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Aquatic Plant Communities of Vermilion County, Illinois

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INTRODUCTION

In many parts of Illinois and adjacent Indiana and Kentucky the coal measures are near the surface, and as a result many thousands of acres have been stripped. This stripping process destroys the original land surface and leaves extensive waste areas, also, numerous ponds and small lakes are usually created. The "new" land is nearly devoid of vegetation, lacks organic material, does not have a definite soil profile, and is subject to extensive erosion.

Because stripping is common in Illinois a number of studies have been undertaken to determine succession rates and composition of both plant and animal pioneer species. In the Illinois stripped lands the successional stages have been examined by McDougall (1925) and Croxton (1928) and later by Brewer and Triner (1956), while Ashby (1964) studied vegetational development under plantations of black locust and shortleaf pine. The movements of mammals into these stripped areas was studied by Verts (1957, 1959). The work by McDougall (1925), listed above, was concerned with the stripped lands of Vermilion County, the same area in which the present study was undertaken.

Though extensive literature is now available concerning the successional trends in the terrestrial habitats of strip-mine areas, very little information is available concerning Illinois aquatic habitats created by strip-mining. Lewis and Peters (1955) examined some of the physical and chemical properties of these habitats in southern Illinois. In the same area Bell (1956) undertook a similar study and examined these conditions and their effect on the development of aquatic and marginal vegetation. Except for this one study no attempt has been made to correlate the physical and chemical properties of these strip-mine ponds with the successional trends of the vascular aquatic vegetation. Because of this the present study was undertaken. This was accomplished by using strip-mine ponds of known age and examining the vascular aquatic plant communities that were present. Also, the physical and chemical properties of these habitats were examined to try and determine the reasons for the vegetation changes observed.

DESCRIPTION OF THE AREA

The strip-mine ponds studied are located directly west of the city of Danville, Vermilion County, Illinois (Fig. 1). This area lies near the northeast boundary of a great coal field which occupies the greater part of Illinois as well as parts of Indiana and Kentucky. In parts of Vermilion County the coal measures referred to as the Danville bed lies close to the surface of the ground. This coal measure, which is 1 to 7 feet thick, is covered with glacial drift of Wisconsin age, and in the stripped area it was from 10 to 40 feet below the surface of the ground.

Drainage for the study area is provided by the North Fork, Middle Fork and Salt Fork Rivers which join to form the Vermilion River. McDougall (1925) described the area as a surface

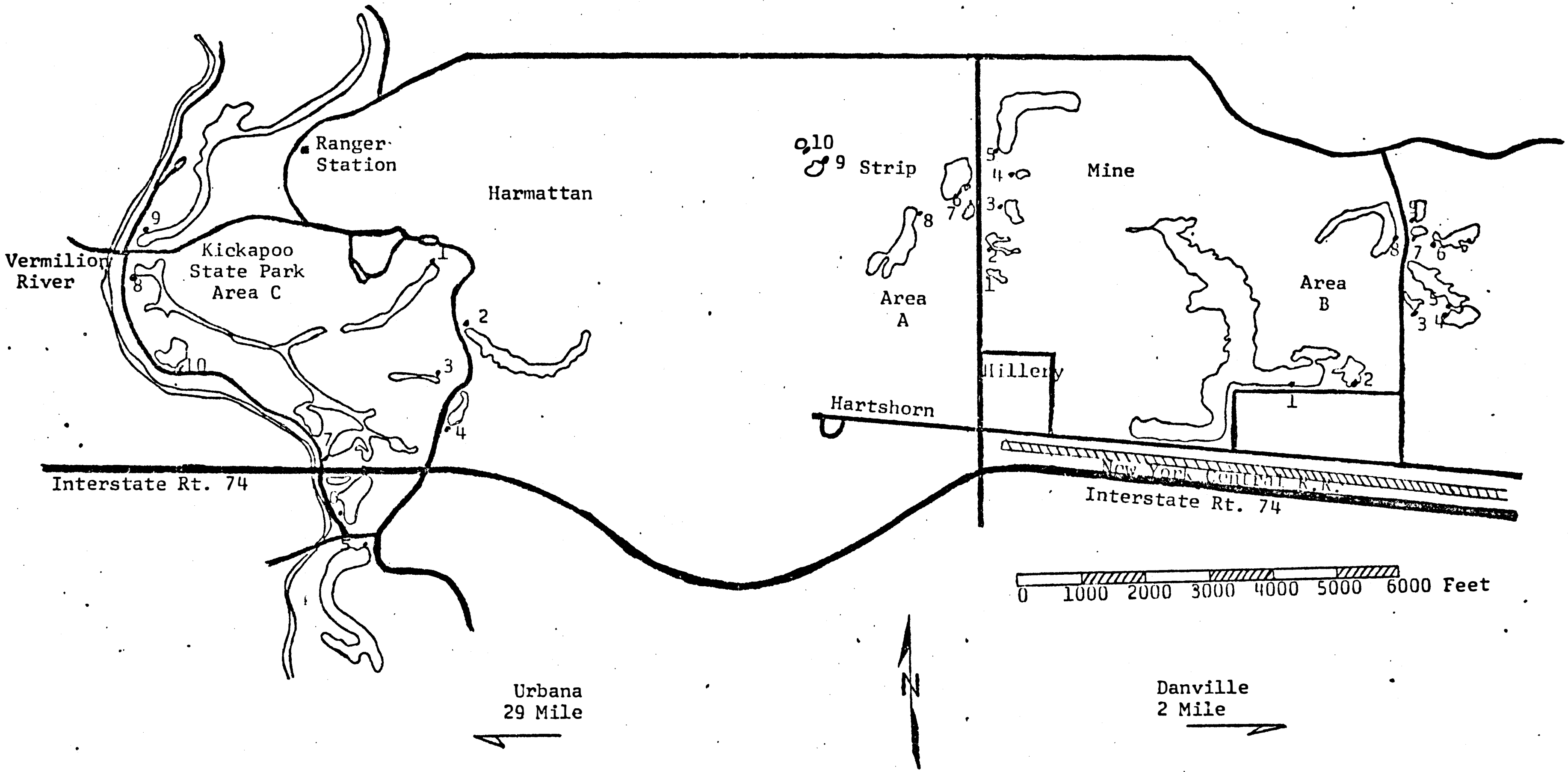

Figure 1. Map showing ponds where aquatic plants were collected and locations where water samples were collected in the strip-mine ponds west of Danville for the months of March through October 1972 at Vermilion County, Illinois.

which is essentially a level plain into which valleys and ravines have been carved by the Vermilion River and its tributaries, these valleys and ravines being generally 50 to 100 feet deep. A general Soil Map of Vermilion County prepared by the U.S.D.A., Soil Conservation Service (1969) described two soil associations in the area in which this study was conducted, these two associations being the Fincastle-Russell Soil Association and the Lawson-Strawn Soil Association. The Fincastle-Russell Association is found in the area of sites A and B. This association is found on nearly level to moderately sloping sites and is transitional between the light-colored soils bordering the streams and the dark-colored prairie soils. These soils were formed in 1 1/2 to 3 feet of silty material (loess) above glácial till. The Lawson-Strawn Soil Association is found in the area of test site C, located in Kickapoo State Park. This association occupies both the nearly level bottomland and the adjoining steep slopes of the State Park. The bottomland soils are the Lawson Type, are somewhat poorly drained and have a thick, dark brown or black silt loam. The Strawn soils occur on the steep slopes and are well drained. They have a grayish-brown over light brownish-gray silt loam surface layer and a yellowish-brown clay loam subsoil.

The climate of the area is similar to that of Urbana, Illinois, which lies 27 miles to the west of the study area. It has an average growing season of 181 days during which it receives 63% of its annual precipitation of 35.9 inches. May and June are usually the wettest months with the rainfall averaging 3.97 and 3.99 inches respectively. The summers are typically hot and humid with 90° F.

temperatures or higher for an average of 25 days each year. An average mean temperature of 74.5° F. is recorded during July, usually the warmest month. January is normally the coldest month of the year, with a monthly mean temperature of 26.5° F. The average yearly snowfall is 22 inches, although most of the winter precipitation occurs as rain. The snowiest month, February, has an average of 5.3 inches of snow each year (Wilson, 1972).

The mining of coal by the stripping process destroys the original land surface. In most of the areas the waste is left in parallel rows of spoil banks 10 to 40 feet high intermingled with ponds ranging in size from small ponds to lakes 20 acres in size. During this study the physical and chemical characteristics of some of these aquatic habitats were studied. In all, a total of 28 bodies of water were examined representing three distinctly different periods of surface mining. The oldest of these areas was mined around the turn of the century and is now within the confines of Kickapoo State Park (Area C). The second area studied was mined about 25 years ago (Area B), while the most recently mined area (Area A) was stripped five to nine years ago.

