Transactions of the Illinois State Academy of Science
(2006), Volume 99, #1&2, pp. 75-86

received 10/25/05
accepted 2/28/06

Current Conservation Status of the Blacknose Shiner, *Notropis heterolepis*, in Illinois

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ABSTRACT

Notropis heterolepis Eignemann and Eigenmann, the blacknose shiner, has been subject to extensive range reduction within the State of Illinois. We reviewed extant voucher material and conducted an intensive field survey of historical and likely localities to characterize the current conservation status (presently listed as endangered) of *N. heterolepis* in the state. Twelve historical lakes, 18 non-historical lakes, 20 historical streams, and 3 non-historical streams were surveyed. Presence of *N. heterolepis* in collections made at known historical localities was examined for three time periods that incorporated major sampling efforts: (a) 1877-1944, (b) 1947-1984, and (c) 1985-2003. Environmental variables discriminating lakes with a resident population from those where the species is absent are identified.

Populations of *N. heterolepis* in Illinois have become increasingly difficult to detect in historical stream systems and it continues to warrant endangered status. Glacial lakes with moderate to dense littoral zone vegetation in a sand substrate are systems most likely to contain a detectable and stable population. We illustrate that *N. heterolepis* populations can remain undetected for considerable periods of time (i.e., decades) when the species is present in low numbers leading to false assumptions of extirpation or absence at some localities. Thus, intensive and repeated surveys are necessary to adequately monitor its conservation status. Results indicate the observed decline is attributable to decreased abundance among extant populations as well as likely extirpations. Insight into population dynamics and other ecological aspects of *N. heterolepis* will allow for the development of informed management strategies in the future.

INTRODUCTION

The blacknose shiner, *Notropis heterolepis*, is widely distributed in North America but has been subject to significant localized reductions in the southern portion of its range.

Notropis heterolepis was described by Eigenmann and Eigenmann (1893) based upon one specimen (35 mm in length) collected from a tributary of the Qu'Appelle River at Fort Qu'Appelle, Saskatchewan (50°46'N, 103°48'W). The species also has been known in Illinois under the name *Notropis cayuga* (Forbes and Richardson 1920), in reference to a description by Meek (1888). However, the latter name was later placed in the synonymy of *Notropis bifrenatus,* a superficially similar and co-occurring species in the Lake Ontario drainage (Hubbs 1926). Two subspecies are currently recognized, *Notropis heterolepis regalis*, endemic to Harvey Lake, Michigan (Hubbs and Lagler 1949), and the nominate form *Notropis heterolepis heterolepis* occupying the remainder of the range.

The historical range of *N. heterolepis* was relatively broad, including the Atlantic, Great Lakes, Hudson Bay, and Mississippi River basins (Page and Burr 1991). Within these basins, the species occurred in well-vegetated lakes and pools of streams from Nova Scotia to Saskatchewan in the north, and from Ohio to Kansas in the south (Page and Burr 1991). Gilbert (1980) reported several populations from the middle Cumberland River drainage in north – central Tennessee. However, these were later described as *Notropis rupestris* (Page and Beckham 1987). Presently, the species is reported as stable and abundant in the northern half of its range, while in the south it is rare with highly localized populations that are declining or are already extirpated (Scott and Crossman 1973; Smith 1979; Becker 1983; Trautman 1981; Pflieger 1997).

The State of Illinois is at the southern extent of the historical range of *N. heterolepis* (Page and Burr 1991). In the first statewide survey of Illinois fishes, Forbes and Richardson (1920) reported that the species' range extended from the Des Plaines River drainage west to the Apple River drainage in the north, south to a locality on Hutchins Creek of the Clear Creek drainage in Union County. Most collections were reported from the Des Plaines, Fox, Rock, and Kankakee River drainages. It was most commonly collected from low gradient streams flowing through sandy soils and having connection to extensive prairie marsh areas, although its occurrence in the northeastern glacial lakes was noted. These conditions were apparently relatively common in the northern half of the state at the time, and probably explain the species' relatively broad distribution there (Forbes and Richardson 1920). This information presented a frame of reference for future investigators to gauge the conservation status of *N. heterolepis* in Illinois.

