC-North were measured on the dam in the east ditch and on the bridge at the impoundment's northeast corner.

WETLAND VEGETATION ANALYSIS

Emergent and Moist-Soil Communities

Emergent and moist-soil vegetation was inventoried during August 1976 with 0.25 m^2 quadrats randomly spaced at 25 m intervals along transects located within major vegetational stands (Figs. 2, 3, 4). A stand is defined as a vegetational unit having similar botanical and physical characteristics (Cowardin and Johnson, 1973). The following data were recorded: 1) the number of stems of each species, 2) the percent areal coverage of the plot by each species, 3) the percent areal coverage of the plot by all species within the plot, and 4) water depth. The number of leaves was recorded instead of stems where floating-leaved species occurred. Percentage of areal coverage was estimated according to the following index after Cowardin and Johnson (1973):

0	absent
1	rare, a few occasional individuals
2	occasional, 1 percent
3	fairly common, 1 - 10 percent
4	common, 11 - 50 percent
5	abundant, 51 - 100 percent

The composition of the wetland communities was quantified in terms of density, dominance, and frequency for each species. The prevalent species within the communities were then ranked according to their importance, as determined by combining relative density, dominance, and frequency into a single importance value (Cox, 1967).

Vegetation cover maps were constructed using 1968 and 1972 Soil

Conservation Service aerial photos and 35 mm colored oblique aerial photos taken in June 1975 and August 1976. Dominant emergent and moist-soil species were determined from quadrat sampling and computed importance values. Some minor stands were not quantified; dominant species within these areas were ranked by random observations.

A voucher collection of the prevalent wetland plants from each study area was placed in the University of Wisconsin - Stevens Point herbarium.

Data from stem counts conducted in willow stands on the west and southeast sections (20 and 10 plots, respectively) of WC-South are included in Appendix A. Data were collected in August 1975 prior to a planned burn but are not summarized because the burn was never completed. Permanent, milacre plots are marked by 5-foot metal posts on the west side and by 2-foot wooden stakes in the southeast section.

Submergent Communities

Submergent vegetation was inventoried on 5-7 August 1976 by a rake-sample method described by Swindale and Jahn (1956) and tested by Jessen and Lound (1962). One sample was taken, instead of four, at each sample point, and points were randomly located along zig-zag transects. Water depth was measured at each sample point. Samples were not taken within emergent vegetation. Approximately one sample was collected per acre of open water.

The composition of submergent vegetation was quantified in terms of frequency and dominance. The prevalent species were then ranked according to their importance, as determined by combining relative frequency and dominance into a single importance value (Cox, 1967).

INVERTEBRATE ANALYSIS

Macroinvertebrates were collected at permanent surface and bottom sample stations randomly dispersed throughout aquatic plant communities on each study area (Figs. 2, 3, 4). Surface samples were not taken where vegetation was not present at station number 3 in WC-North and station 3 in J-Flowage. [In 1975, J-Flowage was sampled on 19 June and 21 July; WC-North and WC-South were sampled 1 July and 4 August. Results of the 1975 samples are not presented.] In 1976, all flowages were sampled at 4-week intervals beginning 16 April and ending 9 July. Biweekly samples were also taken from WC-South 1 April to 9 July 1976.

The surface water (top 8 in. or 19.3 cm) was sampled with a pond life sweep net, 112 in.^{2} (725 cm^2) in area, with a mesh size of 23 openings/inch (2.54 cm). Composite samples of 4, 3.3 ft (1 m) sweeps through the water were made at each sample station. Benthos was sampled with one Ekman dredge grab (36 in.^{2} or 232 cm^2) per station. All samples were stored immediately in 1-gallon (3.8 liters) plastic jugs and preserved in 10 percent formalin.

Macroinvertebrates retained in a No. 35 U.S. Standard Sieve were hand sorted from the substrate and preserved in 70 percent isopropyl alcohol. Aquatic insects, except some dipterans, and gastropds were identified to genera; other taxa were keyed to class, order, or family. Identifications were made with the aid of keys by Hilsenhoff (1975), Pennak (1953), and Usinger (1956). All individuals were counted. Macroinvertebrate volume was determined with a syringe volumetric measuring device that operates by water displacement and measures to the nearest 0.01 milliliter (Myers and Peterka, 1974). Organisms were soaked for 30 to 60 minutes in distilled water and then blotted on paper for 15 to 30 seconds prior to measurement.

Significant differences between the mean volumes (and numbers) of 16 major taxa collected during the 4 sampling periods from 16 April to 9 July 1976 were determined by an analysis of varaince test. Mean values from the surface samples of all impoundments and surface samples form individual impoundments were tested by analysis of varaince (randomized block design). The impoundments were ranked according to their importance, as determined by combining relative average numbers and volumes of invertebrates into a single importance value (Cox, 1967).

RESULTS

SPRING MIGRATION

The 1976 spring waterfowl migration summary is based upon data from this study and that from Baldassarre (1978). Peak numbers of migrant waterfowl occurred throughout April; mallards and Canada geese (*Branta canadensis*) were most prevalent during the first 2 weeks, blue-winged teal, ringed-necked duck (*Aythya collaris*), and lesser scaup (*Aythya affinis*) occurred in relatively constant numbers during the entire month (Table 1). Peak numbers, as determined from migration data collected at the Necedah National Wildlife Refuge (Necedah NWR Annual Repts, 1967-1976) located 7 miles (11 km) south of the study areas, occurred earlier in 1976 than the 10-year average.

Total waterfowl use-days and use-days per acre of wetland were calculated from censuses conducted on each study area, 1 April to 24 May 1976 (Table 2). J-Flowage had 5.3 and 15.5 times more use-days per acre than WC-North and WC-South, respectively. Ring-necked ducks and Canada geese were only present as occassional migrants on the other study areas.

Ring-necked ducks were the most abundant migrants (accounting for

Table 1. A comparison of peak periods of waterfowl migration on six study areas in Wood and Juneau Counties, Wisconsin, 1976, with migration periods determined for the years 1967-1976 at the Necedah National Wildlife Refuge, Juneau County, Wisconsin.[a]

Species	Six Study Areas, 1976	Necedah National Wildlife Refuge, 1967-1976
Canada Goose	April 1 - April 14	April 8 - April 21 (7)[b]
Mallard	April 1 - April 14	April 8 - April 21 (7)
Blue-winged Teal	April 1 - April 30	April 1 - May 7 (10)
Ring-necked Duck	April 1 - May 3	April 8 - April 21 (6)
Scaup	April 4 - April 10	April 8 - April 30 (9)

[a]Six study areas include three from this study and three from Baldassarre (1978).

[b]Number in parentheses is the number of years between 1967 and 1976 when peak migration occurred during the specified time interval.

Table 2. Total waterfowl use-days and use days per acre of wetland on J-Flowage, WC-South, and WC-North, 1 April to 24 May 1976.

Species	Study Area J-Flowage (55 acres)	WC-North (56 acres)	WC-South (94 acres)	Total (205 acres)	Percent of total
Mallard	379 (6.9)[a]	329 (5.9)	83 (0.9)	791 (3.9)	14
Blue-winged Teal	475 (8.3)	277 (4.9)	170 (1.8)	922 (4.5)	17
Canada Goose	621 (11.3)	99 (1.8)	90 (1.0)	798 (3.9)	14
Ring-necked Duck	2710 (49.3)	24 (0.4)	122 (1.3)	2856 (13.9)	51
Others	75 (1.4)[b]	16 (0.3)[c]	6 (0.1)[d]	179 (0.9)	3

[a]Number in parentheses is use-days per acre of wetland.

[b]Bufflehead (Bucephala albeola), American Wigeon (Anas americana), Redhead (Aythya americana), Canvasback (Aythya valisineria), Hooded Merganser (Mergus cucullatus), Wood Duck, Green-winged Teal (Anas crecca).

[c]Wood Duck, Green-winged Teal, Red-breasted Merganser (Mergus serrator).

[d]Wood Duck, American Wigeon, Green-winged Teal.

51 percent of the total use-days) followed by blue-winged teal, Canada geese, and mallards. The number of migrant waterfowl species present on J-Flowage, WC-South, and WC-North was 14, 9, and 8, respectively. A summary of spring and early summer waterfowl and marshland bird use of the three study areas in 1975 and 1976, is presented in Appendix B, Tables 1 and 2.

BREEDING PAIRS

Mallard and blue-winged teal were the only species represented as "indicated pairs" in the "4-in-10" counts (Dzubin,1969); wood ducks were conspicuously absent. In 1975, the total indicated breeding-pair population was 14 mallard pairs (6.83 prs/100 acres of wetland)(Table 3). In 1976, the total breeding pair population was 10 pairs (4.88 prs/100 acres of wetland), consisting of four mallard and 6 blue-winged teal pairs. WC-South held 6 breeding pairs (mallards) in 1975, and 3 pairs in 1976 (all blue-winged teal). WC-North supported 5 breeding pairs (mallards) in 1975, and 3 pairs (1 mallard and 2 blue-winged teal) in 1976. J-Flowage held 3 pairs (mallards) in 1975 and 4 pairs in 1976 (3 mallard, 1 blue-winged teal).

NEST SEARCH

Nest searches in 1975 revealed one blue-winged teal nest on WC-South. No nests were found in 1976. Time expended in nest searching during 1975 and 1976 was 48 and 52 man-hours, respectively. Field crews searched the following number of acres per study area: J-Flowage (52 acres; 21 ha), WC-South (43 acres; 17 ha), and WC-North (31 acres; 13 ha).

Table 3. Pairs of waterfowl observed during breeding pair "4-in-10"[a] counts on three study areas, Wood County, Wisconsin, 1975 and 1976.

	1975			1976		
Study area	Early count	Late count	Pairs/100 acres of wetland	Early count	Late count	Pairs/100 acres of wetland
J-Flowage	3 Mallard	0	5.45	2 Mallard	1 Mallard 1 Blue-winged Teal	7.27
WC-South	4 Mallard	2 Mallard	6.38	0	3 Blue-winged Teal	3.19
WC-North	4 Mallard	1 Mallard	8.92	1 Mallard	2 Blue-winged Teal	5.35
Total	14 Mallard		6.83	4 Mallard 6 Blue-winged Teal		4.88

[a]From Dzubin, 1969.

BROOD OBSERVATIONS

Routine brood searches were not conducted in 1975. In 1976, 26 duck broods were counted on the three study areas. The number of duck broods seen per study area was: WC-North - 12 (5 mallard, 6 blue-winged teal, 1 wood duck), J-Flowage - 10 (6 mallard, 3 blue-winged teal, 1 wood duck), and WC-South - 4 (2 mallard, 1 blue-winged teal, and 1 wood duck). Approximately one half of the mallard and blue-winged teal broods observed on WC-North and J-Flowage were residents; no resident broods were counted on WC-South.

Canada goose broods were observed on each study area during late May but were not seen again after 12 June. Four goose broods were seen on J-Flowage, 2 on WC-North, and 1 on WC-South.

Fifty hours were expended searching for broods (0.96 broods/hr). Broods were seen at a higher hourly rate in the evening (1.13 broods/hr) than in the morning (0.85 broods/hr). Brood searching on WC-South was discontinued after 23 June 1976 because visibility was severely restricted by dense emergent vegetative growth. Only one brood was seen during 10 hours of searching on WC-South; 18 brood observations were made in 19 hours on J-Flowage, and 29 brood observations in 21 hours on WC-North.

NESTING PHENOLOGY

Nest initiation (first egg) and hatching dates of the four major breeding waterfowl species were determined by back-dating broods according to clutch sizes and incubation periods (Johnsgard, 1975). Nesting phenology is based upon 1976 data from this study and that from Baldassarre (1978). Mallard nests were begun during the first 3 weeks of April and renests were initiated during the last week of April through the third week of May (Fig. 5). Most mallard clutches hatched during May. Fifty-nine percent of the blue-winged teal nests were initiated during the third week of May and most clutches hatched during the last week of June. Wood ducks initiated nesting during the second and third weeks of April, while the first eggs of Canada geese were layed during the first week of April.

DUCK BROOD SIZE

Mean duck brood sizes, by age class, for mallard, blue-winged teal, and wood duck (Table 4) were calculated from combined data of this study and that of Baldassarre (1978). Class I, II, and III mallard broods averaged 5.2, 5.1 and 3.5 ducklings, respectively; blue-winged teal broods averaged 7.0, 6.9, and an undetermined number, respectively. Mean brood size of Class III mallard ducklings is based on only 6 observations. There were no significant differences ($P < .05$) between duck brood sizes of this study and of those reported by Jahn and Hunt (1964) (Table 4).

WATERFOWL PRODUCTION

Class II and older duckling production per 100 acres of wetland (1976 only) varied between study areas (Table 5). WC-South had no resident broods and only one transient mallard, blue-winged teal, and wood duck each. J-Flowage and WC-North produced 48 and 64 resident ducklings per 100 acres of wetland, respectively. J-Flowage produced near-equal numbers of resident mallards (27.3) and blue-winged teal (23.6); WC-North produced 51.0 blue-winged teal and 14.3 mallards. Wood duck broods were observed only as transients on the study areas. Production estimates, which included both transient and resident broods, were 9 to 136 percent higher than estimates based solely on resident broods.

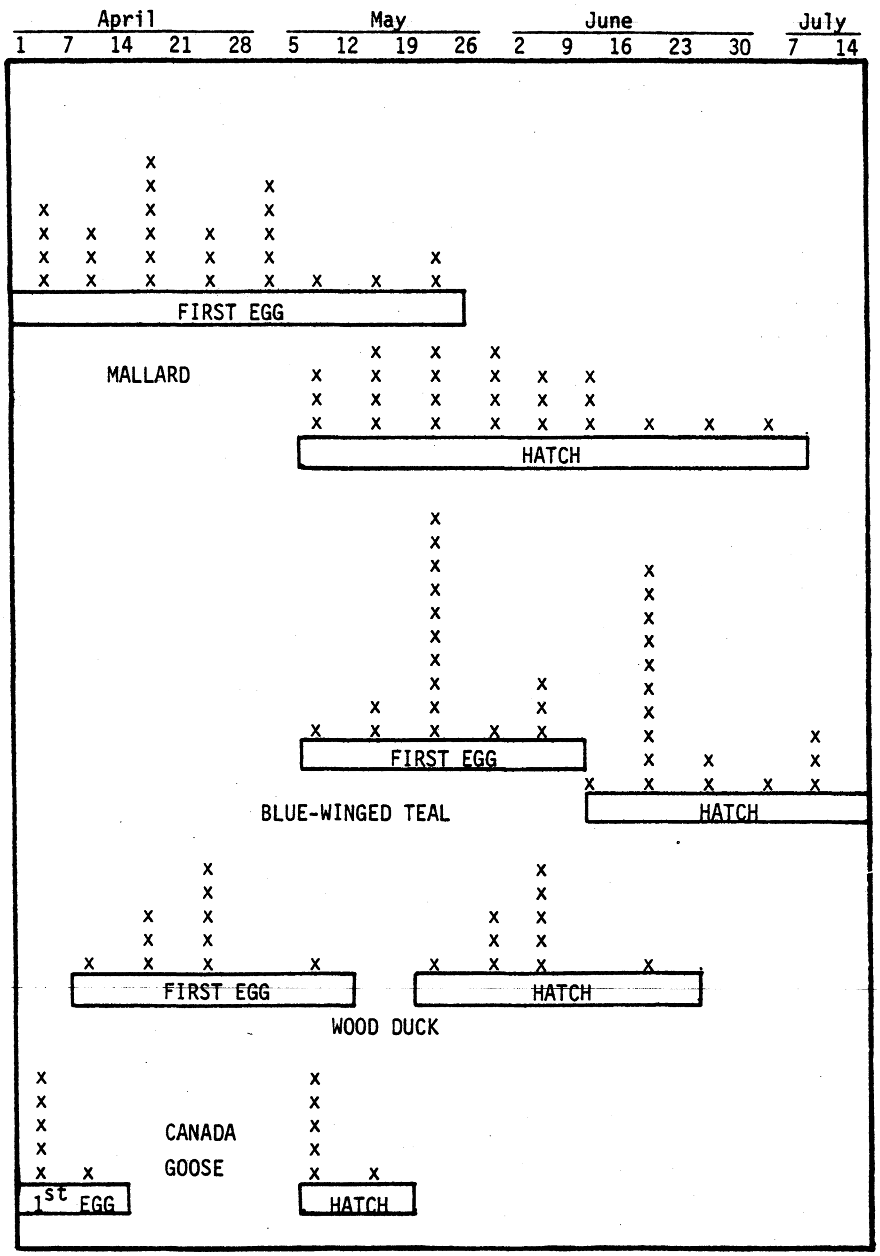

Fig. 5. Observations (x), by week, of first eggs and hatching dates for the major species of breeding waterfowl on six central Wisconsin flowages, 1976, as based on back-dated broods.

Table 4. Mean duck brood sizes, by age classes, of the three major species observed on six study impoundments in central Wisconsin, 1976[a], compared with published regional values.

	Class I		Class II		Class III	
	No. of broods	Size	No. of broods	Size	No. of broods	Size
Mallard	10	5.2 ± 1.0 [b]	23	5.1 ± 0.5	6	3.5 ± 0.7
	(21	7.6 ± 0.5)[c]	(73	6.2 ± 0.3)	(37	5.5 ± 0.4)
Blue-winged Teal	15	7.0 ± 0.8	13	6.9 ± 0.4	no data	
	(34	7.4 ± 0.5)	(46	7.4 ± 0.4)	(12	7.7 ± 0.8)
Wood Duck	7	9.4 ± 1.7	5	5.8 ± 1.4	3	6.7 ± 1.8
	(20	8.7 ± 0.6	(29	7.6 ± 0.5)	(17	5.1 ± 0.9)

[a]Combined data from this study and Baldassarre (1978).

[b]Standard error accompanies the mean.

[c]Numbers in parentheses are values calculated for this region (Forested) of Wisconsin by Jahn and Hunt (1964), except for wood duck values which were based upon state-wide data.

Table 5. Numbers of Class II and older ducklings produced per 100 acres of wetland on J-Flowage, WC-South, and WC-North, 1976.[a]

Study area (acres of wetland)	Mallard	Blue-winged Teal	Wood Duck	Total
J-Flowage (55)	27.3-59.1	23.6-25.5	0-10.9	48.1-95.5
WC-South (94)	0-4.8	0-5.3	0-0	0-10.1
WC-North (56)	14.3-32.1	51.0-66.1	0-14.3	64.1-112.7
All Areas (205)	11.2-26.3	20.0-27.3	0-6.8	31.2-60.4

[a]Lower value includes resident broods only; higher value includes resident plus transient broods.

Area production, based upon combined data from this study and from Baldassarre (1978), for mallard, blue-winged teal, and wood duck ranged from 13-21, 10-13, and 4-9 Class II and older ducklings per 100 acres of wetland, respectively (Table 6).

SIMULATED NEST PREDATOR SURVEY

Predators destroyed 28 percent (33 of 116) of all simulated nests during the 1975 and 1976 breeding seasons (Table 7). Nest destruction rates ranged from 0 to 100 percent within four habitats.

Raccoon (Procyon lotor) and striped skunk (Mephitis mephitis) destroyed 36 and 33 percent of the nests respectively; unknown predators destroyed 30 percent. Seventy percent (21 of 30) of the nest losses in 1976 occurred within the first 2 weeks of exposure (Table 7).

