Figure 1. Longitudinal section of the canine of a bobcat collected in the spring. Best estimate of age is 5 years by the cementum annuli. Dentine shown at A and the dentino-cemental interface (B) is a very faint line. There are four annuli but the first annuli is not formed until the second winter of life.

AN INVENTORY AND STUDY OF BEAVER IMPOUNDED WATER IN MISSISSIPPI [1]

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The beaver (*Castor canadensis*) and its habitat have become extremely controversial in a number of southeastern states, specifically in Alabama, Georgia, and Mississippi. The low prices paid for beaver fur during the last decade, coupled with the increased prosperity of the area, have resulted in near abandonment of beaver trapping. This reduced harvesting of beaver, combined with the moving of nuisance beaver to other areas by the various state game agencies, has created ideal conditions for the beaver populations to expand rapidly.

Beaver activity, especially the beaver-constructed impoundments, resulted in an increasing volume of complaints by land owners. Game conservation agencies became alarmed at the volume of complaints, and in Alabama and Mississippi removed the beaver from the protected category and permitted year around, unlimited killing of these animals. On the credit side of the beaver ledger, it is common knowledge among many sportsmen that beaver ponds attract ducks and provide fishing superior to that found in small streams and creeks. Wildlife biologists recognize the value of beaver ponds for nesting and brooding sites for wood ducks (Beard, 1953) (Speake, 1955) and roosting and feeding areas for migratory waterfowl. Arner (1961) demonstrated that many

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beaver ponds could be managed to produce nearly a ton of duck millet (*Echinochloa crusgalli* var. *frumentacea*) per acre. A study in Missouri (Hanson and Campbell, 1963) revealed that plankton was in significantly greater abundance in beaver ponds than in the feeder streams.

In an effort to evaluate the effects of beaver activity in the state of Mississippi this study was undertaken. The study has two major aspects, the first was to derive an estimate of the number and acreage of beaver impoundments in Mississippi, the second was concerned with ecological effects that beaver impoundments have on the local environment and the fauna and flora of the area.

METHODS AND PROCEDURE

Determining Location and Size of Beaver Ponds

Cooperation with the U. S. Soil Conservation Service, Mississippi Cooperative Extension Service, Mississippi Game and Fish Commission, and the Mississippi Forestry Commission was sound and readily attained. The plan devised through cooperative planning with these agencies was to distribute a county road map with a scale of ½ inch to the mile to each Soil Conservation Service Work Unit within the state of Mississippi with instructions that the Work Unit Conservationist contact the local game warden and forester in the area and work up the following information: the location, age, and size of each beaver pond in the county (with a minimum size of 1 acre being stipulated), and the owner's name and address. Postal cards were printed asking for the same type of information as mentioned above. These cards and a road map were sent to all of the county agricultural agents. The county agents were requested to send the postal cards to 4-H club leaders and rural community leaders in their respective counties with the request that they fill in the requested information and return the postal cards to the agent who in turn utilized this information to locate the beaver ponds on a county road map. This map was returned to the project leader. The maps and data from both sources were then cross-checked, and one final map was made of each county showing the location of the beaver ponds. In a number of instances the County Agent and the Soil Conservationist got together and pooled their information and submitted one map.

In order to determine the accuracy of the acreage estimates submitted by the Soil Conservation Service and the County Agents, a random sampling of 10 percent of the beaver ponds reported in the Loess and Upper Coastal Plain areas was made. These two physiographic areas were selected since these areas contained the bulk of the beaver ponds within the state. The acreage of the ponds was checked through the use of aerial photographs and a dot grid overlay. If the beaver ponds did not show up on aerial photos, a ground measurement was made. A digital computer was used to analyze the data to determine if a statistically significant correlation existed between the acreage measured by the investigators. The formula used for Correlation Coefficient analysis in the Computer was:

$$r = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \cdot \Sigma y^2}}$$

Water Supply

Ten percent of the beaver ponds in two soil resource areas were randomly selected for investigation in the field to determine the percentage of beaver ponds which were established in intermittent streams or seepages and the percentage of beaver dams constructed in permanent streams with year around flow of water.

Water Depth and Plant Coverage

In the beaver ponds randomly selected for study, measurements of water depth were taken, along with field notes concerning plant coverage of the pond areas.

Field investigators walked around the periphery of the beaver impoundments recording species of plants present and estimating the percentage of the flooded area each plant community covered.

Water Table

A knowledge of local water table depths and extent is ecologically important, especially for silvicultural objectives. Two beaver ponds, 10 years or more in age, along with their feeder streams, were selected for water table determinations. One pond area was located on Collins silt loam in the Loess area and one in mixed alluvial soil in the Upper Coastal Plain area. An engineering level was used to establish a base line parallel to the stream bed. Sites for determination of the depth of the water table level were made at intervals along a line perpendicular to th stream bed (Figure 1). The first line of measurement was located on the edge of the stream bed; the second line was 25 feet from the stream bed; the third row was located 125 feet from the stream bed. In the Loess area it was possible to extend the line further than in the study area of the Upper Coastal Plain, and a fourth and fifth line were established at 100 feet increments. A hand auger was used to drill holes 3 inches in diameter to the water table. The holes were capped and measurements were made to determine the depth of the water table at 2-week intervals during the early spring and summer months.

Evaluation of Beaver Damage to Standing Timber

In order to develop an estimate of the damage that beaver were doing to standing timber, basal area determinations were made of dead trees found in 5 percent of the beaver ponds within the Upper Coastal and Loess soil areas of Mississippi. The ponds were randomly selected for study and encompassed a total of 238 acres. A point sampling method made with a wedge prism as described by Grosenbaugh (1952) was used to determine basal area.

The number of points required to sample each pond was derived by using the formula: $n = \frac{c^2}{e^2}$ where:

n = number of points to be taken
c = coefficient of variation
and e = specified limit of error

The coefficients of variations of 15 percent was used for timber stands of high uniformity and normal density. 30 percent for average conditions, and 60 percent for irregular stands with patchy distribution of timber. A standard error of 12 percent was used. For the majority of stands, a coefficient of variation of 30 percent was used. The total length of each tree was estimated by use of a Biltmore stick.

Water and Soil Chemistry

Chemical analyses of soil and water were made on five beaver ponds and their feeder streams. Seasonal change in water quality was determined by analyses made during late winter, spring and summer. During each of these periods temperature, dissolved oxygen content, pH, hardness, carbonate and bicarbonate alkalinities, carbon dioxide, nitrate, and ortho-phosphate were determined. In the late winter and late spring (1967) analyses, sulfates and total iron were measured.