A second statewide survey of fishes (Smith 1979) characterized distributional changes of Illinois fishes resulting from landscape alteration occurring after the Forbes and Richardson survey. Continued presence of *N. heterolepis* was documented for the Fox River drainage and associated glacial lakes, the Rock and Kankakee River drainages. Also, a new population was recorded from Fairfield Ditch #1 of the Green River drainage. Collections from all other localities listed as exhibiting extant populations in Forbes and Richardson (1920) failed to yield any individuals, notably all collections made south of the Kankakee River drainage and in the Des Plaines River drainage, where it was formerly reported at multiple localities. It seems probable that stream populations had either diminished in size or were extirpated at several localities at this time (mid 1950's to 1973).

Page and Retzer (2002) reported the results of a status survey of Illinois' most rare fishes, including *N. heterolepis.* While several extant populations were reported for glacial lakes in Lake and McHenry counties, the authors verified presence at only one stream locality based upon a vouchered specimen collected from the head of Nippersink Creek in McHenry County where it drains Elizabeth Lake.

Distributional surveys that produce vouchered records are the standard for determining conservation status of a fish species. However, specific localities are typically sampled only once during multi-year surveys and a decade or more may pass before a locality is re-visited. Accurate conclusions from surveys describing the status of a species are difficult when results are lacking relatively frequent, locality-specific temporal replication because sampling during a period of low abundance would increase the risk of falsely assuming absence.

To further knowledge about this imperiled species (currently listed as endangered in Illinois), our objective was to gain a more accurate understanding of the current conservation status of *N. heterolepis* by adding a greater degree of site-specific temporal replication to the survey conducted by Page and Retzer (2002). We predicted that a general negative trend in the probability of detecting *N. heterolepis* populations through time would be present, but also that repeated surveys would increase the number of extant populations identified.

METHODS

Collection Review

We reviewed vouchered collection material beyond that considered by Page and Retzer (2002) to account for previously unreported localities. We verified and recorded any collection data (e.g., locality information, date of collection, collectors, and comments) for all Illinois records of *N. heterolepis* at the Cornell University Museum of Vertebrates (CUMV), Field Museum of Natural History (FMNH), National Museum of Natural History (NMNH), University of Florida (UF), University of Michigan Museum of Zoology (UMMZ), Illinois Natural History Survey (INHS), and the Southern Illinois University at Carbondale Fluid Vertebrate Collection (SIUC). Collections at historical localities that did not yield specimens of *N. heterolepis* were noted so that locality specific sampling effort could be estimated through time. Only collections that contained other species likely to associate with *N. heterolepis* were considered in order to exclude collections that occurred in inappropriate habitats.

Conservation Status Survey

We sampled lake and stream systems to determine the presence or absence of *N. heterolepis*, with emphasis on systems having vouchered historical ("historical" systems, hereafter). Other systems within historical drainages without voucher material were targeted as well ("non-historical" systems). In total, 12 historical lakes, 18 non-historical lakes, 21 historical streams, and 3 non-historical streams were surveyed.

In general, sampling effort in historical streams was concentrated at, or as near as could be discerned, to previous collection localities, with additional sampling in localities with appropriate habitat. In non-historical streams, localities with habitats characteristically occupied by *N. heterolepis* were targeted.

In historical and non-historical lake systems, fish were collected from a number of randomly assigned 100-m x 10-m study reaches standardized according to shoreline perimeter. Because site-specific locality data were lacking and littoral zone habitat was often homogenous, we established the following protocol: 0 to 1500 m of shoreline was assigned three study reaches, 1501 to 3000 m of shoreline was assigned five study reaches, 3001 to 4500 m of shoreline was assigned seven study reaches, and >4500 m of shoreline was assigned nine study reaches. These were restricted to the littoral zone (i.e., extending 10 m out from shore) and were established parallel to the shoreline.

Methods of collection for both lake and stream systems included combinations of backpack electrofishing and seining with a 1.8 m x 9.1 m bag seine (3 mm mesh). Collections were preserved in 10% buffered formalin and returned to the lab for identification and vouchered in the SIUC Fluid Vertebrate Collection. Exceptions were made for adult individuals of readily identifiable species (e.g. *Micropterus* spp., *Lepomis* spp.), species of protected status, or when site-specific collection guidelines applied (e.g., at dedicated nature preserves).

Construction of Geochronologies

Status information garnered from our survey was combined with historical data obtained from the collection review in order to examine geochronological trends in overall and locality-specific presence or absence of *N. heterolepis* within Illinois. Collections were grouped into three time periods that incorporated major sampling efforts within the state: (a) 1877-1944, primarily Forbes and Richardson survey; (b) 1947-1984, primarily P.W. Smith survey; and (c) 1985-2003, primarily Page and Retzer survey and Roberts et al. survey. The number of reviewed collections with *N. heterolepis* present relative to the total number of reviewed collections for each time period was reported by lake or stream system on a map in order to present a visual representation of those sites harboring extant populations through time. Systems where *N. heterolepis* had been collected in time period (c) are those most likely to currently harbor extant populations. Stream and lake geochronologies were illustrated and described separately in order to facilitate identification of trends that may be dependent upon system type.

