

Role of water availability on fish assemblage structure: effects of agricultural land use and spawning mode

by

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Abstract

The availability of water has been changing as human demands increase, weather patterns change, and land use is altered. This is a common trend throughout the world as well as in the tributaries of the Middle Chattahoochee River Drainage. While many studies have examined the effects of drought on fish assemblages, few have studied long-term decreases in water availability and associated fish assemblage changes. The aim of this study was to examine the effects long- and short-term effects of water availability on fish assemblages. Stream discharge has steadily decreased in the study area over the last 50 years, leading to fish assemblage homogenization over time. Species that prefer or tolerate low flow conditions such as *Cyprinella venusta*, *Lepomis auritus*, and *Percina nigrofasciata* are becoming dominant and replacing historically dominant species such as *Notropis hypsilepis*, *Lythrurus atrapiculus*, and *Notropis cummingsae*. When looking at short term changes between a dry year and a wet year, some species preferring higher flows, such as *Notropis hypsilepis*, have recovered when water returns after a drought, suggesting that the amount of water is important for the persistence of some species. Land use changes in relation to water availability have also been observed to play a role in fish assemblage homogenization. We believe these changes are occurring based on differential spawning modes. Species that can reproduce successfully in low flow conditions are thriving and expanding their native ranges while species that require higher flows for successful reproduction however are declining overall, despite temporary recovery during wet years.

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Introduction

Water availability has become one of the highest profile conservation topics. Scientists predict that the current distribution of freshwater will change as greenhouse warming increases, causing a shift in water availability that will leave some areas currently wet, dry (Carpenter et al, 1992; Milly et al, 2005). With water availability decreasing as the human population increases, its impact on aquatic systems is of great concern. Drought and consumptive water removal by humans threaten the existence of fishes worldwide and research is needed to understand these complex issues and develop plans to mitigate the effects of reduced water availability on fish assemblages.

Reduced water availability as an aquatic disturbance is almost prominent cause of fish species declines and assemblage shifts (Matthews & Marsh-Matthews, 2003). Some of the most important variables that predict fish community structure include water depth, substratum, and water velocity (Pires et al, 1999). Natural drought and water removal can directly affect all three of these variables, causing negative effects on fish assemblages (Grossman et al, 1990). Fishes living in fluctuating aquatic systems must have physical and/or behavioral adaptations to persist in such unpredictable environments (Humphries & Baldwin, 2003; Matthews & Marsh-Matthews, 2003). Some species of fish are able to thrive in conditions with low water levels, reduced flow, and increased sedimentation while others require high water levels, high flows, and heterogeneous substrate to spawn and survive.

As hydrologic conditions are gradually changing over time, so are fish assemblages. While many studies have concentrated on assemblage recovery following a single drought disturbance, few have examined the effects of both short- and long-term hydrologic change on stream fish assemblages (Matthews & Marsh-Matthews, 2003). Poff and Allan (1995) have

demonstrated that hydrologic variation has a great influence on fish assemblage structure based upon analysis of functional feeding groups. They also hypothesize that longer term hydrologic alterations due to climate change and anthropogenic disturbance could modify fish assemblage structure.

The recovery of fish assemblage structure after a drought can be highly dependent on both the intensity and duration of the drought (Magalhaes et al, 2007). Previous research has shown that in some situations fish recolonization of disturbed stream reaches can occur in less than a year (Lonzarich et al., 1998). The length of time and mechanism of recolonization is dependent on many factors however, including species composition, location of refugia, location of source populations, and spawning mode (Ensign et al., 1997; Adams & Warren, 2005). There is also variation and uncertainty regarding the length of time necessary for recolonization to occur in large streams versus small streams (Lonzarich et al., 1998).

In addition to effects a drought has on fish assemblage structure, land use composition in a watershed can impact the speed and likelihood of recovery (Johnston & Maceina, 2008). The conversion of natural land cover to pine monoculture, agriculture, and urban land uses can have many negative effects on aquatic ecosystems (Peterson & Kwak, 1999) by disrupting water flows, nutrient cycles, and soil structure and composition (Schulte et al., 2007). While the type of land use in a watershed has a large impact on the biological integrity of aquatic systems, intensity and location of the land use are also very influential on the integrity of streams (Wang et al., 2001).

The conversion of natural forest to agriculture causes changes in water availability, stream temperature, sedimentation load, and dissolved oxygen levels (Walser & Bart, 1999; Helms et al., 2009). Temperature tolerance is responsible for the distribution limits for

freshwater fishes (Carpenter et al., 1992). Land used for agriculture makes up the largest fraction of land use in many watersheds across the United States (Allan, 2004). Walser & Bart (1999) studied the effects agricultural land use has on fish community structure and in-stream habitat within the Chattahoochee River system. They hypothesized that agricultural land use both reduces habitat complexity, and has a quantifiable impact on downstream fish community structure. Results from the study supported their hypothesis as they found that fish diversity was much lower in mainstream reaches that drained agricultural watersheds, and that in this situation, downstream reaches served as refugia for many species and were important for maintaining species diversity (Walser & Bart, 1999). Downstream reaches have been found to generally have more complex fish assemblages than in headwater streams due to a steadier stream flow, regardless of stream integrity and condition (Herbert & Gelwick, 2003).

Other types of land use known to have a large impact on water availability and fish assemblage structure are urban land use and pine monoculture. Urban land use alters hydrology due to the large amounts of impervious surface. This impervious surface increases runoff volume from precipitation which causes flood frequency and magnitude to rise, while sustained flows become less frequent (Wang et al., 2001; Craven et al., 2010). Flooding is detrimental to stream channel structure by causing bank erosion, pool habitat loss, and sedimentation (Wang et al., 2001). Increased runoff in urban areas can also wash pollutants into streams, which can alter water quality and impact fish health (Wang et al., 2001). While urban land use increases runoff and decreases the amount of precipitation that percolates the soil, pine monoculture allows water to percolate the soil but has a higher rate of water uptake than other forest types (Swank & Miner, 1968). This can accelerate stream drying in areas with high concentrations of pine monoculture, aggravating the effects of natural drought.

The reduced availability of water can negatively impact the ability of fishes to spawn through elevation of temperature, lack of cues by stream discharge, and the drying of critical spawning habitat (Durham & Wilde, 2006). Some fishes depend on cues such as amount of discharge in a stream or flow regime (King et al., 2008) to initiate reproduction, allowing them to spawn at the time when chances of survival for their offspring are best (Durham & Wilde, 2006). A study by Durham and Wilde (2009) explored the relationship between stream discharge and reproductive success of *Notropis buccula* and *Notropis oxyrinchus*. They found that the largest proportion of young-of-year was produced during periods of increased stream flow. They also found that no young-of-year were produced when there was no flow.