Area A - This area was recently stripped by the Ayrshire Collieries Coal Company. It was referred to as the Harmattan Mine and the stripping was completed in 1968. The nine ponds studied in this area vary in size from less than 1/2 acre to more than 10 acres in size and are located in sections 2 and 3, T19N, R12W. The woody vegetation is essentially non-existent in this area with only a few scattered willows and cottonwoods. The herbaceous plants included a number of pioneer herbs, with sweet clover (Melilotus sp.), foxtail (Setaria sp.), barnyard grass (Echinochloa crusgalli (L.)

Beauv.), smartweed (Polygonum pensvlvanicum L.), and alfalfa (Medicago sativa L.) being the most common. Much of the soil surface is still exposed and all of the steeper slopes are without vegetation. The entire area is essentially in a very early stage of succession with most of the ground still devoid of cover.

Area B - This area was stripped by the United Electric Coal Company with most of the mining being completed by 1955. A total of nine ponds were examined with most of them being less than 1 acre in size. One of the ponds, however, has a surface area of about 20 acres. All of the ponds are located in sections 1 and 2, T19N, T12W. The vegetation in this area is more diverse than Area A. Many trees are present with black locust and red cedar being the most common. Also willows and cottonwoods are present and some hardwoods typical of the surrounding countryside are beginning to become prevalent. Various grasses make up the common type of herbaceous flora, but many of the pioneer species found in Area A are also common. Many of the steeper slopes are still bare or have very little vegetation on them.

Area C - This is the oldest of the three areas studied and is located in Kickapoo State Park. This area was stripped by the United Electric Coal Company around the turn of this century. The ten aquatic areas studied vary from less than 1/2 acre to more than 6 acres in size. These ponds are located in sections 4, 5, 8, and 9, T19N, R12W. The terrestrial vegetation in this area is highly diverse and well established. The dominant trees include black willow, cottonwood, sycamore, and elm, with many box elder, silver maple, hackberry, and ash also being present. The undergrowth is also well established with numerous shrubs and vines and the typical herbaceous understory of moist woodland situations.

MATERIALS AND METHODS

A preliminary survey indicated that the quantity and type of aquatic vascular plants was somewhat unique in each of the three known-aged sites (Area A, B, and C). In these three sites a total of 28 ponds were selected for further study. These ponds were visited once each month from March 1972, through October 1972. On each trip water samples were obtained, various environmental measurements were taken, and observations were made as to the species of aquatic plants present and their abundances.

Water temperature was taken using a standard centigrade thermometer at randomly chosen lakes after it was found that the water temperature varied only $1/2^{o}$ C. throughout the ponds examined. The water temperature was taken from the same location at which the aquatic plants were collected and at an average depth of six inches.

Water samples were collected from each study area in 300 ml bottles and taken to Eastern Illinois University where they were analyzed for turbidity, total iron, nitrates, nitrites, sulfates, and phosphates using the Hach turbidimetric methods (Hach AC-DR Colorimeter). Conductivity was measured using the Hach Model 2200 Conductivity Meter. The pH of these samples was deterimed with the use of a Sargent-Welch Model LS, pH Meter.

Soil samples were also taken from each of the 28 ponds. These samples were obtained from the sites at which the water samples were taken and usually in 1 to 2 feet of water. The soil particle size for each sample was determined by using the Bouyoucos Hydrometer Method of soil analysis. (Bouyoucos, 1962).

Other visits to the 28 ponds were also made to collect each of the species of vascular aquatic plants present and to determine their abundance. For the smaller ponds the entire area was examined while for the larger lakes only a 50 foot area around the site at which the water samples were taken was examined. In all cases samples of the plants were collected in plastic sacks and later pressed and dried in the standard herbarium method. Efforts were made to note the associations of the various species in each individual pond. Eventually each community was identified and the dominant, co-dominant and associated species recorded. All specimens are deposited in the Stover Herbarium of Eastern Illinois University.

RESULTS

Following is an outline of the chemical and physical properties of the ponds studied. A total of 7 chemical properties (pH, nitrates, nitrites, sulfates, phosphates, iron, and conductivity), and 2 physical properties (turbidity and soil particle size) were studied. In conjunction with these physical and chemical studies the vascular plant communities found in these ponds are recorded as to complexity of the associations and the abundance of the species encountered.

pH - The monthly averages of the pH for the lakes were all alkaline except for three, these being Area C in June (7.0), Area A in July (6.7) and Area C in July (6.8). The limestone overburden which now makes up most of the spoil banks is probably responsible for the relatively high pH of the water at the test sites. The ranges for average pH in the study sites fluctuated slightly from sample date to sample date; however, on any one date the pH for all three sites usually fluctuated correspondingly (Table 1). Also, the averages for the three sites never varied by more than 0.6, except in April when Area C was 0.9 lower than Area A. Area B almost consistently had the broadest pH ranges as well as the highest pH values.

Nitrates - Nitrate averages for each of the three areas (Table 2) varied by no greater margin than 6.5 parts per million (ppm) on any date except in July when Area C was 7.9 ppm above Area B and 8.9 ppm above Area A and in August when Area A was 10.4 ppm above Area C and 10.8 ppm above Area A. The averages were generally low, between 2.0 ppm and 6.7 ppm for all months except March when all three areas were high, May when Area C was 11.5 ppm, July when Area C was 10.6 ppm and August when Area A was 14.0 ppm. Unusually high concentrations in May, July and August may be due to sampling error. The large drop in concentration from March to April is probably due to the accumulation of nitrates from the decomposition of organic matter during the winter and its subsequent drop when plant growth begins about April.

Nitrites - Nitrites are formed from nitrates by reduction and are low except in polluted water (Reid, 1961). The amounts of nitrites in the water were extremely low (Table 3) and fairly steady from month to month except during April, when the average in Area A was .027, and June when Area B had an average of .016 with an unusually high reading of .12 ppm at Area B pond 1. This low level of nitrites is an indication that the area is receiving little or no pollution from human sources.

Sulfates - The averages of the sulfate readings for the strip-mine ponds were high (Table 4). They also varied greatly from month to month and from test site to test site. Generally they showed no pattern, except that Area A always had the lowest monthly averages. The average for the test sites during the study period varied from a low of 596 ppm in Area A during March to a high of 1130 ppm in Area C during October. These sulfates probably came from the oxidation of sulfur compounds in the piles of coal dust, shales and other materials in the spoil banks (Crawford, 1942).

Phosphates - The amounts of phosphates in the waters (Table 5) were generally very low except during April, when Area A had an average reading of 3.6 ppm and Area B had 2.5 ppm, and during July, when Area C had an average reading of 1.7 ppm. Other than the above, the monthly averages varied from .07 to .66 ppm. It is assumed that the April and July readings, since they are so unusual, are probably due to an error in testing. Test pond number 4 in Area B had a consistently high phosphate reading. This high reading is believed to be due to phosphate pollution from a nearby septic system.

Iron - The amounts of iron in solution in the ponds of the study area were extremely low (Table 6). The averages were generally very close for any single month, especially during May, June, September and October, and never varied widely at any time. The highest readings were recorded at pond number 5 in test Area A in March and April, with readings of 1.45 and 1.70 ppm respectively, pond 2 in Area C in July with a reading of 1.90 ppm and pond 5 in Area C in August with a reading of 1.90 ppm. Except for these four ponds the concentrations of iron were extremely low and did not vary greatly from pond to pond or area to area.

Conductivity - The averages of the conductivity readings for the test sites were high (Table 7) and a general pattern is easily discernable from the graphs. The older the ponds the higher the average conductivity readings. Area C had the highest readings and Area A had the lowest average readings. Another correlation is apparent in that all three areas will collectively show either an increase or a decrease as compared to the averages for the preceding month. The readings in the study area varied from an average of 384 to 940 reciprocal megohms.

Turbidity - The turbidity of the waters in the study area were generally very similar during any one month (Table 8), with April having the highest monthly average and October having the lowest monthly average. The highest monthly average was in Area A in April with a reading of 35.5 Jackson Turbidity Units (JTU), with pond 5 having a reading 135 JTU. The lowest reading was in Area B in October with an average reading of 1.0 JTU. The high average readings in April could be due to heavy rainfall just prior to the sampling date. The largest difference in turbidity between the three areas was during September, with Area A having a reading 17.2 JTU above that of Area C. In general the readings fluctuated from month to month, but were close for all three areas during any single month.

