Survey of Spring Cavefish (*Forbesichthys agassizii*), Ozark minnow (*Notropis nubilus*) and Largescale Stoneroller (*Campostoma oligolepis*) Status in Illinois

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Summary

Historic records were used to identify areas within Illinois where spring cavefish (*Forbesichthys agassizii*), Ozark minnow (*Notropis nubilus*) and largescale stoneroller (*Campostoma oligolepis*) may be extirpated or overlooked by ongoing collection efforts. Several survey locations were selected for each species with the objective of determining species presence. Spring cavefish were collected at several sites throughout its historic distribution indicating continued persistence of this species. No Ozark minnow or largescale stoneroller were recorded, which suggests extirpation from or greatly reduced abundance in some parts of their historic distributions. This study supports the need for targeted surveys as a valuable information supplement for species that might otherwise be missed or under sampled by existing fisheries collection programs.

Table of Contents

Summary	i
Section 1. Introduction to Study	1
1.1 Background	1
1.2 Species Selection	1
Section 2. Spring Cavefish	2
2.1 Species Description and Distribution Status	2
2.2 Survey Methods	2
2.3 Survey Results	3
2.4 Conclusions	4
Section 3. Ozark Minnow	5
3.1 Species Description and Distribution Status	5
3.2 Survey Methods	6
3.3 Survey Results	6
3.4 Conclusions	7
Section 4. Largescale Stoneroller	7
4.1 Species Description and Distribution Status	7
4.2 Survey Methods	7
4.3 Survey Results	8
4.4 Conclusions	8
Section 5. Study Conclusions	9
Section 6. Literature Cited	9
Tables	
Figures	

Section 1. Introduction to Study

1.1 Background

Preservation of Illinois' biological resources (e.g., biodiversity) is a primary objective for many programs and Divisions (e.g., Division of Natural Heritage, Illinois Wildlife Action Plan, Illinois Natural Areas Inventory) within the Illinois Department of Natural Resources (IDNR). Fundamental to these efforts is knowledge of species' ecological status; however, information regarding the status of many species, especially those that are spatially or numerically rare, is often lacking because they may be missed during standard survey programs, which are often designed to assess broad patterns. Species distribution, abundance and habitat information is crucial to evaluating trends and identifying critical conservation needs.

In Illinois, much of the monitoring for species and habitats occurs as regimented efforts in which areas are repeatedly assessed. In fisheries, for example, the IDNR collects fish community information at defined stream sites that rotate on a five-year schedule, while the Long-Term Resource Monitoring Program surveys fish within the same stream reaches each year. These monitoring programs, and others like them, have value in assessing temporal trends, but may be unable to detect statewide distribution and trends of individual species. Furthermore, rare species may be difficult to detect, especially if their range does not overlap with sample locations or if sampling gear results in low detection efficiency for those species.

Recent efforts to evaluate fish Species in Greatest Need of Conservation (SGNC) status and trends indicate several species have exhibited decline in abundance and/or distribution during the past several decades (Metzke, Hinz, Jr. and Hulin 2012). These species are good candidates for surveys supplemental to existing efforts (e.g., IDNR basin surveys) so that temporal and spatial trends can be more accurately evaluated. Ultimately, it is these targeted efforts that provide a level of detailed need to full assess species status.

The purpose of this study is to evaluate distributions of rare fish species by supplementing existing fish monitoring programs by resampling locations with historic records and filling in spatial sampling gaps through surveys at novel locations. This study serves to update existing distribution information and seeks to investigate the utility of supplemental surveys for determining accurate species distributions.

1.2 Species Selection

As rare fish species are the focus of this study, an initial pool of 49 species was identified by removing threatened and endangered species from the SGNC list (IDNR 2005). Threatened and endangered species were not considered as an alternate mechanism for research and surveys exists for these species, and several concurrent surveys to this study are occurring. Fisheries data were gathered from seven sources during the recently completed fish SGNC update study (Metzke, Hinz, Jr. and Hulin 2012). These data contained collection location and date, and were used to evaluate current (after 1999) and historic (1999 and earlier) distributions for potential focal species. The initial species pool was further reduced by retaining only those species that have not been collected in a Hydrologic Unit Code-8 (HUC8) watershed after 1999, but historically (1999 or older) existed, thereby reducing the pool to those species with declining distribution. Furthermore, large river species were eliminated to ensure selected locations could be surveyed using available gear (i.e., backpack electrofishers). As 15 species met these criteria, only species that were also declining in abundance were included (Metzke, Hinz, Jr. and Hulin 2012), and subsequently, spring cavefish (*Forbesichthys agassizii*), Ozark minnow (*Notropis nubilus*) and largescale stoneroller (*Campostoma oligolepis*) were selected as focal species for this study.

Four of the data sources included records for the focal species: the IDNR's Fisheries Analysis System (FAS) streams database, the Illinois Natural History Survey's (INHS) Museum Collections database, the INHS' Long-Term Resource Monitoring Program (LTRMP) database and the Southern Illinois University-Carbondale fisheries collection database. If the exact coordinates of a record was not available, verbal descriptions and relationships to known points (e.g., IDNR basin survey sites, state parks) were used to georeference the record.

Section 2. Spring Cavefish

2.1 Species Description and Distribution Status

Spring cavefish is a small (usually <9cm) brown or tan, salamander-like fish that inhabits caves, springs and clear streams (Smith 1979, Page and Burr 2011). The species is primarily an invertivore, although cannibalism has been recorded in adults (Hill 1969). Its range includes southeast Missouri, southern Illinois, southwestern Kentucky and central Tennessee (Smith and Welch 1978, Page and Burr 2011). In Illinois, its distribution includes waters within the Cache River, Big Muddy River, Ohio River and Mississippi River (Cape Girardeau unit) HUC8 basins (Figure 1). In addition to agency and institution collection records, Adams, Burr and Wilhelm (2005) conducted a survey of spring cavefish in southern Illinois springs. This effort represents the most recent survey and yielded an additional eleven records beyond those in the fisheries databases (Figure 1).

2.2 Survey Methods

Survey locations for this study were selected from historic records and those from Adams, Burr and Wilhelm (2005), with a focus on those where the species had recently been collected. From this group of potential locations, 30 were visited and 21 were surveyed (some sites could not be located or accessed, while the springs had dried at others), including five previously unsurveyed locations. Spring cavefish were collected using dip netting and hand grabbing at smaller sites (e.g., springs) and with backpack electrofishing units at stream sites. Several water quality (pH, dissolved oxygen, specific conductance, temperature) and habitat (substrate composition, channel form, riparian structure) parameters were recorded at each survey location. All collected fish were identified and recorded while at the site, and the presence of other aquatic organisms was noted. If spring cavefish were successfully collected, a photograph was taken as a visual record of the species' presence.

2.3 Survey Results

The 21 surveyed sites were from four basins and seven counties (Figure 2). Ten sites were springheads or waters originating from springs, while the remaining sites were streams (Table 1). Spring cavefish were collected at nine of the surveyed locations (Table 2), one of which (SNC 7) was a new records for the species. Unsuccessful surveys occurred at three locations where the species had previously been recorded. The mean number of spring cavefish collected (when observed) was 3.7 with a range of 1 to 17. No attempt was made to sample to exhaustion (i.e., survey goal was to determine species presence); therefore, abundance values may not represent total system abundance.

Watershed and stream arc (confluence to confluence segment) characteristics for each site were derived from GIS-based attributions (Table 3). As springs are below the resolution for attribution within the 1:100,000 stream linework, most surveyed locations lacked arc-based information. Those locations with existing data (i.e., stream sites) have a mean drainage area of 18.2km^2 (range 4.0-42.5) and a mean stream order of 1.8 (range 1-3). The mean gradient for these sites is 0.0071 ft/ft (range 0.001-0.0160). Local watersheds (i.e., catchments of stream arcs) were assessed for land use patterns using summary data from 2006 land cover data (Fry *et al* 2011). Agriculture and forested land comprised a proportional local watershed mean of 0.79 (range 0.45-0.98), with the remaining land cover distributed largely amongst pasture, open water and light development. Proportion of forest in local watersheds did not differ significantly between sites where spring cavefish were found and where they were not recorded, but proportion of agriculture was significantly higher in sites with spring cavefish (Table 4).

Instream and riparian features related to substrate, flow, channel units, bank composition and vegetation were characterized at each site (Table 5) to evaluate habitat patterns in relation to spring cavefish distribution. Recorded values were estimated and, in many cases, represent the average condition within the sampled reach. Cobble, claypan and muck were the three most common substrates at sites where spring cavefish were found (mean site composition of 30.6, 17.8 and 16.7%, respectively), although no single substrate type exhibited a significant difference in abundance at sites were the species was found and where it was not (Table 4). Anecdotally, most individuals were collected from under large objects, like cobble, leaves, logs and course woody debris regardless of site substrate conditions. Mean depth at sites with spring cavefish was 0.2m (range 0.1-1.0), while mean width was 2.1m (range 0.5-5.0). Neither of these parameters differed significantly from sites where spring cavefish were not found (Table 4). Flow at all sampled locations varied from nearly no discharge to a moderate velocity. Riffles were the dominate channel unit type at sites with spring cavefish (mean 45.6% of sampled length), while pools dominated sites without the species (mean 49.6%); however, there were no significant differences in channel unit proportionality (Table 4). Vegetation comprised a mean of 7.8% of the instream surface area of survey locations with spring cavefish and 5.4% where the species was not found, and emergent vegetation was the dominate type in both cases. There is no significant difference in amount of vegetation at sites with and without spring cavefish (Table 4). Riparian vegetation was predominately trees (i.e. forest or forested swamp) at the majority of sites (19) and herbaceous vegetation at the remaining locations. The majority of sites also had riparian zone widths greater than 100m, although some had mean widths less than 5m. Channel shading ranged from

0 to 100% canopy cover with a mean of 67.8% at sites with spring cavefish and 69.6% at those without. There was no significant difference in channel shading between the two types of sites (Table 4).

As evaluations of differences in individual habitat characteristics yielded no dissimilarities between sites where spring cavefish were and were not found, non-metric multi-dimensional scaling (NMDS) was used to visualize habitat composition and evaluate similarities amongst sites. Twenty-eight variables were utilized for the NMDS (floating vegetation was removed as none was observed), and variables were normalized to account for differences in value ranges. The first two axes resulting from the NMDS explain a cumulative 29% of the variation in habitat characteristics amongst sites. When points are symbolized according to presence of spring cavefish no differences in site category are apparent (Figure 3). When points were symbolized by waterbody type (spring or stream) or HUC8 location, no differences were observed as well (Figure 4).

Recorded water quality data were recorded at most survey locations (Table 6). Mean pH at sites with and without spring cavefish was 8.15 and 7.81, respectively, and values at sites where the species was recorded were significantly higher than those were it was absent (Table 4). Dissolved oxygen concentration was also significantly higher where spring cavefish was present (mean 9.36 mg/L) than where it was not (mean 7.10 mg/L; Table 4). Mean conductivity was 225 µS/cm and 283 µS/cm where the species was present and not recorded, respectively, and this factor did not differ significantly amongst site categories (Table 4). Temperature was significantly lower at sites where spring cavefish were collected (mean 13.0 ^{o}C, 18.0 ^{o}C; Table 4). Clarity could not adequately be assessed as visibility exceeded maximum water depth at most surveyed sites.