Three-egg nests were destroyed at a higher rate (38 percent) than 1-egg nests (23 percent)(Table 8). The difference was not significant at the 5 percent confidence level, but was significant at the 10 percent level ($X^2 = 3.48$, df = 1). Statistical analyses of 3-egg vs 1-egg nest losses within each habitat were not possible because of a small sample size; however, 8 of 10 nests destroyed in oak-upland habitat contained 3 eggs. Differences between 3-egg and 1-egg nest losses in other habitats involved only one or two nests.

Mean vegetation height at simulated nests ranged from 2.64 decimeters (dm) in mowed-field habitat, to 4.72 dm in dike habitat of WC-North (Table 9). Average vegetation height around destroyed nests was significantly lower ($P < .05$) than vegetation height at successful nests located on dikes of WC-South ($T = 2.815$, df = 16) and WC North ($T = 2.866$, df = 11). There were no significant differences in mean vegetation height between destroyed and successful nests placed in mowed-field

Table 6. Class II and older duckling production on six study areas, Wood and Juneau Counties, Wisconsin, 1976.[a]

Area (acres of wetland)	Mallard	Blue-winged Teal	Wood Duck	Total
MV,B,D[b] (255)	33-41	6-4	19-24	58-69
J-Flowage, WC-South, WC-North (205)	25-53	41-55	0-14	66-122
6 Study Areas	58-94	47-59	19-38	124-191
Production Total Per Acre (460)	.13-.20	.10-.13	.04-.08	.27-.41
Production Total Per 100 Acres (460)	13-20	10-13	4-8	27-41
Production Per 100 Acres in the Central Plain of Wisconsin[c]	20	23	24	42

[a]First value includes resident broods only; second value includes resident plus transient broods.

[b]Three impoundments studied by Baldassarre (1978).

[c]Data reported by Jahn and Hunt (1964) for the years 1951-1956.

Table 7. Cumulative weekly nest destruction rates and predator species of simulated nest predator surveys at J-Flowage, WC-South, and WC-North, 1975 and 1976.

Habitat, location, and date	Number of simulated nests	Cumulative weekly nest destruction, 1976 only			Percent destroyed	Number of nests destroyed by predators		
		Week 1	Week 2	Week 3		Raccoon	Skunk	Others
Spoil Bank WC-South, 1975	8	-	-	3	38	2	1	0
Dike WC-South, 1975	22	-	-	0	0	-	-	-
1975 Totals	30	-	-	3	10	2	1	0
Spoil Bank WC-South, 1976	7	3	6	7	100	4	1	2
Oak Upland J-Flowage, 1976	33	1	7	10	30	2	3	5
Dike WC-North, 1976	14	2	4	5	36	1	3	1
Dike WC-South, 1976	23	1	3	6	26	3	2	1
Mowed Field J-Flowage, 1976	9	1	1	2	22	0	1	1
1976 Totals (percent)	86	8 (23)	21 (70)	30 (100)	35	9	10	10
Total, both years (percent)	116	-	-	33	28	12 (36)	11 (33)	10 (30)

Table 8. Habitat, clutch size, and destruction rates of simulated nest predator surveys at J-Flowage, WC-South, and WC-North, 1975 and 1976.[a]

Habitat and location by year	Number of nests	Number of nests with:		Number of nests destroyed		Total number destroyed (percent)
		1 egg	3 eggs	1 egg	3 eggs	
Dike WC-South, 1975	22	22	0	0	0	0
Dike WC-South, 1976	23	12	11	2	4	6 (26)
Spoil Bank WC-South, 1975	8	8	0	3	0	3 (28)
Spoil Bank WC-South, 1976	7	7	0	7	0	7 (100)
Dike WC-North, 1976	14	7	7	3	2	5 (36)
Oak Uplands J-Flowage, 1976	33	17	16	2	8	10 (30)
Mowed Field J-Flowage, 1976	9	4	5	1	1	2 (22)
Total (percent)	116	77	39	18 (23)	15 (38)	33 (28)

[a]Percent values in parentheses are nest destruction rates.

Table 9. Mean height (dm) of vegetation at simulated nest sites in various habitats on or near J-Flowage, WC-South, and WC-North, 17 May 1976.

Habitat and location	All nest sites	Destroyed nests	Successful nests	Percent nests destroyed
Mowed field J-Flowage	2.69	2.75	2.60	22
Dike WC-South	4.56	3.71[a]	4.86	26
Oak uplands J-Flowage	3.52	4.15	3.24	30
Dike WC-North	4.72	3.60[a]	4.96	36
Spoil bank WC-South	4.64	4.64	b	100

[a]Significantly lower than successful nests ($P < .05$).

[b]No data, all nests were destroyed.

and oak-upland habitats.

All seven simulated nests on the spoil bank of WC-South were destroyed in 1976. Mean vegetation height at these nests (4.64 dm) was near-equal to the height at nests located on dike habitat (4.56 dm and 4.72 dm) where predation rates were only 26 and 36 percent, respectively. Mean vegetation height at nests on the spoil bank was significantly higher ($P < .05$) than at nests in oak-upland and mowed-field habitat, where predation rates were only 30 and 22 percent, respectively ($T = 2.580$, $df = 9$; and $T = 4.339$, $df = 7$).

Dominant vegetation on the five simulated nest study areas was as follows: 1) dike (WC-South) contained dewberry (*Rubus procumbens*), sedges, and clumps of willow and blueberry (*Vaccinium* spp.); 2) dike (WC-North) had sedges, willow, spirea, fern (*Dryopteris* spp. and *Onoclea sensibilis*), and patches of milkweed (*Asclepius syrica*); 3) spoil bank (WC-South) was dominated by clumps of bluejoint grass interspersed with bare soil; 4) mowed-field (west of J-Flowage) consisted of domestic grasses (Gramminae); and 5) oak-uplands (west of J-Flowage), as determined by Kubisiak (1976), was dominated by a mixture of Hill's and white oak-jack pine (*Quercus ellipsoidalis* and *Q. alba* - *Pinus banksiana*) and oak-white pine (*P.strobus*) types. The forest shrub layer was dominated by patches of American hazel (*Corylus americana*), huckleberry (*Gaylussacia baccata*), serviceberry (*Amelanchier* sp.) and sweetfern (*Myrica asplenifolia*). Forest ground layer consisted of sedge (*Carex pennsylvanicum*), blackberry (*Rubus allegheniensis*), bracken fern (*Pteridium aquilinum*), and blueberry.

SOIL QUALITY

Soil analysis data are presented in Table 10. Study area soils were acidic (pH 5.0-5.5), sandy (61-71 percent), and contained 27-38 percent organic matter. Nutrient levels were similar in each flowage, with two exceptions: 1) J-Flowage had calcium and magnesium levels three to four times higher than those in WC-South and WC-North, and 2) SO_4-S content in WC-North was more than twice that of the other flowages.

Ratings for plant nutrient-level requirements in wetland soils are not established, therefore, nutrient levels for Wisconsin field crops (Walsh, 1972) were used to rate wetland soil nutrient levels. Similar ratings for Maine soils were used by Spencer (1963) in evaluating natural and artificial waterfowl marshes in that state. Study area soils had optimal phosphorus levels (50-100 lbs/acre), and were below minimum potassium values (200 lbs/acre). Calcium contents in soils of WC-South and WC-North were between the minimum (500 lbs/acre) and optimal range (1000-2000 lbs/acre), while J-Flowage was above the optimal range. Magnesium content of J-Flowage was within the optimal range (300-600 lbs/acre); WC-North and WC-South magnesium levels were near the minimum reported levels (100 lbs/acre). A pH value of 5.6 was considered satisfactory for organic agricultural soils by Walsh (1972); study area soils (except J-Flowage) were below that level.

WATER QUALITY

Water quality analyses were based upon data collected during the ice-free months of 1975 and 1976; these data are summarized in Table 11. (Horicon Marsh water quality data presented in Table 11 are referred to in the Discussion section.) All water quality data collected from 5 May 1975 to 4 August 1976 appear in Appendix C, Tables 1-3. Study area waters

Table 10. Chemical and physical analysis of soils from three wetland study areas, Wood County, Wisconsin and Horicon Marsh, Dodge County, Wisconsin, 1976.

Analysis	J-Flowage	WC-South	WC-North	Horicon Marsh[d]
pH	5.5	5.0	5.0	7.2
P[a]	115	70	125	64
K[a]	75	75	75	136
Ca[a]	2500	700	800	16,266
Mg[a]	400	80	120	3334
SO_4-S[a]	148	136	328	826
Salts[b]	25	23	29	120
Sand[c]	71	61	65	41
Silt[c]	29	35	32	57
Clay[c]	0	4	3	2
Organic[c] matter	37	27	39	50
NO_3-N[a]	1.0	2.0	1.0	no data

[a]Pounds per acre (ppm = lbs. per acre / 2).

[b]Soluble salts; mhos x 10^{-5} / cm.

[c]Percent.

[d]From Beule and Janisch, 1976b.

Table 11. Mean values for water quality parameters of three study areas, Wood County, Wisconsin, during the ice-free period May 1975 to August 1976, as compared to water of Horicon Marsh, Dodge County, Wisconsin.

Analysis	J-Flowage (n=51)	WC-South (n=27)	WC-North (n=42)	Horicon Marsh[a] (1975)
Total alkalinity (ppm)	28.08	13.11[b]	21.76	291.3
	(2.53)[c]	(0.58)	(1.17)	
DO (ppm)	6.44	7.15	7.33	no data
	(0.27)	(0.28)	(1.25)	
CO_2 (ppm)	11.06	5.51	6.77	no data
	(2.24)	(0.73)	(0.27)	
Specific conductance	68.17	37.23[b]	57.09	471.4
($umhos/cm^2$)	(4.79)	(0.94)	(2.49)	
pH[d]	6.9	6.7	6.8	8.0 (mean)
Color	223.7	187.4	254.7	177.8
Turbidity (JTU)	4.76	2.81	4.93	47.8
	(0.98)	(0.26)	(0.43)	
Temperature	21.4	22.4	21.5	no data
(^oC)	(1.5)	(1.3)	(1.09)	

[a]From Beule and Janisch, 1976a.

[b]Significantly lower than J-Flowage and WC-North ($P < .05$)

[c]Standard error of the mean.

[d]Median.

were soft (mean total alkalinity ranged from 13 ppm in WC-South to 28 ppm in J-Flowage), had low dissolved solid concentrations (mean specific conductance ranged from 37 umhos/cm in WC-South to 68 umhos/cm in J-Flowage), were acidic to circumneutral (pH 6.2 to 7.3), stained brown, and slightly turbid (mean, 3-6 JTU). Mean dissolved oxygen contents ranged from 5.8 ppm to 7.55 ppm during the spring and summer of both years; anaerobic conditions occurred in each impoundment between January and early March 1976. Increases and decreases in water quality parameters were most pronounced during periods of high and low water levels and/or during the winter months (Fig. 6).

There were no significant differences in mean values of water quality parameters between sample points within each study area. This indicates that, where applicable, water quality did not vary significantly between inflow, middle, and outflow points of each impoundment, nor did quality vary significantly between ditches and the impoundments they fed and/or emptied.

Mean values for specific conductance and total alkalinity were significantly lower ($P < .05$) in WC-South than the other study impoundments (Table 11). Other water quality parameters were not significantly different between impoundments. Total alkalinity and specific conductance values were more variable in J-Flowage and WC-North than in WC-South throughout the study (Fig. 6).

Water level fluctuations (measurement data in Appendix D, Tables 1-3) appeared to have more influence on the water quality of J-Flowage than of WC-North or WC-South. In late August 1975, water levels of J-Flowage and WC-North increased by 1.2 and 0.8 feet, respectively, following heavy rainfall (10 inches in 2 weeks). Subsequently, values for alkalinity and specific conductance fell sharply in J-Flowage, but remained

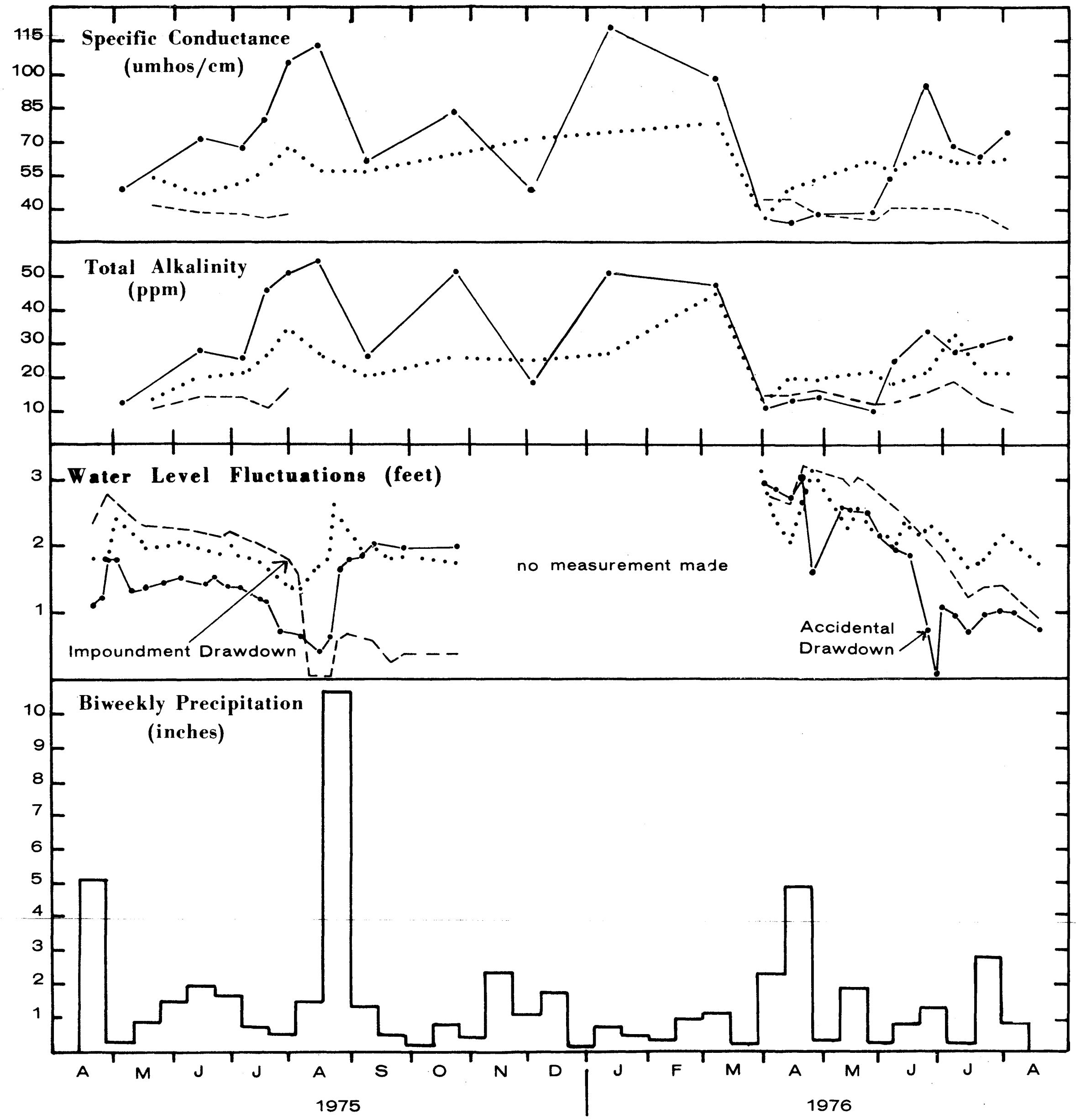

Fig. 6. Relationship of precipitation to impoundment water level fluctuations, total alkalinity, and specific conductance within J-Flowage (·——·), WC-South (------), and WC-North (······), April 1975 to August 1976. Water level fluctuation data are measurements relative to June water depths recorded at centrally-located bench marks (datum) in each impoundment.

constant in WC-North. WC-South was near empty at that time, and, while water levels increased by 0.6 ft, the impoundment remained too shallow to sample.

Water levels of all impoundments dropped sharply during the summer drought of 1976; as impoundments became shallower, total alkalinity and specific conductance values increased considerably in J-Flowage, and showed slight but steady increases in WC-North. Total alkalinity remained constant and specific conductance dropped in WC-South during the drought.

There were no significant differences ($P < .05$) in mean values of phosphorus and nitrogen contents between study areas. Mean ortho phosphorus and total inorganic nitrogen content of the three study areas was 0.017 ppm and 0.175 ppm, respectively (Table 12).

Chlorophyll content of the three study areas was analyzed from water samples collected 20 April 1976. Chlorophyll-A content in J-Flowage, WC-South, and WC-North was 16. 75, 12.71, and 17.89 mg/m^3, respectively (Table 13).

EMERGENT AND MOIST-SOIL VEGETATION

Vegetation quadrat data are summarized in Tables 14-16, where dominant emergent and moist-soil species were ranked within the major communities (stands) of each study area according to their importance values. Importance values were calculated by combining relative density, dominance, and frequency into a single value; these calculations appear in Appendix E, Tables 1-3. The mean number of emergent or moist-soil plant stems per quadrat within the vegetative stands were included in Tables 14-16; stem counts in pure stands were less variable than in mixed stands.

A total of 27 species appeared in samples from all study areas (Table 17). Emergent vegetation was dominated by pure and/or mixed stands of

Table 12. Mean biweekly BOD, phosphorus, and nitrogen contents (ppm) from J-Flowage, WC-South, and WC-North, Wood County, Wisconsin, 31 March to 23 June 1976.

Analysis	March 31	April 14	April 28	May 12	May 26	June 9	June 23	Mean
BOD	1.08	2.90	2.05	2.65	1.23	2.40[a]	3.32	2.22
Ortho P	.008	.039	.009	.019	.019	.004	.021	.017
Total P	.084	.064	.022	.052	.044	.115	.078	.043
NH_4N	.13	.083	.13	.167	.000	.067	.133	.101
NO_2-NO_3N	.000	.000	.063	.233	.000	.163	.063	.075
Total Inorganic N	.13	.083	.193	.400	.000	.230	.196	.175
Kjeldahl N	.84	.62	1.25	1.12	1.28	1.17	1.18	1.07
Organic N	.71	.54	1.12	.95	1.28	1.10	1.05	.96

[a]Value of 7.85 in WC-South not included in mean.

Table 13. Chlorophyll contents (mg/m^3) of composite water samples collected from three study areas, Wood County, Wisconsin, 20 April 1976.

Analysis	J-Flowage	WC-South	WC-North
Chlorophyll-A	16.75	12.71	17.89
Chlorophyll-B	1.36	1.45	3.14
Chlorophyll-C	3.81	4.26	5.27
Pheophytin-A	5.38	3.01	6.53
Chlorophyll-A-Pheophytin	8.07	7.88	7.56
A/B Ratio	12.23	8.74	5.68
A/C Ratio	4.39	2.97	3.39
663B/663A Ratio	1.50	1.54	1.47

Table 14. Importance values[a] of prominent plants in emergent and moist-soil communities of J-Flowage, 13 August 1976.