Low flows and water level fluctuations are believed to reduce the ability of lithophilic spawners to recruit successfully due to nest site dewatering (Grabowski and Isely, 2007). Since species sensitive to water and habitat change tend to die off first, the richness of sensitive species could be an effective measure in determining stream or river health (Allan, 2004; Peterson & Jennings, 2007). In a study by Sutherland et al. (2002), fishes were divided into three different spawning guilds. These guilds included: benthic crevice and gravel spawners, benthic nest builders and associates, and benthic excavators (Sutherland et al., 2002). This helped to distinguish the effects that sedimentation had on groups of fishes and to show a more significant trend in how sedimentation affects fishes with similar spawning strategies. Spawning guilds relating only to flow requirements could also be used to understand the effects of flow on different groups of fishes.

While water availability is the main driver of assemblage change, there are other factors involving reproduction in fishes that influence the recovery of fish assemblages following a disturbance. Ensign et al. (1997) found that recovery rates differed between two groups of fishes

due to varied amounts of parental investment in offspring. Species that tended to prepare substrate and guard nests had a faster recovery than those that do not prepare substrate or guard nests. One explanation for this is a difference in flow requirements for recruitment (Ensign et al., 1997). Lonzarich et al. (1998) investigated differences in recovery by large versus small fish using standard lengths of all fish collected and determined that larger fish were the first to recolonize. Whether certain species are only recolonizing, or recolonizing and recruiting during a given time period is also an important question that has been poorly studied.

As water availability continues to decline due to water withdrawal, natural drought, and changes in land use, stream fish assemblages are homogenizing. Johnston & Maceina (2008) found that species such as the Blackbanded Darter, Blacktail Shiner, and Redbreast Sunfish have replaced many cyprinid species. This could be due to a decrease in water availability over time and a tolerance or preference for low flows by these species, allowing for increased abundance and native range expansion of these species. Through the success of some species and decline of others due to widespread hydrologic alteration, habitat is becoming more homogenous and fish assemblages are homogenizing with it.

The purpose of this study is to investigate the role of water availability as a mechanism of fish assemblage change across a gradient of streams in the Chattahoochee River drainage in both long- and short-term time periods. The objectives of this study are to correlate fish assemblage changes with short-term hydrologic data between the dry and wet years of 2009, 2010 and 2011, as well as long-term from the 1970's through 2011. Also, land use changes are examined as they relate to changes in both water availability and fish assemblages within these watersheds. Finally, the role of spawning mode as affected by water discharge requirements for successful recruitment is correlated to species presence and absence. This research is important because it

combines water availability and land use effects, both of which are currently of great concern and will help highlight areas at the highest risk of habitat and species loss. Understanding the role of spawning mode and recruitment success as it correlates to water availability may shed light on the proximate mechanisms involved in homogenization of fish faunas.

Study Area

In 2010, 42 sites were sampled in the Uchee, Little Uchee, Halawakee, and Wacoochee Creek systems located in Chambers, Lee, and Russell counties, Alabama, which are tributaries to the Chattahoochee River (Fig. 1). These creek systems are composed of 1st-5th order streams which drain into the Chattahoochee River. Stream width varies from 6-50 feet with average depths ranging from 2-32 inches. Halawakee Creek and Wacoochee Creek are located just above the Fall Line in the Piedmont Upland physiographic region while Little Uchee Creek runs along the Fall Line. The Uchee Creek system lies just below the Fall Line and is within the East Gulf Coastal Plain physiographic region. These areas have been the subject of several previous studies for which historic datasets have been compiled. Sites sampled in 2010 for this study were chosen based on availability of these historic data.

Materials and Methods

Site Selection

Sites on Uchee, Little Uchee, Halawakee, and Wacoochee Creeks have been sampled several times within the past decade (Walser & Bart, 1999; Johnston & Farmer, 2004; Johnston & Maceina, 2008). One of these datasets includes thirty-four sites within the Uchee watershed, sampled in 2004 as part of a biodiversity survey for the watershed (Johnston & Farmer, 2004).

An additional set of approximately 40 sites were sampled in 2005 and 2006 in the Wacoochee and Halawakee Creek watersheds as part of a study by Johnston and Maceina (2008) outlining shifts of fish assemblages in southeastern streams. Walser and Bart (1999) sampled this area in 1995 and provided a dataset that was also used in this study. In the summer of 2009, fourteen sites across all three watersheds were sampled to better understand the effect drought had on fish assemblages. All fourteen of those sites were also sampled in 2010 and 2011.

Coordinates for all these historic sites were compiled as a DBF file and imported into ArcMap to be considered as possible sites for this study. Several additional points were also identified at stream/road intersections and were considered for selection. Thirty-one sites were selected based on several criteria that allowed an evaluation of the effects agriculture has on fish assemblages. To properly test this, sites containing a variety of variables were selected. Controls against sites near agriculture were needed so five sites surrounded by forest with only forest upstream, were selected as control sites. These sites are hypothesized to have the least degraded stream channels and most intact fish assemblages. Two sites near urban land use were selected because a study conducted in Wisconsin by Wang et al. (1997) concluded that streams bordered by urban land uses are often more degraded than those bordered by agriculture. In addition to those seven sites, others with differing quantities of agricultural land were selected. Fifteen sites with agriculture surrounding the site in close proximity were selected, and nine sites with forest surrounding the sites and agricultural lands upstream were chosen. Eleven more sites were added because they were sampled in 2009 and were needed to make short-term assemblage comparisons relating to water availability and other environmental influences.

Sampling methods

To ensure accuracy for data comparison, collection methods were modeled after those established previously by Johnston & Farmer (2004). Sampling was conducted using a backpack electrofisher and a 10ft seine over two passes of a stream reach approximately 50-150m, the more precise length of which was dependent on stream order. Habitat data were taken along three to five transects of the stream reaches. The number of transects taken at each site depended on the size of the stream, and were an approximately equal distance apart. Three measurements of flow, depth, depth of fines, and turbidity were taken along each transect. Transect width, substrate composition, percent woody debris, and percent vegetation were also recorded once at each transect. Sedimentation was determined by observing the depth of fines on cobble, boulder, or bedrock using a small ruler along three points at each transect. Flow was measured using a Marsh McBirney flow meter, and depth and transect width were found using tape measures. Substrate composition, percent woody debris, and percent vegetation were all approximated by personal observation. All fishes collected were anesthetized using MS222, preserved in ten percent formalin, and sorted in the laboratory. The specimens were then placed in jars with fifty percent isopropyl alcohol, labeled, and will later be transferred to the Auburn University Museum collection for use in future research.