Samples were taken in 300 ml BOD bottles from a depth of approximately 18 inches; samples were not taken at any other depth since no stratification was shown to exist in a previous study of these areas. All examinations of the water samples, with the exception of the nitrates, sulfates, and ortho-phosphates were kept in an ice slush enroute to the lab.

Hardness, carbonate and bicarbonate alkalinities, and carbon dioxide were measured with the Hach Fish and Stream Kit. This method did not produce detailed accuracy, but should have shown any important differences between the two types of study areas.

The temperature was determined by a Centigrade-Fahrenheit thermometer, and dissolved oxygen was determined by a variation of the Winkler method (1888), even though Itazawa (1957) states that the O_2 content of water with abundant phytoplankton is undervalued by the Winkler method due to absorption of the iodine by the plankton. For the purposes desired, the Winkler method was considered adequate. The pH was determined by use of the Sargent portable pH meter.

For the determination of sulfates, nitrates, orthophosphates, and total iron, the principles followed were basically outlined in Standard Methods for the *Examination of Water and Wastewater* (Farber, 1960). Readings were made on the Model B, Beckman Spectrophotometer. For sulfate determination, the turbidimetric method was employed since it was fast and accurate to a minimum of 1mg/1. The spectrophotometer was set for use at 420 mu, with a blue light, with sensitivity placed at 3, and with a filter. Nitrates were determined by employing the phenoldisulfonic acid method. Billy Patterson of the Mississippi State Chemistry Laboratory modified this procedure by deleting the removal of some significant sources of interference. Readings were taken by the spectrophotometer, which was set for use at 410mu, with a blue light with a filter, and the sensitivity designated at 2. Ortho-phosphate determination was completed by following the amino naphthol sulfonic acid procedure, also shortened by Billy Patterson. The spectrophotometer, for this reading, was set at 690 mu, red light with no filter, and sensitivity at 1 (Taylor, 1964). The total iron content of the samples was measured by the phenanthroline method with the spectrophotometer set at 510 mu, sensitivity at 3, and blue light without filter.

Topsoil and subsoil samples were taken from two localities in each study area by pushing a 1½-inch diameter plastic tube into the pond bottom. The Soil Testing Department in the Extension Service of Mississippi State University analyzed the samples for pH, available phosphate, available potash, and percent organic matter.

Invertebrate Collection

Three methods were used in collecting aquatic insects. Traps were constructed as designated by Judd (1957). These traps were 24" x 24" which provided a sampling area of 4 square feet. One-inch by six-inch pine lumber was used for constructing a square frame; the frame was covered with a canopy of aluminum screen with 1" x 16" mesh. Styrefoam strips measuring 2" x 2" x 12" were attached to the frame of the trap which enabled the trap to float approximately 4 inches above the surface of the water.

Two old beaver ponds (8 years old or over), one medium-aged beaver pond (4-7 years), and two young beaver ponds (0-3 years) were selected in the Upper Coastal Plain soil area and in the Loess soil area giving a total of 10 beaver ponds for both areas. At each site two traps were placed in the shallow water of the beaver pond and two traps were placed in the shallow water of the stream entering the beaver pond. These traps were visited at intervals of approximately two weeks. The insects were collected from the traps by use of an aspirator.

After removal from the trap, the insects were stored in 70 percent alcohol until time of weighing. The insects were then air-dried for 24 hours and weighed on a Sartorius single pan balance scale, to the nearest 1/10,000 of a gram.

The second method used involved the use of a multiple plate sampling device as used by Hester and Dendy (1962). This device was constructed by bolting 8 plates of 3" x 3" squares of ⅛" thick masonite. These plates were separated from each other by placing a 1" x 1" x ⅛" piece of masonite between plates. This device exposed slightly more than 1 square foot of surface. Two assembled samplers were submerged in the shallows of the beaver pond, and two were submerged in the shallows of the upstream portion. These samplers were suspended so that the lower plate was about ½″ above the bottom of the pond. Approximately every two weeks the investigators visited the sampling sites and lifted the sampler to the surface of the water (but did not remove the sampler from the water) and placed a plastic bag beneath the sampler. The sampler was enclosed in the plastic bag for transportation to the laboratory. Upon being returned to the laboratory, the samplers were removed from the bags and held directly over a 5-inch diameter sieve with no. 40 mesh screen. A hose was used to wash the organisms from the plates into the screen. The organisms were removed from the sieve with tweezers and placed in vials of 70 percent alcohol.

The third collecting method consisted of making 5 random 180 degree sweeps moving from shallow water toward deeper water in the beaver ponds and 5 additional sweeps on the upstream portion. A Turtox collecting net which was 10 inches in diameter and 11.5 inches deep was used. The aquatic organisms were removed from the net in the pond and placed in vials containing 70 percent alcohol.

Judd Traps were distributed in the Upper Coastal Plain area on March 7, 1966, and the Loess area on March 18. The multiple plate samplers were distributed in the Upper Coastal Plain area on April 25, 1966, and in the Loess area on May 5, 1966. Sweeping with nets was started on May 30, 1966, in the Upper Coastal Plain and in the Loess area on June 2, 1966.

All invertebrate collections on the Loess area were terminated on June 28, 1966, and on the Upper Coastal Plain on September 8, 1966.

In all of the three procedures mentioned, the aquatic organisms were classified to order or family, and the air-dry weight as well as the total number was recorded for each pond. Statistical analysis was made by randomized complete block design.

Fish Population Study

Fish were collected from ten randomly selected beaver ponds and their feeder streams. Rotenone was applied with a back pump and the fish were collected with seines and hand nets. Identification to species was made and the harvestable sized game fish were measured and weighed and then relative plumpness was determined by the technique described by Thompson and Bennett (1939).

RESULTS AND DISCUSSION

Number, Location, and Size of Beaver Ponds

Cooperating agencies reported a total of 956 beaver ponds with a total acreage of 23,673 acres (Table 1). There were 4 counties which reported a total of 12,179 acres which is over half of the total reported for the entire state of Mississippi. Three of these counties are adjoining and are located in the northeastern corner of the state bordering Alabama. Ten other counties recorded a total of 5,264 acres; the bulk of the beaver ponds reported were found in the northern, central, and east central ¾ portion of the state (Figure 2). The Upper Coastal Plain Soil area contained the largest number of beaver ponds with a total of 364 ponds reported totaling 16,299 acres. Eleven counties reported no beaver ponds of the 1 acre category.

A random sampling of 32 beaver ponds in the Upper Coastal Plain area reported by the cooperating agencies was checked to determine accuracy of the acreage estimates made by the cooperators. Statistical analyses showed there was a significant correlation ($r = .41$) between the acreage estimated by the cooperating agencies and that measured by the investigators using aerial photos and a dot grid overlay or measurements made on the ground. Twenty-four ponds were measured in the Loess soil area and a highly significant correlation was determined for this area ($r = .77$). The total acreage estimated by foresters for all of the National Forest area in Mississippi was only 206 acres. In most of these forest areas beaver dams are continually sought out and drained, and veaver are constantly trapped.