Habitat Discrimination

We characterized habitat for all historical lake systems visited in our survey and several non-historical lake systems in the glacial lakes region in order to identify discriminating habitat variables. These were placed into one of three categories based upon existence of extant voucher material. Historical lakes with individuals of *N. heterolepis* present in collections made within time period (c) were classified as “present,” while those exhibiting voucher material only in time periods (a) and (b) were classified as “absent.” Non-historical lakes were labeled as “non-historical.”

Habitat parameters were quantified within the same study reaches established for fish collection. Each study reach was sub-divided into ten, 10-m x 10-m transects. A 0.25-m x 0.25-m square ring was tossed haphazardly twice at each transect. Vegetative cover (represented as % barren) and substrate composition (represented as % sand, % silt, % clay, % organic detritus, % gravel, % cobble, % boulder, and % shell detritus) were estimated from within the square for each toss. Depth was recorded for each toss location as well.

Assessments of shorezone characteristics and human impact were based upon United States Environmental Protection Agency (USEPA) lake and reservoir bioassessment guidelines (USEPA 2000). Bank erosion was scored on a scale of 0-4 at transects 1,5, and 10, with 0 representing no erosion and 4 representing severe erosion. Susceptibility to human encroachment was estimated by documenting the proximity of residential properties and roads to a 30-m line extending from the middle of transects 1,5, and 10. Scores of 0, 0.5, and 1 were given depending upon if a road or residential property was not present, present but adjacent to the line, or was within the 30-m line, respectively. Values recorded for all habitat parameters from each study reach were averaged to obtain individual, system-level means.

DATA ANALYSIS

All statistical analyses presented in this investigation were computed using JMP-IN software version 4.0.4 and SAS software version 9.1 (SAS institute, Cary, NC).

A G-test for independence was used to determine whether or not observations of presence were equally probable across time periods (a), (b), and (c). Those historical systems that had collections for all three time periods were used as replicates while those that had no collections reported for one or more time periods were excluded from the analysis. Also, because all but two historical lakes had no collections reported for time periods (a) or (b), only data from stream systems were analyzed.

Multivariate analysis of variance (MANOVA) was used to determine if “present,” “absent,” and “non-historical” lakes were significantly separated by the habitat parameters we measured. Canonical analysis (CA) was used to identify habitat variables that were principal discriminators between different lake categories. Data from Elizabeth Lake in McHenry County was excluded because access was limited to only a small portion of the lake and it was felt that the habitat characterization was not representative of the whole system. Percent boulder data was dropped from the analysis in order to lessen the amount of correlation existing between substrate variables and because substrate of this type was seldom represented in any of the lakes we characterized.

RESULTS

Collection Review

Review of the available voucher material yielded previously unreported collections of *N. heterolepis* from several localites including Coon Creek in McHenry County (FMNH 43458, 43480), Piscasaw Creek in McHenry County (FMNH 43358), Potawatomi Gravel Pit in Cook County (FMNH 61759), and Spring Creek in Will County (FMNH 61216). Misidentifications were corrected for collections from the Iroquois River in Iroquois County (CUMV 8149: 1 of 2 is *Hybopsis amnis*, 1 of 2 is *Notropis atherinoides*), an unnamed tributary to the Iroquois River in Iroquois County (CUMV 8143: 1 of 6 is *Notropis texanus*, 5 of 6 are *Hybopsis amnis*), Piscasaw Creek in McHenry County (FMNH 43342: 1 of 1 is *Notropis nubilus*), and Potawatomi Gravel Pit in Cook County (FMNH 61759: 1 of 195 is *Notropis heterodon*). No voucher material was present for records reported in Forbes and Richardson (1920) from the Embarras River, Wabash River, and

Clear Creek drainages in southern Illinois and therefore they were not considered in construction of the geochronology.