Sampling effort and characteristics of the biotic community were recorded at each survey site (Table 2). Mean number of fish species (other than spring cavefish) collected at those sites where spring cavefish was observed was 2.8, while those without spring cavefish had a mean of 4.1 species. Six of the nine locations where spring cavefish were recorded contained no other fish species. Number of additional fish species did not differ significantly amongst site categories (Table 4). When spring cavefish were present in springs no other fish species were present, but in stream systems green sunfish (*Lepomis cyanellus*), bluntnose minnow (*Pimephales notatus*) and banded pygmy sunfish (*Elassoma zonatum*) were the most abundant concurrent species. Amphipods and salamanders were commonly found at sites with spring cavefish, especially at spring sites.

2.4 Conclusions

Few differences in watershed characteristics, channel structure and water quality exist between sites were spring cavefish were found and were they were not (Table 4, Figures 3 and 4). There are several possible explanations for this pattern. First, many of the sites where we did not collect spring cavefish were locations where historic records exist, suggesting these places have characteristics within the tolerance range of the species. The reason(s) why we did not detect presence are not always known, so it is possible historic locations are still inhabitable for spring cavefish. Second, it is possible that the environmental variables most important for determining spring cavefish distribution were not evaluated. For instance, temperature stability, irradiance, flow regime, availability of prey or presence of predators may all influence presence or abundance of spring cavefish, but none of these were evaluated. Finally, spring cavefish may have a wider breadth of environmental tolerance than expected from a semi-subterranean species. It's presence in waterbodies ranging from tiled spring outlets to third order streams, from forested to agricultural catchments and from muck to cobble substrates suggests either adaptive ability or that only a few conditions limit distribution. As pH, dissolved oxygen and temperature were among the few variables that differed amongst sites with and without spring cavefish, perhaps habitat and watershed structure is less critical than water quality.

At a broad scale (i.e., HUC8 watershed), spring cavefish distribution has been stable over the history of occurrence records (Figures 1 and 2). Site specific or small scale distribution is more difficult to evaluate given the species' narrow habitat range and the difficulty in collecting it. This survey indicates spring cavefish populations may become extirpated over a relative short period of time, as suggested by the failure to collect the species at several of Adams, Burr and Wilhelm (2005) sites. As it is more difficult to prove absence than presence, it is possible that spring cavefish may still be extant at historic locations; however, two of Adams, Burr and Wilhelm (2005) sites no longer contain water (i.e., hydrologic changes have caused them to run dry) while the structure of one site was such that missing any spring cavefish would be nearly impossible. On the other hand, two of our sites appeared to be recently established springs, neither of which produced spring cavefish, while another novel site did yield a new record. Local extirpations and the emergence of potential habitat suggest stochastic events may be important in understanding the long-term distribution patterns of this species.

One of the largest concerns for the preservation of spring cavefish in Illinois is the ability of individuals to disperse or immigrate to sink populations, colonize novel locations or recolonize locations where extirpation has occurred. Their propensity for springs and small streams suggests long dispersal events through river networks, especially from one HUC8 to another, might be unlikely. The suggestion that individual clusters of spring cavefish in adjacent watersheds are necessarily connected (Burr *et al* 1996) is likely false. Therefore, potential connectivity of the species' metapopulation (if the population dynamics behave as such) may depend upon subterranean movement across watershed boundaries and around non-traversable aquatic habitats, like large rivers. It is clear spring cavefish utilize underground waterbodies (Smith and Welch 1978, our observations), but their ability to use these as dispersal pathways depends, in part, upon the connectedness of subterranean environments they inhabit. Webb, Taylor and Krejca (1993) surveyed 35 caves within the distribution boundaries of spring cavefish indicating the existence of significant subterranean structure (although they did not note the presence of the species). However, the dispersal potential of these subterranean systems for spring cavefish is unknown. The fragmented nature of spring cavefish populations in Illinois makes this species a good candidate for a more focused evaluation of functional connectivity.

Section 3. Ozark Minnow

3.1 Species Description and Distribution Status

Ozark minnow has a dark lateral stripe extending from its snout to tail, with brownish coloring above and whitish below the stripe. The species grows to approximately 9.5cm. Its range is discontinuous, with one portion in northwest Wisconsin, another extending from southern Wisconsin and southeastern Minnesota to eastern Iowa and northwestern Illinois, and a third that includes eastern Kansas, northern Arkansas and southern and central Missouri (Page and Burr 2011). In Illinois, Ozark minnow has been recorded in eight HUC8 basins in northern Illinois and sporadically in the Mississippi River in southwestern Illinois (Figure 5), although these individuals are thought to be transients from Missouri streams (Smith 1979). Recent collection records suggest potential extirpation from the Kishwaukee River HUC8.

3.2 Survey Methods

Given that individuals collected from the Mississippi River are not considered resident (Smith 1979), potential survey sites were selected from northern Illinois basins, with an emphasis on streams with historic records and those that have not been surveyed but have potential to contain Ozark minnow. To find unsampled locations where surveys efforts could be focused, stream segments with characteristics suitable for Ozark minnow (i.e., those with potential for inhabitation) were identified by determining value ranges for gradient, size, catchment land use, flow and temperature at locations were the species has been recorded (Table 7). These ranges were applied to all streams within the species' historic range and those with the correct combination of characteristics were placed into the pool of potential sample locations (Figure 6). Those with hydrologic connectivity to streams containing historic records were prioritized.

Fish were collected at all sites using backpack electrofishing with a minimum sample effort of 20 minutes. Water quality, habitat measures and fish community notes were taken at each surveyed site (see Section 2.2).

3.3 Survey Results

Twelve sites from four HUC8s and five counties were surveyed for the presence of Ozark minnow. Five of the 12 sites were modeled (potential habitat) locations while the others were locations with historic records (Table 8). No Ozark minnow were collected during survey efforts.

Surveyed locations ranged from 2^{nd} to 4^{th} order (16.1-129.5 km^2 watershed area) with a mix of local catchment land use that varied amongst urban, agriculture and pasture-dominated (Table 9). The most common substrate type within surveyed reaches was gravel, followed by silt and cobble (Table 10). Mean depth was 5.3 m and mean width 4.3 m. Runs were the predominate channel unit type (mean 52.0%). Mean total instream vegetation cover was 17.0%, and bank cover was comprised mostly of bare and herbaceous types (mean 47.1 and 49.6%, respectively). Riparian zone width was moderate (mean 40.8m), and composition was an even mix of trees and herbaceous vegetation. Mean channel shading was 31.7%.

Mean pH at surveyed streams was 8.10 while mean conductivity was 666.6 µS/cm (Table 11). Mean dissolved oxygen concentration was 8.58 mg/L, with a minimum of 7.40 mg/L. Maximum recorded temperature was 24.1 ^{o}C with a mean of 19.7 ^{o}C. Mean water clarity was 0.6 m and ranged from 1.5 to 0.1m.

Mean number of fish species collected at surveyed sites was 8.5 (range 1-14, Table 12). Numerically dominate species at these locations were bluntnose minnow, creek chub (*Semotilus atromaculatus*), central stoneroller (*Campostoma anomalum*), fantail darter (*Etheostoma flabellare*) and white sucker (*Catostomus commersonii*). Also of note was a single carmine shiner (*Notropis percobromus*) collected at site OZM 6.

3.4 Conclusions

Despite surveying streams with a variety of characteristics, some of which include historic records of Ozark minnow, efforts to collect the species were unsuccessful. It is possible that Ozark minnow exist in these streams, but findings of this survey and the pattern of constricting distribution (Figure 5) suggest a spatial decline. Ozark minnow abundance has remained relatively stable during the past decade as compared to previous time periods (Metzke, Hinz, Jr. and Hulin 2012; Karen Rivera, IDNR Streams Biologist, personal communication), which suggests habitat loss in discrete portions of its range.

Land use changes within the Northern Illinois distributional range of Ozark minnow is a possible explanation for the species' declining distribution. Much of the landscape within the historic distribution of Ozark minnow was forested, but those forests have been converted into pasture and cropland (Figure 7). Furthermore, urbanization, primarily in the Rockford and the surrounding areas, has also occurred further reducing available habitat within the species' range.

Section 4. Largescale stoneroller

4.1 Species Description and Distribution Status

Largescale stoneroller is a minnow species with a maximum length of approximately 20cm. It primarily differs from central stoneroller in having fewer (and larger) scales. The species exhibits three distinct distributions in North America: one that includes central Kentucky and Tennessee, western North Carolina, northeast Mississippi and Alabama; another that ranges from northern Arkansas to central Missouri; and a third that includes most of Wisconsin, southeast Minnesota, northeast Iowa and north and central Illinois (Page and Burr 2011).

Historic records for largescale stoneroller in Illinois were from the upper Kaskaskia River, lower Illinois River and Embarras River watersheds in the central part of the state and extended northward to Wisconsin (Figure 8). This distribution encompassed 18 HUC8 watersheds from the Apple, Rock, Illinois, Embarras and Vermillion (Wabash) River basins. Current (since 2000) distribution includes ten HUC8s, with a loss of eleven watersheds and gain of one. The greatest loss of distribution has occurred in central Illinois, although the Rock River basin has also experience declines.

4.2 Survey Methods

Potential survey locations for largescale stoneroller were restricted to central Illinois as this area has experienced the largest spatial decline in the species' distribution. As with Ozark minnow, largescale stoneroller survey locations were chosen from a combination of streams with historic records and those with characteristics suitable for the species (Table 13). Stream segments with suitable range of values were placed into the pool of potential survey locations (Figure 9). Those modeled segments with hydrologic connectivity to streams with historic records were prioritized.

Fish were collected at all sites using backpack electrofishing with a minimum sample effort of 20 minutes. Water quality, habitat measures and fish community notes were taken at each surveyed site (see Section 2.2).

4.3 Survey Results

Nine locations were surveyed in an effort to collect largescale stoneroller (Table 14, Figure 9). Six of those were modeled streams and three were locations with historic records. No largescale stoneroller were collected.

Surveyed streams were 2^{nd} and 3^{rd} order with a mean watershed area of $88.4km^2$ and a mean gradient of 0.0015 ft/ft (Table 15). Local catchment land use was predominately agriculture (mean 0.71). Sand was the most dominate substrate at surveyed locations (mean 39.4%), followed by claypan and gravel (mean 30.0 and 21.7%, respectively, Table 16). Mean depth was 0.6m and mean width was 5.4m. Runs were most abundant with a mean of 59.4% of the surveyed reaches, followed by pools and riffles (mean 12.8 and 27.8%, respectively). Vegetation was present in 19.4% of the instream area, on average, while herbaceous vegetation was the predominate bank cover (mean 85%). Mean riparian width was more than 25m, and was most frequently comprised of herbaceous vegetation. Mean channel shading was 18.3%.

Mean pH at surveyed locations was 8.10, while mean dissolved oxygen 9.25 mg/L (Table 17). Mean conductivity and temperature were 753 µS/cm and 21.4^oC, respectively. Water clarity ranged between 0.3m and >1m.

Mean number of fish species collected during surveys was 10.9 (Table 18). Central stoneroller, sand shiner (*Notropis stramineus*), blackstripe topminnow (*Fundulus notatus*) and bluntnose minnow were the dominate species across survey locations. One carmine shiner was recorded at site LSS 6.