Water Supply

The water supply of 56 randomly selected beaver pond areas was checked in the field. It was found that 71 percent of the ponds were located on intermittent streams or on seepage areas. Only 29 percent of the ponds were constructed on streams with year around flow of water. It was very evident that without beaver activity there would be considerably less acreage available for fish or wood duck production in Mississippi.

Water Depth and Plant Coverage

From the ponds sampled, it was estimated that 56.5 percent of the total acreage of water impounded in beaver ponds in Mississippi was 2.5 feet or less in depth.

Buttonbush (*Cephalanthus occidentalis*) and alder (*Alnus rugosa*) were the shrubby type woody plants most frequently encountered in the older beaver pond areas. These plants were major plant components only in the those ponds over 7 years old. The most frequently encountered herbaceous plant species in the older ponds were rice cut grass (*Leersia oryzoides*) and pond weed (*Potamogeton* spp.)

In the ponds 3 to 6 years old, soft rush (*Juncus effusus*) and swamp smartweed (*Polygonum hydropiperoides*) were most frequently noted; cabomba (*Cabomba caroliniana*) and watershield (*Brasenia schreberi*) weed common aquatic plants in many ponds 4 years old or older. Ponds under 3 years had very few emergents or aquatic plants.

Results of Water Table Studies

Two ponds were used in the study concerning the influence exerted by beaver ponds on the local water table. In one pond located on Collins silt loam in the Loess area a discernible rise in the water table level was found at a distance of 325 feet beyond the peripheral influence of the feeder stream (Figures 3 and 4). In another pond located on an alluvial mixed soil in the Upper Coastal Plain a discernible rise in water level was found at a distance of 125 feet beyond the peripheral influence of the feeder stream. The beaver pond might well have had an effect beyond the levels measured, but the drilling equipment used was not suitable for drilling beyond a depth of 12 feet.

Beaver Damage to Standing Timber

The nuisance factor of beaver activity encompasses a wide variety of aspects including flooding roads, farmland, and forest land as well as girdling trees. From this study it was apparent that the greatest amount of damage centered around their flooding forest areas. Approximately 5 percent (27) of the beaver ponds found in the Upper Coastal Plain and Loess Soil areas of Mississippi were surveyed for timber damage by beaver activity. The ponds surveyed were randomly selected.

The estimated damage included only those trees which were killed or were believed dying. Tupelo gum (*Nyssa aquatica*) and cypress (*Taxodium distichum*) which were living and appeared healthy were not included in the damage estimates, since these species are known to live and thrive naturally in similar wetland conditions and suffer very little from beaver feeding activities.

Of the 27 ponds inventoried, 11 contained living and healthy appearing cypress. In 9 of these ponds (33 percent) either tupelo gum or cypress were the primary tree species. Of the 90 acres of flooded land found in the 9 ponds there was an estimated range of 7.2 to 20.9 cords of cypress and tupelo gum with a mean of 10.72 cords per acre.

Based on this information, it appears evident that beaver, tupelo gum, and cypress can apparently exist together. Both of those tree species are valuable timber species and further silviculture research in this area should be undertaken to determine if timber management in beaver-infested are as should be directed toward those tree species rather than those species more attractive to beaver.

In the other 18 (148 acres) beaver ponds surveyed, the major forest type was that of oak (*Quercus* spp.), sweetgum (*Liquidambar styraciflua*). Timber killed by beaver ranged from 30.5 to 0 cords per acre. The mean number of cords per acre was 9.5 (Table 2). The total number of cords estimated to have been destroyed by beaver activity on 148 acres of water was 1,106 cords. The timber loss was estimated in cords rather than in board feet since the majority of the trees in the beaver impounded areas surveyed were in the pole wood stage, and the emphasis in Mississippi on forest management now is on pulpwood production.

Soil and Water Chemistry

An analysis of soil samples from 5 beaver ponds in the Upper Coastal Plain and from 5 ponds in the Loess soil area showed a greater build-up of available phosphate than found in the feeder streams (Tables 3 and 4). In 8 out of 10 of the above-mentioned ponds, exchangeable potassium showed a build-up greater than in the feeder streams. Organic matter without exception was found in considerably greater amounts in the beaver ponds than in the feeder streams. There appears to be some correlation between build-up of organic matter and increase of aquatic invertebrates (Figure 5). In the water chemistry studies, there was no apparent differences between beaver ponds and the feeder streams (Figure 6). Phosphates were less than 0.10 ppm from all 3 samples taken during winter, spring, and summer. Nitrates were less than 0.10 ppm, with the exception of the winter sample when they were less than .20 ppm. Low oxygen was common in beaver ponds during the August analysis due very probably to increased organic decay during this period. Total iron was relatively low and oxygen concentration was never low enough to create the conditions necessary for build-up of soluble iron to a point which might inhibit aquatic plant growth (Figure 6).

Quantitative Measurements of Aquatic Invertebrates

In the Loess Soil area there were significant increases in weight of invertebrates collected in beaver ponds over those collected in the upstream area by all three collecting devices. In the Upper Coastal Plain soil area the Judd traps and the sweeping technique showed significant increases in weight of invertebrates in the beaver ponds over the feeder streams, while the multiple plate sampler did not show any significant increase of invertebrates in the beaver ponds over those in the feeder strams.

After reviewing the results of the multiple plate collections, it became evident that the plates were providing habitat for a number of different aquatic organisms. Needham (1938) reports the use of floating boards in English trout streams as an aid in increasing mayflies. It should be noted (Tables 5 and 6) that mayflies (*Ephemeroptera*), Gastropods, Isopods, and Oligochaetes were found in significantly greater number in the multiple plate sampling than in the other two methods. Wesley (1967), working with the same 3 collecting techniques while sampling invertebrates in beaver ponds and farm ponds, found similar inconsistencies in sampling results with the multiple plate sampler. For these reasons, we have based our final comparative evaluations of invertebrates on the data obtained from the Judd traps and the sweeping technique (Figures 7 and 8).

No significant difference in quantity of aquatic invertebrates could be determined on the basis of age of the beaver ponds.

The order Diptera had the largest number of organisms captured (Tables 5 and 6). In Judd traps and in the multiple plate samplers, the family Tendipedidae made up the largest number of organisms in this order. Isopods and the larval Tendipeds made up the greatest number of the organisms found in the multiple samplers, and the adult Tendipeds made up the largest number of organisms captured in the Judd traps in both soil areas.