Conservation Status Survey

We documented an extant population of *N. heterolepis* at one of 21 historical stream systems (Fairfield Ditch No. 1: SIUC 50486) and six of twelve historical lake systems (Bangs Lake: SIUC 45775; Cedar Lake: SIUC 61325; Cross Lake: SIUC 50442; Deep Lake: SIUC 61330; Loon Lake: SIUC 45612; and Wooster Lake: SIUC 45601). No new populations were discovered from non-historical streams included in the survey while two additional lake populations were documented at Little Silver and Leopold Lakes in Lake County (SIUC 50404 and 42943, respectively). While the population in Little Silver Lake appears to be natural, the population in Leopold Lake is the result of introductions from nearby Deep and Cedar Lakes as part of a local conservation initiative

Geochronologies

Two of 21 historical stream sites have yielded individuals of *N. heterolepis* within time period (c). The G-test for independence showed that the probability of documenting the presence of *N. heterolepis* in historical streams is not the same across time periods (a), (b), and (c) ($G = 23.27$, $df = 2$, $P < 0.001$). Collections are less likely to include *N. heterolepis* now than during (a).

A majority of historical lake systems lacked reported collections for either time period (a) or (b), therefore trends in the probability of determining presence through time could not be analyzed statistically. However, eight of 12 historical lakes (all within Lake and McHenry counties) (Figure 2) have vouchered collections for time period (c). The status of a population reported for Nippersink Lake in time period (a) is unknown because no collections exhibiting species associated with *N. heterolepis* have been reported since that time.

Habitat Discrimination

MANOVA revealed that "present", "absent", and "non-historical" systems were significantly separated by the habitat parameters we measured (Wilks' Lambda: $F = 2.08$, $df = 22$, $P < 0.05$). Two canonical dimensions were identified that explained 66.7% and 38.3% of the variation in our data, respectively. Canonical dimension one primarily represented a substrate gradient from organic detritus to sand, while canonical dimension two primarily represented a gradient of percent vegetative cover. In general, CA indicated that historical lakes had predominately sand substrates while organic detritus was more dominant in "non-historical" lakes. "Absent" systems were differentiated from these in having a proportionally greater amount of shoreline area that was barren of vegetative cover (Figure 3).

DISCUSSION

Conservation Status in Stream Sytstems

Notropis heterolepis is in danger of extirpation from stream systems in Illinois as indicated by a significant decrease in the probability of successfully collecting specimens through time. However, the current distribution of *N. heterolepis* in streams is obscured due to difficulty documenting extant populations. A good example is the population in

Fairfield Ditch No. 1 of the Green River Drainage. *Notropis heterolepis* was first collected here on 17 July 1963 (INHS 12654, N = 1) but not documented again until 5 June 2003 (SIUC 50486, N = 2), even though four collections from the same general area were made in the interim that included an otherwise similar assemblage of species.

Population dynamics are a likely explanation for difficulty in documenting the presence of *N. heterolepis* in streams. Stream populations of *N. heterolepis* in Illinois may exhibit pronounced inter-annual fluctuations in abundance. Year-class strength for populations of fishes occurring at the range periphery can vary greatly due to the influence of environmental, density-independent effects. This is because conditions necessary for some life history functions occur more sporadically on the periphery than for those occurring in more central locations (Lawler 1965). For southern populations of *N. heterolepis* already existing in low numbers due to habitat degradation, further reductions in abundance that are the result of environmental, density-independent effects likely increase the risk of localized extinction and lead to distributions that are patchy and dynamic through time.

Conservation Status in Lake Systems

Nine extant populations of *N. heterolepis* are known from glacial lake systems of the Fox River drainage found within Lake and McHenry counties. A majority of these populations have only been documented within the past 20 years, coinciding with the first reported collection attempt at many of these locations. Also, records for Cedar Lake, where collections were made for all three time periods, indicate that the species has persisted there since at least 1882. It is probable that several glacial lakes in the region have historically harbored populations of *N. heterolepis* that still persist today, although recent introductions cannot be ruled out (e.g., bait bucket introductions).

CA indicated that moderate to dense vegetation over sandy substrates in the littoral zone was associated with detectable *N. heterolepis* populations. This supports results reported by Roberts et al. (2006) that indicate littoral vegetation is vital to trophic and reproductive aspects of *N. heterolepis* life history.

CONCLUSIONS

The decreased probability of detecting *N. heterolepis* at historical stream localities through time leaves no doubt that the species is imperiled within Illinois. However, under conditions of duress, the species can persist in streams with densities or distributions that make them difficult to detect via traditional sampling techniques. Thus, intensive and repeated surveys are necessary to identify those streams that harbor extant populations. The population within Fairfield Ditch No. 1 in Bureau Co. should receive further study. Investigations into population structure and stream life history characteristics will benefit conservation initiatives in the future. Temporal trends in abundance and distribution should be characterized so that stream surveys can be conducted at times and in locations that are optimal for detecting the presence of *N. heterolepis*.