4.4 Conclusions

Although largescale stoneroller appears to never have been common in central Illinois watersheds, it did have a wide distribution within that portion of the state (Figure 8). Recent distribution in central Illinois is even more sparse, but the decline in distribution may have begun in the early 20^{th} century as approximately 64% of historic records are from 1901 or earlier. Much of this distribution loss occurred in prairie landscapes (Figure 10) suggesting conversion of prairie to agricultural lands, channelization of agricultural streams and the ensuing degradation of those streams may be the culprit. Largescale stoneroller are sensitive to turbidity, siltation and slow flow conditions (Robison and Buchanan 1988, Smith 1979) all of which are associated with agricultural streams. Changes in abundance across the state are not uniform, but the species appears stables at locations were it does persist (Metzke, Hinz, Jr. and Hulin 2012). This pattern further suggests habitat loss controls largescale stoneroller distribution changes.

Section 5. Study Conclusions

Study objectives were to assess the current distributions of spring cavefish, Ozark minnow and largescale stoneroller, and to evaluate the utility of supplemental survey efforts. Although we were successful in recording the persistence of spring cavefish in Illinois, we were unable find evidence of the other two focal species in the watersheds we targeted. Proving species absence is difficult, but our results taken within the context of temporal distribution patterns of Ozark minnow of largescale stoneroller suggest extirpation from portions of their historic ranges. At the very least, our efforts to create a comprehensive evaluation of existing records for these species should be valuable.

Several examples of fish species which are not routinely collected during agency sampling programs but are recorded during targeted efforts exist in Illinois (e.g., Thomas *et al* 2013, Tiemann 2012), some of which never have been recorded within statewide programs. Prior to this study, spring cavefish were last recorded in Illinois by Adams, Burr and Wilhelm (2005) in 2003 during their targeted study. Their and our studies validate the need for targeted surveys to fill in the ecological and distributional information gaps of rare species.

Our study should be viewed as one portion of the total collection effort expended by the various individuals and agencies that conduct fisheries monitoring and research. Unfortunately, very little effort is directed towards the synthesis of fisheries information gathered throughout the state, which is a necessary step in evaluating species status.

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Tables

Table 1. Location information for spring cavefish surveys.

Site ID	Name	Latitude	Longitude	Location Description
SNC 1	Class Spring	37.54596	-89.43933	~ 2km east of Rte 3, 20m north of southern edge of Snake Rd
SNC 2	Deer Spring South	37.56301	-89.44077	~ 1.5km north of SNC 1, middle of Snake Rd
SNC 3	Deer Spring North	37.56301	-89.44077	Adjacent to SNC 2 on Snake Rd
SNC 4	Unnamed Spring	37.54423	-89.43783	~ 0.5km south of SNC 1. Spring originates in forest and flows to hiking path
SNC 5	Otter Pond Spring	37.54209	-89.43841	~ 0.3km south of SNC 4. Spring flows under hiking path
SNC 6	Rattlesnake Ferry Spring	37.61728	-89.41862	~ 1.1km southeast of Big Muddy River on Hutchins Creek Rd
SNC 7	Big Creek at Rattlesnake Ferry Spring	37.61802	-89.41857	~ 100m northwest of SNC 6 on Hutchins Creek Rd., downstream of culvert under road
SNC 8	Crooked Creek	37.31601	-89.16034	< 0.5km east of Rte 51 on Perks Rd at Crooked Creek crossing, upstream of road
SNC 9	Big Creek	37.43094	-89.18288	~ 2.5km east of Rte 51 on Nash Rd at Big Creek north crossing
SNC 10	Max Creek	37.45807	-88.80535	~ 9.0km northeast of Vienna at Rte 147 and Max Creek crossing
SNC 11	Decker Spring	37.51333	-88.28254	~ 3.3km northeast of Tecumsen Lake near 700E Rd and Hogthief Creek
SNC 12	Big Creek	37.57756	-88.30158	~ 0.8km east of 1155 N. Rd on 1125 N Rd., upstream of bridge
SNC 13	Class Spring	37.58820	-89.44016	~ 4.2km northeast of Rte 3 on Snake Rd, upstream and downstream of road
SNC 14	Unnamed Spring	37.36026	-89.35486	~ 1.5km southeast of Union County Cons. Area, on unnamed road, pool along Rd
SNC 15	Perkins Spring	37.23810	-89.43602	~ 3.0km northeast of Thebes on Hastings Ranch Rd
SNC 16	Big Creek	37.41096	-89.16418	~ 7.5km southeast of Anna at Big Creek and Big Creek Church Rd, upstream of road
SNC 17	Dixon Springs Pool and Stream	37.38666	-88.66909	Dixon Springs State Park
SNC 18	Unnamed Tributary to Lusk Creek	37.39510	-88.50936	~ 3.5km northeast of Golconda on Coon Hunter R. at stream crossing, up- and downstream of road
SNC 19	Unnamed Tributary to Big Creek	37.50379	-88.36820	~ 4.2km southeast of Hicks (Rte 34), 1.2km south of Forest Rd 1904
SNC 20	Big Creek	37.53284	-88.32631	~ 5.0km south of 1175N R. on 225E Rd, upstream of crossing
SNC 21	Beartrack Hollow Creek	37.56234	-88.45348	~ 2.5km southwest of Herod on Herod Rd upstream of creek crossing

Table 2. Sampling effort and biotic community information at spring cavefish survey locations.

Site ID	Method	Sample Length (m)	Sample Time (minutes)	n Collected	# Other Fish Species	Other Animals Present
SNC 1	Dip netting & visual	10	15	2	0	Amphipod, planaria, caddisflies, & crayfish
SNC 2	Dip netting & visual	40	20	5	0	Amphipods & salamanders
SNC 3	Dip netting & visual	20	10	2	0	Amphipods & salamanders
SNC 4	Dip netting & visual	5	10	0	0	Salamanders
SNC 5	Dip netting & visual	15	20	1	0	Amphipods & salamanders
SNC 6	Dip netting & visual	80	30	2	0	Amphipods, salamanders, & mayflies
SNC 7	Backpack electrofishing	30	18	2	3	
SNC 8	Backpack electrofishing	100	25	1	11	
SNC 9	Dip netting & visual	200	60	0	1	
SNC 10	Backpack electrofishing	100	25	1	11	
SNC 11	Dip netting, visual, & backpack electrofishing	50	30	0	1	Amphipods & crayfish
SNC 12	Backpack electrofishing	100	30	0	8	
SNC 13	Dip netting & hand grabbing w/ small nets	40	30	17	0	Amphipods & salamanders
SNC 14	Dip netting	3	5	0	0	Amphipods
SNC 15	Dip netting & hand grabbing w/ small nets	100	20	0	1	Amphipods
SNC 16	Backpack electrofishing	150	35	0	13	
SNC 17	Backpack electrofishing	200	30	0	3	
SNC 18	Dip netting & hand grabbing w/ small nets	400	35	0	2	
SNC 19	Dip netting & hand grabbing w/ small nets	250	45	0	1	
SNC 20	Backpack electrofishing	250	45	0	16	Crayfish
SNC 21	Backpack electrofishing	100	20	0	3	

Table 3. Stream and local watershed land use characteristics at spring cavefish survey locations. Sites without stream characteristics are springs or are too small to be included in the 1:100,000 stream linework.

	Stream Characteristics			Proportional Land Use		
Site ID	Drainage Area (km^2)	Stream Order	Gradient (ft/ft)	Agriculture	Urban	Forest
SNC 1*				0.58	0	0.28
SNC 2*				0.57	0	0.33
SNC 3*				0.57	0	0.33
SNC 4				0.58	0	0.28
SNC 5*				0.58	0	0.28
SNC 6*				0.03	0	0.92
SNC 7*				0.03	0	0.92
SNC 8*	33.4	3	0.001	0.37	0	0.08
SNC 9	13.5	2	0.006	0.46	0	0.21
SNC 10*	24.5	2	0.002	0.22	0	0.45
SNC 11				0.07	0	0.65
SNC 12	6.2	1	0.008	0.09	0	0.65
SNC 13*				0.40	0	0.48
SNC 14				0.22	0	0.76
SNC 15				0.03	0	0.87
SNC 16	21.9	2	0.003	0.32	0	0.41
SNC 17	5.2	1	0.014	0.06	0	0.76
SNC 18	4.0	2	0.010	0.07	0	0.49
SNC 19	42.5	1	0.016	0.07	0	0.85
SNC 20	26.4	2	0.002	0.07	0	0.64
SNC 21	4.3	2	0.009	0.11	0	0.57

* spring cavefish collected at this site

Table 4. Results of ANOVA tests comparing survey locations where spring cavefish were found and where they were not. Tendency is the direction in which the locations with spring cavefish differ from those without when ANOVA results are statistically significant.

Comparison	df	F value	P value	Tendency
Proportion forest in local watershed	1, 19	1.74	0.203	
Proportion agriculture in local watershed	1, 19	4.59	0.045	higher
Proportion muck/silt substrate	1, 19	1.12	0.303	
Proportion organic substrate	1, 19	0.63	0.438	
Proportion wood substrate	1, 19	0.07	0.800	
Proportion claypan substrate	1, 19	1.05	0.318	
Proportion sand substrate	1, 19	0.02	0.904	
Proportion gravel substrate	1, 19	0.10	0.760	
Proportion cobble substrate	1, 19	0.64	0.434	
Proportion boulder substrate	1, 19	0.74	0.400	
Proportion bedrock substrate	1, 19	2.99	0.100	
Mean water depth	1, 19	2.33	0.143	
Mean wetted width	1, 19	0.16	0.694	
Proportion run	1, 19	0.02	0.879	
Proportion riffle	1, 19	1.85	0.189	
Proportion pool	1, 19	2.19	0.156	
Instream vegetation	1, 19	0.51	0.486	
Percent channel shading	1, 19	0.02	0.901	
pH	1, 17	8.26	0.011	higher
Dissolved oxygen concentration	1, 17	11.76	0.003	higher
Conductivity	1, 17	0.85	0.370	
Temperature	1, 17	9.21	0.007	lower
Additional fish species richness	1, 19	0.34	0.569	

Table 5. Instream and riparian characteristics at spring cavefish survey locations.

	Substrate Composition (%)									Channel and Flow			Channel Unit Comp. (%)		
Site ID	**Muck/Silt**	**Organic**	**Wood**	**Claypan**	**Sand**	**Gravel**	**Cobble**	**Boulder**	**Bedrock**	**Mean Depth (m)**	**Mean Width (m)**	**Flow**	**Run**	**Riffle**	**Pool**
SNC 1*	90		10							0.3	2	Very low			100
SNC 2*	10						90			0.1	1	Moderate		60	40
SNC 3*							100			0.1	0.5	Low		90	10
SNC 4			20		80					0.1	1	Low		95	5
SNC 5*	45	45			10					0.1	1	Low	100		
SNC 6*		25			50		25			0.1	0.75	Moderate		90	10
SNC 7*							60		40	0.5	3	Moderate	10	60	30
SNC 8*		10		80		10				0.5	5	Moderate	70	10	20
SNC 9							20		80	very little water present	n/a	None			100
SNC 10*		10		80	10					0.5	5	Low	70	10	20
SNC 11						10	40		50	0.8	2	Moderate	20	60	20
SNC 12						10	50		40	0.8	5	Moderate	50	10	40
SNC 13*	5	10				85				0.1	1	Moderate		90	10
SNC 14	50	50								1.0	1.5	Very low			100
SNC 15	20	20		60						0.1	0.5	Low	85	10	5
SNC 16				10		30	60			0.3	3	Low	40	40	20
SNC 17						10	60		30	0.5	1	Low	30	35	35
SNC 18						10	70	20		0.2	0.5	None			100
SNC 19						10	90			0.5	0.5	Low		10	90
SNC 20						10	50		40	0.5	5	Low	70	10	20
SNC 21						5	80		15	0.3	2	Low	10	30	60

* spring cavefish collected at this site

Table 5 (continued). Instream and riparian characteristics at spring cavefish survey locations.