The fourteen sites that were sampled in both 2009 and 2010 were also sampled the summer of 2011. Sampling methods remained consistent and five sites were selected to be repeatedly sampled three times with at least a week between each sample. This was done to demonstrate the consistency and effectiveness of our sampling methods.

Data analysis

The Morisita similarity index was used to calculate the similarity of each site's fish assemblage between recent and historic samples. Fourteen sites were sampled in 2009, 2010, and 2011 to show similarity over short time periods. Morisita similarity was calculated for ten sites with samples from 2010 and pre-1980 to demonstrate persistence of assemblage changes over a long time period. Two additional subsets of the sites were used to show more gradual changes over several time periods, moderate in length. Morisita similarity values were interpreted according to Matthews et al. (1988) with values <0.4 considered to have low similarity and values >0.8 considered highly similar. Nonmetric multidimensional scaling of Morisita similarity was used to visualize temporal changes in fish assemblages among creek systems and various sites. Three sites on Wacoochee Creek were selected to show temporal changes in fish assemblages between 1969 and 2011. One site from each of the four creek systems was also selected to show temporal changes between 1995 and 2010. Lastly, three sites from the Uchee Creek system that are frequently disturbed by drought were selected to show short and longer term changes in fish assemblages from 2004 through 2011. In addition, SAS was used to visualize temporal assemblage changes across seventeen sites between 1970, 1995, 2009, 2010, and 2011 using correspondence analysis.

Pearson correlation coefficients between similarity and hydrology were calculated using PAST. There were at least three similarity values for each site due to multiple year comparisons. Similarity by site was compared to time between sample years and the percent of peaks above the 75th percentile flow. Using SPSS, percentile flows were calculated for each month using monthly discharge data from USGS at Fort Mitchell from 1969 to 2011. The percent of monthly flows correspond to the number of years between sample used in similarity value calculations. In

addition to individual site correlations, Pearson correlation coefficients were also calculated for each stream. The same data were used, only sites were combined within each of the four major streams in the study area. To further display trends in water availability, a boxplot was compiled using daily discharge data from the USGS gauge at Fort Mitchell from 1960-2010. Each box represents five combined water years labeled as the beginning year of the first water year and the ending year of the fifth water year.

In addition to variation in flow, land use is known to have an affect on fish assemblage stability. To analyze land use within the study area, the National Land Cover Datasets (NLCD) for 1992 and 2001 were downloaded and imported into ArcMap 9.3.1. The huc12 watersheds layer for the State of Alabama was also uploaded into ArcMap and the watersheds within the study area were isolated. Classification of land use was converted from Anderson Level Classification II to Anderson Level I for both greater accuracy and ease of analysis given that I also created a land use layer for 2011.

To create the 2011 land use layer, Landsat images for March 2011 when there was 0% cloud cover were downloaded. Then the images were loaded into ERDAS Imagine and a supervised classification was used to classify the pixels into the types of land use they represent. Initially Anderson Level II classification was used, but groups were combined to Level I as were the other two land use layers. All three land use layers were separately clipped to each of the watersheds to get the percentage of each type of land use within the watersheds (Fig. 7). Land use was also analyzed on a smaller scale by placing a 2km buffer immediately upstream of each site and calculating land use percentages within each buffer.

To identify the impacts of land use on fish assemblages, all 2010 and 2011 data were combined and variables describing the assemblages were compared to land use and habitat

variables at the respective sites using Pearson Correlation Coefficients calculated using PAST. To identify any differences based on stream order, the 2010 dataset was then separated into two groups and biotic variables including species richness, number of individuals, percent sensitive minnows, and percent *Lepomis auritus* at each site were compared to the upstream land use using Pearson Correlation Coefficients (Jones et al., 1999). Habitat variables are often heavily influenced by the land use around the streams and within the watershed in general. Linear regressions were run using both SPSS and PAST to find important relationships between habitat variables, assemblage characteristics, and land use.

To identify the role spawning mode plays in fish assemblage change or persistence, each species caught had to first be assigned to a spawning guild. Many pieces of literature including Boschung and Mayden (2004), Johnston and Page (1992), and Page (1985) were used to identify the life history strategies of each species with regards to flow preference and necessity. Since our primary concern is the response of each species to changes in flow, species are classified into high flow, moderate flow, and low flow preference guilds. High flow species are those that require high flows for successful spawning and recruitment. Moderate flow species are those that prefer heavier flows but can succeed reproductively and survive in lower flow drought conditions. Low flow species are those that prefer low or no flow for reproduction and recruitment.

For every sample, the percent of individuals representing each guild was calculated. These percentages were compared to land use and habitat data for the entire study area, as well as separately for the Uchee System and Halawakee/Wacoochee Creeks using Pearson Correlation Coefficients. In addition, linear regression was used to find and confirm relationships

between each of the three spawning guilds and flow data that were taken during sampling in 2010 and 2011.

The issue of whether certain species are recolonizing an area during a wet year, or persisting and reproducing regardless of flow is also of concern. In an attempt to understand this, standard length was measured for every individual of the most abundant species for each sample from 2009-2011. Lengths at maturity for all measured species were gathered from Boschung and Mayden (2004) and the number of juveniles and adults of each of these species are reported by site and year for reference.

Results

A large amount of both recent and historic data ranging from 1969 through 2011 is an integral part of this study, allowing us to make both short and long-term comparisons between fish assemblages (Appendix 1, 2). There is variability in sampling method, however our methods, consistent with samples from as far back as 1995 are believed to be the most effective; so presumably recent surveys should detect greater species richness. To ensure that our methods were consistent, 5 sites were sampled 3 times in the summer of 2011 with at least one week between each sample (Appendix 3). A similarity analysis using the Morisita Index suggested that samples at each site were highly similar to each other, except for site 16 which showed moderate similarity for comparisons B-C and A-C (Table 1).

Water availability is changing in the study area with a gradual decrease over time, however a spike in discharge in 2010 has allowed for a long term analysis of faunal change as well as short-term change between a dry year and a wet year (Fig. 2). A comparison of fish assemblage composition over time illustrates persistence at some sites and homogenization at

others. The Morisita Index was used to identify assemblage similarity across several years between 1969 and 2010. The assemblages at most sites have changed greatly between the 1970's and 2010 with only 2 out of 10 sites showing high similarity and 2 showing moderate similarity (Table 2). All assemblage similarity comparisons between 1995, 2004, and 2010 for 7 sites show either high or moderate similarity with only one exception, Hospilika Creek (Table 3). Interestingly, assemblage similarity comparisons for more recent samples taken in 2004, 2009, and 2010 are more variable with most falling into the moderate category (Table 4). For many of the sites, assemblage change seemed to happen mostly between the 1970's and 1990's as collections from the 2000's primarily include highly tolerant, cosmopolitan species (*Cyprinella venusta*, *Lepomis auritus* and *Percina nigrofasciata*), and native cyprinids have all but disappeared.