Soil Particle Size - Area A had the highest average percentage of sand content in the soil (Table 9) of the three areas sampled, with more than half of its soil content (55.8%) being sand. Seven of the ten sites sampled in Area A had a reading of over 50%. Area B had the second highest average percentage for sand content. Area C had the highest average percentage for silt with 45.5%, while Area A had the lowest average percentage for silt. Areas B and C were very close in the average percentages of clay present (15.2 and 14.27% respectively).

Vegetation - Aquatic vegetation was found to be present in all of the ponds sampled except for three, these sites being pond 10 in Area A and pond 7 and 9 in Area B. Area A, pond 10 was an extremely shallow pond which was completely silted in prior to the completion of the study. Area B, ponds 7 and 9 were both small ponds, and although they had terresterial vegetation lining their banks, no aquatic vegetation was present.

In Area A six of the ponds had Chara sp. present while eight of the ponds had one or more species of Potamogeton present. Potamogeton americanus was present in three ponds and is classed as a dominant in pond 8 where it was abundant around the edge of the pond. Potamogeton foliosus was found scattered in three ponds and in association with P. americanus in one while P. pusillus was found scattered in two ponds and in association in two ponds. In general, the aquatic plants were not abundant in any pond except pond number 8 and were usually found growing in isolated clumps.

In Area B a larger variety although not necessarily a larger quantity of plants was found. Chara sp. was present in three ponds and Potamogeton foliosus was present in five. P. pectinatus and P. pusillus were found in pond 6. Naias quadalupensis was the dominant species in pond 6 and Heteranthera dubia was found in this pond. The aquatic plants occurred only in clumps except in pond 6 where they were completely covering the bottom of a shallow bay where the samples were collected.

The vegetation present in Area C was the most diverse in species and had the largest biomass of any of the three areas sampled. The only exception was pond 4 which had only a small amount of Chara sp. present. The number of species in a single pond varied from a low of 4 in ponds 2 and 3 to a high of 11 in pond 10. Chara was present in every pond as was some species of Potamogeton. In this area the plants generally occurred in masses which covered large areas of the bottoms of the shallow portion of the ponds. There were eleven species of plants out of the total of nineteen species recorded in the ponds of this area which occurred only in ponds in Area C. Of these eleven plants, one was found to be dominant in the pond in which it was recorded and six were found to be co-dominants in one or more ponds for which they were recorded.

Table 10 is a chart which lists the aquatic plants found and the ponds in which they were found. It also identifies whether the plants were dominant, co-dominant or associated.

DISCUSSION

pH - Crawford (1942) found that the water acidity due to the presence of mineral acids appeared to be the decisive factor influencing the development of the strip-lakes in central Missouri. The source of these acids was reported to probably have been the sulfur and iron pyrites (Fe S) found in the coal and shale of the spoil banks. In contrast Lewis and Peters (1955) and Bell (1956) found that the majority of the ponds they studied had a pH value that was slightly basic. The reason given for this was the excessive amounts of limestone found in the spoil banks. The pH of the water sampled in this study was found generally to be basic, and there appears to be no general trend in the pH values of the samples which would indicate any difference between the three areas on this basis.

<u>Nitrates</u> - Nitrates are important in aquatic systems for their role in the synthesis and maintenance of protein, and the amounts of nitrates present in a body of water are regulated by the processes of production and decomposition of organic matter in the lake (Reid, 1961). Welch (1952) states that nitrates supply nitrogen in its most available form for use by plants. Ruttner (1964) indicates that nitrates may come from the soil, since nitrates are water soluble. The numerous bodies of water tested in this study were sampled for nitrates because it was felt that this could possibly be the controlling factor in the plant growth in the various ponds. However, nitrate concentration in the ponds appeared to show no relationship to the age of the pond nor to the quantity or type of plant material present in any of the areas sampled.

<u>Nitrites</u> - The amounts of nitrites present in the ponds of the sample area were extremely low and appeared to have no relation to the plant material found in the ponds.

<u>Sulfates</u> - Crawford (1942) states that the sulfates present in the area in which his study was conducted came from the oxidation of sulfur compounds in piles of coal dust, shales, and mine refuse. Sulfur is necessary for the composition of protein in plants (Welch, 1952). The sulfate readings for Area A were always lower than those for either Area B or Area C, but there appears to be no correlation between sulfate concentration and the presence or absence of particular plants for any of the ponds.

Phosphates - The ponds sampled in the study were tested for phosphates. Phosphorus has been found to be an important nutrient for algal growth, which when present in massive blooms is considered a manifestation of the entrophication process (Allen and Kramer, 1972). The phosphate samples for this study were found to be extremely low, except for one test site which was receiving outfall from a septic system (test pond number 4 in Area B). The only apparent change this caused to the aquatic plant community of this pond was that the surface of the water was usually covered with Lemna minor. There appeared to be no relationship between the concentration of phosphates and the presence or absence of aquatic plants.

Iron - Crawford (1942) found concentrations of iron in the waters of strip-mine ponds in central Missouri that were considerably higher than those found in this study. The readings for iron in ponds that Crawford studied were as high as 168 ppm. Campbell and Lind (1969) had readings as high as 155 and 168 ppm. They state that the spoil banks are the source of the iron in the strip-mine ponds they sampled. They also found that as the pH of the lake goes up the concentration of iron goes down, and that when the iron goes out of solution the water generally becomes extremely clear and transparent. Welch (1952) states that iron is necessary for the production of the chlorophyll molecule and can be toxic at high concentrations. The concentrations of iron in the ponds sampled for this study were extremely low and did not vary greatly at any time during the study.

Turbidity - Strip-mine ponds are generally extremely clear due to the flocculation of the negatively charged particles by positive ions and the filtering action of the ferric oxide precipitate (Bell, 1956). Crawford (1942) and Heaton (1951) both state that as pH increases turbidity will increase and Heaton (1951) further states that turbidity could influence plant growth through reducing the amount of light reaching the chlorophyll in the plant by coating the leaves of the plant as the suspended materials settle out of solution. The turbidity values for the area tested were generally low, and the averages for each area were close for any given month. The source of the turbidity in the areas tested was undoubtedly the steep slopes surrounding the lakes, with the materials reaching the ponds in rain-water runoff. However, the values for Area C, where the watershed was better protected by plant cover than in either of the other two areas, were not consistently lower. In fact, there appears to be no consistent pattern in the relationships of the monthly averages for the turbidity readings for one area versus the other two areas. The data for this study gives no indication which shows that turbidity could be the determining factor affecting the plant growth in the ponds.

Conductivity - As is clearly discernible in the graph in Table 7, the older the stripped area, the higher the average conductivity reading in that area as compared with the younger bodies of water for the same month. This data corresponds with the information from Swindle and Curtis (1957) when they stated that the conductivity of the water was the environmental factor which showed the best correlation with the aquatic vegetation in their studies. They reported that as the conductivity of the test areas rose, the quantities of aquatic vegetation increased. This observation corresponds with the findings of this project, for the older ponds with the higher average monthly conductivity readings not only had a readily apparent larger quantity of aquatic plants but they also had a greater number of different species present. Area C, the oldest area, had ponds with as few as one species present and ponds with as many as eleven species present. The average number of species present in the ponds of Area C was 6.5.

The quantity of plant material present in the older ponds was readily apparent, with some of the shallower areas having the bottom completely covered with a mat of vegetation. These high densities of plant material seemed to be the rule rather than the exception. The only pond outside of Area C having anything comparable to this was pond 6 in Area B. The sample location of pond 6 in Area B was in a sheltered cove which had a fairly high concentration of plants and also had the largest number of species of any of the ponds in Area A or B.

The conductivity of the ponds sampled for this paper ranged from 384 to 940 reciprocal megohms. These values are not nearly as high as those found to be typical of strip-mine ponds by Lewis and Peters (1955), who found conductivity readings of 900 to 4,000 reciprocal megohms and Bell (1955) who recorded readings of 500 to 5,000 reciprocal megohms.

Conductivity is a reading of the relative amount of electrolytes present in the water. Welch (1952) states, "It has been claimed that, other things being equal, the richer a body of water is in electrolytes, the greater the productivity". This appears to be borne out in this study to some extent, in that Area C with the highest conductivity readings had the greatest quantity as well as the greatest variety of aquatic vegetation present. However, Area B, which had a consistently higher conductivity reading on an average than Area A, had a lesser number of species of plants present. There was no readily discernible difference in the quantities of plant materials present between Areas A and B.