Stand, location, and size (acres)	Species	Importance value	Number of species in stand	Mean number[b] of stems per $0.25m^2$
Burreed	Burreed	1.611	8	65 ± 35
South end	Arrowhead	.480		
(9)	Spikerush	.289		
	Rice cut-grass	.239		
	Soft-stem bulrush	.137		
Cattail	Cattail	2.023	3	60 ± 13
Central	Rice cut-grass	.064		
section	Arrowhead	.032		
(2.5)				
Cattail	Cattail	1.674	7	128 ± 80
East of dike	Spikerush	.473		
(5.5)	Rice cut-grass	.348		
	Burreed	.156		
	Beggar tick	.136		
Rice cut-grass	Rice cut-grass	.983	13	343 ± 208
and spikerush	Spikerush	.795		
Along ditch	Arrowhead	.459		
(10)	3-Way sedge	.198		
	Burreed	.177		
Soft-stem	Soft-stem bulrush	1.286	7	92 ± 76
bulrush	Spikerush	.748		
East of dike	Burreed	.665		
(3)	Arrowhead	.266		
	Rice cut-grass	.259		
Wet meadow[c]	Blue-joint	.724	10	no data
East of	Beggar tick	.396		
ditch	Cattail	.337		
(11)	Willow	.165		

[a]Importance value = relative density + relative dominance + relative frequency (Cox, 1967).

[b]Includes all species within plots; standard deviation accompanies mean.

[c]Ranked by random notations of species frequency and percent coverage.

Table 15. Importance values[a] of prominent plants in emergent and moist-soil communities of WC-South, 29 July 1976.

Stand, location, and size (acres)	Species	Importance value	Number of species in stand	Mean number of stems per $0.25m^2$ [b]
Spikerush Banding throughout (38)	Spikerush	2.46	7	824 ± 358
Burreed East-central (10)	Burreed	2.050	7	112 ± 44
	Arrowhead	.384		
	Spikerush	.355		
	3-Way sedge	.114		
Mixed-emergent Throughout (21)	Spikerush	1.346	10	324 ± 138
	3-Way sedge	.750		
	Arrowhead	.483		
	Soft-stem bulrush	.128		
Emergent sedge South (4)	*Carex rostrata*	1.480	9	77 ± 40
	Spikerush	.574		
	Arrowhead	.454		
	3-Way sedge	.174		
Sedge meadow South (52)	*Carex lasiocarpa*	1.978	8	152 ± 40
	Wool-grass bulrush	.266		
	Bluejoint grass	.255		
	Marsh St. John's wort	.208		
	Marsh loosestrife	.195		
Wool-grass bulrush Banding throughout (46)	Wool-grass bulrush	1.108	13	93 ± 48
	Carex lasiocarpa	.500		
	Spikerush	.289		
	Bluejoint grass	.229		
	Marsh loosestrife	.223		

[a]Importance value = relative density + relative dominance + relative frequency (Cox, 1967).

[b]Includes all species within the plots; standard deviation accompanies the mean.

Table 16. Importance values[a] of prominent plants in emergent and moist-soil communities of WC-North, 5 August 1976.

Stand, location, and size (acres)	Species	Importance value	Number of species in stand	Mean number[b] of stems per $0.25m^2$
Mixed-emergents North end (2)	Rice cut-grass	.995	6	348 ± 208
	Spikerush	.994		
	Burreed	.474		
	Arrowhead	.375		
Mixed-emergents West side (4)	Spikerush	1.163	7	375 ± 198
	Rice cut-grass	.529		
	Arrowhead	.457		
	Burreed	.312		
	Sagittaria spp.	.221		
	Manna grass	.214		
Cattail South end (5)	Cattail	1.312	7	156 ± 54
	Spikerush	.762		
	Rice cut-grass	.298		
	Burreed	.280		
	Arrowhead	.111		
White water lily South end (11)	White water-lily	.957	2	
	Floating-leaved pondweed	.364		
	Spikerush	.590	7	85 ± 174
	Burreed	.466		
	Wild rice	.422		
Wool-grass bulrush (16)	Wool-grass bulrush	.991	21	191 ± 105
	Spikerush	.509		
	3-Way sedge	.318		
	Arrowhead	.237		
	Bedstraw	.120		
	Carex rostrata	.109		
Sedge meadow North end (3)	*Carex cannescens*	.792	19	194 ± 140
	Wool-grass bulrush	.590		
	Spikerush	.302		
	Arrowhead	.284		

[a]Importance value = relative density + relative dominance + relative frequency (Cox, 1967).

[b]Includes all species within the plots; standard deviation accompanies the mean.

Table 17. Emergent and moist-soil plants present on three study areas, Wood County, Wisconsin, August 1976.

Species	J-Flowage	WC-South	WC-North
Equisetum fluviatale	x		x
Typha latifolia	x	x	x
Sparganium americanum	x	x	x
Sagittaria latifolia	x	x	x
Sagittaria spp.			x
Zizania aquatica	x		x
Glyceria canadensis			x
Glyceria borealis	x	x	
Leersia oryzoides	x		x
Calamagrostis canadensis	x	x	
Dulichium arundinaceum	x	x	x
Eleocharis palustris	x	x	x
Scirpus heterochaetus			x
S. validus	x	x	x
S. cyperinus	x	x	x
Carex lasiocarpa		x	
C. rostrata	x	x	x
C. comosa	x		x
C. cannescens			x
Polygonum lapathifolium	x	x	
Polygonum spp.		x	x
Hypericum boreale		x	x
Lysimachia terrestris		x	x
Lycopus spp.	x	x	x
Bidens coronata	x	x	x
B. cernua	x		x
Galium spp.	x	x	x
Total	19	18	23

spikerush (Eleocharis palustris), burreed (Sparganium americanum), arrowhead (Sagittaria latifolia), rice cut-grass (Leersia oryzoides), 3-way sedge (Dulichium arundinaceum), and cattail (Typha latifolia). Moist-soil stands were dominated by wool-grass bulrush, two sedges (Carex lasiocarpa and C. rostrata), blue-joint grass and/or willow.

Emergent vegetation covered 51 acres (51 percent) of J-Flowage (Fig. 7). Burreed and mixed-emergent stands containing rice cut-grass, spikerush, and arrowhead were dominant. Cattail appeared in small, pure stands in the central portion of the impoundment and in larger, mixed stands on the impoundment's periphery, where it was stunted and contained more stems (blades) per quadrat than in pure stands. Soft-stem bulrush (Scirpus validus) was common in the east section of J-Flowage.

Moist-soil vegetation covered 50 acres on J-Flowage. Drier sites were dominated by stands of willow or blue-joint grass, and mixed stands of willow, blue-joint, and spirea. Wetter sites contained mixtures of beggar tick (Bidens spp), blue-joint, and cattail.

Emergent vegetation covered 69 acres (22 percent) of WC-South (Fig. 8). Spikerush was the most conspicuous species, dominating mixed-emergent stands of 3-way sedge and arrowhead, and occurring in pure, dense (824 stems/0.25m^2) bands throughout the emergent vegetation areas of the impoundment.

Three moist-soil plant types covered a total of 174 acres (56 percent) of WC-South; they were: 1) a sedge (Carex lasiocarpa) meadow covering 52 acres (17 percent), 2) several willow islands totaling 78 acres (25 percent), and 3) strips of wool-grass bulrush and C. lasiocarpa covering 46 acres (15 percent) of the impoundment.

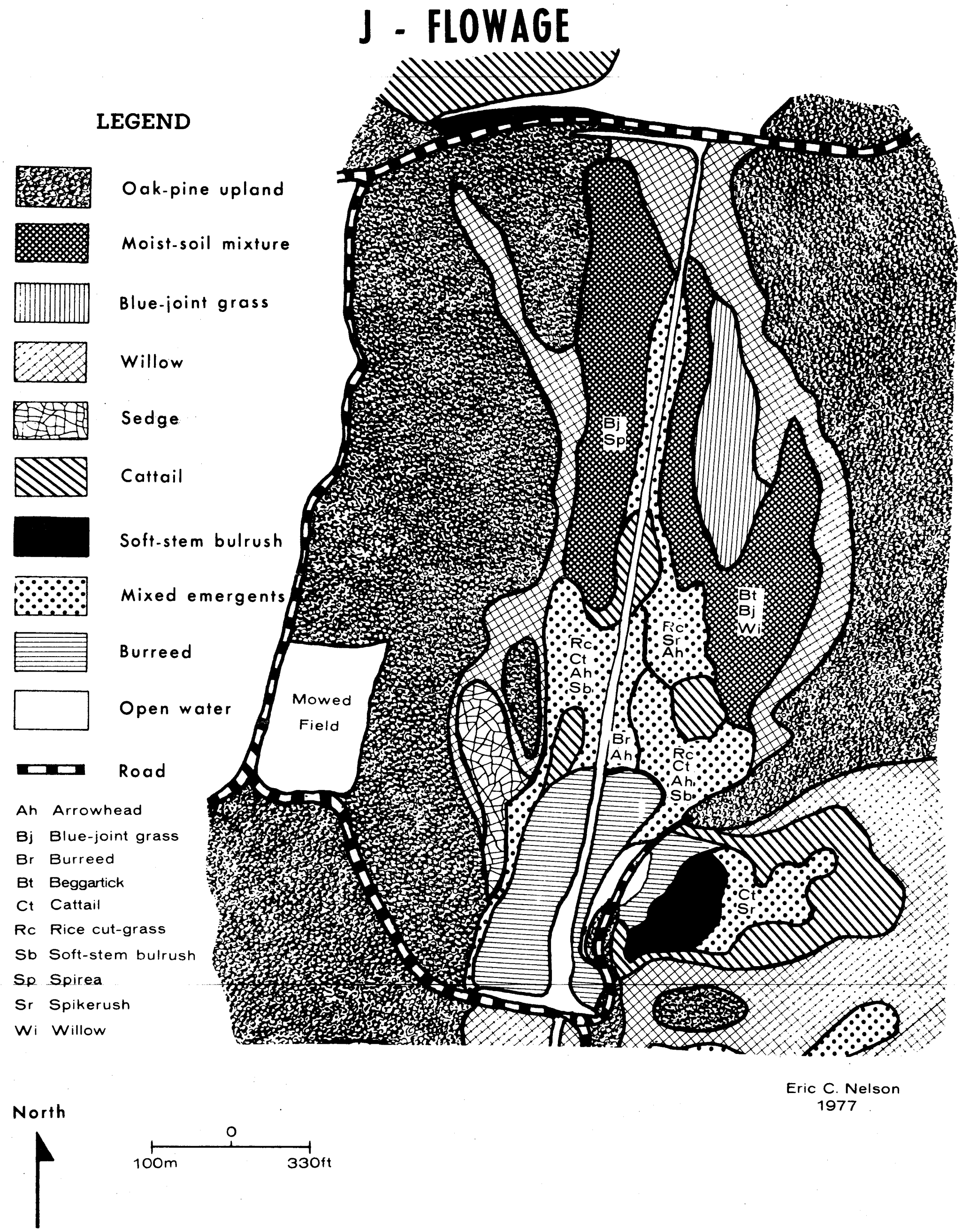

Fig. 7. Vegetation cover map of J-Flowage, Sandhill Wildlife Area, Wood County, Wisconsin, 1976.

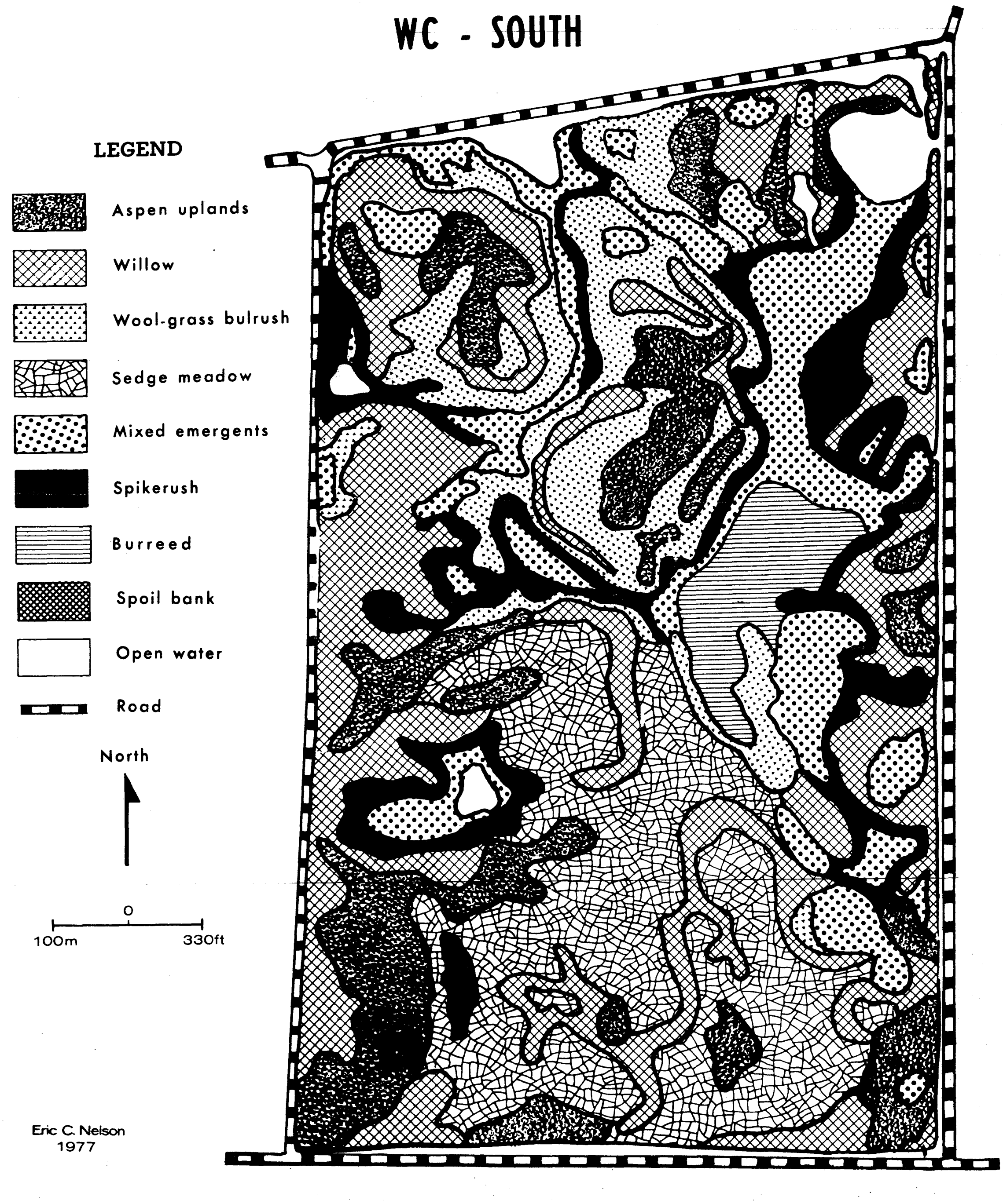

Fig. 8. Vegetation cover map of WC-South, Wood County Wildlife Area, Wood County, Wisconsin, 1976.

Emergent vegetation covered 26 acres (26 percent) of the wetland area on WC-North (Fig. 9). Thirty of 102 wetland acres were open water. Mixed-emergent stands on the impoundment's north and west sides were dominated by spikerush and rice cut-grass; arrowhead and burreed occurred in several scattered sites in these areas. A cattail stand (5 acres) occurred at the impoundment's south end.

A dense stand of white water lily (*Nymphaea odorata*) mixed with floating-leaved pondweed (*Potamogeton natans*) covered 11 acres (11 percent) of the impoundment's south end. Spikerush, burreed, and wild rice (*Zizania aquatica*) grew in low densities within the water lily.

Wool-grass bulrush and willow occurred in well-defined bands between upland and emergent sites. A sedge (*Carex cannescens*) meadow (3 acres) occurred in the impoundment's north end. The southwest portion of WC-North, covering 37 percent of the wetland area, contained a mixture of stunted cattail, willow, and scattered areas of beggar tick and smartweed (*Polygonum* spp.).

SUBMERGENT VEGETATION

The dominant vegetation of the submergent communities in each study area is summarized in Table 18, where dominant species within open water areas were ranked according to their importance values (Ref. methods). Most submergent communities were dominated by coontail (*Ceratophyllum demersum*) or waterweed (*Anacharis canadensis*). An exception occurred in the north end of WC-North where coontail and water moss (*Fissidens* sp.) were codominant.

Separate importance values were calculated for the east and west sections of J-Flowage. Coontail was most important in the west section, appearing in 19 of 20 samples and having a relative rake density of

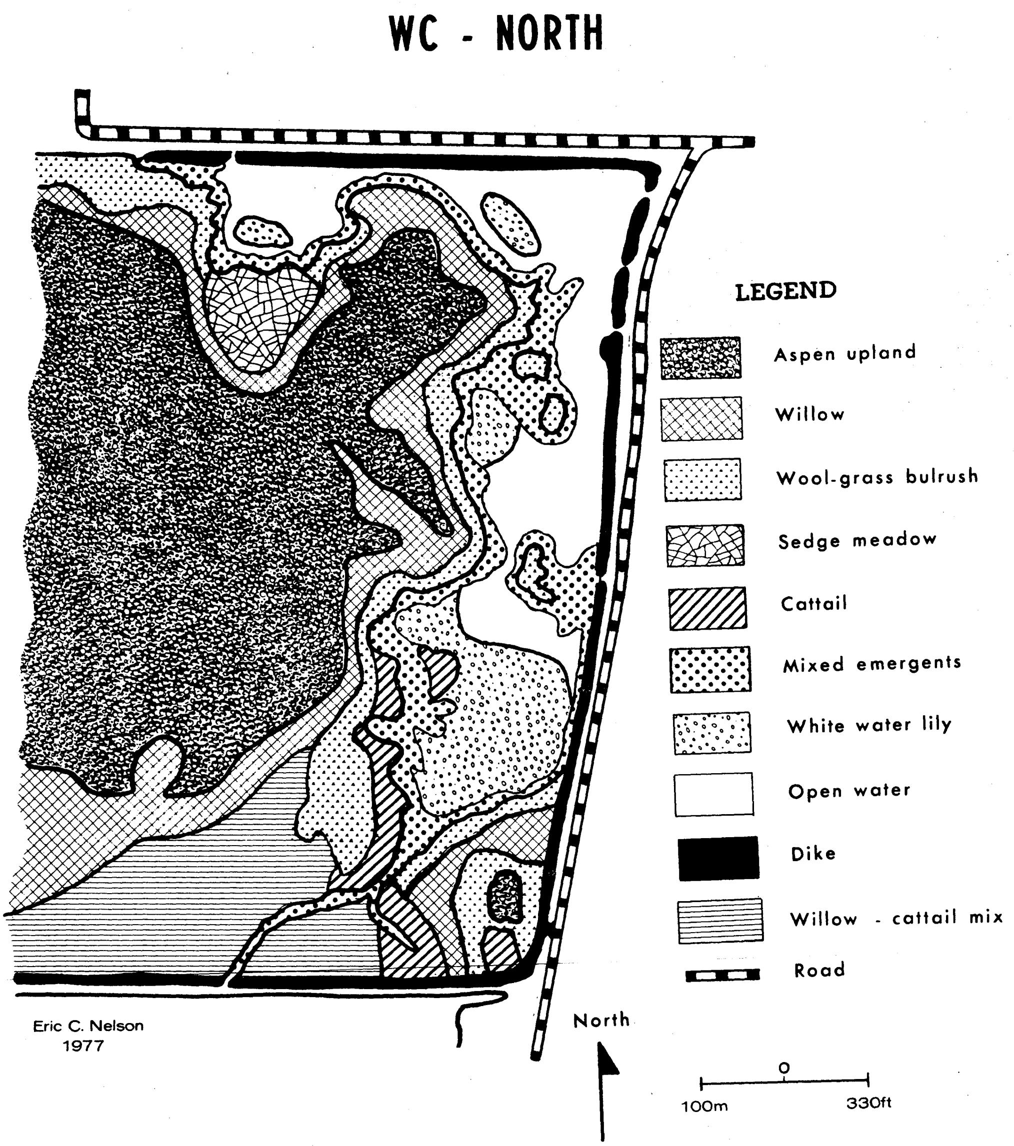

Fig. 9. Vegetation cover map of WC-North, Wood County Wildlife Area, Wood County, Wisconsin, 1976.