	Vegetation Type & Density (%)				Bank Composition (%)					Riparian Structure				
Site ID	Emergent	Submergent	Overhanging	Floating	Bare	Herbaceous	Woody	Trees	Bedrock	Right Width (m)	Right Composition	Left Width (m)	Left Composition	Shading (%)
SNC 1*	10				100					> 100	Trees & swamp	> 100	Trees	100
SNC 2*						80		20		> 100	Trees	> 100	Trees	50
SNC 3*						80		20		> 100	Trees	> 100	Trees	50
SNC 4	5				50	50				> 100	Trees	> 100	Trees	100
SNC 5*	10				50	50				> 100	Trees	> 100	Trees	100
SNC 6*	20					70			30	> 100	Trees	> 100	Trees	100
SNC 7*					50				50	> 100	Trees	> 100	Trees	30
SNC 8*					50	40		10		5	Trees	5	Trees	30
SNC 9										5	Trees	50	Trees	20
SNC 10*	5		5		70	20		10		1	Trees	50	Trees	70
SNC 11	20				20	60			20	> 100	Trees	50	Herbaceous	0
SNC 12	10				80	10		10		5	Trees	> 100	Trees	90
SNC 13*	10	10			80	20				> 100	Trees	> 100	Trees	80
SNC 14					No bank					2	Herbaceous	> 100	Trees	100
SNC 15					100					> 100	Trees	> 100	Trees	90
SNC 16					90	10				10	Trees	5	Trees	80
SNC 17	5	10			30	20			50	1	Herbaceous	> 50	Trees	25
SNC 18	5					80			20	50	Trees	50	Trees	90
SNC 19					60	30	10			> 100	Trees	> 100	Trees	90
SNC 20	10				70	20			10	> 100	Trees	5	Trees	60
SNC 21					20	70		10		> 100	Trees	> 100	Trees	90

* spring cavefish collected at this site

Table 6. Water quality measures taken at spring cavefish locations.

Site ID	pH	DO (mg/l)	Conductivity (µS/cm)	Temperature (°C)	Estimated Clarity (m)
SNC 1*	8.55	7.55	242	13.1	>0.5
SNC 2*	8.44	8.97	136	13.0	>0.25
SNC 3*	8.25	9.34	127	12.6	>0.5
SNC 4	7.98	8.48	167	12.9	>1
SNC 5*	7.77	8.43	248	12.9	>0.1
SNC 6*	8.18	9.86	245	11.2	>0.1
SNC 7*	7.96	10.14	251	11.1	1.0
SNC 8*	8.08	10.57	301	13.3	1.0
SNC 9	NR	NR	NR	NR	NR
SNC 10*	8.16	10.07	139	14.1	0.75
SNC 11	7.62	7.14	201	12.0	>1.5
SNC 12	7.83	10.47	150	11.6	1.0
SNC 13*	7.96	9.31	339	16.0	>0.2
SNC 14	NR	NR	NR	NR	1.0
SNC 15	7.54	5.46	662	15.1	>0.1
SNC 16	8.30	8.19	437	24.0	1.0
SNC 17	7.80	5.52	113	21.0	0.75
SNC 18	7.41	5.05	241	22.0	1.0
SNC 19	7.97	6.32	347	20.5	>0.75
SNC 20	8.04	8.49	362	22.2	1.0
SNC 21	7.58	5.87	145	18.5	1.5

* spring cavefish collected at this site
NR = not recorded

Table 7. Range of conditions present at stream arcs with records of Ozark minnow.

Channel Characteristics			Land Use Proportion						Annual Flow (Yield, cms/km^2)			Mean Daily July
			Local Watershed			Upstream Watershed						
Gradient (ft/ft).	Link	Sinuosity	Urban	Agriculture	Forest	Urban	Agriculture	Forest	High Flow	Average Flow	Low Flow	Temperature (^oC)
0-0.008	3-3042	1.02-1.77	0-0.49	0.05-0.85	0-0.69	0-0.15	0.13-0.79	0.01-0.43	0.0059-0.0233	0.0005-0.0087	<0.0001-0.0058	17.3-27.8

Table 8. Location information for Ozark minnow surveys.

Site ID	Name	Latitude	Longitude	Site Type	Location Description
OZM 1	Rush Creek	42.3088	-88.66693	Modeled	~4km northwest of Marengo, north of Carmack Rd on Noe Rd
OZM 2	North Fork Kinnikinick	42.45042	-88.93475	Record	~23km north of Belvidere on McCurry Rd
OZM 3	North Fork Kinnikinick	42.4354	-88.98392	Record	~8km northeast of Rockford, north of Elevator Rd, on Love Rd
OZM 4	North Fork Kinnikinick	42.43252	-89.0033	Record	~7km northeast of Rockford, east of Highway 251, on Willowbrook Rd
OZM 5	Mill Creek	42.15941	-89.33205	Modeled	~16km northeast of Mount Morris, north of Rte 72, on Water Rd
OZM 6	Leaf River	42.12527	-89.4333	Modeled	~8km north of Mount Morris on Mount Morris Rd
OZM 7	Grove Creek	42.27569	-89.27073	Record	~2km south of Pecatonica on Comly Rd
OZM 8	South Fork Apple River	42.42538	-90.00365	Record	~8km south of Warren, west of Rte 78, on North Stockton Rd
OZM 9	Hells Branch	42.40019	-90.16536	Record	~1.5km downstream of Apple Canyon Reservoir
OZM 10	Irish Hollow Creek	42.314	-90.30658	Record	~6.5km west of Elizabeth on South Rodden Rd
OZM 11	Little Rush Creek	42.25448	-90.19078	Modeled	~8km southeast of Elizabeth on East Hanover Rd
OZM 12	Rush Creek	42.29357	-90.12795	Modeled	~9km southeast of Elizabeth on East Bethel Rd

Table 9. Stream and local watershed land use characteristics at Ozark minnow survey locations.

	Stream Characteristics			Proportional Land Use		
Site ID	Drainage Area (km^2)	Stream Order	Gradient (ft/ft)	Agriculture	Urban	Forest
OZM 1	79.9	2	0.0017	0.52	0	0.07
OZM 2	28.6	2	0.0050	0.16	0.01	0.16
OZM 3	52.2	2	0.0039	0.24	0.49	0.11
OZM 4	52.2	2	0.0039	0.24	0.49	0.11
OZM 5	51.9	3	0.0017	0.41	0.01	0.06
OZM 6	129.5	4	0.0012	0.57	0	0.37
OZM 7	16.1	2	0.0023	0.58	0	0.09
OZM 8	36.5	3	0.0078	0.32	0	0.15
OZM 9	55.2	3	0.0030	0.24	0	0.25
OZM 10	32.7	3	-0.0003	0.22	0	0.10
OZM 11	38.9	2	0.0022	0.33	0	0.12
OZM 12	59.0	3	0.0028	0.24	0	0.20

Table 10. Instream and riparian characteristics at Ozark minnow survey locations.

	Substrate Composition (%)									Channel and Flow			Channel Unit Comp. (%)		
Site ID	Muck/Silt	Organic	Woody	Claypan	Sand	Gravel	Cobble	Boulder	Bedrock	Mean Depth (m)	Mean Width (m)	Mean Flow	Run	Riffle	Pool
OZM 1	10				20	70				0.7	4	Moderate	60	20	20
OZM 2	20					50	30			0.5	3	Moderate	50	25	25
OZM 3				10		60	30			0.5	4	Moderate	30	20	50
OZM 4					10	90				0.8	4	Low	0	10	90
OZM 5	50			40	10					0.5	4	Moderate	70	10	20
OZM 6				10	10	80				0.5	6	High	50	40	10
OZM 7	40			10		50				0.3	2	Low	80	10	10
OZM 8						30	70			0.4	4	Moderate	60	30	10
OZM 9	50					40	10			0.5	7	Low	20	20	60
OZM 10	70			20		10				0.4	4	Moderate	70	10	20
OZM 11	10			90						0.7	3	High	90	10	0
OZM 12				50		50				0.5	7	High	40	20	40

Table 10 (continued). Instream and riparian characteristics at Ozark minnow survey locations

	Vegetation Type & Density (%)				Bank Composition (%)					Riparian Structure				
Site ID	Emergent	Submergent	Overhanging	Floating	Bare	Herbaceous	Woody	Trees	Bedrock	Right Width (m)	Right Composition	Left Width (m)	Left Composition	% Shading
OZM 1	5		10		10	90				3	Herbaceous	3	Herbaceous	0
OZM 2	10		5		10	90		20		20	Trees	5	Trees	30
OZM 3	5		10		50	40		10		5	Trees	5	Trees	50
OZM 4			10		60	35		5		2	Trees	5	Trees	80
OZM 5			10		70	30				3	Trees	5	Trees	50
OZM 6	5		5		30	70				5	Herbaceous	5	Herbaceous	0
OZM 7	20		10		50	50				>100	Herbaceous	>100	Herbaceous	30
OZM 8			5		75	20			5	3	Trees	>100	Herbaceous	50
OZM 9			10		40	40	20			>100	Trees	>100	Trees	10
OZM 10	5		20		80	20				>100	Trees	>100	Herbaceous	70
OZM 11			10		10	90				5	Herbaceous	5	Herbaceous	0
OZM 12	5		5		80	20				>100	Herbaceous	>100	Herbaceous	10

Table 11. Water quality measures taken at Ozark minnow locations.

Site ID	pH	DO (mg/l)	Conductivity (µS/cm)	Temperature (°C)	Estimated Clarity (m)
OZM 1	8.12	10.02	784	17.2	1.5
OZM 2	8.18	8.84	703	22.5	1
OZM 3	8.18	8.56	794	21.5	0.5
OZM 4	8.36	9.12	750	21.9	0.5
OZM 5	8.13	8.12	705	17.0	0.4
OZM 6	8.10	8.44	660	19.7	1
OZM 7	8.06	8.24	788	15.5	0.3
OZM 8	8.21	9.81	621	19.0	1.0
OZM 9	8.18	8.26	403	24.1	0.5
OZM 10	8.06	7.52	523	18.4	0.3
OZM 11	7.65	7.40	NR	19.0	0.1
OZM 12	7.95	NR	601	20.5	0.4

Table 12. Sampling effort and biotic community information at Ozark minnow survey locations.

Site ID	Method	Sample Length (m)	Sample Time (minutes)	n Collected	# Other Fish Species
OZM 1	backpack electrofishing	200	40	0	14
OZM 2	backpack electrofishing	200	30	0	10
OZM 3	backpack electrofishing	150	30	0	10
OZM 4	backpack electrofishing	100	20	0	5
OZM 5	backpack electrofishing	150	30	0	3
OZM 6	backpack electrofishing	20	30	0	10
OZM 7	backpack electrofishing	200	20	0	1
OZM 8	backpack electrofishing	200	30	0	11
OZM 9	backpack electrofishing	150	30	0	10
OZM 10	backpack electrofishing	200	30	0	11
OZM 11	backpack electrofishing	100	20	0	4*
OZM 12	backpack electrofishing	200	30	0	8

* sample could not be completed; this value is an estimate based on incomplete sample identification procedure.