Soil Particle Size - Swindale and Curtis (1957) stated, "That the qualities of the water cannot be solely responsible for the character of the plant communities growing in it . . ." They go on to state that smaller plants are found in parts of the lake with exposed, sandy-substrates whereas species with longer, flexuorus stems and leaves were found in bays with richer substrates. The greater the plant diversity and plant size the lower the amount of sand present in the soil. They go on to say that submerged plant communities often vary within the same lake, with the better developed communities being found in bays and sheltered places with rich soil. Bell (1956), Crawford (1942) and Heaton (1951) all stated that the steep sides of the banks of the strip-mine ponds must be considered important to the existing aquatic plant material, since suitable soil exposure must be present if plants are to grow.

Sculthorpe (1967) states that water chemistry does not influence the distribution of rooted vascular plants, unless it is correlated with variations in the substrate, and that the main influence of the substrate upon distribution of rooted vegetation is due to its physical texture. Moore and Clarkson (1967) state in their paper that the most important factor influencing plant establishment and growth is the substrate.

The soil of these strip-mine ponds sampled in Vermilion County do show a correlation between the percentages of sand, silt and clay and the presence or absence of aquatic vascular vegetation. Ponds in Area C had the highest average percentage of silt present in their substrate and the least amount of sand, whereas ponds with the lowest amount of diversity of plant vegetation, Area A, had the highest amount of sand and the lowest amount of silt.

The amounts of clays present did not follow a pattern related to the above data. It is doubtful that the amount of silt present in the substrate is the controlling factor in the presence of the greater amount of vegetation in the ponds in Area C versus the ponds in either Area A or B because when we analyze the percentages for the ponds in these areas (Table 9) on an individual basis there appears to be exceptions to this rule. However, the composition of the substrate must still be considered important in the analysis of the factors affecting the presence or absence of aquatic vegetation in these ponds.

Vascular Aquatic Plants - Little work has been done in the past in the way of identifying the vascular aquatic plants found in the ponds of strip-mined areas in Illinois. Two papers which list aquatic plants found in strip-mined ponds were written by Bell (1956) and Lewis and Peters (1955).

Considerably more work has been done concerning the general distribution of aquatic plants throughout Illinois. An extensive collection of aquatic plants is at the Illinois State Museum, with the majority of these specimens being collected during 1964 and 1965 by Conservation Biologists of the Division of Fisheries, Department of Conservation. A description of this project has been completed by Lopinot (1965) and Winterringer (1966).

A flora of the vascular hydrophytes of Illinois, including the general distribution of each species, has been compiled by Winterringer and Lopinot (1966). A detailed study of a few families of hydrophytes have been compiled, with the Haloragaceae and Hippuridaceae having been revised by Meyer and Mohlenbrock (1966), the Alismales by Mohlenbrock and Richardson (1967) and the Lemnaceae by Weik and Mohlenbrock (1968).

Other studies concerning state-wide distribution of hydrophytes have been completed by Jones and Fuller (1955), Winterringer and Evers (1960) and Mohlenbrock (1967, 1970). Regional studies or reports concerning new county records make up most of the remaining literature on the aquatic vascular plants in Illinois. A bibliography of these studies is presented in a recent paper by Dolbeare and Ebinger (1975).

A listing of the aquatic plants identified in this study is given in Table 10, which also shows the area as well as the pond where these plants were collected. In addition, it also shows how they occurred relevant to any other plants that were present in that same pond. The occurrence classification used was as follows:

1. Dominant - plant which was present in the greatest abundance.
2. Co-dominant - plant which was present in abundance approximately equal to that of one or more other plants.

3. Associated - plant that was growing with other plants and no dominance was apparent, or a plant that was occurring with plants which were clearly dominant.
4. Scattered - plant did not form a solid mat of vegetation over the bottom of the pond.
5. Associated and scattered - plants were scattered over bottom of pond as well as growing in association with other plants.

Plant communities of the ponds of Area A (the area with the youngest ponds) were made up of three species in two of the ponds, two species in four ponds, one species in three different ponds, and one pond containing no aquatic plants. Chara sp. was the most frequent in these ponds, with Potamogenton foliosus and P. pusillus also being common.

Plant communities of the ponds of Area B (the middle-age ponds) were made up of five species in one pond, two species in one pond, and one species in five different ponds. Two of the ponds in this area contained no aquatic plants. The plant most commonly encountered was Potamogenton foliosus, with Chara sp. being the second most frequently collected plant in these ponds.

Plant communities of Area C (the oldest ponds) contained the most diverse plant communities of any of the three areas. The diversity of these communities is evident when it is noted that the area contained 6.5 different plant species per pond, with ten being the highest diversity and one species being the lowest.

Chara sp. was found to be present in all ponds, with Potamogeton pectinatus being present in eight of the ten ponds. There were eleven species recorded for Area C which were not found in either Area A or Area B. Two plants were present in Area A which were not found in Area C, and one plant was found in Area B which was not recorded for Area A or Area C.

From the chart it is clearly evident that Area C has the greatest diversity of any of the three areas. The information that is not shown, but which was readily discernible in the field, was that the ponds of Area C also contained a considerably larger quantity of plant material than either of the other two areas.

Lewis and Peters (1955) reported Potamogeton foliosus as being abundant in ponds with average or high pH values and Chara fragilii as being present in many ponds with high pH values. Crawford (1942) reported that a lake which was extremely alkaline contained Potamogeton foliosis, P. diversifolia and Chara sp. Bell (1956) reported that Potamogeton foliosus and Chara sp. were present in the majority of the 52 strip-mines ponds studied which exhibited pH values between 6.0 and 8.0. Potamogeton foliosus and Chara sp. were the two species of plants most commonly encountered in the strip-mine ponds sampled for this study.

CONCLUSION

The presence, distribution and abundance of aquatic vegetation in the strip-mine ponds of Vermilion County studied for this paper show correlation to only two of the variables studied, these being conductivity and soil particle size. The distribution and quantity of aquatic plants in the strip-mine ponds of Vermilion County is affected by the conductivity of the water, with an increase in both quantity and diversity being correlated with an increase in conductivity. In addition, soils containing a high amount of silt and low amount of sand tend to support a larger quantity as well as a more diverse growth of aquatic plants than soils high in sand and low in silt content. It is felt that neither of these factors alone, nor when considered together, should be thought to be responsible for the variety and quantity of aquatic plant vegetation present, but rather that other factors play an important role in the distribution of plants in these ponds and should be considered in future studies; factors such as the steepness of the slope of the pond basin and organic matter content of the soil. Other less apparent, but equally important factors, such as soil runoff into ponds from adjoining lands may also exist which do influence aquatic plants in these ponds, and these should also be investigated in future work.

TABLES

Each bar in the following bar graphs represents the following information: The maximum and the minimum reading in that area on that date plus the average of all the readings (shown as a horizontal line) in that area for that date. The wide portion of the bar represents the standard deviation for that area.

TABLE 1

THE pH IN THE STRIP-MINE PONDS OF AREAS A, B AND C FOR THE MONTHS OF MARCH THROUGH OCTOBER, 1972, AT VERMILION COUNTY, ILLINOIS