Using nonmetric multidimensional scaling of Morisita similarity, a more in-depth look was taken at specific sites and systems. A representation of the three sites on Wacoochee Creek from years 1969-2011 reveals that site 12 has undergone the most change over time with assemblages at site 14 remaining fairly consistent and site 13 varying moderately (Fig. 6). Samples taken in 1995, 2004/2006, and 2010 at four sites of similar size representing each of the major creeks in the study area were further analyzed. Assemblages at site 12 on Wacoochee Creek underwent the most change, while site 16 on Little Uchee Creek remained the most stable. Assemblages at site 7 on Halawakee and site 38 on Uchee Creek both changed moderately (Fig. 7). Lastly, since sites 26, 31, and 32 have variable similarity across short time periods, assemblage data for these sites for years 2004, and 2009-2011 was analyzed (Fig. 8). Site 26 displayed extremely high similarity among the four years while sites 31 and 32 displayed very little similarity among each of the four years (Fig. 8).

Changes in similarity may be linked to changes in water availability over the past 50 years. To better understand trends in water availability, hydrographs were constructed using average yearly discharge and average summer discharge data (Fig. 2). Over time, water availability has decreased and become more variable leading to increased species homogenization, causing assemblages to become more similar (Fig. 3). A boxplot of daily discharge data in five year increments demonstrates how, regardless of spikes in discharge, the trend over time has been a decrease in water. The median flows from 1960-1980 in groups of 5 water years are all at or above 100 ft³/s while from 1980-2010 all but one of the medians are at or below 100 ft³/s (Fig. 11). The seventy-fifth percentile flows from 1980-2010 also show a gradual decrease over time. Apart from natural drought, water withdrawals from the human population could be another possible explanation for these trends as they have increased with population growth (Figs. 4, 5). While the water withdrawal data are rough estimates due to error, they do show a clear positive trend with the most withdrawals coming from Russell County for agricultural purposes (Fig. 4).

The decrease in water availability in the study area may be having an effect on the fish assemblages within its streams. The correlations between assemblage similarity and peaks above monthly seventy fifth percentile flows within the same time interval yielded no conclusive result with only two significant coefficients for sites 25 and 26. A comparison between assemblage similarity and number of years between samples also yielded no conclusive results as a whole (Table 6). When similarities were compared by creek system to year intervals and peaks above the seventy fifth percentile, the only significant correlation was -0.58 between assemblage similarity in the Little Uchee Creek system and number of years between samples (Table 7).

Since whole assemblages do not appear to be changing consistently enough to detect changes using these statistics, abundance and stability of individual species over long and short time intervals were analyzed using correspondence analysis. Three of the most sensitive minnow species including *Notropis hypsilepis*, *Notropis cummingsae*, and *Lythrurus atrapiculus* show the highest probability of association with the 1970's meaning they were most abundant during that time period (Fig. 9). Most notable is that *Percina nigrofasciata* and *Cyprinella venusta* show the highest probability of association with 2010 while *Lepomis auritus* and *Semotilus thoreauianus* show relatively even probability of association with 2011, 2010, and 2009 (Fig. 9). In looking at the same species for only 2009-2011, the more homogenous species such as *Percina nigrofasciata*, *Cyprinella venusta*, *Lepomis auritus*, and *Lepomis macrochirus* appear to have a high probability of association with all three years (Fig. 10). The more sensitive species show a weak association with all of the years with *Lythrurus atrapiculus* and *Notropis cummingsae* most highly associated with 2010 and *Notropis hypsilepis* most highly associated with 2011 (Fig. 10).

Short-term comparisons of fish assemblages between dry (2009, 2011), and wet (2010) years showed high resiliency at some sites but not others (Table 5). Nearly all sites with high similarity values were larger streams, most of which have a forested riparian zone. The exceptions are two sites (20 and 26) on small streams that had similarity values of >90% (Table 5). The least similar sites (31-33) are all first order streams with surrounding habitat considered relatively pristine for this watershed. At least two of these were completely dry during 2008 (pers. obs.), and all three went dry again in July of 2011. This variability is best illustrated by the assemblage comparison for site 33, which went from only two species in 2009 to nine in 2010, staying at nine in early June 2011 and zero as the stream dried in July 2011.

Since 1992, there has been a steady decrease in the amount of forested land in each of the four watersheds, and a noticeable increase in urban and agriculture (Fig. 12). The Halawakee and Little Uchee Creek watersheds have experienced the steadiest loss of forest, with all four watersheds experiencing a steady increase in urban land use. The amount of agriculture in each of the watersheds has varied over time with the Uchee watershed having the highest proportion of agricultural land use (Fig. 12). Pine monoculture was also considered, with its highest concentration in the Wacoochee Creek watershed and lowest concentration in the lower part of the Little Uchee Creek watershed (Fig. 13).

The greatest loss of forest near any site is 29 percent upstream of site 14 on Wacoochee Creek between 1992 and 2011. The similarity between assemblages at this site in 1995 and 2010 is moderate. Site 22 suffered a loss of 26 percent of its forest upstream and gained 17 percent urban land use and 11 percent agricultural land use from 1992 to 2011. Its assemblages between 1995 and 2010 also display moderate similarity (Table 9). The least impacted site appears to be site 38 on Uchee Creek with a loss of 8 percent forest and a gain of 2 percent agriculture and 7 percent urban land uses between 1992 and 2011. The assemblages at this site display high similarity between 1995 and 2010 (Table 9).

There have been fewer changes in land cover from 2001-2011 than from 1995-2011 with some changes being either positive or slight. Land upstream of sites 7 and 12 have gained forest and lost agricultural land use since 2001, positively influencing the stream sites. Two of the three sites positively influenced by land use change since 2001 exhibit high assemblage similarity between samples from the early 2000's and 2010. Seven of the twenty-one sites had only slight changes in land use with no real positive or negative influence on the stream habitat with four of those sites exhibiting moderate assemblage similarity (Table 10).