Table 18. Importance values of prominent submerged plant species in J-Flowage, WC-South, and WC-North, 5-7 August 1976.

Study area and mean rake density (percent)	Species	Relative frequency	Relative density	Importance value
J-Flowage West Section (40)	Ceratophyllum demersum	.487	.740	1.227
	Anacharis canadensis	.154	.077	.231
	Potamogeton amplifolius	.128	.074	.202
East Section (84)	Anacharis canadensis	.453	.786	1.221
	Ceratophyllum demersum	.200	.171	.371
	Potamogeton spp.	.133	.029	.162
WC-North (58)	Ceratophyllum demersum	.353	.418	.771
	Fissidens spp.	.177	.326	.503
	Nitella spp.	.162	.131	.293
	Utricularia vulgaris	.095	.030	.125
WC-South East Side (8.75)	Isoetes spp.	.143	.374	.519
	detritus	.429	trace	.429
	Rotala romisior	.086	.161	.247
	Nitella spp.	.057	.169	.226
West Side (64)	Anacharis canadensis	.500	.767	1.267
	Utricularia vulgaris	.200	.051	.251
	Nitella spp.	.150	.086	.236
	Fissidens spp.	.050	.095	.145

74 percent. Waterweed and two species of pondweed (Potamogeton amplifolius and P. conferoides) were also present in the west section of J-Flowage, but were not important. Waterweed was most important in the east section of J-Flowage; it was collected in 7 of 8 samples and had a relative density of 77 percent.

Submergent vegetation in WC-North was dominated by coontail; water moss was codominant in the impoundment's north end. Water milfoil (Myriophyllum spp.) and bladderwort (Utircularia vulgaris) were present but not important.

Submergent vagetation was conspicuously lacking in the east side of WC-South. (Only 6 of 20 rake samples contained vegetation.) A small area (3 acres) on the west side of WC-South had a dense stand (mean rake density 64 percent) of waterweed.

INVERTEBRATES

Results of the invertebrate survey are presented in Table 19 (surface invertebrates) and Table 21 (bottom invertebrates). A total of 97 taxa (2 Phyla, 7 Classes, 14 Orders, 49 Families, 73 Genera, and 10 Species) were present on all study areas; WC-South had 70 taxa, WC-North 67, and J-Flowage 57 taxa (Appendix F, Table 1). The appearance of several species of Coleoptera in WC-South, and several genera of Odonata in WC-North accounted for the higher number of taxa in those impoundments than in J-Flowage.

Surface Invertebrates

The average volume of surface invertebrates for all study areas was lowest on 16 April (1.89 ml/m^3) and highest on 14 May (8.36 ml/m^3). Volumes dropped slightly in June and July. Average numbers of surface invertebrates for all study areas were also lowest on 16 April (773/m^3),

Table 19. Mean number and volume (ml) of surface invertebrate taxa per m^3 in J-Flowage (n = 7), WC-South (n = 8), WC-North (n = 5), and three flowages combined (n = 20), 1 April to 9 July 1976.[a]

Taxa and study area	1 April	16 April	29 April	14 May	27 May	11 June	24 June	9 July	Seasonal average
<u>All Invertebrates</u>									
J-Flowage		790		2811		3262		965	1957
		2.06		11.86		10.51		4.52	7.24
WC-South	157	652	1256	1289	1071	811	780	1365	923
	0.84	0.84	1.87	3.98	4.62	4.27	5.52	6.59	3.56
WC-North		948		1471		2850		1336	1651
		3.32		10.45		4.30		6.27	6.09
All Flowages		773		1867		2179		1231	1513
		1.89		8.36		5.93		5.85	5.51
<u>Caenis</u> (Caenidae, Emphemeroptera)									
J-Flowage		0.5		31		93		158	71
		0.01		0.10		0.29		0.32	0.18
WC-South	0	0	0.5	1	1	2	3	123	16
	0	0	<0.01	< 0.01	<0.01	<0.01	<0.01	0.17	0.02
WC-North		42		167	42		426		169
		0.06		0.44		0.15		0.72	0.34
All Flowages		11		53		44		214	81
		0.02		0.15		0.14		0.36	0.16
<u>Odonata</u>									
J-Flowage		7		48		82		45	46
		0.56		2.80		1.72		0.77	1.46
WC-South	1.3	35	27	59	56	43	20	18	32
	0.12	0.37	0.36	1.04	0.81	1.15	0.77	0.79	0.68
WC-North		41		82		73		43	60
		1.71		4.70		1.14		2.12	2.4
All Flowages		28		61		64		33	38
		0.77		2.57		1.54		1.13	1.10
<u>Hemiptera</u>									
J-Flowage		5		7		52		81	36
		0.04		0.11		0.35		1.69	0.55
WC-South	0.5	1	10	8	56	39	50	64	29
	0.01	0.03	0.14	0.09	0.21	0.36	0.55	1.03	0.30
WC-North		6		33		54		61	39
		0.03		0.04		0.22		0.40	.17
All Flowages		4		14		47		68	33
		0.03		0.09		0.32		1.07	0.38

Table 19 (continued).

Taxa and study area	1 April	16 April	29 April	14 May	27 May	11 June	24 June	9 July	Seasonal average
Others									
J-Flowage		121 0.26		697 1.17		216 0.80		206 0.29	210 0.63
WC-South	46 0.04	68 0.07	450 0.54	564 1.36	268 1.04	134 0.37	143 2.55	141 0.85	227 0.85
WC-North		37 0.16		409 2.56		686 1.03		198 0.09	333 0.96
All Flowages		77 0.15		571 1.60		404 0.49		177 0.35	307 0.65

[a]J-Flowage and WC-North were sampled at four-week intervals, 16 April to 9 July; WC-South was sampled biweekly from 1 April to 9 July.

but maintained highest abundance during May (1867/m^3) and June (2179/m^3); average numbers then dropped in July.

J-Flowage had the largest population of surface invertebrates; quantities were less in WC-North and least in WC-South. This ranking of study areas was determined by calculating importance, derived by combining relative average volumes and numbers of surface invertebrates into one importance value (Table 20).

Statistical tests (analysis of variance, simple randomized design) showed that average volumes and numbers of invertebrates did not vary significantly ($P < .10$) between the study areas when data were combined for the entire sampling period.

The largest average volume of surface invertebrates appeared in mid-May in J-Flowage (11.86 ml/m^3) and WC-North (10.46 ml/m^3), but did not occur until early July in WC-South (6.59 ml/m^3)(Fig. 10). Invertebrate volume in WC-South (3.98 ml/m^3) was only 34 and 38 percent of the volumes in J-Flowage and WC-North, respectively on 14 May. This volume was significantly lower (at the ten percent confidence level, and nearly so at the 5 percent level; $df_{2,17}$; $F=3.56$) than in the other study areas. WC-South had similarly low invertebrate volumes on 16 April.

Average volume of surface invertebrates in J-Flowage remained high in May and June but in early July, invertebrate volumes dropped to 43 percent of the May peak. In WC-North, invertebrate volume dropped sharply from 14 May to 11 June and increased slightly between June and July. Surface invertebrate volume in WC-South increased from April to July but never reached the May and June levels present in J-Flowage.

Surface invertebrate abundance (numbers/m^3) generally correlated with volumetric increases and decreases, except in WC-North where a

Table 20. Importance values[a] of three study areas, as determined by surface invertebrate populations during the spring and early summer, 1976, Wood County, Wisconsin.

Rank	Study area	Average number (per m^3)	Relative number	Average volume (per m^3)	Relative volume	Importance value
1	J-Flowage	1957	.422	7.24	.419	.841
2	WC-North	1651	.356	6.09	.354	.710
3	WC-North	1029	.222	3.92	.227	.449

[a]Importance value = relative number + relative volume of invertebrates collected from each study area for the entire sampling period (16 April to 9 July; four samples collected at four-week intervals).

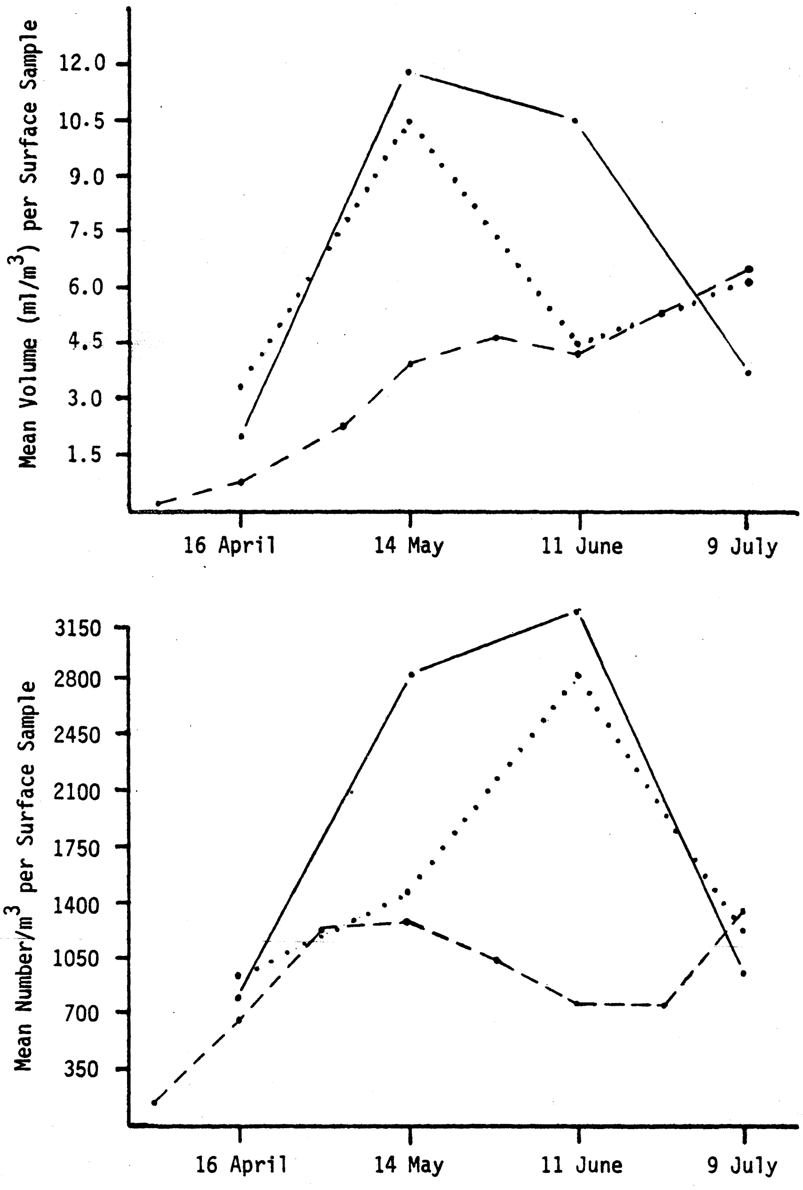

Fig.10. Mean number and volume of surface invertebrates collected from J-Flowage (·——·), WC-South (-----), and WC-North (·····), 1 April to 9 July 1976.

significant decrease in invertebrate volumes from 14 May to 11 June was accompanied by a similar increase in numbers. Gastropod and Odonate numbers in WC-North increased from May to June but their numbers decreased, and chironomid numbers increased 444 percent from May to June but their volumes increased by only 30 percent (Table 19).

The dominant surface taxa included Mollusca (Planorbidae, Amnicolidae, and Sphaeriidae), Odonata (Coenagrionidae and Libellulidae), Diptera (Chironomidae), Ephemeroptera (Caenidae, *Caenis*), Hemiptera (Corixidae and Gerridae), and Coleoptera (Dytiscidae and Hydrophilidae) (Fig. 11).

Mollusca, Odonata, and Chironomidae were the most voluminous taxa throughout the sampling period. These taxa reached their largest volumes on 14 May, except in WC-South where volumes were greatest 11 June (Odonata) and 9 July (Mollusca and Chironomidae).

Volumes and numbers of the taxa Anisoptera, *Caenis*, and Chironomidae were significantly lower ($P < .05$) in WC-South than in the other study areas on 14 May. WC-South also had lower amounts (not significant) of Ceratopogonidae, Gastropoda, and Oligochaeta. Quantities of Sphaeriidae and Coleoptera were significantly larger ($P < .05$) in WC-South than the other study areas on 14 May. Differences in invertebrate quantity (according to the major taxa) between study areas during April, June, and July were not as pronounced as in May.

The fingernail clams (Pelecypoda, Sphaeriidae) and, to a lesser extent, the snails *Gyraulus* and *Helisoma* (Gastropoda, Planorbidae) were the most prominent molluscs present in WC-South. In WC-North, the snails *Amnicola* (Gastropoda, Amnicolidae), *Helisoma* and *Gyraulus*, and fingernail clams were most prominent. *Amnicola* was not found in J-Flowage and only

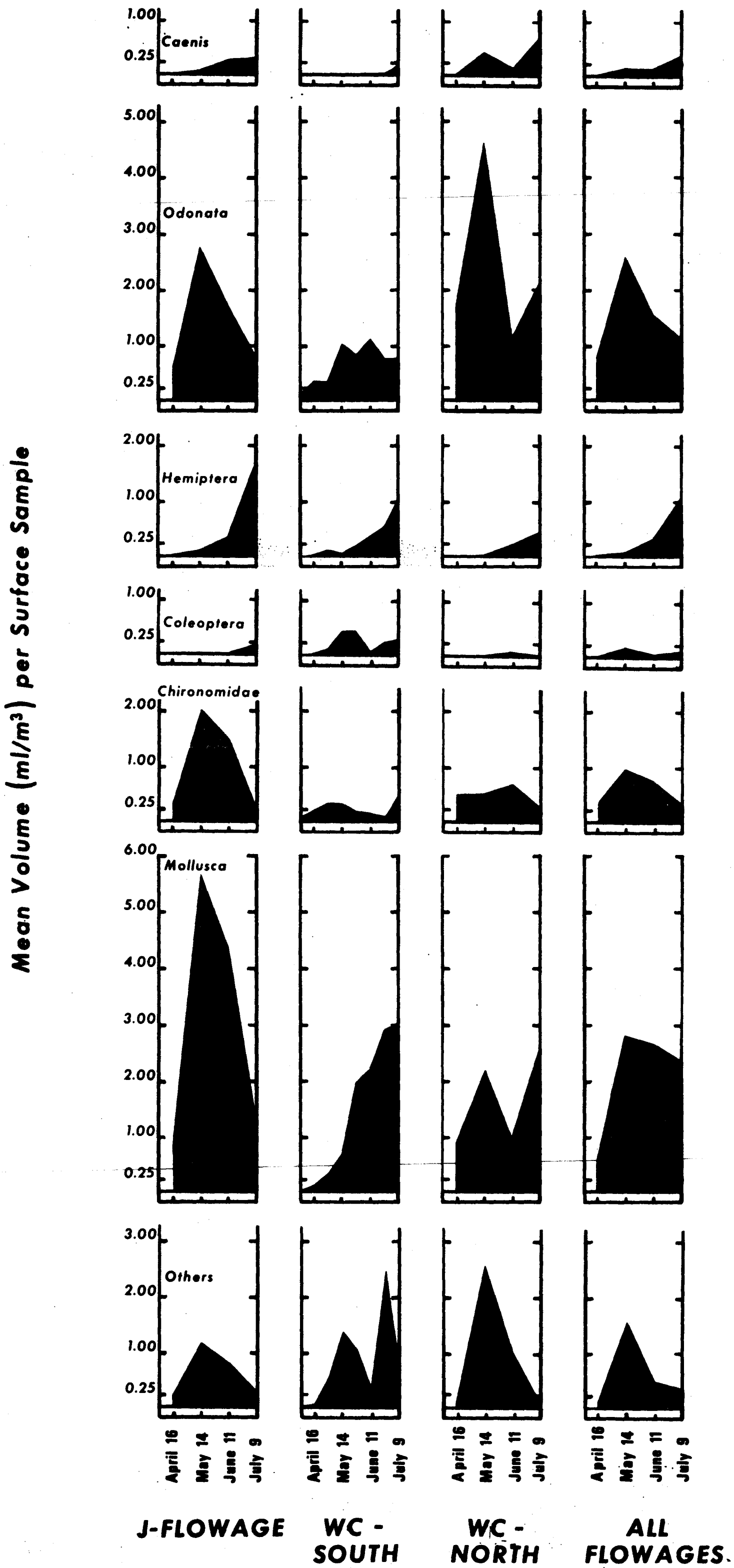

Fig. 11. Mean volume of the major surface invertebrate taxa in three study areas, Wood County, Wisconsin, 1 April to 9 July 1976.

one specimen was found in WC-South. The molluscs of J-Flowage were dominated by Gyraulus, Helisoma, and (in June) by Physa (Gastropoda, Physidae).

The most prevalent odonates in WC-South were two damselflies, Lestes (Zygoptera, Lestidae) and Enallagma (Coenagrionidae), and one dragonfly, Leucorrihinia (Anisoptera, Libellulidae). In WC-North Leucorrihinia and three other genera dominated the odonate order. The prominent odonates in J-Flowage were Leucorrihinia and Enallagma.

Hemipteran (Corixidae and Gerridae) volumes were greatest on 9 July in all impoundments. Caenis volume was also highest 9 July, except in WC-North where it peaked 14 May and 9 July. Coleopteran volume was conspicuously low in J-Flowage and WC-North, but occurred in some quantity (dominated by the families Dytiscidae, Hydrophilidae, and Haliplidae) in WC-South during the month of May (Fig. 11).

All other taxa, when combined, reached their greatest volume on 14 May in all study areas; WC-South had a second volumetric peak on 24 June. The most abundant taxa of the combined group were: J-Flowage - Hirudinea, Pyralidae, and Trichoptera; WC-South - Conchostraca and Hirudinea; and WC-North - Hirudinea and Oligochaeta.

The collection of Haliplus apostolicus (Coleoptera, Haliplidae) was the sixth state record, and H. triopsis was the most northern collection of that species in Wisconsin (pers. comm., Feb. 16, 1977, William L. Hilsenhoff, Dept. of Entomology, Russell Laboratories University of Wisconsin - Madison, Wis.).

Bottom Invertebrates

The combined average volume of bottom (benthic) invertebrates for all study areas was 7.63 ml/m^2 on 16 April, it declined from May through June, and reached its highest average on 9 July (11.14 ml/m^2)(Table 21).