In all three sampling techniques used, Odonota nymphs and adults proved to be considerably more abundant in the beaver ponds than in the upstream sites.

Fish Population Study

Seventeen species of fish were collected from the beaver pond areas and 10 species were collected from the feeder streams; more species of game fish were found in the beaver ponds than in the feeder streams (Table 7). Random samples of game fish collected from both the feeder streams and beaver ponds were measured and weighed to determine their degree of plumpness as described by Thompson and Bennett (1939). The game fish collected from the beaver ponds were generally fatter fish than those collected from the feeder streams.

CONCLUSION

A state-wide inventory of beaver ponds in Mississippi revealed a total of 956 beaver impoundments (one acre in size or larger) with a total acreage of 23,673 acres. Seventy-one percent of the beaver ponds were located on intermittent streams. Over one-half of the total acreage of water impounded by the beaver contained shallows of 2.5 feet or less in depth.

The beaver impoundments raised the local water table levels and very probably improved site conditions for cypress and tupelo gum. Timber destroyed by beaver was largely limited to sweet gum and oak. Cypress and tupelo gum were not killed by the shallow flooding found in most beaver impoundments and suffered very little from beaver feeding activities.

The majority of the beaver impoundments had a greater build-up of phosphate, potash, and organic matter in the bottom soil of the beaver ponds than in the soil of the feeder stream bottoms.

By and large, the beaver ponds sampled produced a greater weight of invertebrates than their feeder streams. More species of fish were collected from beaver ponds than from their feeder streams. The game fish species collected from beaver ponds were generally fatter than the same species collected from their feeder streams.

It appears from these studies that the beaver ponds in Mississippi provide excellent habitat for certain species of fish and waterfowl, and thus have a high recreational potential. Beaver activity has resulted in some economic loss to forestry, but silvicultural practices might very well be modified so that beaver damage could be significantly reduced, and the beaver ponds maintained for the benefit of wildlife.

LITERATURE CITED

Arner, D. H. 1963. Production of duck food in beaver ponds. *J. Wildl. Mgmt.* 27:78-81.

Beard, Elizabeth B. 1953. The importance of beaver in waterfowl management at the Seney National Wildlife Refuge. *J. Wildl. Mgmt.* 17:398-436.

Farber, L. (ed.) 1960. Standard methods for the examination of water and wastewater. American Public Health Association, Inc., New York 19, New York. 626 pp.

Grosenbaugh, L. R. 1952. Plotless Timber Estimates—New, Fast, Easy. *J. For.* 50:32-37.

Hanson, W. D. and R. S. Campbell. 1963. The effects of pool size and beaver activity on distribution and abundance of warm-water fishes in a North Missouri stream. *American Midland Naturalist.* 69:136-149.

Hester, E. F. and J. S. Dendy. 1962. A multiple plate sampler for aquatic macroinvertebrates. *Trans. American Fisheries Soc.* 19:420-421.

Judd, W. W. 1957. A study of the population of emerging and littoral insects trapped as adults from tributary water of the Thames River at London, Ontario. *Amer. Midl. Nat.* 58:394-412.

Needham, Paul R. 1938. Trout streams, conditions that determine their productivity and suggestions for stream and lake management. Comstock Publishing Co., Inc., Ithaca, N. Y. 233 pp.

Speake, D. W. 1955. Waterfowl use of creeks, beaver swamps, and small impoundments in Lee County, Alabama. *Proc. Southeastern Assoc. Game and Fish Commissioners Meeting.* 9:178-185.

Taylor, M. P. 1964. A survey of certain physical, chemical, and biological characteristics of the Tombigbee River. M.S. Thesis, Mississippi State Univ. 55pp.

Thompson, D. H., and Bennett, G. W. 1939. Ill. Nat. Hist. Surv. Biol. Notes. 11:1-24.

Wesley, David E. 1967. An ecological comparison of beaver ponds and Farm Ponds with emphasis on productivity of inverterbrates and fish. M.S. Thesis, Mississippi State Univ. Library, State College. 49 pp. (Unpubl.)

TABLE 1. Number and Acreage of Ponds Reported by Cooperating Agencies for Each Land Resource Area of Mississippi

Land Resource Areas	Number of Ponds Reported	Total Estimated Acreage	Average Acreage Per Pond
Delta	62	2,425	39.11
Loess	239	2,282	9.55
Upper Coastal Plain*	364	16,299	44.70
Lower Coastal Plain	235	1,971	8.39
Blacklands	38	404	10.63
Interior Flatwoods	18	292	16.22
Totals	956	23,673	24.76

TABLE 2. Timber Damage Caused by Beaver Activity

Acres Per Pond	Number Cords Per Acre	Total No. Cords
10	10.3	103.0
3	11.9	35.7
60	7.0	420.0
2	3.8	7.6
10	30.5	305.0
2	21.8	43.6
3	12.9	38.7
4	11.7	46.8
1	0.0	0.0
10	0.0	0.0
1	0.0	0.0
1	0.0	0.0
1	0.0	0.0
2	17.1	34.2
3	11.0	33.0
2	19.2	38.4
8	0.0	0.0
25	0.0	0.0

* Only 320 of these ponds could be definitely ascertained as being in the Upper Coastal Plain. The other 44 ponds placed in this soil area were in an edaphic transitional zone.

TABLE 3. A Comparison of Soil Analyses of Beaver Ponds and Upstream Sites in the Upper Coastal Plain Soil Area

Study Area	pH Pond	pH Upstream	lbs. P_2O_5 per acre Pond	lbs. P_2O_5 per acre Upstream	lbs. exchangeable potash Pond	lbs. exchangeable potash Upstream	percent organic matter Pond	percent organic matter Upstream
1	5.1	5.0	157(M+)	67-102(L+)	240(M—)	6-96(L—)	4.90	1.15
2	5.4	5.2	77(L+)	35- 63(L)	108(L)	6-96(L—)	2.08	0.55
3	5.1	5.1	84(L+)	0- 31(L—)	230(L+)	6-96(L—)	2.15	0.18
4	5.2	5.1	35- 63(L)	0- 31(L—)	6- 96(L—)	6-96(L—)	1.77	0.25
5	5.5	5.2	39(L)	0- 31(L—)	180(L+)	6-96(L—)	1.77	0.18

TABLE 4. A Comparison of Soil Analyses of Beaver Ponds and Upstream Sites in the Loess Soil Area