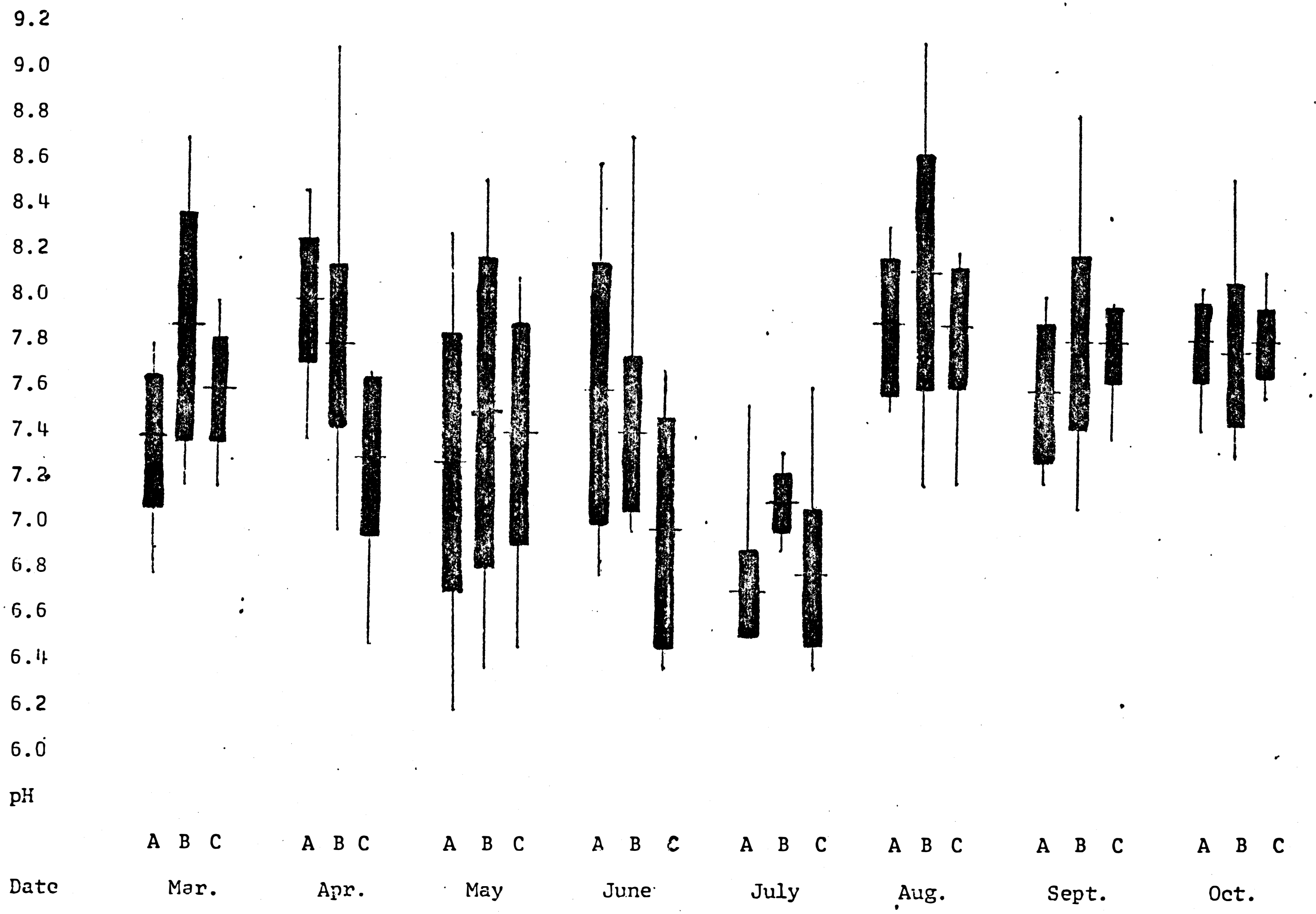

TABLE 2

THE PARTS PER MILLION (P.P.M.) OF NITRATES (NO_3)
IN THE STRIP-MINE PONDS OF AREAS A, B AND C FOR THE MONTHS OF MARCH THROUGH OCTOBER, 1972,
AT VERMILION COUNTY, ILLINOIS

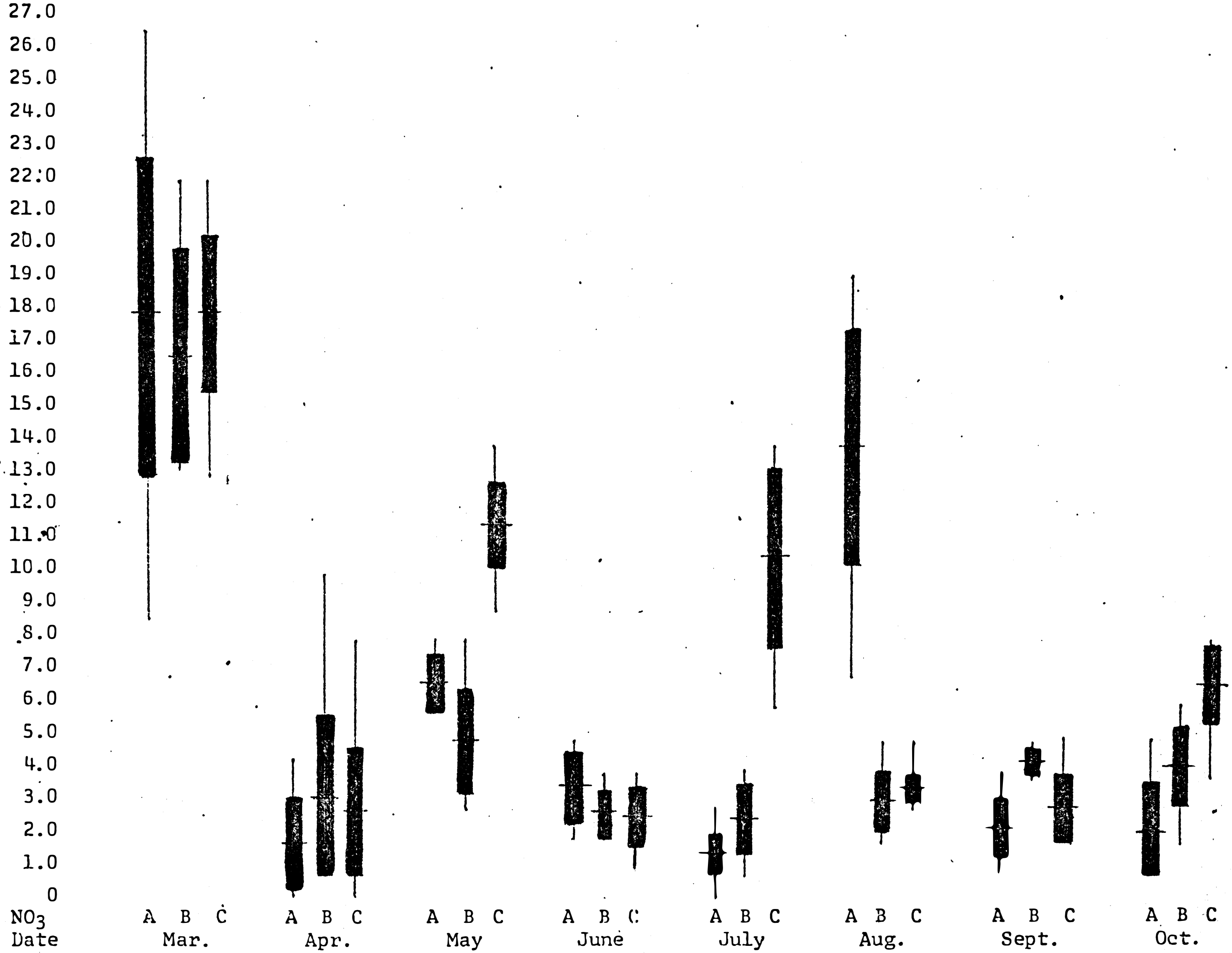

TABLE 3

THE PARTS PER MILLION (P.P.M.) OF NITRITES (NO_2)
IN THE STRIP-MINE PONDS OF AREAS A, B AND C FOR THE MONTHS OF MARCH THROUGH OCTOBER, 1972,
AT VERMILION COUNTY, ILLINOIS