Table 21. Mean number and volume (ml) of benthic invertebrate taxa per m^2 in J-Flowage (n = 8), WC-South (n = 8), WC-North (n = 6), and all flowages combined (n = 22), 1 April to 9 July, 1976.[a]

Taxa and study area	1 April	16 April	29 April	14 May	27 May	11 June	24 June	9 July	Seasonal average
All Invertebrates									
J-Flowage		1972		1891		1137		3141	2035
		6.08		2.80		2.89		7.37	4.79
WC-South	1509	2699	1573	3211	5447	2974	517	4289	2777
	6.03	5.76	2.18	7.70	8.70	8.08	1.67	13.17	6.54
WC-North		2147		1544		668		1990	1140
		13.45		9.55		3.49		13.57	10.02
All Flowages		2291		2277		1677		3241	2372
		7.63		6.38		4.94		11.14	7.52
Hirudinea									
J-Flowage		5		0		5		22	8
		0.54		0		0.03		0.59	0.29
WC-South	5	75	11	11	0	5	0	22	16
	3.88	1.75	0.03	1.08	0	0.49	0	2.99	1.28
WC-North		9		0		0		9	5
		0.04		0		0		0.07	0.03
All Flowages		33		4		6		18	16
		0.88		0.39		0.19		1.31	0.69
Oligochaeta									
J-Flowage		59		587		86		334	267
		0.11		0.35		0.11		0.11	0.17
WC-South	334	668	361	670	2726	943	27	620	794
	1.45	0.59	1.16	2.18	3.45	1.27	0.03	0.40	1.27
WC-North		147		726		22		36	233
		0.13		2.15		0.04		0.13	0.61
All Flowages		312		662		380		357	428
		0.30		1.51		0.51		0.22	0.64
Odonata									
J-Flowage		5		5		11		22	11
		0.70		0.05		0.27		0.38	0.35
WC-South	0	27	0	11	27	38	5	22	16
	0	0.46	0	0.05	0.35	2.96	0.32	1.37	0.69
WC-North		101		65		14		86	72
		6.72		3.59		1.44		6.57	4.58
All Flowages		41		24		22		39	32
		2.04		1.02		1.57		2.43	1.77

Table 21 (continued).

Taxa and study area	1 April	16 April	29 April	14 May	27 May	11 June	24 June	9 July	Seasonal average
Chironomidae									
J-Flowage		1686 4.36		884 1.18		921 1.16		2667 5.68	1340 3.10
WC-South	776 0.38	1482 0.94	350 0.14	1412 0.32	2215 2.69	1676 1.56	232 0.14	3001 4.93	1393 1.39
WC-North		1647 1.55		503 0.43		395 0.22		884 0.61	857 0.70
All Flowages		1599 2.39		972 0.67		1052 1.05		2302 4.03	1481 2.04
Gastropoda									
J-Flowage		43 0.08		16 0.03		27 0.86		22 0.03	27 0.25
WC-South	16 0.05	103 1.35	11 0.03	43 0.14	5 0.05	167 0.08	210 0.46	318 0.35	109 0.31
WC-North		86 3.88		36 4.72		79 1.08		316 4.09	129 3.44
All Flowages		76 1.48		31 0.53		92 0.64		210 1.25	102 0.98
Sphaeriidae									
J-Flowage		54 0.19		286 1.00		32 0.22		43 0.24	104 0.41
WC-South	0 0	70 0.08	469 0.73	102 0.59	75 0.57	64 0.27	16 0.43	194 1.43	124 0.64
WC-North		52 0.17		72 0.83		65 0.47		108 1.01	74 0.62
All Flowages		60 0.14		161 0.80		53 0.67		116 0.88	98 0.62
Others									
J-Flowage		120 0.11		113 0.19		55 0.25		31 0.34	80 0.22
WC-South	377 0.27	274 0.58	371 0.10	942 3.34	399 1.59	80 0.45	27 0.30	112 1.70	323 1.04
WC-North		86 0.96		142 0.83		93 0.25		560 1.09	220 0.78
All Flowages		170 0.41		423 1.46		72 0.33		200 1.03	216 0.81

[a]J-Flowage and WC-North were sampled at four-week intervals, 16 April to 9 July; WC-South was sampled biweekly from 1 April to 9 July.

Average numbers of bottom invertebrates were nearly constant in April and May ($2291/m^2$ and $2277/m^2$, respectively), then dropped in June, and reached their highest numbers in July ($3241/m^2$).

WC-South had the highest average number ($2777/m^2$) of benthos for the entire season; WC-North had the largest average volume ($10.02\ ml/m^2$) of bottom invertebrates (Table 21). Relative average numbers and volumes of benthos in each study area were combined to determine relative importance (importance values); WC-South ranked highest, followed by WC-North, and then J-Flowage (Table 22).

Monthly trends in abundance and volume of benthic organisms were similar in J-Flowage and WC-North (Fig. 12). Quantities declined from 16 April to 11 June and then increased to levels slightly greater than the 16 April quantities by 9 July. However, average benthic invertebrate volumes in WC-North were two to three times larger than in J-Flowage on 16 April ($13.45\ ml/m^2$), 14 May ($9.55\ ml/m^2$), and 9 July ($13.57\ ml/m^2$). Volumes in both flowages were relatively low and nearly equal in mid-season (WC-North = $3.49\ ml/m^2$ and J-Flowage = $2.89\ ml/m^2$).

In WC-South, abundance and volume of benthic invertebrates showed a steady monthly increase from April to June, and then increased rapidly to their largest quantities on 9 July. Volumes in WC-South were similar to WC-North on 14 May and 9 July, but were two times less on 16 April and two times greater on 11 June.

Different taxa were dominant in each study area (Fig. 13). Relatively small numbers of large Chironomidae were dominant in the benthos of J-Flowage throughout the season, and were usually present in larger volumes in J-Flowage than the other study areas. Fingernail clams and the snail Physa, had slight peaks during May and June, respectively,

Table 22. Importance values[a] of three study areas, as determined by bottom invertebrate populations during the spring and early summer, 1976, Wood County, Wisconsin.

Rank	Study area	Average number (per m^2)	Relative number	Average volume (per m^2)	Relative volume	Importance value
1	WC-South	3293	.509	8.68	.370	.897
2	WC-North	1140	.176	10.02	.427	.603
3	J-Flowage	2035	.315	4.79	.204	.519

[a]Importance value = relative number + relative volume of invertebrates collected from each study area for the entire sampling period (16 April to 9 July; four samples collected at four-week intervals).

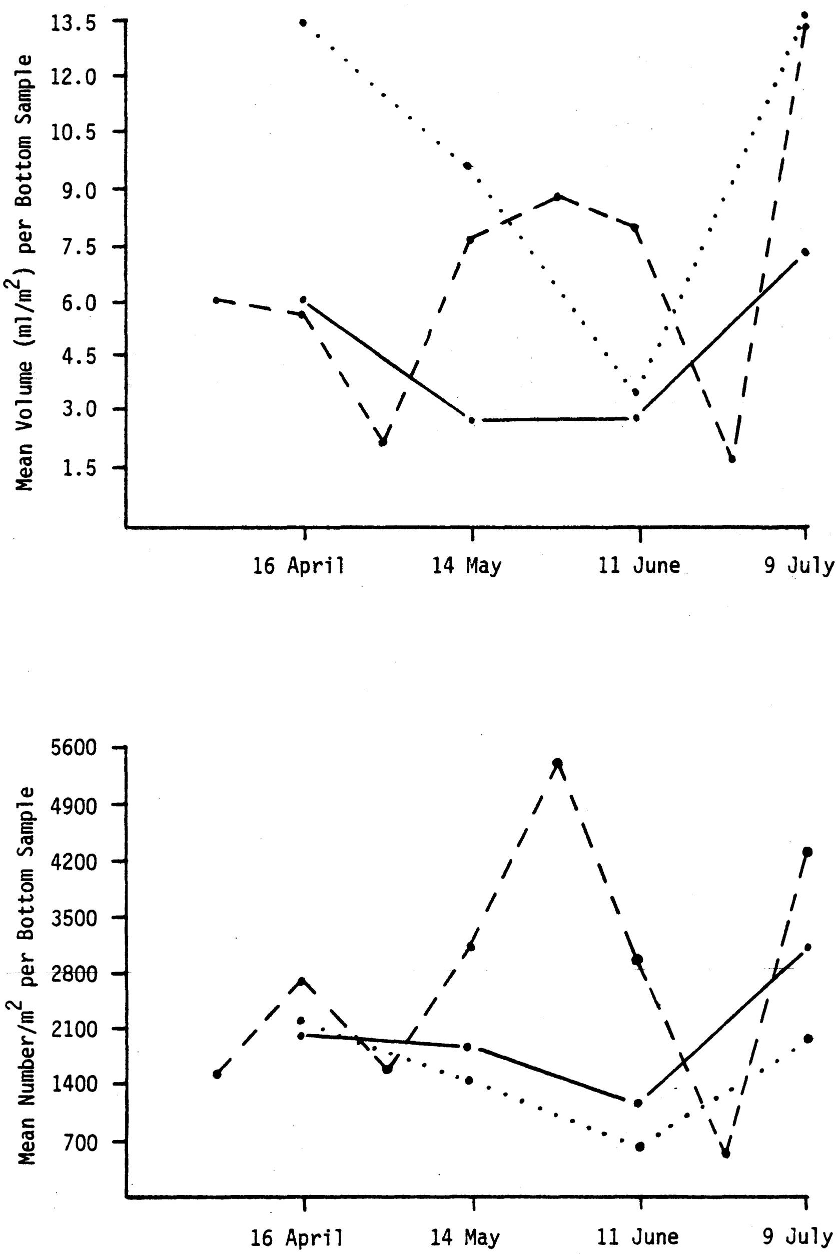

Fig. 12. Mean number and volume of bottom invertebrates collected from J-Flowage (·——·), WC-South (-----), and WC-North (·····), 1 April to 9 July 1976.

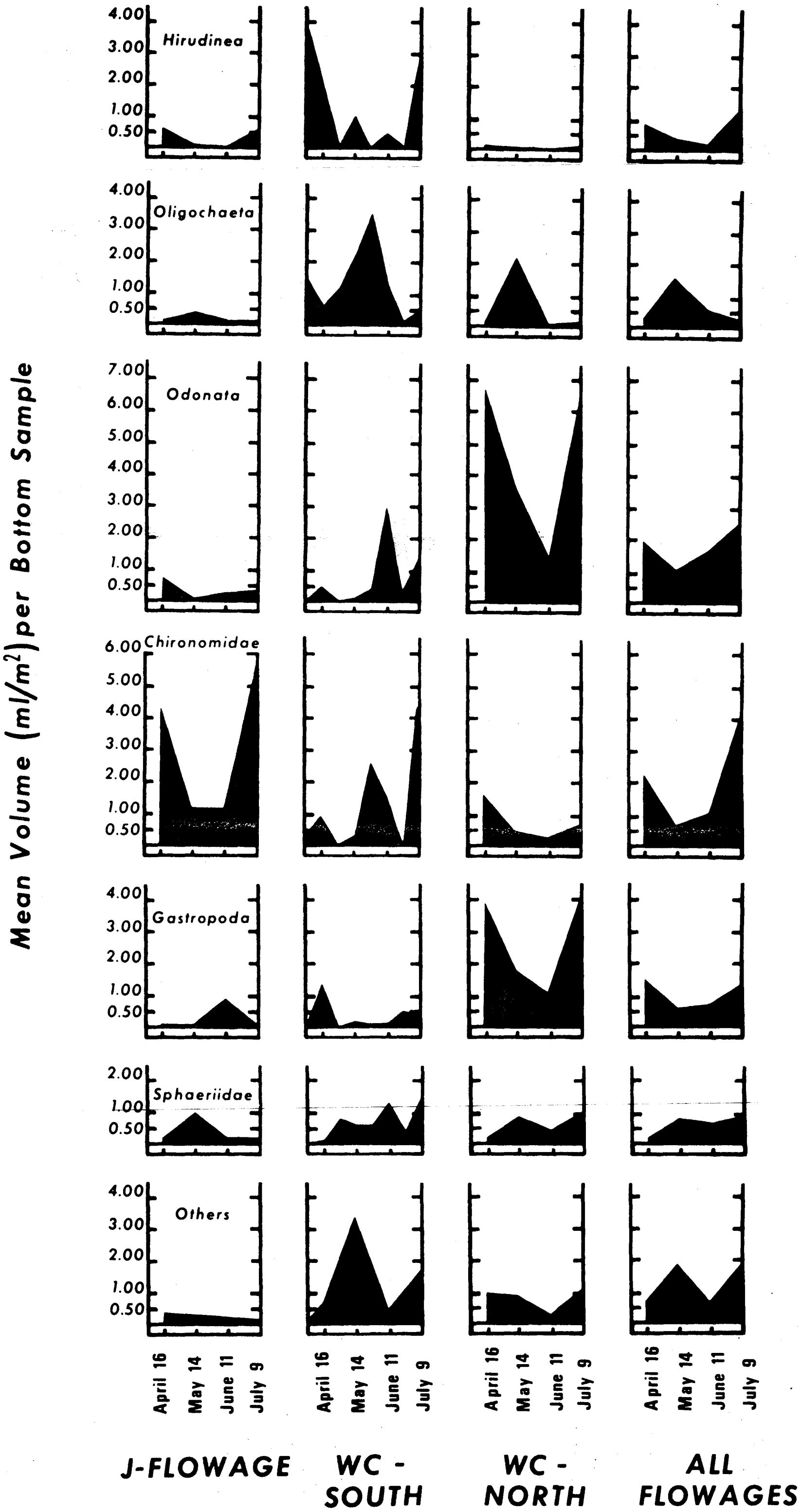

Fig. 13. Mean volume of the major bottom invertebrate taxa in three study areas, Wood County, Wisconsin, 1 April to 9 July 1976.

in J-Flowage.

Hirudinea and Oligochaeta generally dominated the benthos in WC-South; Conchostraca and Ceratopogonidae were also abundant during April and early May. These four taxa, and fingernail clams, were more voluminous in WC-South than in the other study areas. Clam shrimp (Conchostraca) occurred almost exclusively in WC-South.

Large volumes of Odonata (Anisoptera, Libellulidae and Corduliidae) and the snail Helisoma occurred in WC-North throughout the season; Chironomidae and Oligochaeta populations peaked during April and May, respectively. WC-North produced the greatest volumes of odonates and gastropods throughout the season.

The contribution of incidental taxa to the total benthic invertebrate volume was minimal, except for conchostracans in WC-South on 14 May, and the mayfly Caenis in May and July in WC-North (Fig. 13).

DISCUSSION

SPRING MIGRATION

Peak numbers of migrating waterfowl occurred earlier in 1976 than the 10-year average; this was a product of early warm weather. J-Flowage may have received more use than the other study areas because it contained more waterfowl food (burreed, arrowhead, rice cut-grass, and beggar tick seeds). Similar heavy waterfowl use was observed on B-Flowage (Sandhill Wildlife Area) by Baldassarre (1978) where burreed, rice cut-grass, and arrowhead were also abundant.

The uncommonly long stop-over of migrating ring-necked ducks on J-Flowage in 1976 also occurred at Horicon Marsh in southeastern Wisconsin, and has been observed in earlier years (pers. comm., Richard Hunt, Dept. of Natural Resources, Box D, Horicon, Wis.).

WATERFOWL BREEDING PAIRS AND PRODUCTION

Historically, waterfowl breeding pair densities and production have been lower in central Wisconsin than in southern Wisconsin's high waterfowl production areas (Horicon Marsh). Aerial breeding bird counts, conducted from 1965 to 1969, showed Sandhill Wildlife Area populations were approximately one-third those found on the Horicon Marsh Wildlife Area (March et al, 1973). Jahn and Hunt (1964) showed that breeding pair densities in the Central Plain physiographic region were about half the densities of the Eastern Ridges and Lowlands physiographic region during the period 1951-1956. They reported blue-winged teal and mallard pair densities in the Central Plain ranged from 6-15 and 3-12 pairs per 100 acres of wetland, respectively. My population estimates were in the lower one half of the reported numbers, indicating that Sandhill has a lower breeding population than the rest of the Central Plain.

Study area duckling production ranged from 0.27 to 0.41 ducklings per acre of wetland (estimated from combined data of this study and that of Baldassarre, 1978) and was 64 percent of the 1951-1956 Central Plain estimates and only 27 percent of the production standard established by Jahn and Hunt (1964) of one duckling per acre on the better quality wetlands of Wisconsin for the years 1951-1956.

Mallard, blue-winged teal, and wood duck production at Wood County were 65, 43, and 17 percent, respectively, of the 1951-1956 estimates reported for the Central Plain region. These estimates indicate that area production has declined and that production of blue-winged teal and wood duck has declined at a faster rate than that of the mallard. March et al (1973) concluded that Wisconsin's total duck populations had not changed appreciably between 1949-1950 and 1965 and 1970 but indicated mallard numbers had increased and blue-winged teal declined through the period. Changing habitat conditions (advanced plant succession) have probably affected blue-winged teal more than mallard (see discussion of habitat quality).

Small invertebrate populations (a function of poor quality habitat) probably reduced the attractiveness of the study areas to waterfowl early in the season. Whitman (1976) found breeding pairs feeding extensively on impoundments immediatley after ice-thaw, and suggested that the availability of food (invertebrates) was an important factor in determining early spring use of impoundments by waterfowl. (See invertebrate discussion section.)

Breeding pairs that used the study areas apparently dispersed according to available surface water area, whereas, duck broods selected more biologically productive wetlands. Pair densities varied between study areas and years (a function of low populations) but no single impoundment had a consistantly higher or lower number of "indicated pairs." However, duck broods selected the most fertile impoundments, J-Flowage and WC-North, and in that context, those areas were considered brood "sinks." More than twice the number of duck broods were observed as indicated pairs on J-Flowage and WC-North. WC-South had the lowest brood use; it also had the least productive habitat of the three study areas. Patterson (1976) found similar correlations in pond utilization by breeding ducks and duck broods in Ontario, and hypothesized that duck populations were regulated by these relationships.

SIMULATED NEST PREDATORS

Wood County predator activity is relatively low, indicating predation is not an important limiting factor in waterfowl production. The average nest predation rate (28 percent) was lower than that at Necedah National Wildlife Refuge (92 percent destroyed), the Lower Souris Refuge in North Dakota (24 to 64 percent destroyed), or ungrazed cover at the Horicon Marsh Wildlife Area (57 percent destroyed) in past years (Marsh, 1969). Wood County predation rates are similar to those found at the Horicon and Eldorado Marshes in 1969, when predator densities and nest losses were low; higher predator densities and nest losses were found in those areas during 1964 and 1965 (March, 1969).

There is no clear relationship between nest success and the height of vegetation around the nest. Byers (1974), in Iowa, found that simulated nests having deeper litter, denser cover, and greater vegetation height were not more successful than others; this was contrary to studies concerning natural nest success in North Dakota's dense, idle, upland habitat (Duebbert and Kantrud, 1974).

NESTING HABITAT

Nesting cover (sedge, sedge-willow-spirea mixtures, wool-grass bulrush, and a sparse understory in wooded uplands) is marginal. Preferred blue-winged teal nesting habitat (grassland types with ample residual cover; Johnsgard, 1975) is generally lacking on and near the study areas. Mallards prefer dry nesting sites with tall vegetation, but will adapt to different habitats (Johnsgard, 1975); they, therefore may not have been as affected by the lack of adequate nesting habitat as were blue-winged teal.