Study Area	pH Pond	pH Upstream	lbs. P_2O_5 per acre Pond	lbs. P_2O_5 per acre Upstream	lbs. exchangeable potash Pond	lbs. exchangeable potash Upstream	percent organic matter Pond	percent organic matter Upstream
1	5.6	5.3	35- 63(L)	0-31(L—)	100-154(L—)	6-96(L—)	.95	0.12
2	5.1	5.3	165-251(H)	0-31(—)	160-234(L—)	6-96(L—)	1.33	0.12
3	5.1	5.3	67-102(L+)	0-31(L—)	160-234(L+)	6-96(L—)	1.33	0.12
4	5.0	5.0	67-102(L+)	0-31(L—)	6- 96(L—)	6-96(L—)	2.87	0.55
5	5.2	5.5	67-102(L+)	0-31(L—)	160-234(L+)	6-96(L—)	1.15	0.07

TABLE 5. A Comparison of the Number and Kinds of Invertebrates Collected from Judd Traps, Multiple Plate Samplers, and Random Sweeps in the Upper Coastal Plain Soil Area

Classification	Judd Beaver Pond	Judd Upstream	Multiple Plate Sampler Beaver Pond	Multiple Plate Sampler Upstream	Sweeps Beaver Pond	Sweeps Upstream	Totals
Diptera (Tendipedidae, Tipulidae, etc.)	1,243	1,709	135	141	17	0	3,245
Odonata (Zygoptera, Anisoptera, etc.)	82	17	61	29	301	0	490
Hemiptera (Belostomidae, Corixidae, etc.)	7	2	2	0	462	3	474
Ephemeroptera (Baetidae, Heptageniidae, etc.)	3	10	35	84	37	0	169
Trichoptera	10	12	..	14	1	..	37
Araneida	171	147	..	..	6	..	324
Hymenoptera	3	4	..	..	..	..	7
Plecoptera	....	5	..	..	..	..	5
Coleoptera (Dytiscidae, Hydrophilidae, etc.)	....	6	12	17	35	0	70
Amphipoda (Gammaridae, etc.)	....	..	52	12	131	0	195
Isopoda	....	..	153	19	4	..	176
Megaloptera (Sialidae, etc.)	....	..	..	4	..	..	4
Hirudinea	....	..	15	2	3	..	20
Decapoda (Palaemonidae, etc.)	....	..	..	..	24	..	24
Gastropoda (Physa, etc.)	....	..	18	113	258	5	394
Pelecypoda (Sphaeriidae, etc.)	....	..	15	6	26	1	48
Oligochaeta	....	..	33	..	..	..	33
Totals	1,519	1,912	531	441	1,305	9	5,715

TABLE 6. A Comparison of the Number and Kinds of Invertebrates Collected from Judd Traps, Multiple Plate Samplers, and Random Sweeps in the Loess Soil Area

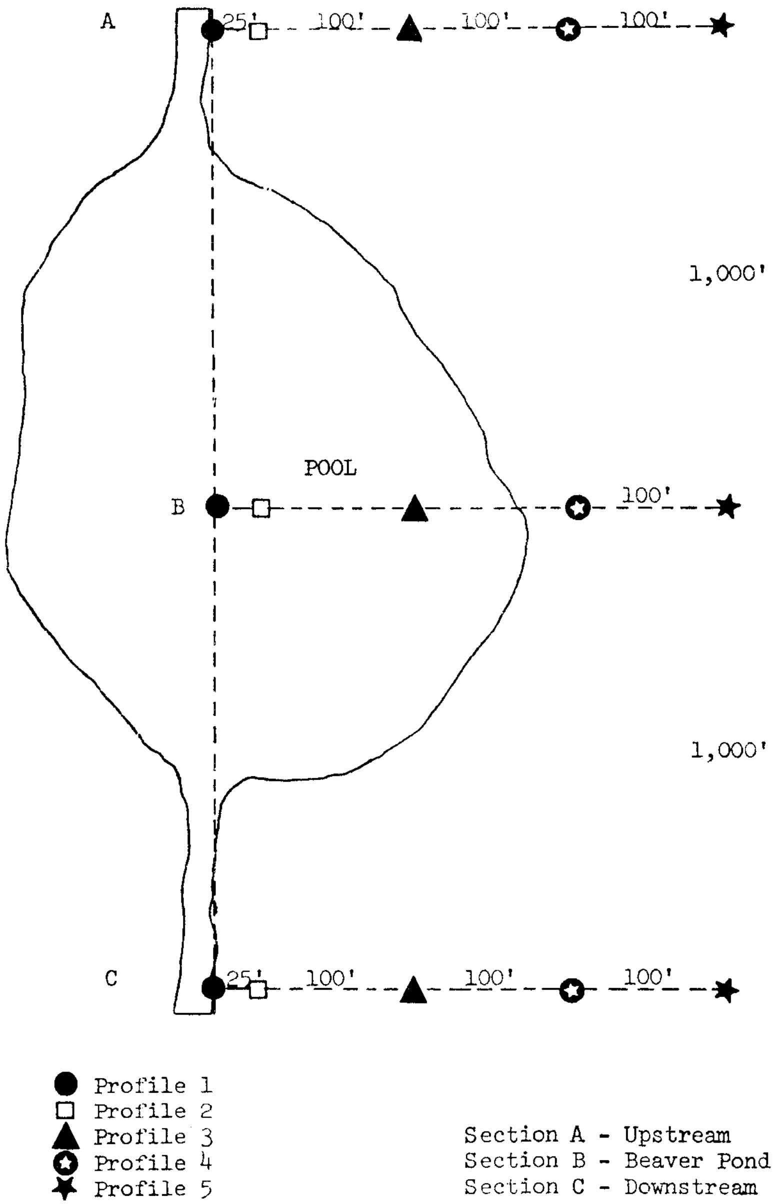
Classification	Judd Beaver Pond	Judd Upstream	Multiple Plate Sampler Beaver Pond	Multiple Plate Sampler Upstream	Sweeps Beaver Pond	Sweeps Upstream	Totals
Arachnida	75	45	..	..	..	..	120
Coleoptera (Dytiscidae, Psephenidae, Hydrophilidae, etc.)	1	0	..	..	5	0	6
Diptera (Tendipedidae, Tipulidae, etc.)	1,634	570	357	186	36	4	2,787