Land use may have different effects on water flow based on the size of the stream. For first and second order streams, the number of fish collected show a positive and significant relationship with the percent forested area 2km upstream (Table 11). There is a significant negative relationship between number of fish collected and the percent agriculture within a 2km buffer upstream of the site. For larger 3rd, 4th, and 5th order streams the relationships are opposite with the number of individuals being negatively correlated with the percent forest and positively correlated with the percent agriculture (Table 11). For these larger streams, species richness is also negatively and significantly correlated with percent forest while positively correlated with percent urban land use (Table 11). Interestingly, when looking at the entire study area, pine monoculture appears to positively affect the percent of green sunfish and centrarchids overall in an area (Table 12). In looking at the relationships between each land use type and assemblage similarity, the only significant relationship is a negative one between assemblage similarity and percent agriculture, $R^2=0.113$, $p<0.05$ (Fig. 14). Assemblage similarity and percent forest display a slightly positive relationship, $R^2=0.043$, $p=0.22$, assemblage similarity and percent pine monoculture also display a slightly positive relationship, $R^2=0.009$, $p=0.58$, and assemblage similarity and percent urban land use display a very weak negative relationship, $R^2=0.002$, $p=0.78$ (Figs. 15, 16, 17).

These changes in assemblage are driven by the reproductive needs of each species. Species were assigned to spawning guilds based solely upon the water flow needs of each species (Table 13). High flow species are those that require year round base flows for successful reproduction and recruitment. Moderate flow species prefer higher flows but their life history strategies have adapted to allow them to reproduce and survive during lower flows as well. Low flow species are those that prefer areas with low flows, such as most centrarchids, most of which

are considered to be homogenous species that can find suitable habitat in nearly any stream reach. The percent individuals in each spawning guild at each site were compared to the site's average flow for both 2010 and 2011. Linear regression showed a weak and insignificant positive relationship between percent high flow species in an assemblage and average flow, $R^2=0.03$, $p=0.18$ (Fig. 18). There was a stronger positive and significant relationship between percent moderate flow species in an assemblage and average flow, $R^2=0.16$, $p<0.05$ (Fig. 19). There was a negative relationship between percent low flow species in an assemblage and average flow suggesting that they do best in areas with little or no flow, $R^2=0.16$, $p<0.05$ (Fig. 20).

While flow is important for successful reproduction and recruitment of many species, the more tolerant species prefer little to no flow and can even succeed in degraded habitats. Five sites suffer frequent drying events and were observed to be mostly dry in the late summers of both 2008 and 2011. In 2009, all but one of the five assemblages were made up entirely of species preferring low flows, site 31 having a ten percent makeup of individuals preferring high flows. In 2010 there was more diversity with all assemblages but site 31 containing species that prefer high or moderate flows. This was not surprising as this was the wettest of the three years. In 2011, only isolated pools were available for sampling at each site and the percent of low flow preferring species at each site was intermediate between the dry year 2009, and the wet year, 2010. Regardless of the availability of water however, homogenous low-flow loving species were dominant in all three years (Table 14).

In support of the trends in water availability over the past 50 years, sensitive species requiring high flows for spawning have either gone undetected at some sites since the 1970's, such as *Lythrurus atrapiculus* (Tables 15, 16), or were detected again in 2010 and 2011 after

going undetected for many years, such as *Notropis hypsilepis* (Tables 15, 17). Other species requiring high flows for spawning, such as *Hybopsis winchelli*, *Luxilus zonistius*, *Nocomis leptocephalus*, *Notropis amplamala*, and *Notropis longirostris* are also most abundant in the wet year 2010 at site 13 on Wacoochee Creek (Table 16). While sensitive species can only succeed in their preferred conditions, species such as *Cyprinella venusta*, *Lepomis auritus*, *Lepomis cyanellus*, and *Percina nigrofasciata* remain in an area once they are established, regardless of the hydrological conditions (Tables 15, 16, 17).

To understand the impacts land use and stream flow have on the ability of each spawning group to survive and reproduce in an area, these variables were compared to the percent of each spawning guild represented in the assemblages using Pearson Correlation Coefficients. The assemblages in Halawakee and Wacoochee Creeks were most impacted by land use as moderate flow preferring species were positively correlated with percent forest and negatively correlated with agriculture and urban land uses. There was also a significant negative relationship between percent low flow species and average flow for Uchee and Little Uchee Creek assemblages. Also in Uchee and Little Uchee Creeks, percent moderate flow species were positively and significantly correlated with average flow and stream width (Table 18).

Lastly, while it may be evident that more sensitive species were detected in a wet year (2010) than in dryer years (2009, 2011), it is important as to whether this is purely due to recolonization or if these fish spawned in these areas during higher flows. In an effort to understand this, standard length was measured for the most abundant species in each sample and separated into juveniles and adults based on the age at maturity (Table 19). Most notably, in the site 12 sample in 2010, 18 *Notropis hypsilepis* individuals were caught, 12 of which were

juveniles. At site 13 in 2010, of the 70 *Luxilus zonistius* individuals that were collected, 52 were juveniles (Appendix 4).

Discussion

Evidence previous to this study suggested that assemblages are changing in the tributaries of the Middle Chattahoochee River Drainage (Johnston & Maceina, 2008). The use of historic data from as early as 1969 has allowed for the identification of gradual changes in species composition in many fish assemblages in the study area. Helms et al. (2009) conducted a similar study in which they investigated the roles of land use and hydrology in fish assemblage change and while they did not investigate trends over time, they did see how these factors are driving fish assemblage change. Not only are fish assemblages changing locally, the flora and fauna or the world, are experiencing native invasions and homogenization of species through human interference (Scott & Helfman, 2001). Fish species are homogenizing due to both human introduction as well as range expansion of tolerant natives in response to changes in habitat (Walters et al., 2003).

The results of this study confirm previous observations made by Johnston and Maceina (2008) that an expansion of homogenous species into streams previously dominated by sensitive minnow species is occurring. Species richness in some of these streams has actually increased due to the addition of these more tolerant species to previously dominant sensitive species which are declining in numbers due to environmental change. Both decreases in water availability and corresponding changes in land use are likely responsible for the faunal changes detected in Halawakee, Wacoochee, Little Uchee, and Uchee Creek systems (Walser & Bart, 1999; Matthews & Marsh-Matthews, 2003).

Over time, water availability in the study area has gradually changed likely due to both drought and increased water withdrawals. Johnston and Maceina (2008) reported an approximate 40% decrease in water availability from 1949 to 2006. The hydrograph and boxplot constructed for this study both indicate that there has been a decrease in streamflow in the study area over the past 50 years. By looking at assemblage similarity between samples taken over the past 40 years, it became evident that assemblage similarity is linked to water availability but changes are not fully explained by hydrological variation alone.