Table 13. Range of conditions present at stream arcs with records of largescale stoneroller.

Channel Characteristics			Land Use Proportion: Local Watershed			Land Use Proportion: Upstream Watershed			Annual Flow (Yield, cms/km^2)			Mean Daily July
Gradient (ft/ft)	Link	Sinuosity	Urban	Agriculture	Forest	Urban	Agriculture	Forest	High Flow	Average Flow	Low Flow	Temperature (^{o}C)
0-0.016	1-3242	1.01-2.77	0-0.81	0.01-0.94	0-0.78	0-0.76	0.02-0.94	0.01-0.30	0.0104-0.0233	0.0012-0.0107	<0.0001-0.0072	17.9-25.1

Table 14. Location information for largescale stoneroller surveys.

Site ID	Name	Latitude	Longitude	Site Type	Location Description
LSS 1	East Branch Embarras	39.94667	-88.14209	Record	~7.5km north of Villa Grove, east of Rte 130, on 1700E Rd between 400 and 500N Rd
LSS 2	East Branch Embarras	39.93816	-88.16481	Record	~7.5km north of Villa Grove, west of Rte 130, slightly north of 400N Rd
LSS 3	Hammond Mutual Ditch	39.75479	-88.6346	Modeled	~4km north of Lovington, north of 2400N Rd
LSS 4	Little Kickapoo Creek	40.37741	-88.90095	Modeled	~10km southeast of Bloomington, south of Interstate 74, on 1900E Rd
LSS 5	Little Prairie Creek	40.28985	-89.1136	Record	~5km southeast of McLean, north of the county line, on 050N Rd
LSS 6	Rock Creek	40.59344	-89.22169	Modeled	~20km northwest of Normal, south of Interstate 74, north of 2100E Rd, on 1650E Rd
LSS 7	Tower Wall Ditch	40.48759	-88.16096	Modeled	~5km northwest of Paxton, east of Rte 115 on 600N Rd
LSS 8	Indian Creek	40.6655	-88.52593	Modeled	~9.5km south of Fairbury on 2100E Rd, west of 2200E Rd
LSS 9	Felky Ditch	40.87545	-88.48243	Modeled	~12km east of Pontiac, on 1700N Rd

Table 15. Stream and local watershed land use characteristics at largescale stoneroller survey locations.

	Stream Characteristics			Proportional Land Use		
Site ID	Drainage Area (km^2)	Stream Order	Gradient (ft/ft)	Agriculture	Urban	Forest
LSS 1	88.7	2	0.0008	0.91	0.01	0.01
LSS 2	130.8	3	0.0000	0.76	0	0.02
LSS 3	177.5	3	0.0033	0.22	0.02	0.00
LSS 4	32.1	2	0.0030	0.59	0	0.01
LSS 5	38.2	3	0.0019	0.83	0.01	0.01
LSS 6	75.0	3	0.0024	0.37	0.06	0.18
LSS 7	83.9	3	0.0005	0.91	0.01	0.01
LSS 8	89.5	3	0.0005	0.87	0.01	0.01
LSS 9	80.3	3	0.0009	0.90	0	0.01

Table 16. Instream and riparian characteristics at largescale stoneroller survey locations.

	Substrate Composition (%)									Channel and Flow			Channel Unit Comp. (%)		
Site ID	Muck	Organic	Woody	Claypan	Sand	Gravel	Cobble	Boulder	Bedrock	Mean Depth (m)	Mean Width (m)	Mean Flow	Run	Riffle	Pool
LSS 1				10	90					0.75	5	Low	100	0	0
LSS 2	10			80	10					1	7	Low	10	0	90
LSS 3	10			30	60					1	4	High	70	0	30
LSS 4				10	30	60				0.5	5	Moderate	20	40	40
LSS 5	10				45	45				0.5	3	Moderate	60	20	20
LSS 6	10				40	50				0.5	7	Moderate	20	40	40
LSS 7				80	20					0.25	4	Low	100	0	0
LSS 8	20			60		10				0.5	6	Low	85	5	10
LSS 9					60	30	10			0.5	8	Low	70	10	20

Table 16 (continued). Instream and riparian characteristics at largescale stoneroller survey locations.

	Vegetation Type & Density (%)				Bank Composition (%)					Riparian Structure				
Site ID	Emergent	Submergent	Overhanging	Floating	Bare	Herbaceous	Woody	Trees	Bedrock	Right Width (m)	Right Composition	Left Width (m)	Left Composition	% Shading
LSS 1	5		5		10	90				2	Herbaceous	2	Herbaceous	0
LSS 2	5		5		10	90				>100	Herbaceous	>100	Herbaceous	0
LSS 3		20	5		30	70				>100	Herbaceous	50	Herbaceous	10
LSS 4		5	5		20	70		10		5	Trees	50	Trees	80
LSS 5		5	5		10	90				3	Herbaceous	3	Herbaceous	0
LSS 6			5		30	60		10		10	Trees	10	Trees	70
LSS 7		70	10			100				5	Herbaceous	5	Herbaceous	0
LSS 8	5		10			95		5		1	Herbaceous	5	Herbaceous	5
LSS 9			10			100				1	Herbaceous	1	Herbaceous	0

Table 17. Water quality measures taken at largescale stoneroller locations.

Site ID	pH	DO (mg/l)	Conductivity (µS/cm)	Temperature (°C)	Estimated Clarity (m)
LSS 1	8.13	7.44	692	18.8	>1
LSS 2	7.85	8.00	694	19.7	0.3
LSS 3	8.10	14.08	702	21.3	0.5
LSS 4	7.87	6.86	728	19.8	1
LSS 5	7.87	12.23	732	18.9	1
LSS 6	8.09	9.28	744	22.9	0.75
LSS 7	8.68	9.01	689	22.9	>0.25
LSS 8	7.91	7.91	725	25.9	0.5
LSS 9	8.37	8.41	1072	22.6	0.5

Figures

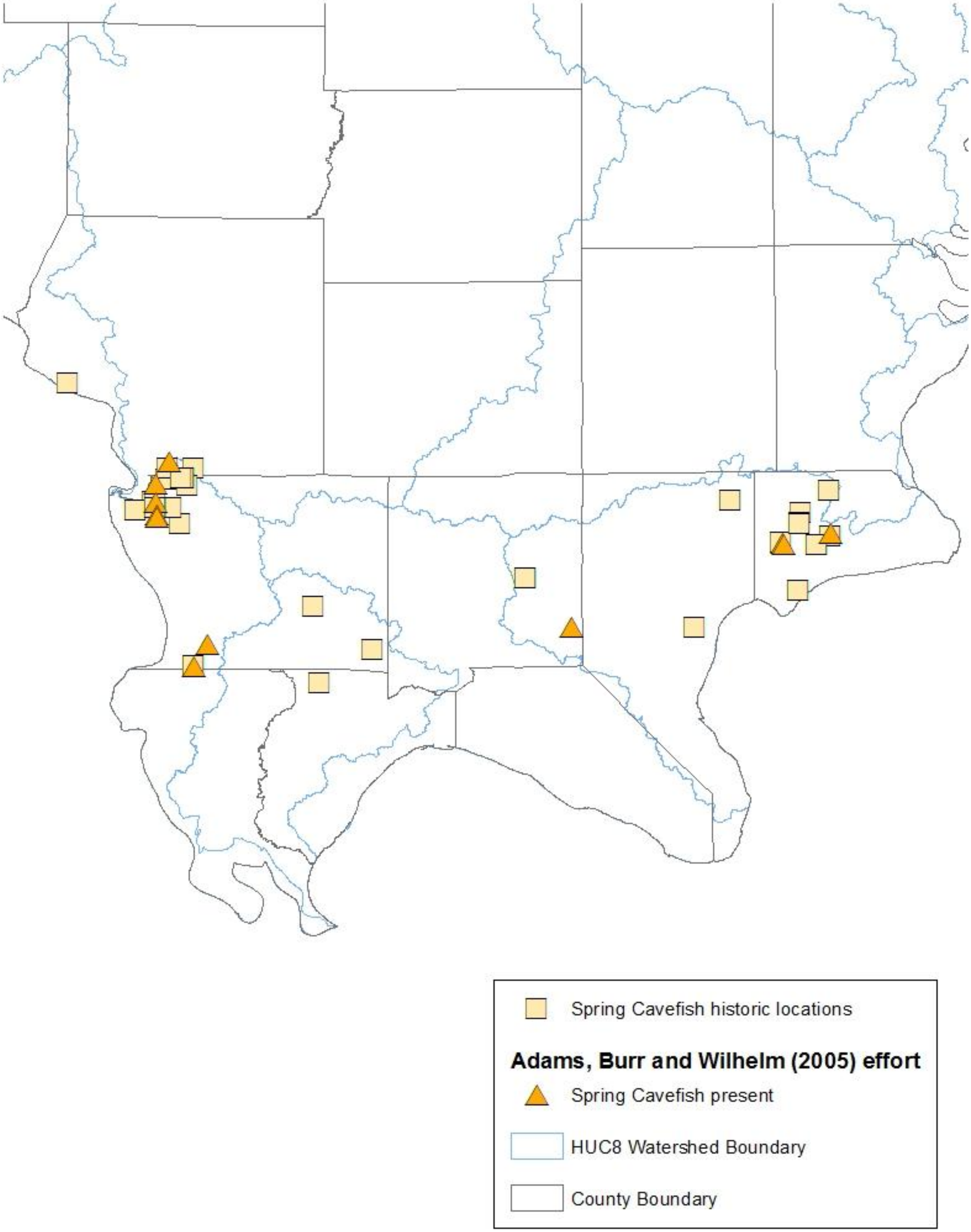

Figure 1. Spring cavefish collection records, including Adams, Burr and Wilhelm (2005) efforts which represent the most recent records.