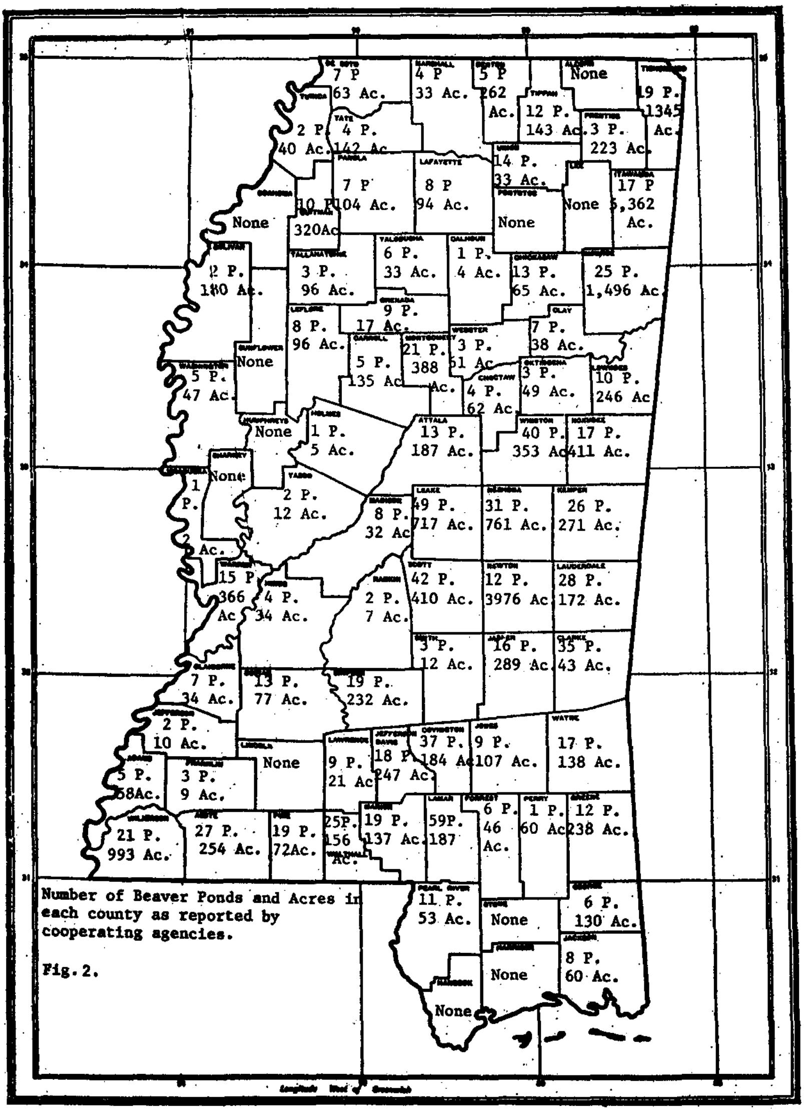
Classification	Judd Beaver Pond	Judd Upstream	Multiple Plate Sampler Beaver Pond	Multiple Plate Sampler Upstream	Sweeps Beaver Pond	Sweeps Upstream	Totals
Hemiptera (Belostomidae, Nepidae, Notonectidae, Corixidae, etc.)	1	0	..	..	20	23	44
Odonata (Zygoptera, Anisoptera, etc.)	46	2	36	2	53	0	139
Orthoptera	1	0	..	..	..	..	1
Trichoptera	3	0	..	..	..	..	4
Amphipoda (Gammaridae, etc.)	....	..	11	0	32	0	43
Ephemeroptera (Baetidae, Heptageniidae, etc.)	....	..	11	8	7	0	26
Gastropoda (Physa, etc.)	....	..	29	2	35	0	66
Hirudinea	....	..	19	0	1	0	20
Isopoda	....	..	7	0	1	0	8
Oligochaeta	....	..	25	0	..	..	25
Pelecypoda	....	..	1	0	..	..	1
Totals	1,761	647	496	198	190	27	3,319

TABLE 7. Fish Species Found in Sampling Beaver Ponds and Feeder Streams

Fish	Beaver Pond	Feeder Stream
Amiidae		
Amia calva (Bowfin)	X	
Aphredoderidae		
Aphredoderus sayanus (Pirate perch)	X	X
Catostomidae		
Catostomus commersoni (White sucker)	X	
Centrarchidae		
Centrarchus macropterus (Flier)		X
Chaenobryttus gulosus (Warmouth)	X	X
Elassoma zonatum (Banded pygmy sunfish)	X	
Lempomos cyanellus (Green sunfish)	X	
Lepomis macrochirus (Bluegill)	X	X
Lepomis microlophus (Redear sunfish)	X	
Lepomis punctatus miniatus (Western spotted sunfish)		X
Micropterus salmoides (Largemouth bass)	X	X
Pomoxis annularis (White crappie)	X	
Pomoxis nigromaculatus (Black crappie)	X	
Clupeidae		
Dorosoma cepedianum (Gizzard shad)	X	
Cyprinidae		
Cyprinus carpio (Carp)	X	
Hybopsis sp. (Chub)		X
Notemigonus crysoleucas (Golden shiner)	X	X
Cyprinodontidae		
Fundulus sp. (Topminnow)		X
Esocidae		
Esox niger (Eastern chain pickerel)	X	X
Ictaluridae		
Ictalurus melas (Black bullhead)	X	
Poeciliidae		
Gambusia affinis affinis (Gambusia)	X	X

FIGURE 1. PLAN OF SITES FOR LOCATION OF WATER TABLE





Number of Beaver Ponds and Acres in each county as reported by cooperating agencies.

Fig. 2.

FIGURE 3. SECTIONS SHOWING LOCATION OF WATER TABLE FOR A BEAVER POND AND ITS FEEDER STREAM IN THE LOESS SOIL AREA.