Notropis heterolepis populations in glacial lakes appear stable but occur in only a small number of these. Immediate steps need to be taken to maintain the integrity of the nine glacial lakes known to harbor extant populations (Figure 2). Managers should ensure that moderate to dense vegetation is maintained in littoral areas so that suitable feeding and reproductive habitat is available (Roberts et al. 2006).

The documented decline of *N. heterolepis* in Illinois and other Midwestern states may be a harbinger of an overall decline in the ecological integrity of aquatic systems in this region. A broad review characterizing the structure and status of fish assemblages inhabiting Midwestern lakes and streams that incorporates aspects of individual species life history would provide insight into larger trends in ecological structure and function of these systems.

ACKNOWLEDGEMENTS

This paper is based on a M.S. thesis submitted by M.E. Roberts to Southern Illinois University Carbondale. Equipment and supplies were provided by the Department of Zoology and Max McGraw Wildlife Foundation. Funding was provided by Max McGraw Wildlife Foundation, Chicago Wilderness, Conservation 2000, the Illinois Department of Natural Resources, and the United States Fish and Wildlife Service. A.M. Davis, K. Janus, R. Eichelberger, A. DeFore, A. Levin, and K. MacCarthy provided field and lab assistance. The authors wish to thank the Lake County Health Department Lakes Management Division, Liberty Prairie Foundation, and the forest preserve districts of Lake, McHenry, Cook, Will, Kane, and DuPage Counties for site information and access. M.R. Whiles, V.J. Santucci, Jr., J.E. Garvey, and three anonymous reviewers provided valuable comment to earlier drafts of the manuscript.

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Figure 1. Lotic geochronology of *Notropis heterolepis* in Illinois. Lines refer to localities with extant voucher material reviewed from three time periods that incorporated major sampling efforts within the state: a (1877 – 1944), b (1947 – 1984), and c (1985 – 2003). Locality specific data are: number of reviewed collections with *N. heterolepis* present, relative to the total number of reviewed collections for each time period. Localities with individuals of *N. heterolepis* present in collections made during time period c are those most likely to still have extant populations.