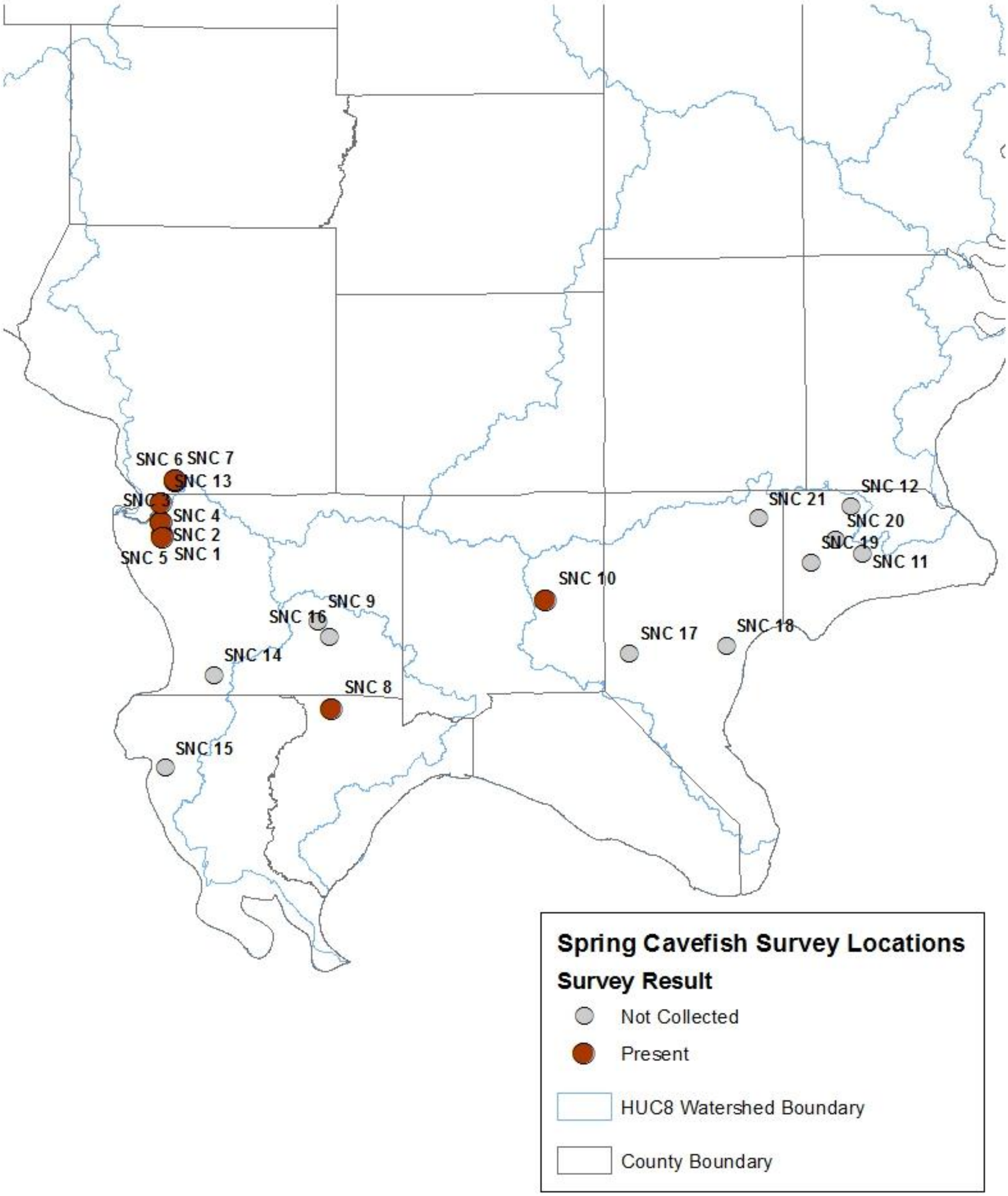

Figure 2. Survey locations and result during 2013 study.

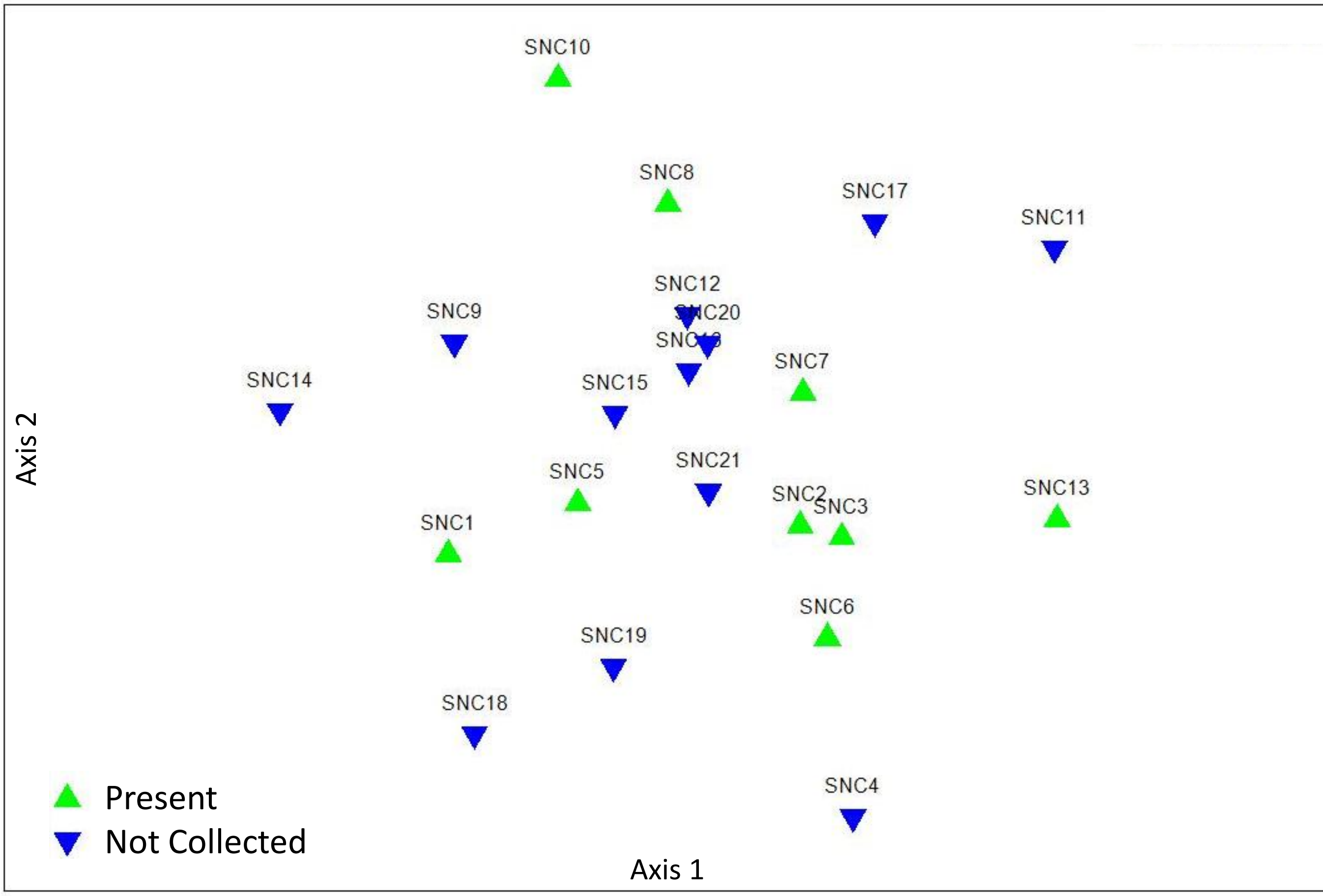

Figure 3. Non-metric multi-dimensional scaling of habitat characteristics (Table 5) at spring cavefish sampling locations. Total variation explained by axis 1 and 2 is 29.0%. Points (sites) are symbolized according to sampling success (i.e., present or not collected).

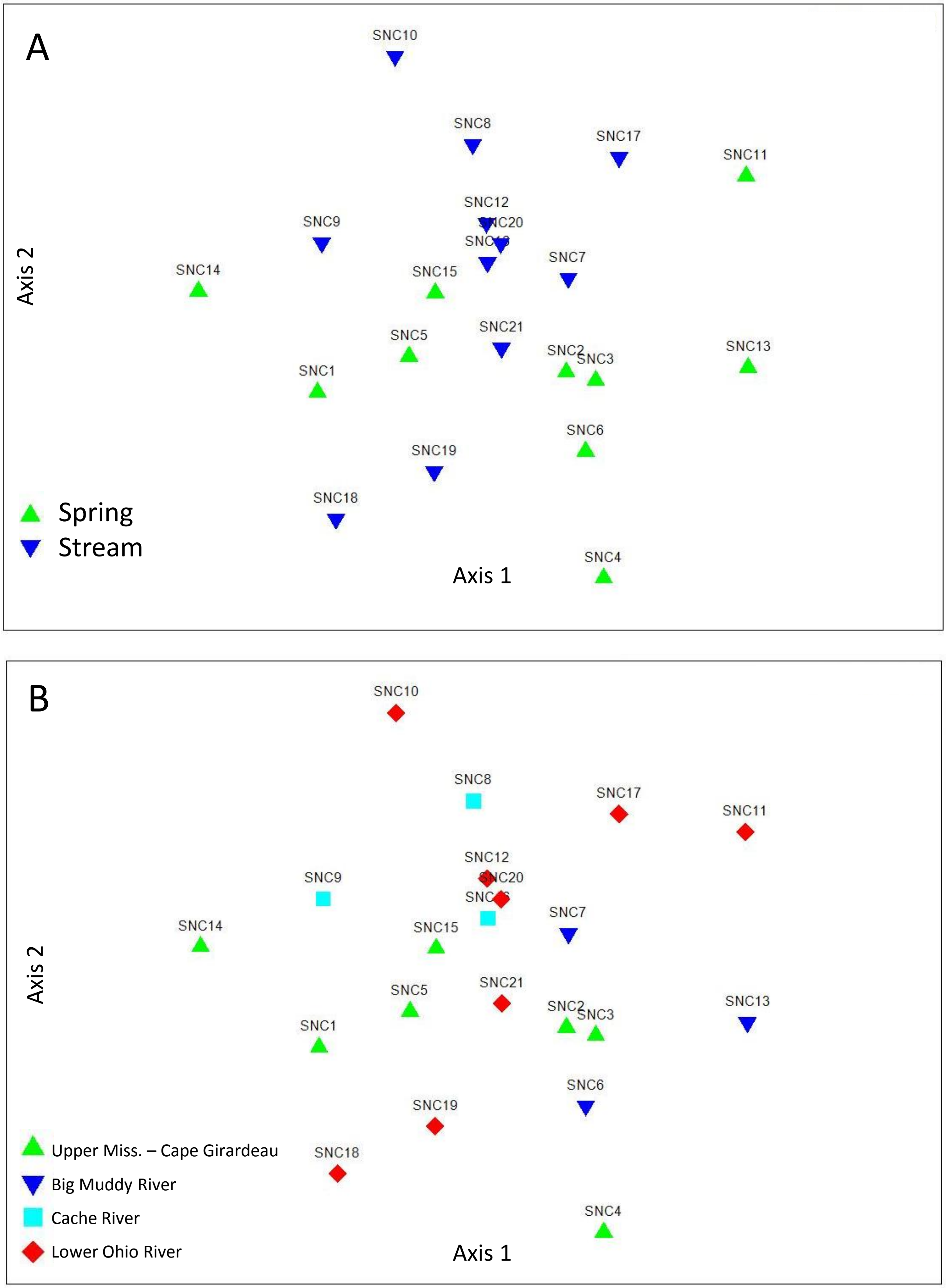

Figure 4. Non-metric multi-dimensional scaling of habitat characteristics (Table 5) at spring cavefish sampling locations. Points (sites) are symbolized according to water body type (A) or HUC8 (B).