WATER AND SOIL

Poor water and soil qualtiy on the Wood County study areas has an adverse influence on waterfowl production. My data confirm the conclusion of Jahn and Hunt (1964) that wetlands associated with soft ground water [as the Wood County impoundments] have lower potential as waterfowl habitat than do hard-water wetlands [as in Horicon Marsh].

Wood County waters are slightly acidic, soft, and have low values of specific conductance. Nitrogen and phosphorus contents indicate that area fertility is mesotrophic (moderate) and impoundment waters contain insufficient inorganic nitrogen to produce heavy algal growths (Sawyer, 1947). Horicon Marsh waters are alkaline (pH = 8.0), hard, and fertile. Reported values for specific conductance and total alkalinity in Horicon Marsh (Beule and Janisch, 1976a) are from 7 to 13, and from 10 to 22 times greater, respectively, than in Wood County waters. Mean nitrogen contents (Total N, Organic N, and NH_4N) in outflow waters of Horicon Marsh (Johnson, in press) for the period Sept. 1974 through Aug. 1975 are 12.1, 1.1, and 3.1 times greater, respectively, than the spring and summer mean values for the Wood County impoundments. Total phosphorus content is 13.5 times greater in Horicon Marsh water than in Wood County.

Higher phosphorus and nitrogen levels in Horicon Marsh may be the result of a constant, high nutrient input from the richly fertilized agricultural watershed. Uttormark et al (1974) reported that the contribution of nutrients to lakes from steep-sided and cultivated farmlands could be considerable.

The Wood County impoundments are not exposed to similarly high-level nutrient sources. However, a potentially important nutrient source for the Wood County impoundments lies with the cranberry culture of the area. Swindale and Jahn (1956) attributed comparatively high submergent vegetation production in a local impoundment (Coles Flowage, located next to, and north of WC-North) to the indirect drainage of fertilized cranberry-bog water into the flowage.

Wood County soils are acidic (cf. circumneutral in Horicon Marsh) and contain from 5 to 41 times less calcium, magnesium, sulfate, and soluble salts than Horicon Marsh (Table 11). Phosphorus is the only major soil nutrient to have higher values (nearly two times greater) in Wood County than Horicon Marsh. Phosphorus probably occurs in higher levels in Wood County because soils contain high amounts of partially decomposed organic matter. Kadlec (1960) suggested that the colloidal content of partially decomposed organic matter absorbs phosphorus, and to a lesser extent potassium, from the water and accumulated them in an unavailable form. Organic matter decomposition is slower in cool, acidic soils [as in Wood County] than in warmer, neutral or alkaline soils [as in Horicon Marsh] (Phillips, 1970). Therefore, faster rates of organic matter decomposition in Horicon Marsh result in reduced amounts of partially decomposed organic matter available for phosphorus absorption. Horicon Marsh organic soils (histosols) are in a sapric (well-decomposed) condition (Beule, 1974). Wood County soils contain partially decomposed vegetation, indicating they are in a fabric (least-decomposed) or hemic (intermediate) condition (McKinzie, 1974).

AQUATIC AND MOIST-SOIL VEGETATION

Low duck production on the Wood County study areas correlates with vegetation species composition and density, and the degree of interspersion of open water.

WC-South has the lowest duck production and the most advanced stage of plant succession of the three study areas. Sedge (*C. lasiocarpa*) and willow mixtures have replaced shallow-water and emergent vegetative types that are preferred by waterfowl for resting and required by dabbling ducks for feeding (Jahn and Hunt, 1964). Emergent vegetation on WC-South is essentially a dense spikerush monoculture and has little interspersed open water. Linde et al, (1976) and Weller and Fredrickson (1974) indicated that monocultures are low quality marsh habitat for a diversity of wildlife species. Whitman (1976) speculated that dense emergent growths limit brood movement and vision and therefore, decrease the availability of invertebrates to broods. Submergent vegetation, an important substrate for aquatic invertebrates (Krull, 1970), is scarce in WC-South.

The sparsity of open water (3 percent of the impoundment) on WC-South probably limits the attractiveness of the marsh to wildlife in general. Weller and Fredrickson (1974) found that a hemi-marsh (a marsh in which open water was well interspersed with emergent cover at a ratio of 50:50) had the greatest bird numbers and diversity.

Higher duck production in J-Flowage and WC-North correlate with vegetational configurations that are typical of an earlier successional stage than is present in WC-South. Although these flowages are not hemi-marshes, they contain a diversity of emergent species that occur in lower densities than in WC-South.

Dense stands of coontail and waterweed in J-Flowage, and coontail in WC-North, facilitate area duck production by providing substrate for aquatic invertebrates (important duck foods during the breeding season; Swanson and Meyer, 1973). These submergents, and other species having finely-dissected leaves, harbor more invertebrates than other macrophytes (Krull, 1970; Andrews and Hasler, 1944; Moyle, 1961; Arner et al, 1968). Coontail had the second largest volume of invertebrates within the various vegetational types present in WC-North.

J-Flowage and WC-North would be more attractive to waterfowl if the former contained more openings and the latter more emergents interspersed throughout the open water.

The occurrence of emergents on each study area is probably influenced by plant succession and hydrologic characters (see discussion on wetland hydrology, below) more than by water chemistry. Species diversity is greater, and water quality better, on J-Flowage and WC-North than on WC-South, but B-Flowage (Sandhill Wildlife Area; Baldassarre, 1978) has similar species composition to J-Flowage and WC-North, and softer water (similar to WC-South).

AQUATIC INVERTEBRATES

Aquatic invertebrates are an important food source for waterfowl during the breeding season; invertebrates dominate the diets and are probably required to satisfy the dietary demands of breeding and juvenile ducks (Swanson and Meyer, 1973). Low invertebrate populations during the breeding season are probably the most crucial factor inhibiting total duck production on the Wood County study areas. McKnight (1974) and Whitman (1976) have attributed increased waterfowl production on newly-created waterfowl impoundments to an abundant and available aquatic invertebrate population.

Invertebrate populations on Wood County are probably smaller than those in areas of higher duck production. However, comparisons of regional populations are difficult to make because of differences in species composition, habitats, and sampling techniques. Benthic invertebrate volume (as measured by random samples) was six times greater in New York ponds (Krull, 1976) than the Wood County impoundments; the New York ponds provided adequate invertebrate life to waterfowl early in the season. Type IV wetlands (Shaw and Fredine, 1956) near Horicon Marsh (pers. comm., Feb. 22, 1978; William Wheeler, Dept. of Natural Resources, Box D, Horicon, Wisconsin) had 3.5 to 20 times larger surface and benthic invertebrate volumes, respectively, than the Wood County areas; these data are biased, however, because invertebrates were collected from known waterfowl feeding areas at Horicon, whereas the Wood County collections were random. Similar selective sampling on North Dakota's productive (undisturbed) seasonal wetlands (Swanson et al, 1974) yielded 6 to 11 times more invertebrates than Wood County throughout the season.

Study area duck production is probably low because large invertebrate populations are not available during critical periods in the life cycles of breeding waterfowl. More mallard hens are not attracted to the marshes because of the paucity of invertebrates during April and into May. Productive wetlands in Nova Scotia (Whitman, 1976) and New York (Krull, 1976) had high numbers and biomass of invertebrates soon after ice-melt; this did not occur on the Wood County areas. Krapu (1974) suggested that "availabliity of aquatic invertebrates is a major proximate factor influencing the onset of laying" by pintail (Anas acuta) hens. Holm and Scott (1954) showed that mallard egg production and egg hatchability was unsatisfactory with a reduced (less than 17 percent) protein diet. Whitman (1976) indicated that the composition, abundance, and avialablity of invertebrate populations were important factors in determining the early spring use of impoundments by waterfowl.

Low invertebrate volumes in WC-North and WC-South during June and into July may inhibit renesting attempts by blue-winged teal. Experiments conducted in North Dakota (Swanson and Meyer, 1977) showed that blue-winged teal hens terminated renesting attempts with reduced availability of a high protein diet.

The relationship between invertebrate quantities and waterfowl production on each study area is evident. WC-South has the lowest duck production and lowest average quantities of surface invertebrates of the three study areas. Relatively high duck production on J-Flowage and WC-North correlate with high volumes and numbers of surface organisms during May and June, thus providing a food source for late-nesting blue-winged teal and early mallard broods on those study areas.

Invertebrate species composition is most favorable for waterfowl production in J-Flowage and WC-North; J-Flowage has relatively high volumes of midges, gastropods, and odonates, and WC-North has gastropods and odonates. These taxa are scarce and/or occur late in the season in WC-South.

Midges appear in North Dakota wetlands during early spring and serve as an ideal source of protein for females during egg production and for ducklings during early development (Swanson, 1977).

The snail Gyraulus (common in J-Flowage and WC-North) is an important food item selected by breeding blue-winged teal in North Dakota (Swanson et al, 1974); Dirschl (1969) found that gastropods accounted for 43 and 48 percent of the foods consumed by adult blue-winged teal in May and June in the Saskatchewan River Delta; composition dropped to 19 percent in July, after the peak of the breeding season.

A major portion of the invertebrates found in the study areas consists of odonates; their importance as blue-winged teal and mallard foods is questionable. Swanson et al (1974) found a significant rejection of odonates by breeding blue-winged teal in North Dakota. Driver et al (1974) indicated that odonates were among those taxa least selected by young dabbling ducks but showed that one damselfly species was among those species able to satisfy potential amino acid requirements of ducklings. Sugden (1973) reported that downy pintail and adult lesser scaup (Aythya affinis) utilize zygopterans (Odonata), indicating that odonates are potentially important waterfowl foods. Odonates are probably utilized by study area waterfowl because of their abundance, availability, and the lack of other taxa (Crustaceans) that are important foods for breeding ducks (Swanson and Meyer, 1973). Although blue-winged teal do not select for odonates, they are opportunistic and change their diets in response to habitat changes (Swanson and Meyer, 1977).

Comparisons of monthly and biweekly invertebrate sampling routines on WC-South revealed that both methods effectively showed seasonal population trends of surface invertebrates, but not of benthic organisms. Biweekly sampling showed major population declines early and late in the season, and a significant increase in benthic invertebrates in late June. These changes were not detected by monthly samples.

WETLAND HYDROLOGY AND PHYSIOGRAPHY

Differences in hydrologic and physiographic characters between the study areas account for variations in habitat quality and the attractiveness of the study areas to waterfowl.

WC-South is surrounded by drainage ditches and dikes that direct water around and out of the impoundment, not through it (Fig. 3). The impoundment receives no surface runoff from the surrounding area; ground water and direct precipitation are the impoundment's only source of water and dissolved nutrients. Conversely, water flows into J-Flowage and WC-North via ditches and over land (Figs. 2 and 4). The watersheds provide water flow from adjacent marshes and uplands, and indirect flow (via ditches) from distant wetlands, thus magnifying the size of the watersheds to approximately one square mile.

Variations in surface water flow, associated with precipitation, through J-Flowage and WC-North produces greater fluctuations in water levels and water chemistry than that which occurs in WC-South (Fig. 6). These unstable conditions probably enhance productivity in J-Flowage and WC-North. Swanson et al (1974) attributed high productivity in prairie wetlands to unstable water conditions.

J-Flowage and WC-North impoundments also have steeper sides and more exposed mud flats that are subject to drying and occasional periods of flooding than does WC-South. Moist-soil vegetation (rice cut-grass and beggar tick) thrive in the mud flat areas, providing important seed foods. Upon flooding they die and decay rapidly, releasing nutrients and providing substrate for an abundance of aquatic invertebrates. Whitman (1976) found similar relationships between moist-soil plants and invertebrate abundance in Nova Scotia. The dryer sites in WC-South are occupied by species (spikerush, sedge, and wool-grass bulrush) more adapted to permanent flooding. The decaying organic matter from these species is slowly filling the WC-South impoundment.

Much of WC-South is subject only to spring flooding, or is covered by only 1-2 inches I2.5-5 cm) of water during the summer. Dense vegetation and shallow water conditions restrict brood movement and accessibility to aquatic invertebrates. J-Flowage and WC-North have permanent, deeper water areas for brood use. It is probable that broods moved into J-Flowage and WC-North as surrounding wetlands became dry in early summer. These flowages are edaphically richer, and provide more water for brood utilization than does WC-South. The importance of semipermanent and permanent wetlands for brood-rearing is well established (Smith, 1971; Swanson and Meyer, 1977; and Sanderson and Bellrose, 1969).

RECOMMENDATIONS

Waterfowl production on the Wood County study areas can be increased by improving breeding habitat through wetland management. Waterfowl and other wetland wildlife will benefit by the practice of water-level manipulations, controlled burns, soil scarifications, creating potholes, and fertilization.

I recommend an initial, 1-year drawdown of each study impoundment followed by spring flooding. Thereafter, summer drawdowns, conducted on a 5 to 7 year rotation, should be implemented. Water-level control is probably the most important technique used in wetland management (Sanderson and Bellrose, 1969). Studies by Cook and Powers (1958), Kadlec (1962), Harris and Marshall (1963), Anderson and Glover (1967), Whitman (1976), and others show that old and new waterfowl impoundments undergo increased productivity and become more attractive to breeding waterfowl with a sequence of water-level drawdowns and floodings.

Soil organic matter and nutrient contents should be monitored after each drawdown because drawdowns that are conducted too frequently may decrease impoundment fertility. Cook and Powers (1958) studied low-fertility northern marshes and found that organic matter decomposition was very rapid, and that released nutrients leached out of the impoundments, resulting in lower wetland fertility.

Water-level manipulation on WC-North is dependent upon the installation of a water control structure in the south dike, where water now enters the impoundment through an eroded opening, and at the northeast corner; the north and east dikes should be repaired. If these modificaations of WC-North are impractical, partial drawdowns and refloodings should be implemented by controlling water flow into the impoundment from the south. Modifications of the present ditch system on WC-South (and adjacent impoundments) are necessary before reflooding by surface-water flow can be achieved.

Advanced succession has filled in WC-South and reduced the area of open water and emergent vegetation. Reverting succession to an earlier stage is a management challenge. Management objectives should be to reduce willow and sedge growth, lower the marsh floor, and create openings. After drawing down WC-South, high-intensity burns should be conducted in late summer to release nutrients, thereby increasing soil fertility, and to eliminate willow and sedge; spring flooding would retard subsequent willow sprouting (Linde, 1969). The summer burns may also eliminate sections of peat on the marsh floor, thereby creating a desireable pothole effect by breaking up monotypes and providing an interspersion of open water (Linde, 1969). Potholes (1-2 acres in size, with sloping sides) should be constructed by bulldozing (Linde, 1969), where burns fail to open up areas covered by dense sedge.

Increased marsh fertility on the Wood County Wildlife Area could be achieved by diverting fertilized cranberry-bog water into the impoundments. This would require modification of the present drainage system. Swindale and Jahn (1956) suggested that waterfowl habitat in the Wood County Wildlife Area could be improved by pumping fertilized cranberry-bog water into the flowages. The feasibility of such a project should be investigated.

Grassland nesting cover is lacking near the study areas and probably limits nesting by blue-winged teal more than it does the mallard because mallards will utilize other habitats more readily. Blocks of dense grassland should be established in uplands where openings now exist (west of J-Flowage) and where shrubby areas may be cleared (south of J-Flowage and east of WC-South). Duck nests located in dense, idle upland vegetation are less likely to be destroyed by predators than nests in other habitats (Duebbert and Kantrud, 1974). Grassland blocks should not be established immediately adjacent to wetlands, thereby avoiding nest predation by raccoon. Fritzell (1978), in North Dakota, found that raccoon activity was centered around wetlands (and building sites) and they seldom used upland habitats; he suggests that the upland location is, in itself, a significant factor in decreasing nest predation by raccoons.

The implementation of these management practices on other state-owned impoundments in the region could result in a significant contribution to the state's breeding duck population.

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APPENDICES

Appendices, continued.

Appendix A.

Table 1. Shrub stem counts from permanent milacre plots on the west side of WC-South, 29 August 1975.

Plot number	Number of stems			Height of Salix spp (ft)
	Salix spp	Spirea tomentosa	Rubus strigosus	
1	26	117	0	4
2	20	134	0	4.5
3	16	81	0	7
4	66	60	0	4
5	14	126	15	3.5
6	15	2	0	5.5
7	64	0	0	6
8	51	91	0	6
9	51	121	0	6
10	9	61	5	5
11	41	45	0	5
12	11	72	0	3
13	37	106	0	6
14	31	39	0	5
15	11	8	0	5.5
16	22	31	0	6.5
17	50	168	0	5
18	21	68	0	4.5
19	33	110	0	6.5
20	36	72	0	7

Appendix A. (continued).

Table 2. Shrub stem counts from permanent milacre plots in the southeast corner of WC-South, 30 August 1975.

	Number of stems			
Plot number	Salix spp	Spirea tomentosa	Rubus strigosus	Height of Salix spp (ft)
1	50	91	0	7
2	50	103	16	6
3	38	53	21	8
4	52	42	27	9
5	41	85	5	6
6	110	57	0	8.5
7	35	28	0	8
8	83	8	0	10
9	58	36	0	8
10	71	57	0	11

Appendix B.

Table 1. Results of waterfowl censuses of J-Flowage, 1975 and 1976.[a]

J-Flowage - 1975

	April			May						June				
Species	20[b]	26[b]	30[b]	2[b]	4	11	19	27[c]	29[c]	3[c]	5[c]	13	20	26
Mallard	5pr	5pr	1pr, 1M	2pr						1pr	1pr, 10M,3F	31		11
Blue-winged Teal	4M	4pr	2pr	8pr, 8M	4pr						3M		2M	1pr
Canada Goose	2pr		1pr	1pr										
Ring-necked Duck		3pr, 1M	1pr	1pr	2pr									
Black Duck				1pr										
Pied-billed Grebe			1	1	1pr									
Total birds	18	23	10	35	12	4	0	0	0	2	18	31	2	14

Appendix B. Table 1 (continued).

J-Flowage - 1976

Species	April 1	April 7	April 11	April 14	April 16	April 20	April 22	April 25[b]	April 28[b]	April 30[b]	May 3[b]	May 6	May 10	May 14	May 17[c]	May 19[c]	May 21[c]	May 24[c]
Mallard	1pr, 16M,8F	7pr, 1M	3pr, 1M,2F	4pr	13pr	3M	1M	1M		2pr, 1M	1pr, 5M	2M	1pr, 2M		1pr	1pr, 3M	1M	4M
Blue-winged Teal	2pr	3M,2F		1pr, 3M	6pr, 3M,1F	12pr, 7M	5pr, 25	1pr, 1M	5pr	2pr, 8M,3F	1pr, 9M	3pr	3pr, 1M	1pr	2pr		1pr, 1M	1pr
Canada Goose	40	62	14	20	6			4	1pr		7	1	2pr		1pr	2pr		
Ring-necked Duck	94	86	30	85	34	130	57	39	126	108	79	20	1pr, 1M		1M	1pr	1pr	1pr
Pied-billed Grebe		4		1		4	1		4	1		2	3			1	1	
Coot		4		12		21	1	1	6		3	4			1			
Green-winged Teal						1M												
Hooded Merganser	2pr																	
Bufflehead	4M												1M					
Redhead	2pr	1pr																
Canvasback	2M,1F	1pr																
Wood Duck																2M	1M	
American Wigeon				1pr					2pr	1pr								
Horned Grebe						1			1									
Total birds	179	180	53	133	82	191	95	48	153	131	107	35	22	2	9	14	8	8

[a]M = male; F = female; pr = pair; B = brood.