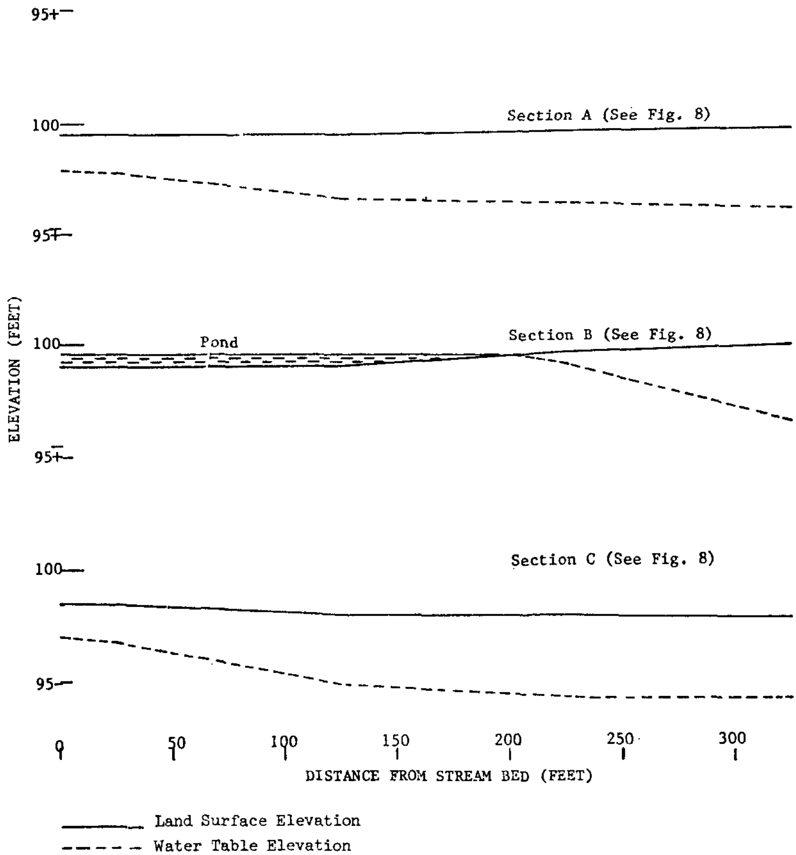
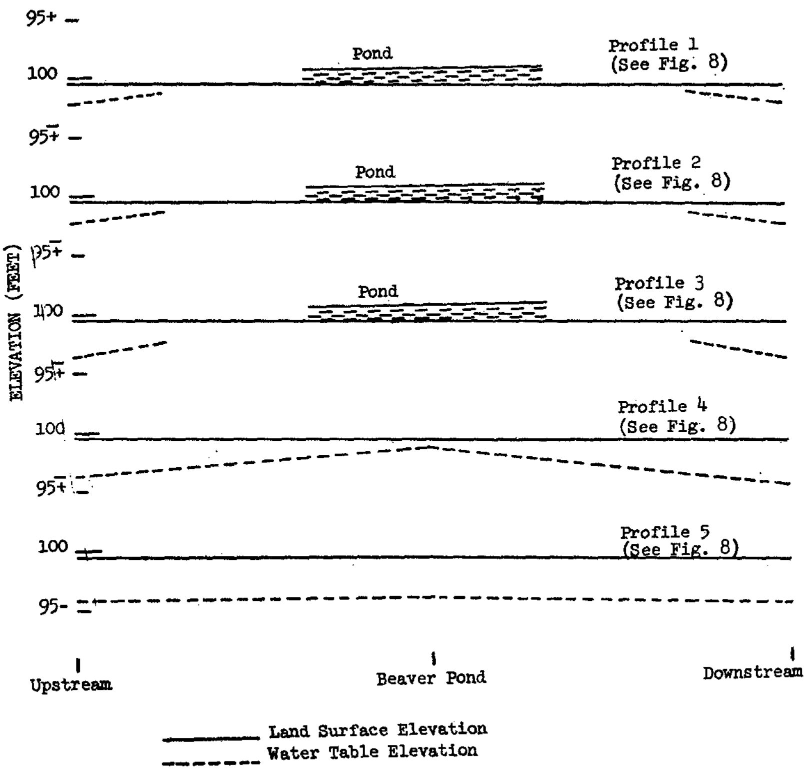


FIGURE 4. PROFILE OF WATER TABLE FOR A BEAVER POND AND ITS FEEDER STREAM IN THE LOESS SOIL AREA.



DRY WEIGHTS OF INVERTEBRATES COLLECTED FROM BEAVER PONDS AND FEEDER STREAMS IN THE UPPER COASTAL PLAIN AND THE LOESS SOIL AREAS OF MISSISSIPPI.

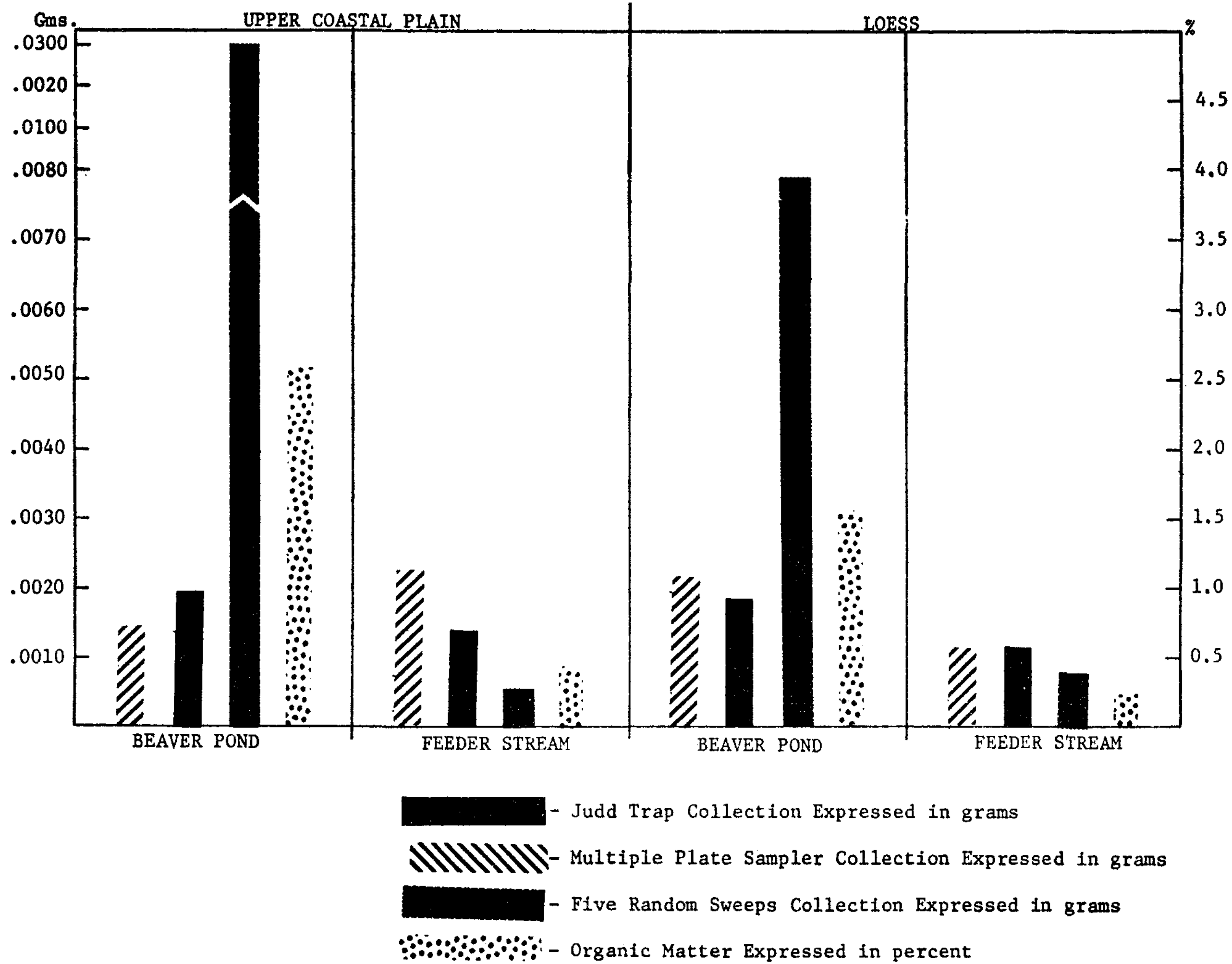


FIGURE 6 . A COMPARISON OF WATER QUALITY OF BEAVER PONDS SAMPLED IN LATE SPRING, LATE SUMMER, AND LATE WINTER.