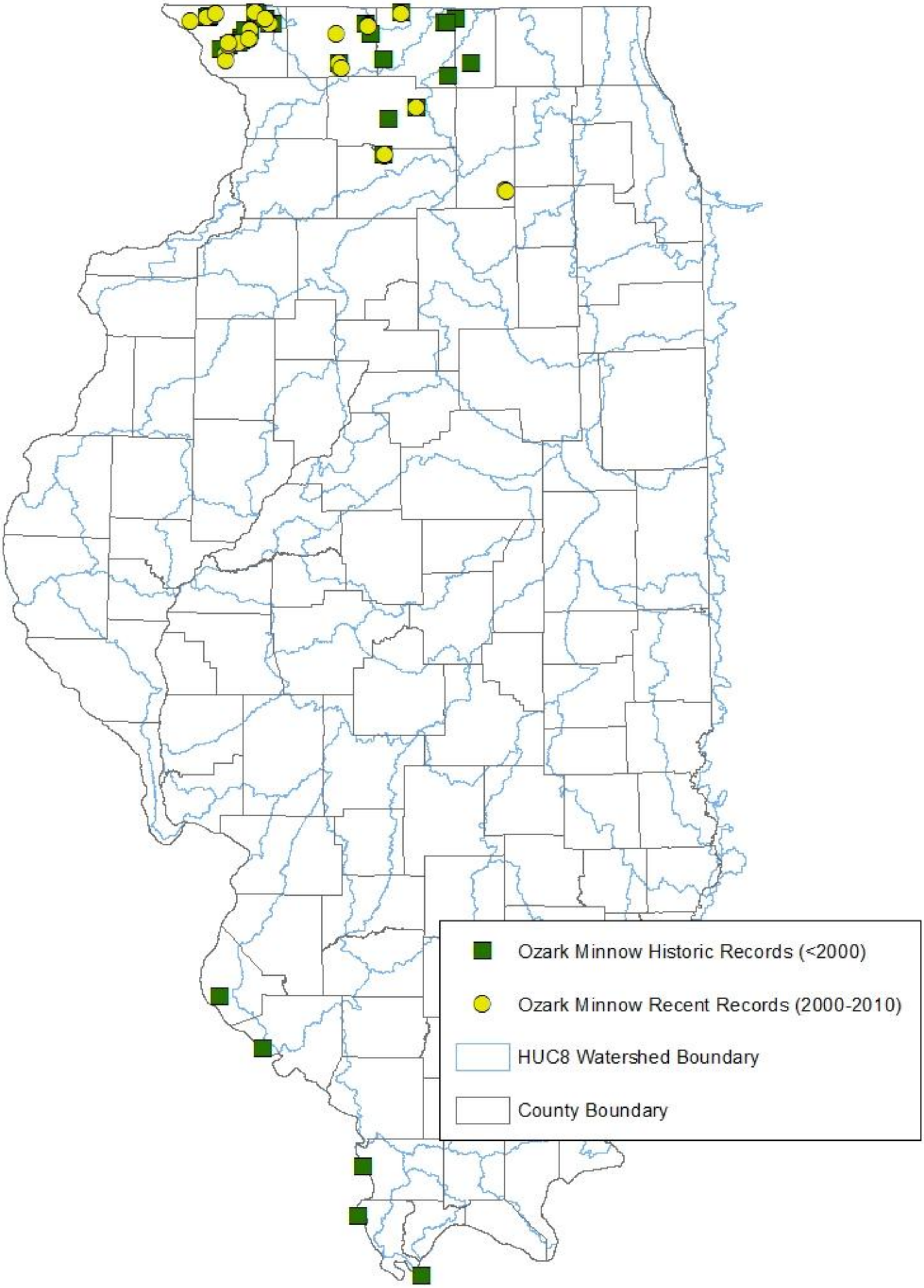

Figure 5. Recent and historic distribution of Ozark minnow.

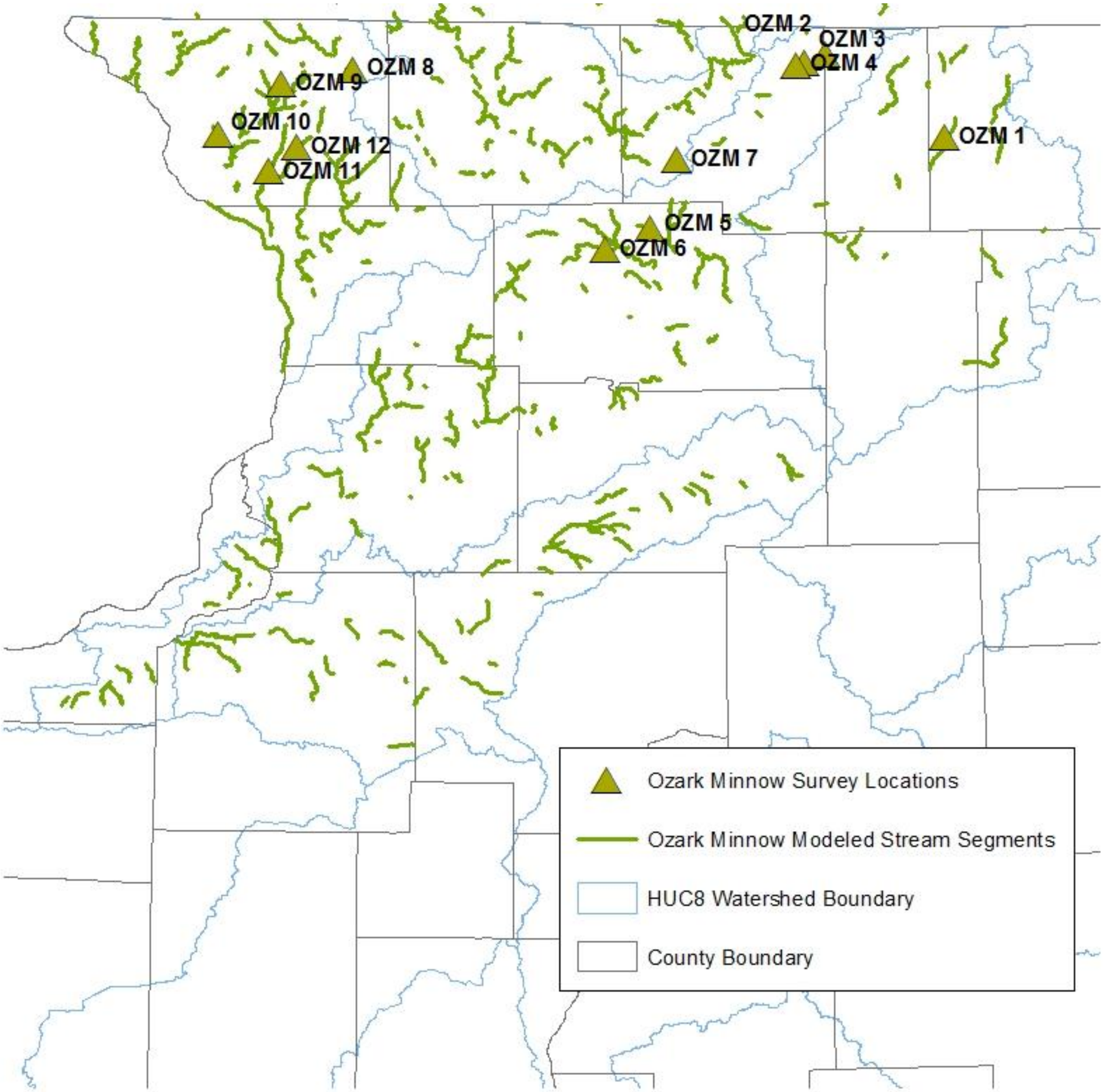

Figure 6. Ozark minnow survey locations and potential stream arcs identified by habitat suitability model.

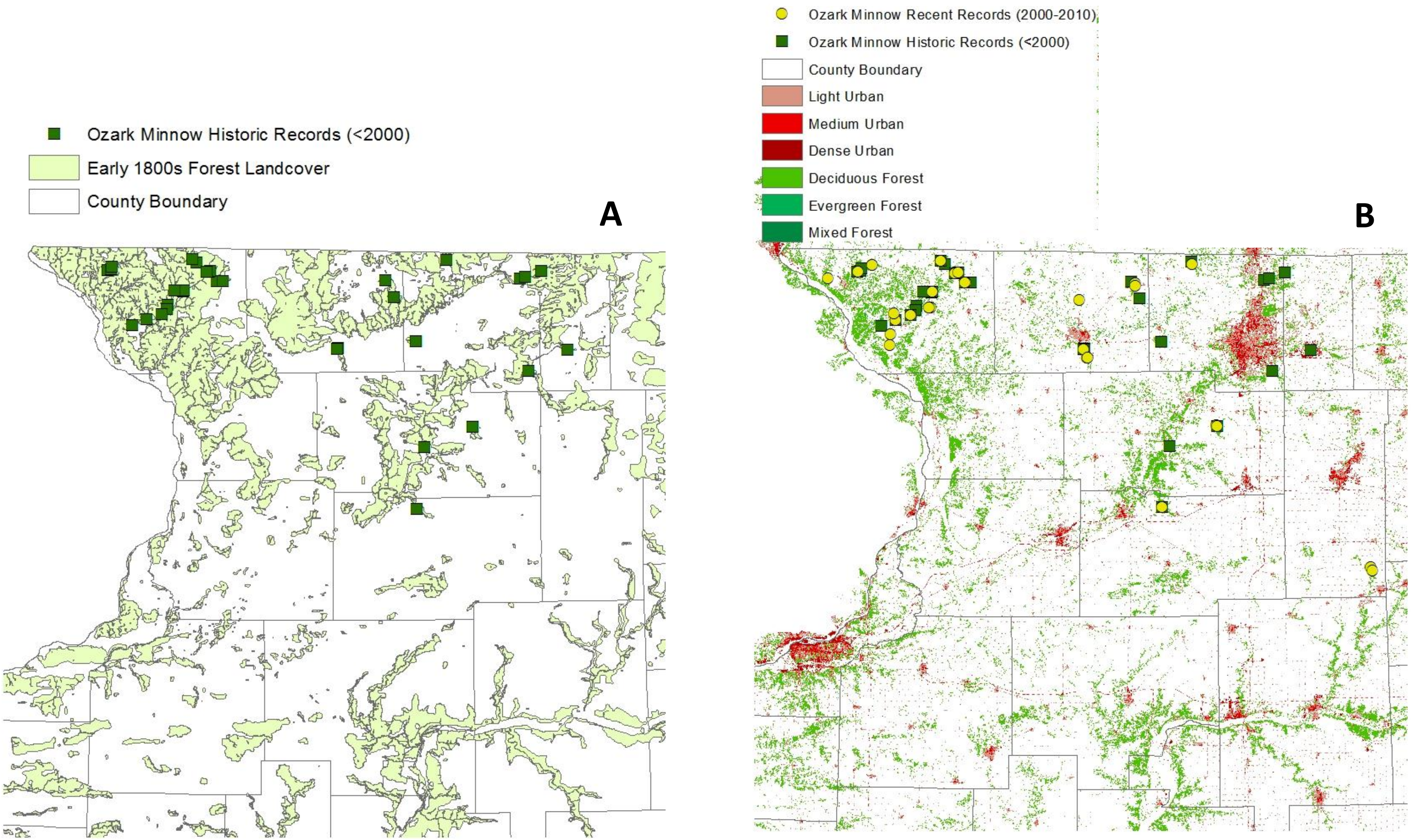

Figure 7. Comparison of 1800s landcover (A) and 2006 landcover (B). Ozark minnow distribution (green squares) occurred in a region of Illinois that was largely forested. Much of those forests have been converted to pasture and agriculture land. Several urban areas have also developed within the historic distribution.