Assemblages have changed drastically between 1970 and 2010 with six out of ten sites having very low similarity. Two of the ten sites have high similarity. Site 28 in Adam's Branch has only had two dominant species from 1980-2010, *Pteronotropis euryzonus* and *Semotilus thoreauianus* while site 14 on Wacoochee Creek has maintained a high similarity between 1969 and 2010 due to its relatively pristine habitat. The low similarity of the majority of sites examined during these time periods coincides with reduced streamflow in the area. When looking at similarity between assemblages from 1995, 2004, and 2010, most assemblages are either highly or moderately similar, suggesting that all three years had similar hydrologic regimes or that assemblages changed mostly between the 1970's and 1995. When looking at a shorter time scale between 2004, 2009, and 2010 the assemblages with low similarity were those observed to be dry in 2008 and 2011, suggesting their similarity is low due to frequent disturbance and recolonization. An even shorter time scale between 2009, 2010, and 2011 revealed high similarity between all samples except for the same frequently disturbed sites. This could mean that while entire assemblages do not change drastically from a dry year to a wet year at most sites, certain species may become more successful in addition to the core group (Scott & Helman, 2001). The response of assemblages to drought is also dependent on magnitude and

duration of low flows and three years of data may not be enough to observe changes due to short term changes of water availability (Magalhaes et al., 2007). Another possible explanation is that recovery of assemblages from drought can be rapid and while there may have been a significant temporary change in assemblages, they may not have been detected at their worst (Humphries & Baldwin, 2003).

In comparing assemblage similarity over time between samples and percent flow peaks above the 75th percentile, the general trend was a negative relationship between assemblage similarity and time, and a positive relationship between similarity and percent peaks above the 75th percentile. This means that assemblages are more similar between short time periods and that assemblages are more similar the more high flows there are within the time period between samples. This supports the idea that higher, sustained instream flows support more stable assemblages as habitat needs for the most species are met (Grossman et al., 1990).

Wacoochee Creek is a diverse system and has maintained its biological integrity over time. It is over 60 percent forest, more than any other watershed studied, and also has the lowest percentage of urban land use of all the watersheds. Site 12 is farthest downstream and closest to Lake Harding which may explain why it has had the most assemblage change out of the three sites sampled on Wacoochee Creek from 1969 through 2011. Of the three sites, 14 has remained the most stable and similar from 1969 through 2011. In looking at sites of similar size from each of the four creeks studied between 1995, 2004/6, and 2010, the assemblages at site 12 on Wacoochee Creek were the most variable, while the assemblages at site 16 on Little Uchee Creek were the most similar. The habitat at site 16 has remained relatively pristine compared to the rest of the study area and since it is a larger site, it maintains a relatively steady flow year round. The assemblages at sites 26, 31, and 32 between 2009, 2010, and 2011 were visualized

using Nonmetric Multidimensional Scaling as well to see how assemblages at frequently disturbed sites respond between dry and wet years. The assemblages at site 26 remained almost identical between the three years because only 4-6 species were present each year and *Lepomis macrochirus* was the only species for which more than four individuals were collected across all three years. The assemblages at sites 31 and 32 varied greatly among years, likely because variation in flow and stream drying forced species to seek areas of permanent flow until habitat at these sites became available for recolonization (Davey & Kelley, 2007). There also appeared to be a shift in dominance between the few species that can tolerate the habitat conditions present at these sites.

As stated previously, most assemblage change likely happened between the 1970's and 1995, so correspondence analysis was used to associate species with the years for which they were most abundant. The most sensitive minnow species, *Notropis hypsilepis*, *Lythrurus atrapiculus*, and *Notropis cummingsae* were dominant in the 1970's but have been collected very rarely since 1995. Homogenous species that are expanding their native range and succeeding in more degraded habitats such as *Lepomis macrochirus*, *Semotilus thoreauianus*, *Lepomis auitus*, *Cyprinella venusta*, and *Percina nigrofasciata* have been collected in high abundance recently and are most highly correlated with 2009, 2010, and 2011. A potential mechanism for their presence and persistence in streams is dispersal in response to damming on the Chattahoochee River. Two somewhat sensitive minnow species, *Notropis amplamala*, and *Notropis longirostris* are continuing to do relatively well at larger sites with clean substrate.

Assemblage changes and species declines are also occurring due to changes in land use. Forest continues to be converted into agriculture and urban land use to support the growing human population (Harding et al., 1998). Since impervious surfaces associated with urban land

use cause water to enter streams faster resulting in erosion and flashy unsustained flows, in stream habitat is altered (Helms et al., 2009). Agricultural land uses also results in increased runoff rates, carrying with it nutrients and sediment which pollute the streams and embed the substratum (Walser & Bart, 1999).

The pattern of land use change in the study area is similar to the rest of the country, with forest gradually and consistently being converted into urban and agricultural land uses. It should also be noted that pine monoculture is known to deplete groundwater stores at a faster rate than other forest compositions (Swank & Miner, 1968). The Wacoochee Creek watershed has the highest concentration of pine monoculture, while the lower Little Uchee Creek watershed has the smallest concentration. While pine monoculture may have an additive effect on some areas, it is not enough to alter the assemblages in Wacoochee Creek at sites 13 and 14 as they have remained relatively stable since 1969. All land use change from 1992 to 2011 has been negative while some recent change from 2001 to 2011 has either been slight or positive with regards to land use change. Assemblage similarity between 1995 and 2010 is moderate or high for all but one of the fourteen sites analyzed despite the magnitude at which forest has been converted. This suggests that, compared to hydrologic change, the effect of land use change on assemblages is either minimal or targeted to certain species or groups. The effects of land use may be more directly linked to habitat integrity as well, only affecting fish assemblages secondarily and therefore having a smaller impact than hydrology, which has a more direct effect on fish assemblages (Walser & Bart, 1999).

According to the data for smaller streams, the higher the concentration of forest upstream of a site, the more fish in the stream in general. In contrast, the more agricultural land use there is upstream of a site, the fewer fish there were. The opposite was true for larger streams and species

richness actually appeared to be higher at sites with higher concentrations of urban land use and lower at sites with high concentrations of forest. Land use has a direct influence on many stream habitat variables, especially substrate heterogeneity, water velocity, turbidity, and amount of fines (Walser & Bart, 1999; Helms et al., 2009).