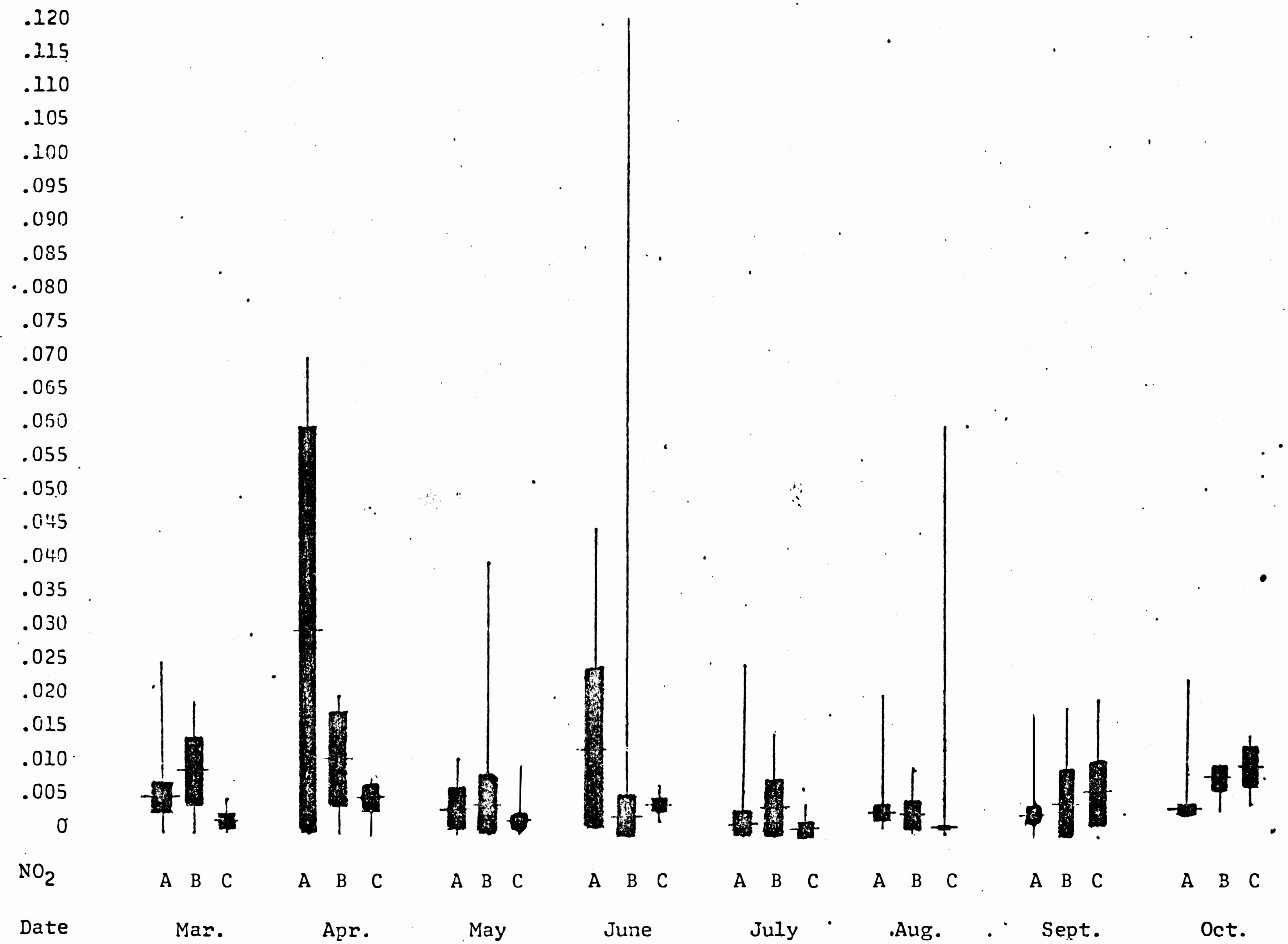

TABLE 4

THE PARTS PER MILLION (P.P.M.) OF SULFATES (SO_4)
IN THE STRIP-MINE PONDS OF AREAS A, B AND C FOR THE MONTHS OF MARCH THROUGH OCTOBER, 1972,
AT VERMILION COUNTY, ILLINOIS

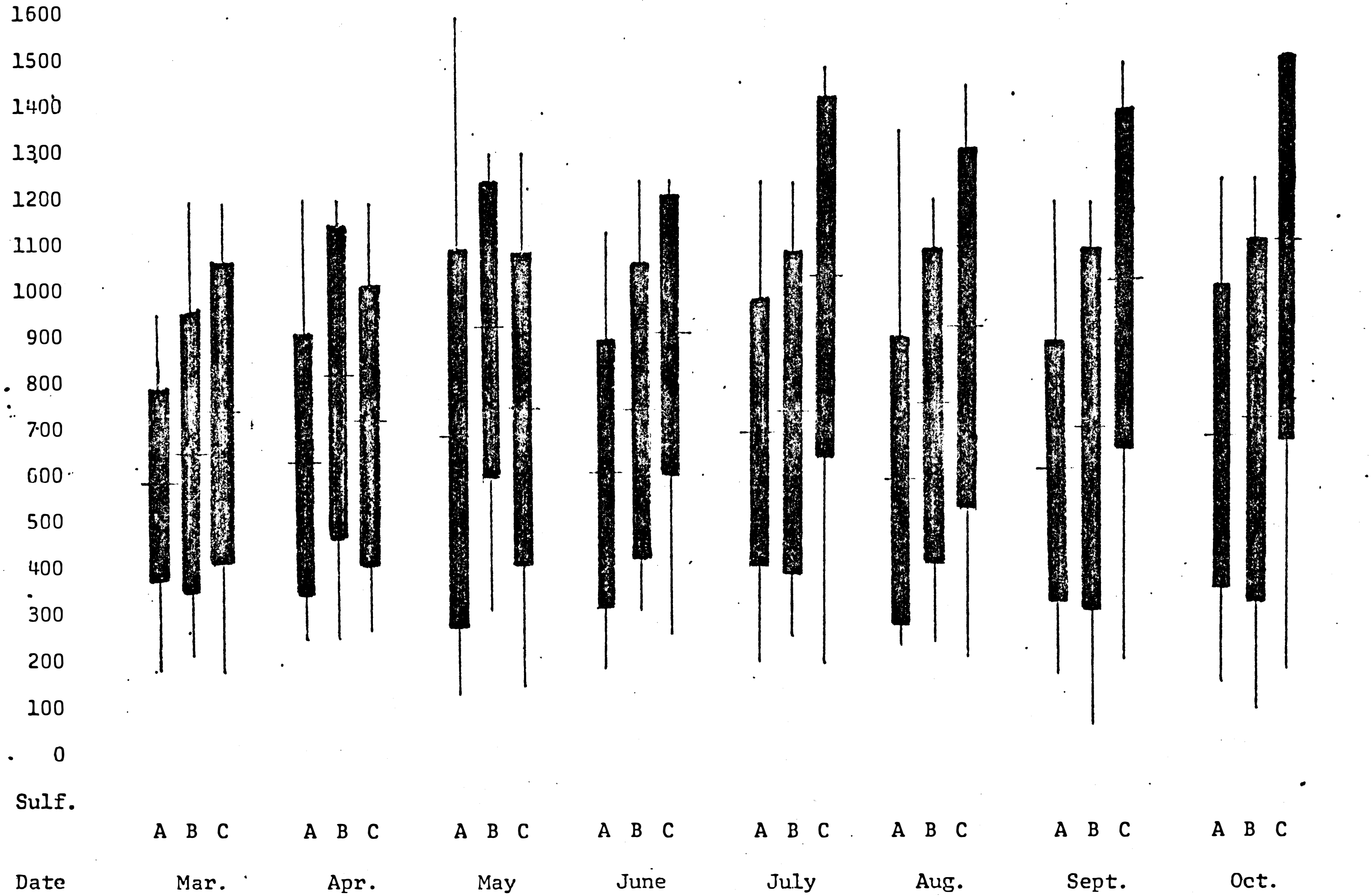

TABLE 5

THE PARTS PER MILLION (P.P.M.) OF PHOSPHATES (PO_4) IN THE STRIP-MINE PONDS OF AREAS A, B AND C FOR THE MONTHS OF MARCH THROUGH OCTOBER, 1972, AT VERMILION COUNTY, ILLINOIS