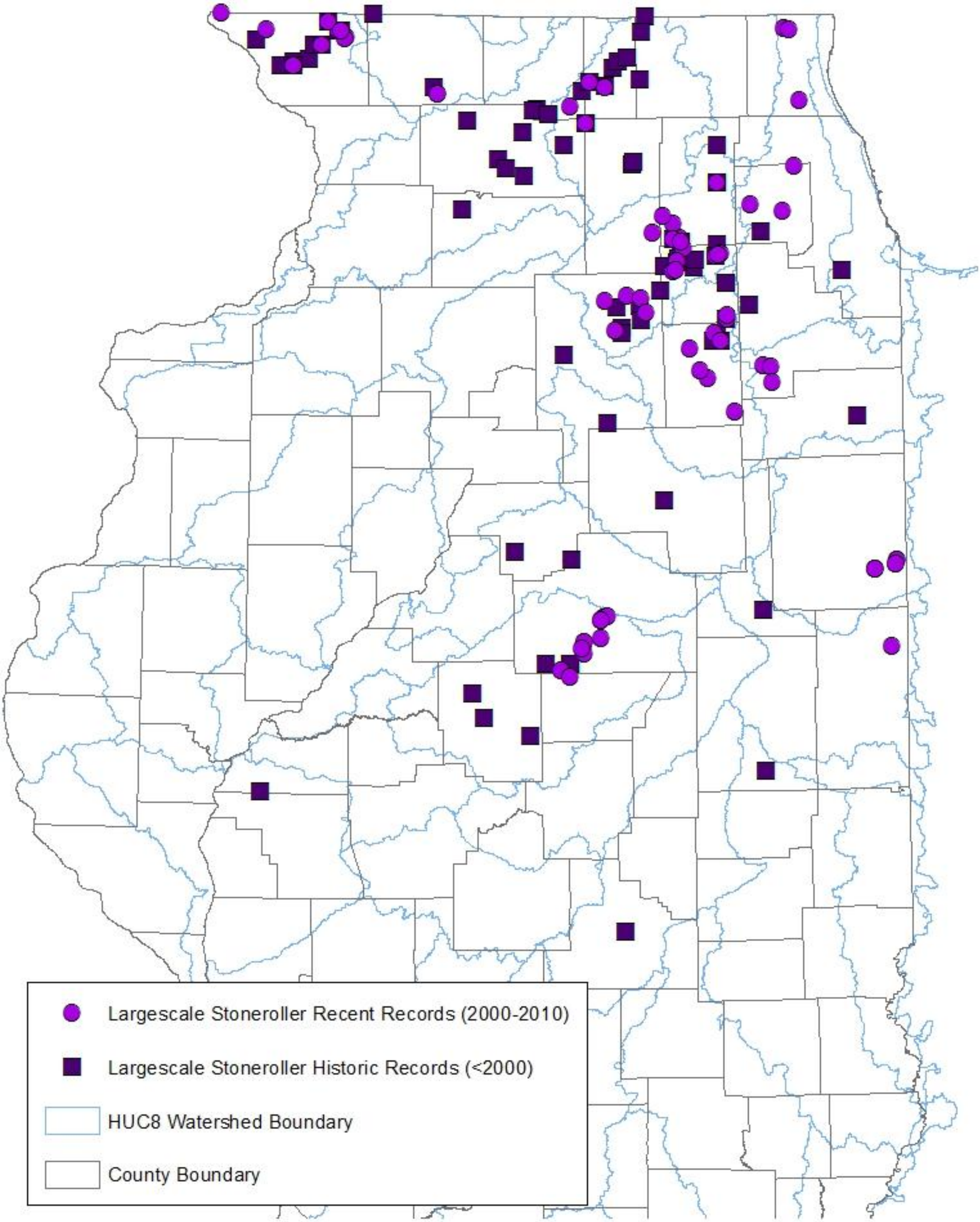

Figure 8. Recent and historic distribution of largescale stoneroller.

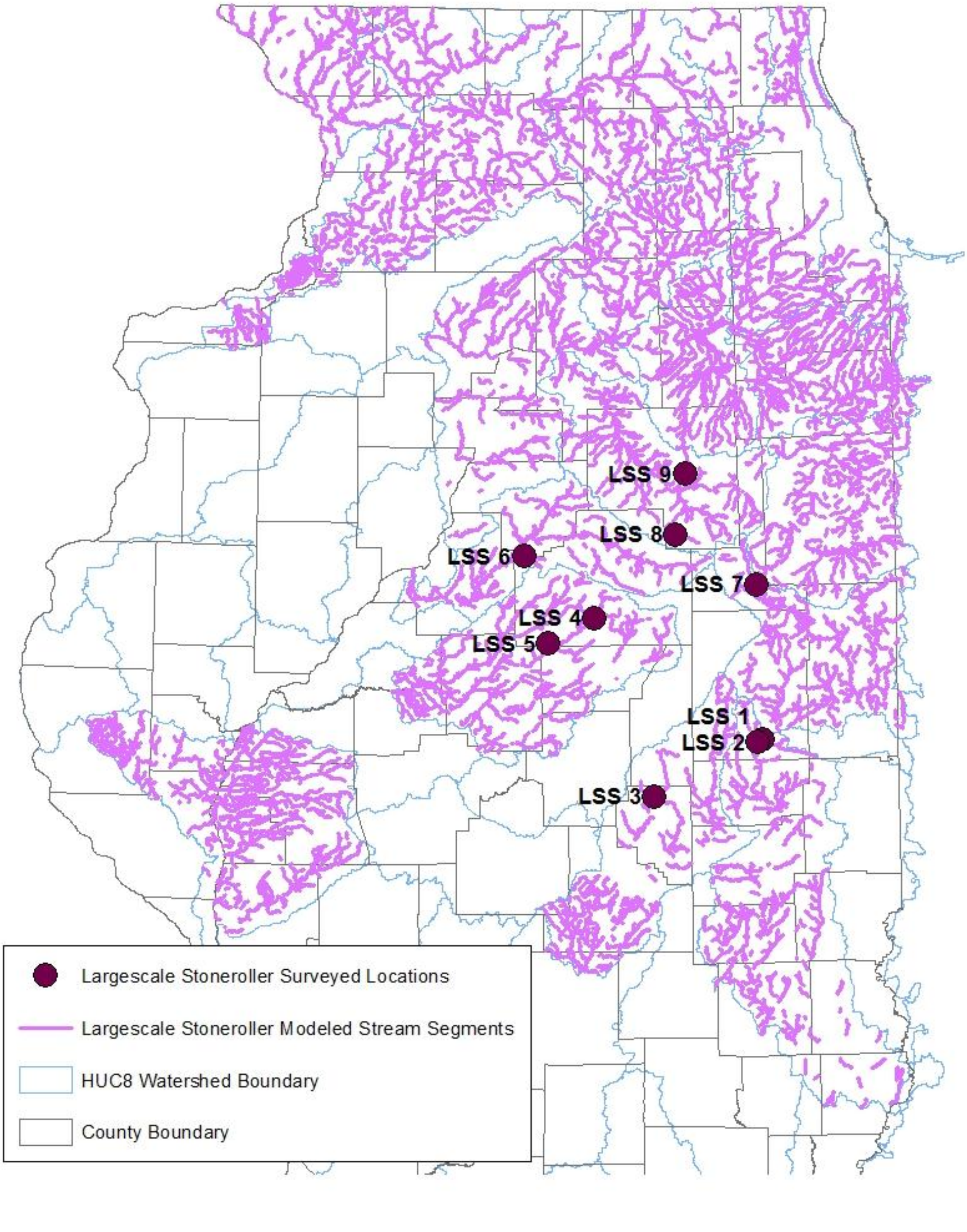

Figure 9. Largescale stoneroller survey locations and potential stream arcs identified by habitat suitability models.

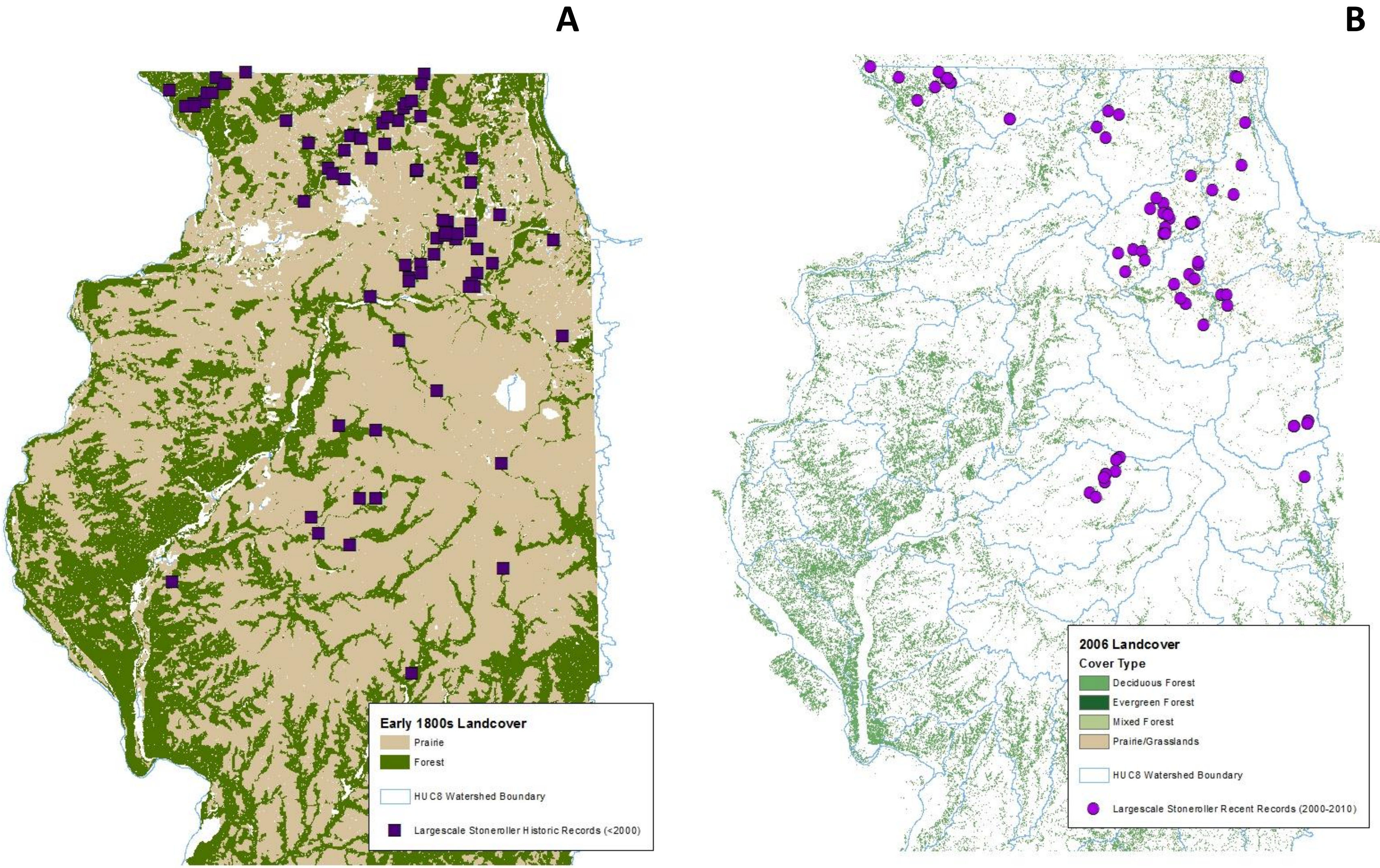

Figure 10. Comparison of early 1800s landcover (A) and 2006 landcover (B). Historic largescale stoneroller distribution occurred in forested streams within largely prairie landscapes (A). Nearly all Illinois prairie has been converted to agricultural lands and forested riparian zones are highly fragmented (B).