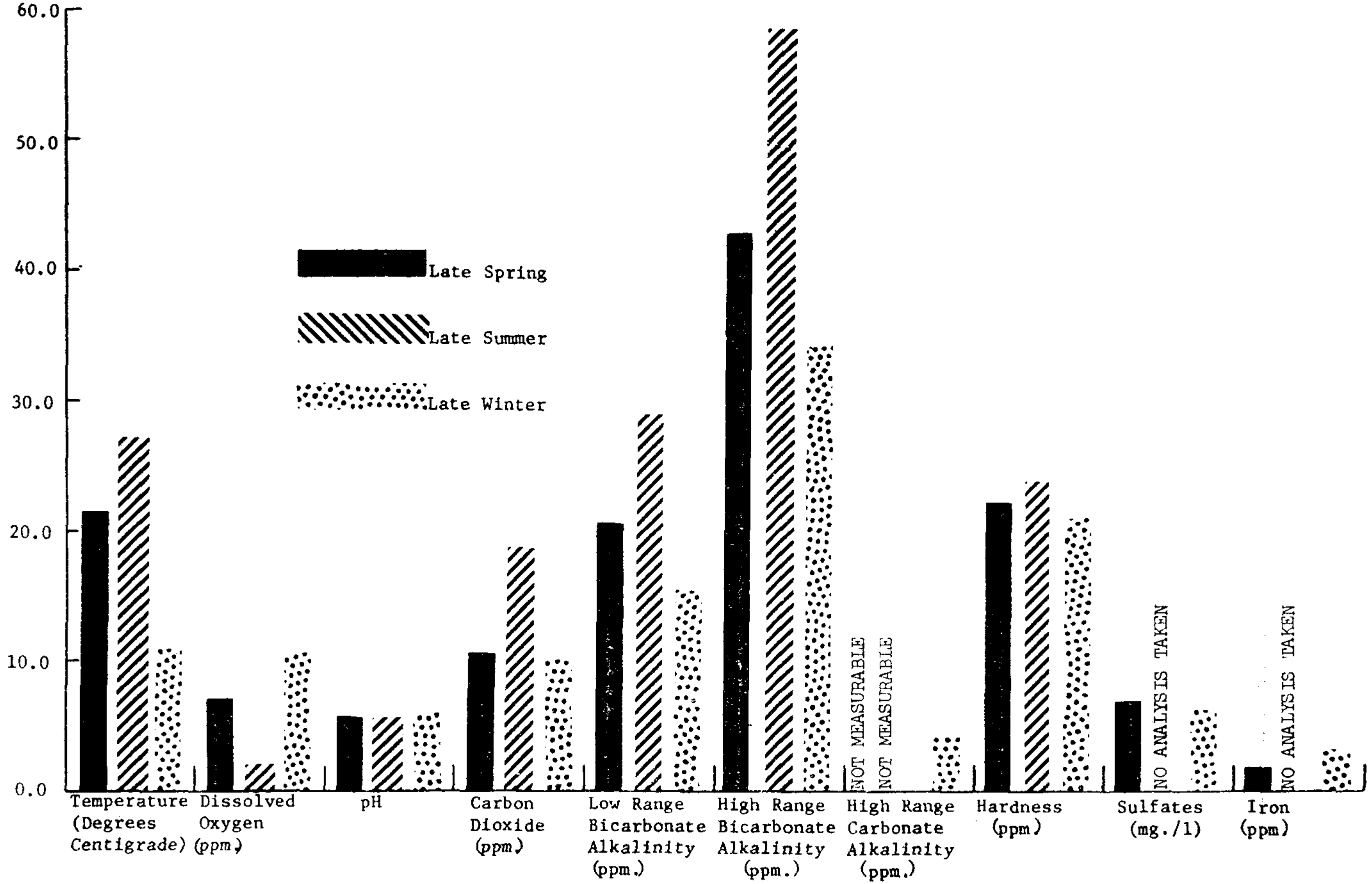


FIGURE 7. A COMPARISON OF THE MEAN DRY WEIGHTS PER TRAP DAY OF INVERTEBRATES COLLECTED WITH JUDD TRAPS FROM TEN BEAVER PONDS AND THEIR FEEDER STREAMS IN THE LOESS AND UPPER COASTAL PLAIN SOIL AREAS.

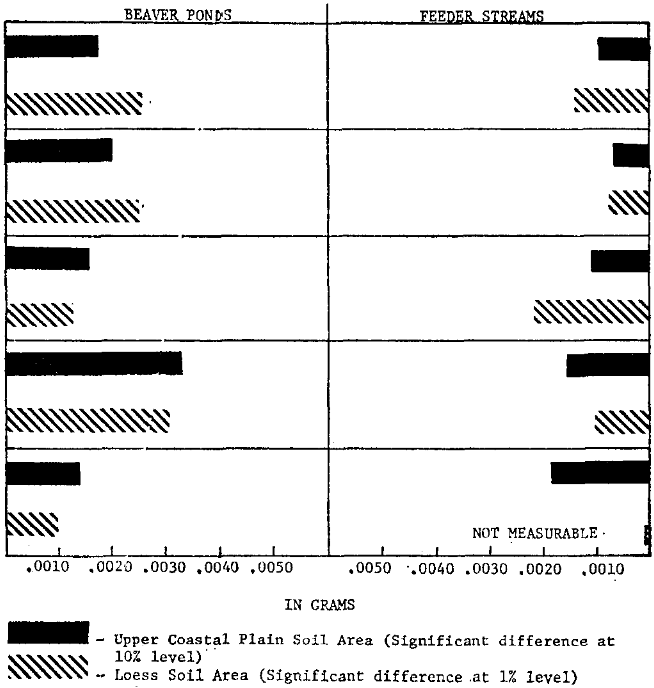


FIGURE 8. A COMPARISON OF THE MEAN DRY WEIGHTS PER SWEEP DAY OF INVERTEBRATES COLLECTED WITH FIVE RANDOM SWEEPS PER SITE FROM TEN BEAVER PONDS AND THEIR FEEDER STREAMS IN THE LOESS AND UPPER COASTAL PLAIN SOIL AREAS.