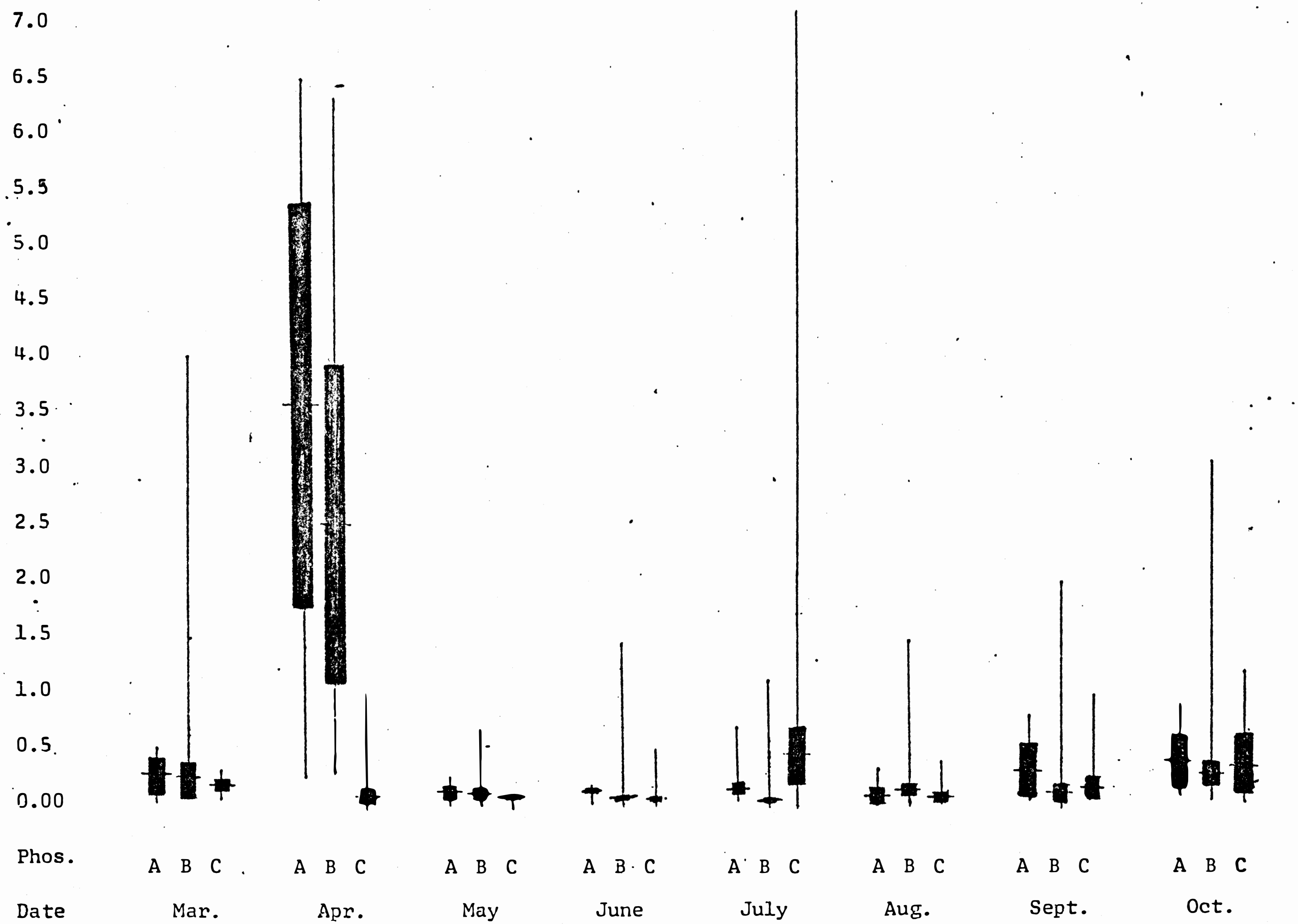

TABLE 6

THE PARTS PER MILLION (P.P.M.) OF IRON (Fe)
IN THE STRIP-MINE PONDS OF AREAS A, B AND C FOR THE MONTHS OF MARCH THROUGH OCTOBER, 1972,
AT VERMILION COUNTY, ILLINOIS

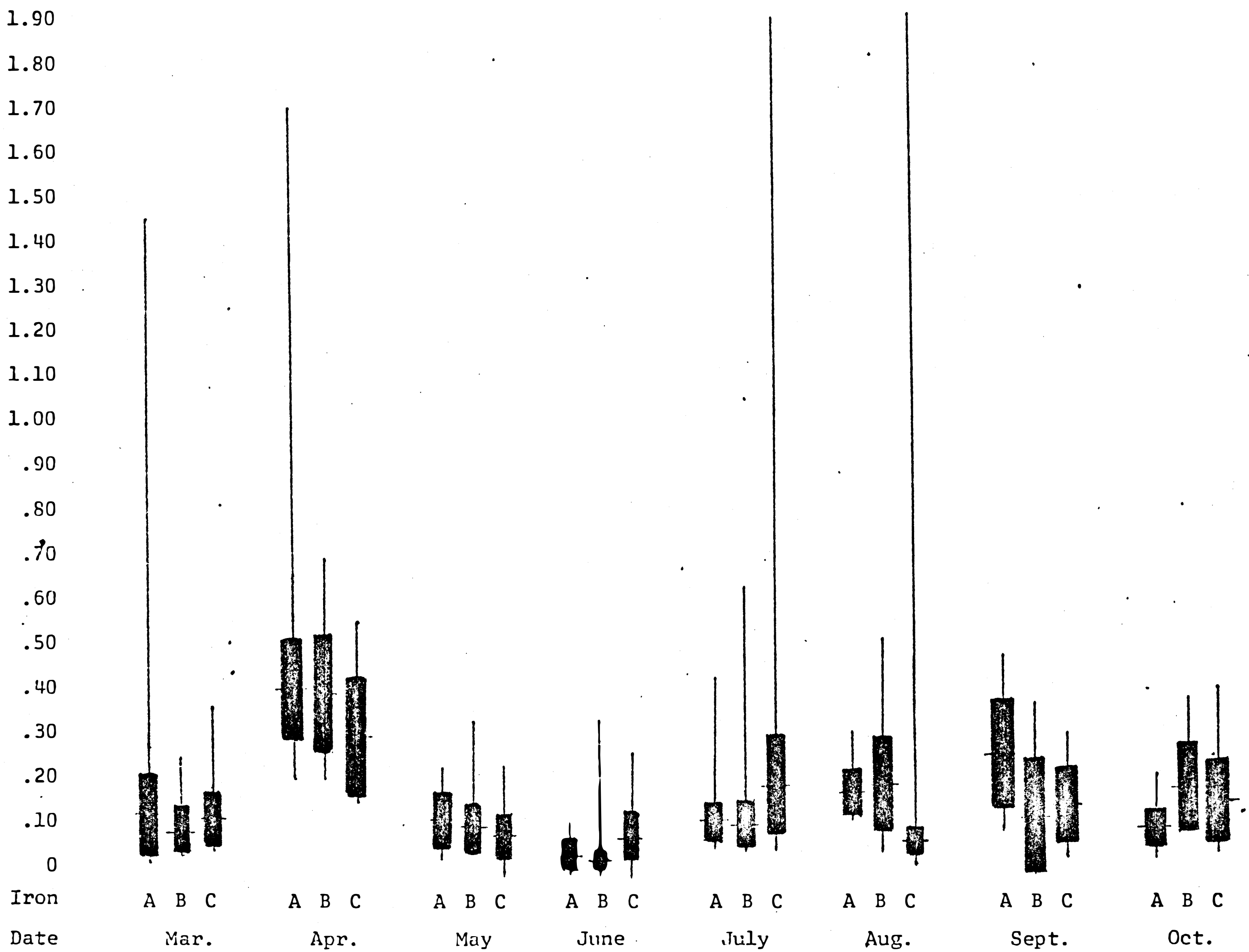

TABLE 7

THE SPECIFIC CONDUCTANCE (MICRO MHOS/CM)
FOR THE STRIP-MINE PONDS OF AREAS A, B AND C FOR THE MONTHS OF MARCH THROUGH OCTOBER, 1972,
AT VERMILION COUNTY, ILLINOIS