Centrarchids, especially *Lepomis cyanellus* were more abundant at sites with high concentrations of pine monoculture, a land use which tends to dewater streams at an accelerated rate (Swank & Miner, 1968). This is likely due to their tolerance for degraded habitats and preference for low flows (Herbert & Gelwick, 2003). Overall, agricultural land use appears to be most responsible for assemblage change of all the land uses as there is a negative correlation between the percent of agriculture within a 2km buffer upstream of a site and assemblage similarity. This is understandable as there is more agriculture than urban land use and these are the source of problems with erosion, sedimentation, turbidity, and pollutants all of which negatively affect fish assemblage stability (Wang et al., 1997).

The success of certain species in a stream can be predicted based on their flow requirements for successful spawning and recruitment as well as the environmental conditions (Durham & Wilde, 2006; Grabowski & Isely, 2007). Many species, especially lithophilic spawning fish such as many minnows and suckers, which deposit eggs on clean substrate in shallow flowing waters are the most vulnerable to decreased water availability (Grabowski & Isely, 2007). Conversely, species such as most Centrarchids prefer low flows for spawning as they deposit eggs in nests that are at risk of washing away if flows are too heavy and pools are unavailable (Herbert & Gelwick, 2003).

Sensitive species, mostly minnows such as *Cyprinella callitaenia*, *Campostoma pauciradii*, *Lythrurus atrapiculus*, *Notropis hypsilepis*, and *Pteronotropis euryzonus*, require

higher flows for survival and recruitment. With the gradual decreases in water availability these species are declining, rarely detected in the areas where they used to be abundant or even dominant. Species falling under this category are being replaced by species that have either adapted to succeed in low flow environments, or prefer low flow environments. Species that prefer higher flows but have adapted to low flow conditions include *Cyprinella venusta*, *Hybopsis winchelli*, and *Percina nigrofasciata*. These species are increasing in abundance across the entire study area and are expanding their native range. Species that prefer low flows are becoming the most successful as flows continue to decrease and habitat becomes more degraded. These species are the most common in all sites and are considered “homogenous” (Scott & Helfman, 2001). Species falling under this category include *Semotilus thoreauianus*, *Esox americanus*, *Gambusia holbrooki*, *Lepomis auritus*, and *Lepomis cyanellus*.

Several sites in the Uchee Creek System that frequently experience drying events are almost entirely made up of homogenous species preferring low flows. However when comparing assemblages from 2009, 2010, and 2011, there were more species preferring high flows in 2010 than in either of the two dry years suggesting that after a drought, more sensitive species still make an effort to recolonize available habitat. This was evident at sites 12, 13, and 16 as well when *Notropis hypsilepis* was detected in 2010 and 2011 after going undetected since 1970 at two of the sites. This suggests that although this species went undetected, it was persisting somewhere waiting for more habitat to become available for colonization. At site 13, sensitive minnow species were clearly more abundant in 2010 than in 2009 or 2011 as well.

The question to answer is whether these sensitive species are spawning and recruiting successfully during these wet years to maintain a population or whether they are simply recolonizing habitat as it becomes available and seeking refugia as habitat becomes unavailable

(Magoulick et al., 2003). Fishes typically move to deeper water when their current habitat reaches a critical depth and when water levels increase, they take it as a cue to move back to their original habitat (Davey et al., 2006). Standard lengths of the most abundant species in each assemblage allowed for the identification of how many adults and juveniles of each species composed each assemblage. Most *Notropis hypsilepis* individuals caught at site 12 in 2011 were juveniles, meaning they may have been recruited in 2010 and persisted at the site through 2011. Also, at site 13, most of the *Luxilus zonistius* individuals collected in 2010 were juveniles, many of them small enough to require a microscope for identification. While the recruitment of these species is good for assemblage recovery, the majority of centrarchids caught at all sites across all years were juveniles meaning they are either spawning successfully regardless of habitat condition or dispersing from elsewhere. There were also many juvenile *Cyprinella venusta* and *Percina nigrofasciata* individuals collected across all years further suggesting they have adapted to lower flow conditions and are reproducing successfully even in drier years.

Conclusions

Fish assemblages are shifting on both a local and global scale as climate patterns change and human influences grow. Both water availability and land use change are primarily responsible for these shifts. As the human population expands, forest is converted into agriculture and urban land uses, both of which degrade stream habitat and contribute to the homogenization of fish assemblages. In this study area, decreased water availability is like the most important driver of change as this coincides with a decline in species such as *Notropis hypsilepis* requiring high flows for survival and spawning success. There is evidence for this species especially, that there is some recovery during a wet year after drought as this species was

detected in 2010 and 2011 after appearing absent since 1970 at two sites. Species preferring low flows for spawning and survival such as most Centrarchids are thriving and expanding their native ranges, homogenizing assemblages as water availability continues to decrease overall. Some species such as *Cyprinella venusta* and *Percina nigrofasciata* generally prefer higher flows for successful recruitment, however they have adapted to lower flow conditions and are becoming more abundant as sensitive species continue to decline.

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Table 1. Morisita similarity values for sites sampled three times in summer of 2011. The letters A, B, and C correspond to the first, second and third sample. The dates on which these samples were taken are reported in Appendix 3. Bolded values indicate high similarity (>.80).

Site	Creek	Order	A-B	B-C	A-C
13	Wacoochee	3	0.929	0.967	0.905
16	Little Uchee	3	0.927	0.698	0.573
20	Watula	2	0.879	0.899	0.896
21	Whites	3	0.863	0.949	0.805
22	Hospilika	4	0.897	0.835	0.813

Table 2. Morisita similarity index calculations between 2010 and samples collected before 1980 for ten study sites. Numbers in bold indicate low similarity (<.40) and those with an * indicate high similarity (>.80).

Site #	Creek	Sample Years	Morisita Similarity
12	Wacoochee	1970-2010	0.13
13	Wacoochee	1969-2010	0.67
14	Wacoochee	1969-2010	0.82*
19	Flake	1953-2010	0.17
25	Little Uchee	1971-2010	0.09
28	Adam's Branch	1980-2010	0.82*
30	Trib of Uchee	1976-2010	0.01
38	Uchee	1978-2010	0.19
39	Trib of Uchee	1955-2010	0.23
40	Uchee	1968-2010	0.58

Table 3. Morisita similarity index calculations between 1995, 2004, and 2010 for seven study sites. Numbers in bold indicate low similarity (<.40) and those with an * indicate high similarity (>.80).

Site #	Creek	1995-2004	2004-2010	1995-2010
15	Phelps	0.48	0.74	0.65
17	Peters	0.90*	0.89*	1.00*
18	Little Uchee	0.80*	0.74	0.91*
21	Whites	0.62	0.73	0.72
22	Hospilika	0.43	0.37	0.60
38	Uchee	0.65	0.68	0.96*
40	Uchee	0.66	0.72	0.73

Table 4. Morisita similarity index calculations between 2004, 2009, and 2010 for eight study sites. Numbers in bold indicate low similarity (<.40) and those with an * indicate high similarity (>.80).