[b]Early "4-in-10" count.

[c]Late "4-in-10" count.

Appendix B.

Table 2. Results of waterfowl censuses of WC-South, 1975 and 1976.[a]

WC-South - 1975

Species	April 20	April 21[b]	April 26[b]	April 30[b]	May 2[b]	May 4	May 11	May 19	May 27[c]	May 29[c]	June 3[c]	June 5[c]	June 13	June 20
Mallard	4pr, 8M	3pr	2pr, 3M	3pr, 3M	1pr, 6M	2pr, 1M	4pr	10M	5M	1pr, 4M	7M, 1F	10M	2M, 1F	2F
Blue-winged Teal	3M				2pr	1pr, 1M		1M	1M			1M	2M	
Green-winged Teal		1pr		1pr	2pr	1pr								
Canada Goose		2pr		2pr		1 lone	1 lone, 1pr							
Ring-necked Duck					1pr									
Coot			5	2	7	1	1							
Pied-billed Grebe	1	4	6	3		5				1				
Hooded Merganser	1M													
Bufflehead	2M, 1F			1F										
American Wigeon			1pr											
Total birds	23	16	17	21	25	17	12	11	6	7	8	11	5	2

Appendix B. Table 2 (continued).

WC-South - 1976

Species	April										May							
	1	7	11	14	16	20	22	25[b]	28[b]	30[b]	3[b]	6	10	14	17[c]	19[c]	21[c]	24[c]
Mallard	1pr		2pr		1pr	1pr	1M		1M	1M	1pr, 1M	2M	1pr	2pr, 1M	2M		1M	
Blue-winged Teal				1pr		4pr	1pr		2pr		3M, 2F	5pr, 1M	2M, 1F	1pr, 1M	4M	1pr, 2M	1pr, 3M,1F	1pr, 3M
Canada Goose	5pr	1pr	1 lone					1	1	2		1		2pr	2pr			1
Wood Duck																1pr, 1F	1F	
Pied-billed Grebe		1				2	1	2	3	1	3pr	4		2				
American Wigeon								1pr	1pr									
Ring-necked Duck			2M, 1F	5pr, 1M	1pr	3pr	1pr, 2M,1F	2pr	1pr	2pr	3pr							
Coot	4		1	4	3	5	1	3		3		1		1	1	2		
Green-winged Teal								1pr										
Total birds	16	3	9	17	7	20	10	12	15	11	20	19	5	15	10	9	8	6

[a]M = male; F = female; pr = pair; B = brood

[b]Early "4-in-10" count.

[c]Late "4-in-10" count.

Appendix B.

Table 3. Results of waterfowl censuses of WC-North, 1975 and 1976.[a]

WC-North - 1975

Species	April				May						June			
	20	21[b]	26[b]	30[b]	2[b]	4	11	19	27[c]	29[c]	3[c]	5[c]	13	20
Mallard	6pr	8pr	5pr, 3M	2pr, 2M	4pr	2pr, 2M	2pr, 3M	1M		4M	1M			
Blue-winged Teal	5M		1pr, 1M	4pr, 1M	5pr, 2M	3pr, 9M	2pr				1pr			
Canada Goose	1pr	1pr		1 lone	2pr	1 lone	1 lone				1pr+ 5 gos	1pr		
Wood Duck												1M		1M
Lesser Scaup	2M, 1F		2pr				2M, 1F							
Pied-billed Grebe	6	12		2	1	6								
Total birds	28	30	20	18	23	28	15	1	0	4	10	3		1

Appendix B. Table 3 (continued).

WC-North - 1976

Species	April										May							
	1	7	11	14	16	20	22	25[b]	28[b]	30[b]	3[b]	6	10	14	17[b]	19[b]	21[b]	24[b]
Mallard	2pr	3pr, 3M, 2F	6pr, 1M	3pr, 2M, 1F	3pr			1pr	1pr, 1M	1M	1pr, 4M	1pr, 4M	1pr, 6M	1F, 4M	6M	6M	1pr, 6M	4M
Blue-winged Teal				13pr, 5M	6M, 1F	7pr					1pr, 2M	5pr	3pr, 3M	1pr, 3M	1pr, 4M	1pr, 6M	1pr	1pr, 3M
Canada Goose	1pr, 1 lone		1pr	1 lone		1pr				1	3	6	2	2		2	2	3
Wood Duck									1M									2M
Green-winged Teal			2pr														1M	
Pied-billed Grebe				5					2	3	2	1			2	1		
Ring-necked Duck	1pr								2pr	1pr								
Red-breasted Merganser						5F												
Total birds	9	11	17	46	13	21	0	2	10	7	15	23	19	12	14	17	13	14

[a]M = male; F = female; pr = pair; B = brood.

[b]Early "4-in-10" count.

[c]Late "4-in-10" count.

Appendix C.

Table 1. Water quality data from three sample points on J-Flowage, Sandhill Wildlife Area, 5 May 1975 to 4 August 1976.

J-Flowage - Inflow

Date	Depth (cm)	Temp (°C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975									
May 05	61	15	8.4	3.8	10	6.9	36	1.5	260
Jun 14	58	18	7.4	2.8	10	6.5	46	2	210
Jul 05	58	25	4.4	12	20	6.5	49	5	360
Jul 19	51	23	3.7	60	68	6.3	101	31	440
Jul 31	49	22	3.3	18	64	6.9	149	15	460
Aug 15	50	20	4.0	28	68	6.7	140	24	480
Sep 13	50	13	9.4	1.6	12	7.3	34	1.5	120
Oct 25	79	10	2.5	26	20	6.3	208	32	480
Dec 06	76	3	7.9	26	20	6.0	40	4	270
1976									
Jan 13	76	1	3.7	14	30	6.9	96	5	260
Mar 08	76	2	2.6	22	38	6.7	87	6	260
Mar 31	122	5	10.3	3.5	8	6.7	24	2	220
Apr 14	137	15	9.0	6	12	6.7	28	1	200
Apr 28	122	19	8.6	4.5	14	6.8	34	1	190
May 26	82	21	7.3	2.6	6	6.7	27	1	190
Jun 09	79	26	5.8	12	42	6.8	64	2	320
Jun 23	85	24	3.9	11	46	6.9	120	no data	320
Jul 07	82	28	3.5	11	38	6.8	81	12	350
Jul 21	85	24	3.8	7.5	32	6.9	77	11	320
Aug 04	88	19	2.5	18	44	6.7	100	10	380

Appendix C. Table 1 (continued).

J-Flowage - Middle

Date	Depth (cm)	Temp (^oC)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975									
May 05	122	16	8.8	3.4	12	6.9	38	1.5	240
Jun 14	120	19	5.8	11	34	6.9	82	4.9	260
Jul 05	128	25	4.5	12	24	6.7	72	6	335
Jul 19	104	27	5.5	8	36	6.9	68	5	190
Jul 31	81	29	4.7	0.6	46	7.0	85	5	150
Aug 15	73	27	9.5	6	54	8.2	102	3	160
Sep 13	100	15	6.7	11	36	7.3	77	1	90
Oct 25	140	10	7.8	17	42	6.8	88	2	100
Dec 06	137	2	1.9	6	14	6.9	51	3	285
1976									
Jan 13	122	1	0	55	66	6.5	132	12	360
Mar 08	131	0.5	0	65	75	6.6	42	10	220
Mar 31	152	5	6.3	55	12	6.5	39	no data	200
Apr 14	122	14	8.3	7	14	6.7	35	2	250
Apr 28	140	16	7.9	3.5	12	7.0	35	3	230
May 26	140	23	7.5	1.5	12	7.2	43	3	230
Jun 09	137	28	6.2	8	22	6.7	52	1	320
Jun 23	79	22	7.6	3.4	26	7.2	87	2	200
Jul 07	91	28	7.3	2.2	22	7.3	61	2	190
Jul 21	82	24	9.6	0.1	36	8.6	59	2	150
Aug 04	122	22	7.2	6	26	6.9	70	2	190

Appendix C. Table 1 (continued).

J-Flowage - Outflow

Date	Depth (cm)	Temp (^oC)	Disolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975									
May 05	128	16	8.1	3	12	7.0	42	2	180
Jun 14	122	19	5.6	6	38	7.1	84	5	190
Jul 05	128	26	4.2	10	32	6.7	77	3	335
Jul 19	94	29	6.3	4	30	7.1	69	2	150
Jul 31	91	27	4.5	8	40	7.0	81	1.5	150
Aug 15	76	24	5.5	6	40	7.1	94	2	150
Sep 13	94	15	6.5	3	26	7.3	67	1	40
Oct 25	137	10	7.6	90 (?)	88	6.4	84	2	90
Dec 06	137	2	3.3	10	16	6.7	54	3	100
1976									
Jan 13	152	1	0	20	54	6.9	130	11	260
Mar 08	147	0.5	0	45	56	6.6	108	10	200
Mar 31	168	5	7.4	10	12	6.5	39	2	200
Apr 14	122	14	8.2	5	10	6.7	36	1	200
Apr 28	137	19	7.8	6	14	6.7	40	2	240
May 26	171	23	5.6	4	12	6.7	43	2	230
Jun 09	116	28	5.8	2	8	6.8	50	1	300
Jun 23	140	22	7.3	7	28	6.9	75	2	190
Jul 07	140	28	6.5	2	20	7.2	57	2	150
Jul 21	140	24	7.0	5	20	6.9	50	2	130
Aug 04	122	22	5.7	11	22	6.6	50	2	80

Appendix C.

Table 2. Water quality data from two sample points on WC-South, Wood County Wildlife Area, Wood County, Wisconsin, 22 May 1975 to 4 August 1976.

WC-South - Middle

Date	Depth (cm)	Temp (°C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975									
May 22	64	26	5.0	10	10	6.3	40	2	160
Jun 14	61	22	6.6	4	16	6.9	37	3	150
Jul 05	46	27	6.7	9	14	6.5	38	2	220
Jul 19	61	30	6.8	2	8	6.8	35	2	190
Jul 31	52	28	5.4	3	14	6.9	32	2	170
Aug 07	Impoundment Drawdown								
1976									
Mar 31	61	5	10.5	18	16	6.4	41	2	190
Apr 14	46	14	9.0	4	14	6.9	43	2	180
Apr 28	61	19	8.4	0.8	16	6.6	38	6	180
May 26	61	23	7.0	4	12	6.3	35	6	150
Jun 09	61	26	6.5	7	14	6.6	40	4	320
Jun 23	61	22	4.6	11	14	6.4	37	3	280
Jul 07	46	28	5.4	7	20	6.7	39	3	280
Jul 21	46	25	6.3	5	14	6.7	41	3	260
Aug 04	55	20	8.2	2	8	6.9	30	3	120

Appendix C. Table 2 (continued).

WC-South - Outflow

Date	Depth (cm)	Temp (^{o}C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975									
Jun 14	88	22	6.3	2	10	7.0	37	2	140
Jul 05	91	27	6.0	3	12	6.8	35	3	230
Jul 19	91	29	6.0	1	12	7.1	34	3	160
Jul 31	85	30	8.5	6	18	6.8	40	3	180
Aug 07	Impoundment Drawdown								
1976									
Mar 31	91	5	9.9	11	12	6.5	53	2	170
Apr 14	91	14	9.5	3	14	7.1	42	1	180
Apr 28	94	20	8.2	4	14	6.8	34	2	160
May 26	98	23	8.5	4	10	6.7	33	2	140
Jun 09	91	26	5.8	4	10	6.7	37	6	200
Jun 23	79	22	6.5	2	16	7.1	39	4	210
Jul 07	73	28	5.8	4	16	6.9	37	2	180
Jul 21	49	25	6.6	2	10	7.0	30	2	160
Aug 04	61	19	6.2	8	10	6.4	29	2	100

Appendix C.

Table 3. Water quality data from three sample points on WC-North, Wood County Wildlife Area, Wood County, Wisconsin, 22 May 1975 to 4 August 1976.

WC-North - Middle-South End

Date	Depth (cm)	Temp (^oC)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975									
May 22	52	27	5.1	4	12	6.7	52	0.5	no data
Jun 14	55	24	5.1	2	18	7.4	46	8	420
Jul 15	55	29	6.6	2	20	7.3	49	15	400
Jul 19	46	30	7.0	0.1	22	7.6	45	6	360
Jul 31	30	30	7.0	2	26	7.4	52	8	280
Aug 15	36	24	4.4	4	32	6.6	64	5	200
Sep 13	40	15	9.3	4	24	7.2	61	9	310
Oct 25	43	7	9.9	50	28	6.2	66	8	300
Dec 06	46	1	7.8	18	25	6.7	77	5	200
1976									
Jan 13	30	1	0	no data	50	7.0	70	3	500
Mar 08	46	1	0	28	52	6.7	60	3	320
Mar 31	61	5	9.3	20	10	6.2	33	2	260
Apr 14	30	18	8.9	8	24	7.0	48	4	300
Apr 28	49	20	8.0	8	20	6.7	50	3	300
May 25	55	24	6.9	8	24	6.7	64	4	310
Jun 09	55	26	6.4	11	18	6.5	41	2	300
Jun 23	49	21	6.1	3	24	7.2	66	5	230
Jul 07	30	29	7.5	6	26	6.9	56	5	270
Jul 21	30	24	7.9	5	20	6.9	70	9	310
Aug 04	24	20	4.8	6	24	6.9	57	8	300

Appendix C. Table 3 (continued).

WC-North - Middle-North End

Date	Depth (cm)	Temp (^{o}C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1976									
Mar 31	91	5	9.6	5	20	6.9	33	4	280
Apr 14	46	16	9.2	2	12	7.1	48	4	300
Apr 28	67	21	8.8	5	16	6.7	52	3	250
May 26	85	24	7.1	7	18	6.7	132	3	230
Jun 09	73	26	5.7	5	22	7.0	57	2	240
Jun 23	79	22	5.3	5	22	7.0	53	4	240
Jul 07	73	29	5.8	6	20	6.8	50	3	210
Jul 21	70	24	5.4	5	16	6.8	48	2	170
Aug 04	67	21	2.5	7	16	6.7	51	4	180

Appendix C. Table 3 (continued).

WC-North - Outflow

Date	Depth (cm)	Temp (^oC)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975									
Jun 14	177	22	6.0	4	20	7.0	47	6	320
Jul 05	168	28	6.2	7.0	20	5.8	53	6	400
Jul 19	174	28	6.1	9	30	6.3	68	9	240
Jul 31	180	31	7.0	2.2	40	7.5	82	8	290
Aug 15	143	26	2.9	7.0	20	7.3	49	4	180
Sep 13	152	13	7.4	3.2	16	6.7	51	7	250
Oct 25	201	9	9.2	10	22	6.6	61	7	210
Dec 06	168	1	6.9	24	22	6.3	63	8	260
1976									
Jan 13	168	1	4.9	15	26	6.8	73	11	430
Mar 08	172	0.5	3.6	45	34	6.4	77	11	200
Mar 31	183	5	8.1	15	8	6.2	35	3	170
Apr 14	138	16	8.8	2	18	7.3	48	5	210
Apr 28	152	19	8.3	6	18	6.8	54	4	240
May 26	198	24	7.9	10	20	6.6	57	4	260
Jun 09	165	26	7.0	7	20	6.7	67	1	180
Jun 23	168	22	4.4	9	18	6.6	72	2	350
Jul 07	152	28	6.0	7	50	7.1	73	3	260
Jul 21	140	24	5.1	7	24	6.8	62	5	110
Aug 04	155	21	4.7	22	36	6.5	75	4	80

Appendix D.

Table 1. Water level measurements[a], day to day water level fluctuations, and water depths relative to a bench mark (datum[b]) in J-Flowage, April 1975 to August 1976.

J-Flowage - Inflow

Date (1975)	Reading (feet)	Day to day fluctuation (feet)	Date (1976)	Reading (feet)	Day to day fluctuation (feet)
Apr 18	6.66		Apr 01	5.4	
26	6.29	+.37	07	5.5	-.10
30	5.78	+.51	14	5.53	-.03
May 02	5.85	-.07	20	5.32	+.21
11	6.32	-.47	25	6.28	-.96
19	6.40	+.08	May 06	5.83	+.45
28	6.56	-.16	19	5.15	+.68
Jun 05	6.26	+.30	21	6.05	-.90
14	6.29	-.03	24	6.05	0
16	6.24	+.05	28	6.16	-.09
19	6.23	+.01	Jun 03	6.18	-.02
26	6.31	-.08	07	6.38	-.20
Jul 05	6.30	+.01	11	6.32	+.06
08	6.34	-.04	16	6.38	-.06
10	6.39	-.05	23	6.50	-.12
14	6.41	-.02	27	Accidental drawdown	
17	6.44	-.03	29	6.80	-.30
19	6.49	-.03	Jul 07	6.92	-.12
25	6.40	+.09	15	7.25	-.33
Aug 07	6.95	-.55	21	7.02	+.23
15	7.12	-.17	29	6.95	+.07
16	7.14	-.02	Aug 04	7.05	-.10
21	6.72	+.42	19	7.23	-.18
22	7.01	-.29			
25	6.30	+.71			
26	6.31	-.01			
29	6.34	-.03			
Sep 05	6.37	-.03			
28	6.42	-.05			
Oct 25	6.44	-.02			

Appendix D. Table 1 (continued).

J-Flowage - Outflow

Date (1975)	Reading (feet)	Day to day fluctuation (feet)	Relative depth (feet)	Date (1976)	Reading (feet)	Day to day fluctuation (feet)	Relative depth (feet)
Apr 18	4.09		1.02	Apr 01	2.51		2.90
26	3.95	+.14	1.16	07	2.58	-.07	2.83
30	3.36	+.59	1.75	14	2.63	-.05	2.78
May 02	3.37	-.01	1.74	20	2.40	+.23	3.01
11	3.84	-.47	1.27	25	3.92	-1.52	1.49
19	3.79	+.05	1.32	May 10	2.90	+1.02	2.51
27	3.71	+.08	1.40	14	2.91	-.01	2.50[b]
28	3.73	-.02	1.38	21	2.93	-.02	2.48
Jun 05	3.66	+.09	1.47	24	3.00	-.07	2.35
14	3.74	-.08	1.39	28	3.21	-.21	2.14
16	3.68	+.06	1.45	Jun 03	3.23	-.02	2.12
19	3.63	+.05	1.50[b]	07	3.41	-.18	1.94
26	3.78	-.15	1.35	16	3.91	-.50	1.44
Jul 05	3.80	-.02	1.33	23	4.62	-.71	0.73
10	3.88	-.08	1.25	27	Accidental drawdown		
14	3.96	-.08	1.17	29	4.25	+.37	1.10
17	3.98	-.02	1.15	30	4.22	+.03	1.13
19	4.00	-.02	1.13	Jul 07	4.41	-.19	0.94
25	4.46	-.46	0.67	15	4.65	-.24	0.70
Aug 07	4.51	-.05	0.62	21	4.40	+.25	0.95
16	4.74	-.23	0.39	29	4.30	+.10	1.05
21	4.52	+.22	0.61	Aug 04	4.35	-.05	1.00
25	3.52	+1.00	1.61	19	4.60	-.25	0.75
26	3.56	-.04	1.57				
29	3.40	+.16	1.73				
Sep 05	3.34	+.06	1.79				
13	3.13	+.21	2.00				
28	3.21	-.08	1.92				
Oct 25	3.17	+.04	1.96				

[a]Measurements made on inflow and outflow water control structures.