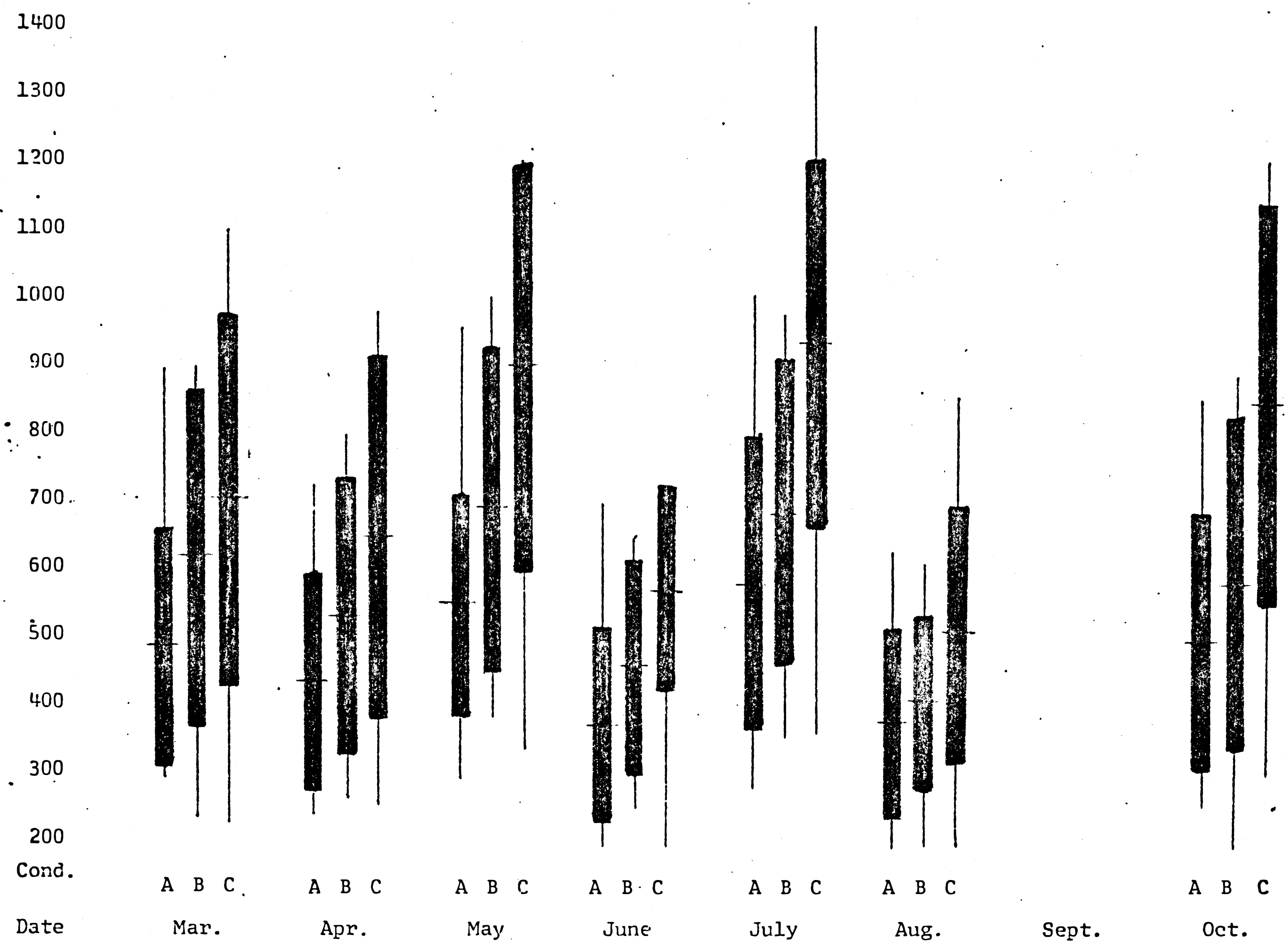

TABLE 8

THE JACKSON TURBIDITY UNITS (JTU) OF TURBIDITY
IN THE STRIP-MINE PONDS OF AREAS A, B AND C FOR THE MONTHS OF MARCH THROUGH OCTOBER, 1972,
AT VERMILION COUNTY, ILLINOIS

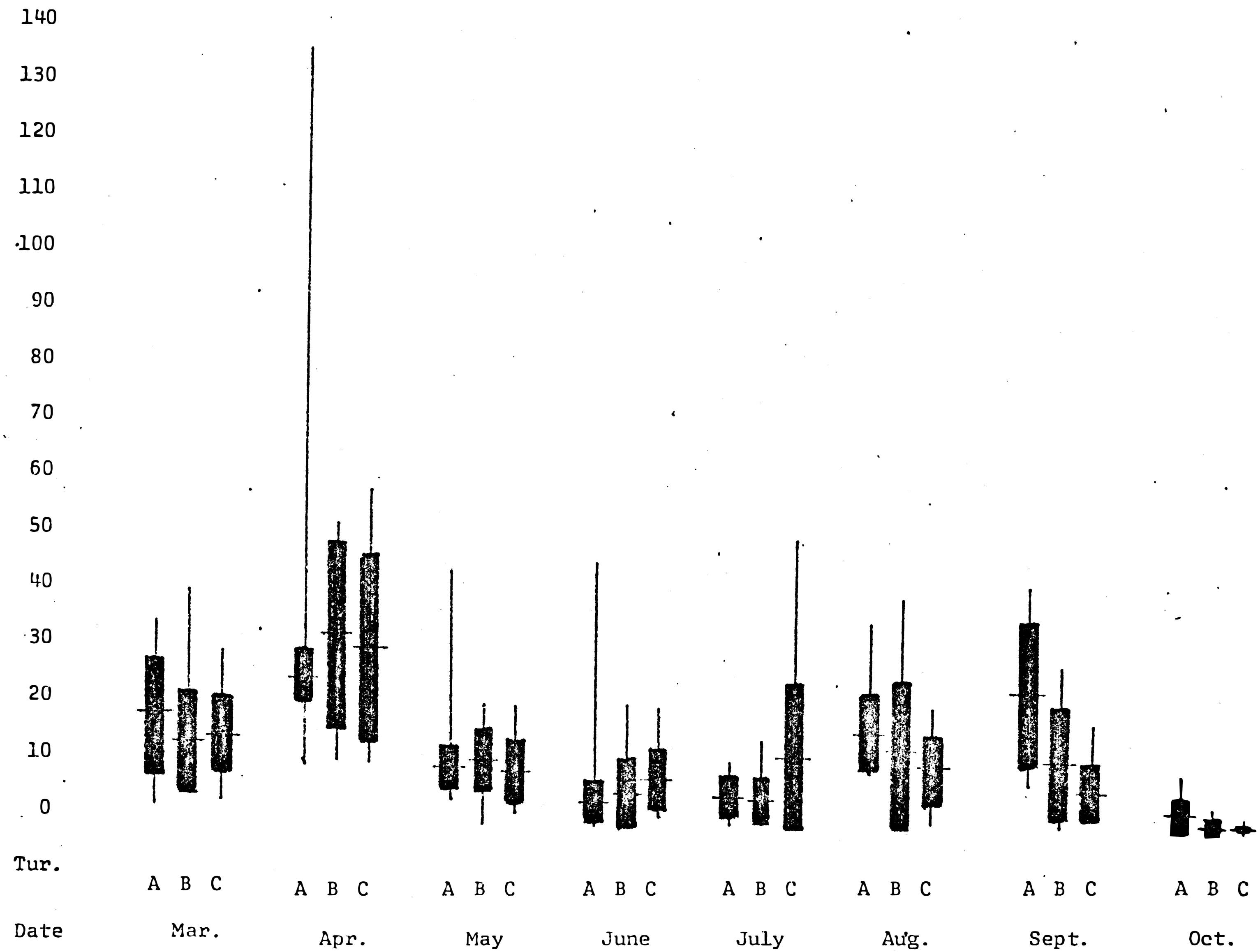

TABLE 9

THE PERCENTAGES OF SAND, SILT, AND CLAY FROM BOTTOM SOIL SAMPLES
OF THE STRIP-MINE POND OF AREAS A, B, AND C FOR THE MONTHS OF MARCH THROUGH OCTOBER, 1972,
AT VERMILION COUNTY, ILLINOIS

AREAS	1	2	3	4	5	6	7	8	9	10	Average
A	55	69	31	25	77	69	56	53	39	84	55.8
B	48	34	44	43	39	51	52	65	48		47.1
C	91	38	37	51	17	19	67	25	34	28	40.7
SAND											
A	38	28	53	58	19	21	31	32	46	9	33.5
B	35	48	42	46	41	29	34	29	35		37.7
C	9	53	53	34	58	62	26	55	54	47	45.1
SILT											
A	7	3	16	17	4	10	13	15	15	7	10.7
B	17	18	14	11	20	20	14	6	17		15.2
C	0	9	10	15	25	19	7	20	12	25	14.2
CLAY											

TABLE 10

PLANT DISTRIBUTION AND COMMUNITY RELATIONSHIP IN SELECTED STRIP-MINE PONDS OF VERMILION COUNTY, ILLINOIS

Area A

Plants	1	2	3	4	5	6	7	8	9	10
Chara. sp.	D	A	D	S	S	S				
Potamogenton foliosus	A			S	S				S	
P. americanus		A			S			D		
P. pusillus		A/S	A/S				S	A		
P. pectinatus										
P. crispus										
Elodea occidentalis										
Naias quadalupensis										
Naias flexilis										
Ludwigia palustris										
Veronica catenata										
Ceratophyllum demersum										
Zannichellia palustris										
Marsilea quadrifolia										
Myriophyllum heterophyllum										
Dianthera americanus										
Echinordorus rostratus										
Heteranthera dubia										

Area B

Plants	1	2	3	4	5	6	7	8	9
Chara. sp.			S		S	A			
Potamogenton foliosus	S	S	S	S				S	
P. americanus									
P. pusillus						A			
P. pectinatus						A			
P. crispus									
Elodea occidentalis									
Naias quadalupensis						D			
Naias flexilis									
Ludwigia palustris									
Veronica catenata									
Ceratophyllum demersum									
Zannichellia palustris									
Marsilea quadrifolia									
Myriophyllum heterophyllum									
Dianthera americanus									
Echinordorus rostratus									
Heteranthera dubia						A			

Area C

Plants	1	2	3	4	5	6	7a*	7b*	8	9	10
Chara. sp.	D	A	d	S	A	A	A	A	A	A	A
Potamogenton foliosus	A	A	d		d				A	A	A
P. americanus	A	D				A			A	A	A
P. pusillus											
P. pectinatus	A	A			A	A		d	A	A	A
P. crispus						A	A			A	A
Elodea occidentalis	d										
Naias quadalupensis											
Naias flexilis	A										
Ludwigia palustris			A		A				A		A
Veronica catenata			A								
Ceratophyllum demersum					d	d		A			A
Zannichellia palustris					A				A		A
Marsilea quadrifolia						d	d	d		A	
Myriophyllum heterophyllum						d	d		d	A	d
Dianthera americanus							d		d		d
Echinordorus rostratus										D	
Heteranthera dubia										A	A

A = associated S = scattered D = dominant d = co-dominant
(See Text For Explanation of These Classifications)

* Two different classifications in pond 7, these were a deep water association (7a) and a shallow water association (7b).

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