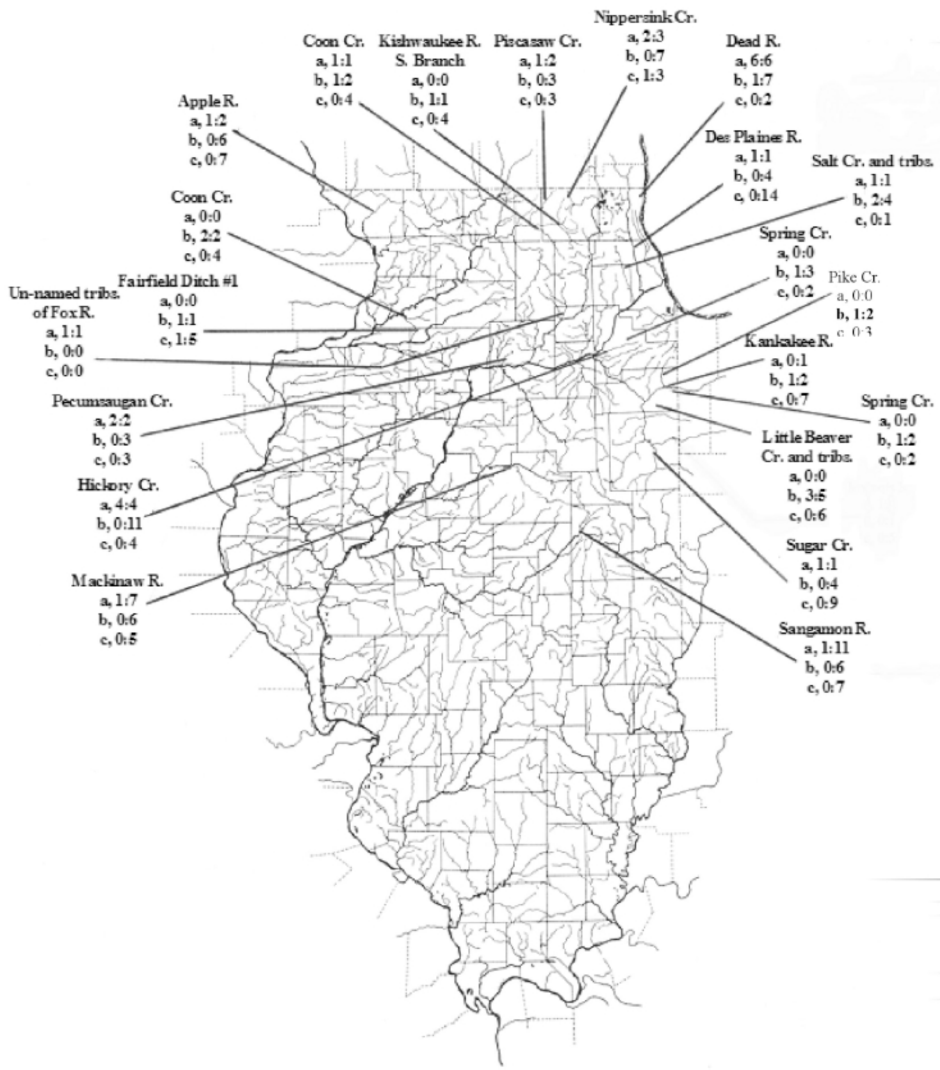

Figure 2. Lentic geochronology of *Notropis heterolepis* in the glacial lakes region of northeastern Illinois. Lines refer to localities with extant voucher material reviewed from three time periods that incorporated major sampling efforts within the state: a (1877 – 1944), b (1947 – 1984), and c (1985 – 2003). Locality specific data are: number of reviewed collections with *N. heterolepis* present, relative to the total number of reviewed collections for each time period. Localities with individuals of *N. heterolepis* present in collections made during time period c are those most likely to still have extant populations.

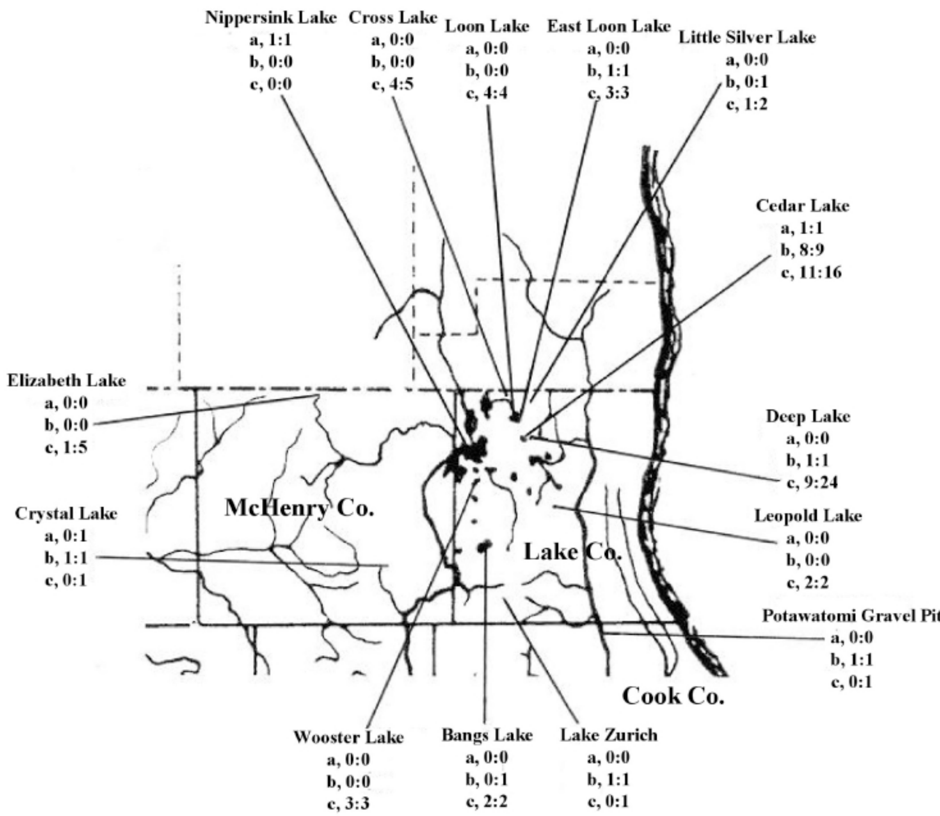

Figure 3. Habitat characteristics of present, absent, and non-historical lakes described within two canonical dimensions. Axes within the plot represent individual habitat parameters where length of the axis for each parameter corresponds to its overall explanation of among-class variation.