[b]Datum; water depth measured at invertebrate sample station number 2.

Appendix D.

Table 2. Water level measurements[a], day to day water level fluctuations, and water depths relative to a bench mark (datum[b]) in WC-South, April 1975 to August 1976.

WC-South - Outflow

Date (1975)	Reading (feet)	Day to day fluctuation (feet)	Relative depth (feet)	Date (1976)	Reading (feet)	Day to day fluctuation (feet)	Relative depth (feet)
Apr 21	2.11		2.28	Apr 01	2.34		2.69
30	1.68	+.43	2.71	07	2.36	-.02	2.67
May 02	1.78	-.10	2.61	14	2.37	-.01	2.66
11	2.02	-.24	2.37	20	2.18	+.19	2.85
19	2.12	-.10	2.27	22	1.91	+.27	3.12
29	2.15	-.03	2.24	26	1.90	+.01	3.13
Jun 05	2.18	-.03	2.21	29	1.93	-.03	3.10
14	2.22	-.04	2.17	May 06	2.00	-.07	3.02
26	2.29	-.07	2.10[b]	10	2.03	-.03	2.99
Jul 01	2.21	+.08	2.18	14	2.14	-.11	2.88
05	2.29	-.08	2.10	19	2.10	+.04	2.92
08	2.32	-.03	2.07	24	2.13	-.03	2.89
10	2.35	-.03	2.04	Jun 03	2.39	-.26	2.63
17	2.40	-.05	1.99	07	2.50	-.11	2.52
19	2.42	-.02	1.97	09	2.60	-.10	2.42
25	2.54	-.12	1.85	18	2.84	-.24	2.18
30	2.63	-.09	1.76	23	3.02	-.18	2.00[b]
Aug 05	2.87	-.24	1.52	29	3.14	-.12	1.88
07	2.82	+.05	1.59	Jul 07	3.45	-.31	1.57
Drawdown				15	3.80	-.35	1.22
11	4.89	-2.07	-0.48	21	3.65	+.15	1.37
15	5.45	-.55	-1.03	29	3.62	+.03	1.40
18	5.43	+.02	-1.01	Aug 04	3.72	-.10	1.30
22	5.10	+.33	-0.68	19	4.10	-.38	0.92
26	3.89	+1.24	0.56				
27	4.33	+.47	1.03				
30	4.71	-.38	0.65				
Sep 13	4.84	-.13	0.52				
20	5.09	-.25	0.27				
28	5.00	+.09	0.36				
Oct 25	4.98	+.02	0.38				

[a]Measurement made at outflow tube in the northeast corner of WC-South.

[b]Datum; water depth measured at "middle" water sample station.

Appendix D.

Table 3. Water level measurements[a], day to day water level fluctuations, and water depth relative to a bench mark (datum) in WC-North, April 1975 to August 1976.

WC-North - Dam

Date (1975)	Reading (feet)	Day to day fluctuation (feet)	Relative depth (feet)	Date (1976)	Reading (feet)	Day to day fluctuation (feet)	Relative depth (feet)
Apr 21	4.71		1.77	Apr 01	4.10		3.06
30	4.72	-.01	1.76	07	4.80	-.70	2.36
May 02	4.12	+.50	2.36	14	5.16	-.36	2.00[b]
11	4.35	-.23	2.13	25	4.06	+1.10	3.10
19	4.57	-.22	1.91	26	4.18	-.12	2.98
29	4.52	+.05	1.95	May 06	4.48	-.30	2.68
Jun 05	4.48	+.04	2.00[b]	14	4.92	-.42	2.26
14	4.54	-.06	1.94	19	4.65	+.27	2.53
26	4.64	-.10	1.84	21	4.70	-.05	2.48
Jul 01	4.53	+.11	1.95	24	4.91	-.21	2.27
05	4.65	-.08	1.87	Jun 03	5.12	-.21	2.06
08	4.71	-.06	1.81	07	5.26	-.14	1.92
10	4.73	-.02	1.79	09	4.85	+.41	2.33
17	4.81	-.08	1.71	18	5.06	-.21	2.12
19	4.92	-.09	1.62	23	4.93	+.13	2.25
30	5.17	-.25	1.37	29	5.02	-.09	2.16
Aug 05	5.23	-.05	1.32	Jul 07	5.19	-.17	1.99
07	5.28	-.05	1.27	15	5.55	-.36	1.63
15	4.92	+.36	1.63	21	5.41	+.14	1.77
22	4.81	+.09	1.72	29	5.05	+.36	2.13
26	3.93	+.88	2.60	Aug 04	5.15	-.10	2.03
30	4.32	-.39	2.21	19	5.46	-.31	1.72
Sep 05	4.63	-.31	1.90				
13	4.59	+.04	1.94				
20	4.75	-.16	1.78				
28	4.73	+.02	1.80				
Oct 25	4.81	-.08	1.72				

Appendix D. Table 3 (continued).

WC-North - North Bridge (data collected in 1976 only)

Date (1976)	Reading (feet)	Day to day fluctuation (feet)	Relative depth (feet)
Apr 01	4.20		3.18
07	5.00	-.80	2.38
14	5.38	-.38	2.00[c]
25	4.36	+1.01	3.01
May 06	5.17	-.81	2.21
10	5.17	0	2.21
12	4.90	+.27	2.48
14	5.11	-.21	2.27
17	4.97	+.14	2.41
19	5.00	-.03	2.38
24	5.00	0	2.38
Jun 03	4.92	+.08	2.46
07	5.02	-.10	2.36
09	5.13	-.11	2.25
18	5.23	-.10	2.15
23	5.22	+.01	2.16
29	5.31	-.09	2.05
Jul 07	5.45	-.14	1.91
15	5.80	-.35	1.56
21	5.65	+.15	1.71
29	5.35	+.30	2.01
Aug 04	5.38	-.03	1.98

[a]Measurements made at dam in the east ditch, and at the bridge in the northeast corner of WC-North.

[b]Datum; water depth measured at invertebrate sample station number 5.

[c]Datum; water depth measured at invertebrate sample station number 3.

Appendix E.

Table 1. Calculation of importance values[a] for prominent species in the major emergent and moist soil plant communities of J-Flowage, 13 August 1976.

Community (sample size) and species	Density (stems/plot)	Relative density	Dominance (percent cover)	Relative dominance	Frequency	Relative frequency	Importance value
Burreed - South end (n=45)							
Sparganium americanum	48	.570	.224	.681	.820	.360	1.611
Sagittaria latifolia	8	.100	.038	.116	.600	.264	.480
Eleocharis palustris	14	.161	.061	.049	.180	.079	.289
Leersia oryzoides	8	.094	.023	.070	.180	.079	.243
Scirpus validus	3	.032	.007	.021	.180	.079	.137
Others (3 species)	4	.039	.021	.062	.310	.138	.239
Cattail - Central Section (n=10)							
Typha latifolia	56[b]	.938	.225	.987	1.000	.980	2.905
Leersia oryzoides	3	.047	.002	.007	.100	.098	.152
Sagittaria latifolia	1	.015	.002	.007	.100	.098	.120
Cattail - East of Dike (n=11)							
Typha latifolia	63	.489	.440	.871	1.000	.314	1.674
Elocharis palustris	39	.302	.029	.057	.364	.114	.473
Leersia oryzoides	16	.122	.028	.055	.545	.171	.348
Sparganium americanum	5	.038	.002	.004	.364	.114	.156
Bidens cernua	2	.018	.002	.004	.364	.114	.136
Others (2 species)	3	.020	.003	.005	.546	.172	.197

Appendix E. Table 1 (continued).

Community (sample size) and species	Density (stems/plot)	Relative density	Dominance (percent cover)	Relative dominance	Frequency	Relative frequency	Importance value
Rice cut-grass and Spikerush - Bordering Ditch (n=25)							
Leersia oryzoides	110	.322	.318	.457	.880	.204	.983
Eleocharis palustris	165	.480	.142	.204	.480	.111	.795
Sagittaria latifolia	28	.083	.101	.145	1.000	.231	.459
Dulichium arundinaceum	12	.035	.036	.052	.480	.111	.198
Sparganium americanum	15	.044	.028	.040	.400	.093	.177
Others (8 species)	13	.026	.073	.100	1.080	.249	.375
Soft-stem bulrush - East of Dike (n=19)							
Scirpus validus	23	.159	.203	.456	.684	.271	1.286
Eleocharis palustris	77	.526	.043	.097	.316	.125	.748
Sparganium americanum	29	.196	.107	.240	.579	.229	.665
Sagittaria latifolia	6	.041	.026	.058	.421	.167	.266
Leersia oryzoides	9	.061	.042	.094	.263	.104	.259
Others (2 species)	2	.016	.024	.044	.263	.104	.164

[a]Importance value = relative density + relative dominance + relative frequency.

[b]Leaf blades.

Appendix E.

Table 2. Calculation of importance values[a] for prominent species in the major emergent and moist-soil plant communities of WC-South, 29 July 1976.

Community (sample size) and species	Density (stems/plot)	Relative density	Dominance (percent cover)	Relative dominance	Frequency	Relative frequency	Importance value
Mixed Emergents (n=16)							
Eleocharis palustris	235	.731	.196	.365	.938	.250	1.346
Dulichium arundinaceum	39	.122	.212	.395	.875	.233	.750
Sagittaria latifolia	32	.100	.086	.160	.875	.233	.483
Scirpus validus	3	.010	.019	.035	.312	.083	.128
Others (6 species)	15	.035	.024	.041	.752	.200	.276
Spikerush (n=19)							
Eleocharis palustris	803	.976	.563	.941	1.000	.543	2.460
Others (6 species)	20	.023	.035	.058	.843	.456	.537
Burreed (n=15)							
Sparganium americanum	79	.702	.453	.920	1.000	.428	2.050
Sagittaria latifolia	8	.075	.026	.053	.600	.256	.384
Eleocharis palustris	21	.190	.011	.022	.333	.143	.355
Dulichium arundinaceum	3	.025	.002	.003	.200	.086	.114
Others (3 species)	1	.007	.001	.001	.013	.053	.061

Appendix E. Table 2 (continued).

Community (sample size) and species	Density (stems/plot)	Relative density	Dominance (percent cover)	Relative dominance	Frequency	Relative frequency	Importance value
Emergent Sedge (n=11)							
Carex rostrata	26	.335	.470	.812	1.000	.333	1.480
Eleocharis palustris	29	.374	.028	.048	.455	.152	.574
Sagittaria latifolia	11	.146	.038	.082	.727	.242	.454
Dulichium arundinaceum	4	.047	.021	.036	.272	.091	.174
Others (5 species)	7	.097	.022	.067	.546	.181	.345
Sedge Meadow (n=14)							
Carex lasiocarpa	130	.858	.474	.861	1.000	.259	1.978
Scirpus cyperinus	9	.057	.056	.098	.429	.111	.266
Calamagrostis canadensis	7	.049	.012	.021	.714	.185	.255
Hypericum boreale	3	.016	.004	.007	.714	.185	.208
Lysimachia terrestris	2	.010	.011	.018	.643	.167	.195
Others (3 species)	1	.009	.012	.001	.357	.092	.102
Wool-grass bulrush (n=13)							
Scirpus cyperinus	43	.462	.408	.743	1.000	.220	1.108
Carex lasiocarpa	22	.226	.118	.215	.538	.119	.500
Eleocharis palustris	11	.116	.001	.002	.461	.102	.286
Calamagrostis canadensis	7	.076	.006	.011	.385	.085	.229
Lysimachia terrestris	2	.020	.001	.002	.615	.135	.223
Others (8 species)	8	.099	.015	.026	1.540	.338	.463

[a]Importance value = relative density + relative dominance + relative frequency.

Appendix E.

Table 3. Calculation of importance values[a] for prominent species in the major emergent and moist-soil plant communities of WC-North, 5 August 1976.

Community (sample size) and species	Density (stems/plot)	Relative density	Dominance (percent cover)	Relative dominance	Frequency	Relative frequency	Importance value
Mixed Emergents - North End (n=10)							
Leersia oryzoides	81	.232	.343	.460	1.000	.303	.995
Eleocharis palustris	205	.591	.165	.221	.600	.182	.994
Sparganium americanum	40	.116	.131	.176	.600	.182	.474
Sagittaria latifolia	15	.043	.076	.102	.700	.212	.375
Others (2 species)	7	.017	.031	.040	.400	.120	.177
Mixed Emergents - West Side (n=18)							
Eleocharis palustris	294	.623	.218	.323	.833	.217	1.163
Leersia oryzoides	61	.129	.182	.270	.500	.130	.529
Sagittaria latifolia	33	.069	.105	.156	.889	.232	.457
Sparganium americanum	21	.044	.073	.108	.611	.160	.312
Sagittaria spp.	36	.075	.040	.059	.333	.087	.221
Glyceria borealis	24	.050	.052	.077	.333	.087	.214
Scirpus validus	2	.004	.004	.006	.111	.029	.039
Cattail - South End (n=16)							
Typha latifolia	51[b]	.263	.632	.843	1.000	.206	1.312
Eleocharis palustris	95	.497	.064	.085	.875	.180	.762
Leersia oryzoides	18	.092	.029	.039	.813	.167	.298
Sparganium americanum	22	.115	.017	.023	.688	.142	.280
Sagittaria latifolia	3	.014	.005	.007	.438	.090	.111
Others (2 species)	3	.019	.002	.002	.356	.074	.095

Appendix E. Table 3 (continued).

Community (sample size) and species	Density (stems/plot)	Relative density	Dominance (percent cover)	Relative dominance	Frequency	Relative frequency	Importance value
White water lily - South End (n=39)							
Nymphaea odorata	10	.103	.255	.448	.718	.406	.957
Potomogeton natans	8	.058	.074	.078	.282	.159	.364
Eleocharis palustris	46	.458	.036	.072	.106	.060	.590
Sparganium americanum	19	.185	.039	.078	.359	.203	.466
Zizania aquatice	18	.174	.081	.161	.154	.087	.422
Others (4 species)	1	.021	.071	.047	.131	.084	.152
Wool-grass bulrush - South End (n=22)							
Scirpus cyperinus	35	.183	.501	.687	1.000	.121	.991
Eleocharis palustris	75	.395	.027	.037	.636	.077	.509
Dulichium arundinaceum	27	.143	.058	.080	.772	.093	.318
Sagittaria latifolia	13	.069	.034	.047	1.000	.121	.237
Galium tinctorium	5	.027	.004	.005	.727	.088	.120
Carex rostrata	3	.018	.042	.058	.273	.033	.109
Others (15 species)	31	.164	.063	.085	3.862	.466	.715
Sedge Meadow - North End (n=16)							
Carex cannescens	79	.407	.207	.269	.813	.116	.792
Scirpus cyperinus	24	.121	.272	.353	.813	.116	.590
Eleocharis palustris	38	.194	.042	.055	.375	.053	.302
Sagittaria latifolia	16	.081	.067	.087	.813	.116	.284
Others (15 species)	37	.193	.182	.235	4.201	.598	1.026

[a]Importance value = relative density + relative dominance + relative frequency.

[b]Leaf blades.

Appendix F.

Table 1. Check-list of invertebrates collected from the Wood County study areas between 1 April and 9 July 1976.

Taxa	Study area		
	J-Flowage	WC-South	WC-North
Annelida			
Oligochaeta	x	x	x
Chaetogaster		x	
Hirudinea	x	x	x
Crustacea			
Conchostraca		x	
Cladocera	x	x	x
Amphipoda			
Gammarus	x		x
Decopoda			x
Arachnida	x	x	x
Hydracarina	x	x	x
Insecta			
Collembola		x	x
Ephemeroptera			
Baetidae			
Baetis	x		x
Caenidae			
Caenis	x	x	x
Ephemeridae			
Hexagenia			x
Odonata			
Zygoptera			
Coenagrioniidae			
Enallagma	x	x	x
Nehalennia	x	x	x
Lestidae			
Lestes	x	x	x
Anisoptera			
Corduliidae			
Tetragoneuria		x	x
Dorocordulia	x		
Libellulidae			
Somatochlora			x
Leucorrhinia	x	x	x
Libellula			x
Ladona julia			x
Sympetrum	x	x	x
Pachydiplax			x
Aeshnidae			
Aeshna		x	x
Anax	x		x
Gomphidae			
Arigomphus			x

Appendix F, Table 1, continued.

Taxa	J-Flowage (Study area)	WC-South (Study area)	WC-North (Study area)
Hemiptera			
Gerridae			
Gerris	x	x	x
Veliidae			
Microvelia			x
Notonectidae			
Buenoa	x	x	x
Pleidae			
Plea striola	x	x	x
Nepidae			
Ranatra	x	x	x
Belostomatidae			
Belostoma	x	x	x
Corixidae	x	x	x
Hydrometridae			
Hydrometra		x	
Saldidae		x	
Trichoptera			
Polycentropodidae			
Polycentropus			x
Cyrnellus		x	
Hydoptilidae			
Oxethira	x	x	x
Brachycentridae			
Micrasema		x	
Phryganeidae			
Agrypnia		x	
Banksiola	x	x	
Ptilostomis			x
Leptoceridae			
Oecetis	x	x	x
Trianoides	x		x
Lepidoptera			
Pyralidae			
Nymphula	x	x	x
Paraponyx	x	x	x
Coleoptera			
Haliplidae			
Haliplus	x	x	x
immaculicollis	x	x	x
cribrarius			x
connexus			x
triopsis	x	x	
apostolicus	x		
leopardus		x	
Peltodytes tortulosus	x	x	x

Appendix F, Table 1, continued.

Taxa	Study area		
	J-Flowage	WC-South	WC-North
Dytiscidae			
Acilius			x
Hydrovatus	x		
Hydroporus	x	x	x
Agabus	x	x	
Hygrotus			
farctus		x	
Sayi	x	x	x
Illybius	x	x	
Colymbetes	x	x	
Dytiscus	x	x	
Celina		x	x
Coptotomus	x	x	
Liodessus		x	
Desmopachria convexa		x	
Gyrinidae			
Gyrinus		x	
Dineutus		x	
Hydrophilidae			
Helophorus		x	
Hydrochus	x		
Berosus		x	x
Tropisternus	x	x	x
Enochrus	x	x	x
Helodidae			x
Chrysomelidae			
Donacia		x	x
Cuculionidae	x	x	x
Diptera			
Orthorrapha			
Nematocera			
Tipulidae			
Dicronota	x	x	x
Culicidae			
Chaoborus	x		
Chironomidae	x	x	x
Ceratopogonidae	x	x	x
Brachycera			
Stratiomyiidae	x		
Tabanidae			
Crysops	x	x	x
Cyclorrapha			
Scatophagidae			x
Anthomyiidae			
Limnophora		x	

Appendix F, Table 1, continued.

Taxa	Study area		
	J-Flowage	WC-South	WC-North
Gastropoda			
Pulmonata			
Physidae			
Physa	x	x	x
Lymnaeidae			
Bulimnaea			x
Stagnicola	x		x
Lymnaea		x	
Planorbidae			
Gyraulus	x	x	x
Helisoma	x	x	x
Ancylidae			
Ferrisia	x	x	x
Ctenobranchiata			
Amnicolidae			
Amnicola		x	x
Viviparidae			
Campeloma		x	
Pelecypoda			
Sphaeriidae	x	x	x
Total number of taxa	57	70	67
Total taxa collected from all study areas			97