Site #	Creek	2004-2009	2009-2010	2004-2010
18	Little Uchee	0.68	0.90*	0.74
20	Watula	0.82*	0.91*	0.84*
21	Whites	0.72	0.83*	0.73
22	Hospilika	0.30	0.60	0.37
23	Little Uchee	0.52	0.65	0.78
26	Island	0.64	0.97*	0.63
31	Adam's Branch	0.07	0.20	0.11
32	Maringo	0.13	0.32	0.70

Table 5. Morisita similarity index calculations for fourteen sites between 2009 and 2011. Numbers in bold indicate low similarity (<.40) and those with an * indicate high similarity (>.80).

Site #	Creek	Stream Order	2009-2010	2010-2011	2009-2011
12	Wacoochee	4	0.70	0.84*	0.66
13	Wacoochee	3	0.86*	0.54	0.65
14	Wacoochee	3	0.75	0.79	0.71
16	Little Uchee	3	0.85*	0.86*	0.67
18	Little Uchee	3	0.90*	0.86*	0.79
20	Watula	2	0.91*	0.91*	0.94*
21	White's	3	0.83*	0.84*	0.75
22	Hospilika	4	0.60	0.90*	0.77
23	Little Uchee	4	0.65	0.76	0.37
26	Island	2	0.97*	0.92*	0.93*
31	Adam's Branch	2	0.20	0.39	0.30
32	Maringo	2	0.32	0.51	0.54
33	Adam's Branch	3	0.47	0.54	0.51
36	Snake	2	0.56	0.69	0.52

Table 6. Pearson correlation coefficients between assemblage similarity of several sites and the percent of peak flows above the 75th percentile within the same time interval. Bolded values indicate a high correlation and those with a * indicate significance at p<0.05.

Similarity	Year Difference	Peaks above 75th percentile
site 7	0.150	0.030
site 12	-0.880*	0.002
site 13	0.170	0.220
site 14	-0.410	-0.350
site 15	-0.160	0.980
site 16	-0.140	-0.080
site 17	0.960	0.060
site 18	0.120	0.140
site 20	-0.920	0.980
site 21	-0.430	0.850
site 22	-0.060	0.490
site 23	0.190	0.000
site 25	-0.992	-0.998*
site 26	-0.986*	0.990*
site 28	-0.620	-0.900
site 31	-0.880	0.950
site 32	0.370	-0.190
site 38	-0.710	-0.480
site 40	0.050	0.560
site 41	0.960	0.650

Table 7. Pearson correlation coefficients for assemblage similarity of four stream systems and percent of peak flows above the 75th percentile. Bolded values indicate significance at $p < 0.05$.

Stream system	Year Difference	Peaks above 75th percentile
Halawakee Creek	0.230	0.060
Wacoochee Creek	-0.240	0.106
Little Uchee Creek	-0.580	0.010
Uchee Creek	-0.120	0.090

Table 8. Conversion of Anderson Level Classification II to Level I for all historic NLCD layers and new land use layer. This conversion increases both accuracy and ease of analysis.

Level II	Level I
Developed-open Developed-low intensity Developed-medium intensity Developed-high intensity Barren land(rock/sand/clay)	Urban
Deciduous forest Evergreen forest Mixed forest Shrub/scrub	Forest
Grassland Pasture/hay Cultivated crop	Agriculture
Water Wooded wetland Herbaceous wetland	Water

Table 9. Land use change between 1992 and 2011 within each site's buffer and the influence of this change. Similarity is calculated between samples from 2010 and 1995. Species richness is for 2010 samples to give reference to stream size and integrity.

Site	Similarity	Species richness	% Change forest	% Change agriculture	% Change urban	Influence
5	Low	4	-13	+ 3	+ 13	Negative
6	High	5	-26	+ 16	+ 8	Negative
7	Moderate	13	-19	+ 11	+ 9	Negative
12	Moderate	12	-18	+ 18	-3	Negative
13	High	15	-26	+ 10	+ 8	Negative
14	Moderate	16	-29	+ 9	+ 9	Negative
15	Moderate	12	-22	+ 9	+ 8	Negative
16	High	15	-18	+ 2	+ 13	Negative
17	High	3	-8	+ 7	+ 3	Negative
18	High	13	-18	+ 11	+ 4	Negative
21	Moderate	10	-14	+ 8	+ 9	Negative
22	Moderate	17	-26	+ 11	+ 17	Negative
38	High	20	-8	+ 2	+ 7	Negative
40	Moderate	16	+ 1	+ 4	+ 12	Negative

Table 10. Land use change between 2001 and 2011 within each site's buffer and the influence of this change. Similarity is calculated between 2010 and samples from 2001-2006 depending on sample year for each site. Species richness is for 2010 samples to give reference to stream size and integrity.

Site	Similarity	Species richness	% Change forest	% Change agriculture	% Change urban	Influence
7	Low	13	+ 7	-9	0	Positive
8	Low	10	-22	+ 13	+ 7	Negative
12	High	12	+ 9	-11	+ 1	Positive
13	Low	15	-9	-2	+ 4	Negative
15	Moderate	12	-6	-4	+ 6	Slight
16	High	15	-12	+ 2	+ 8	Negative
17	High	3	0	0	-1	Positive
18	Moderate	13	-6	+ 8	-4	Slight
20	High	8	-24	+ 12	+ 11	Negative
21	Moderate	10	-10	+ 6	+ 3	Negative
22	Low	17	-5	+ 14	-9	Slight
23	Moderate	17	-18	+ 7	+ 8	Negative
25	High	19	-1	-3	-1	Slight
26	Moderate	4	-2	-2	+ 1	Slight
27	Low	1	-10	+ 2	+ 3	Negative
28	High	8	-11	+ 2	+ 6	Negative
31	Low	4	-9	+ 2	+ 6	Negative
32	Moderate	8	-9	+ 3	+ 3	Negative
35	Low	6	-3	+ 2	+ 2	Slight
38	Moderate	20	0	-2	+ 7	Slight
40	Moderate	16	-6	+ 6	+ 10	Negative

Table 11. Pearson correlation coefficients comparing biotic variables to land use percentages from 2010. The dataset was divided into two sets; one containing first and second order streams, the other containing third through fifth order streams.

	1st and 2nd Order			3rd, 4th, and 5th Order		
	% Forest	% Agriculture	% Urban	% Forest	% Agriculture	% Urban
Species Richness	0.29732	-0.38121	-0.12099	-0.64384	0.46498	0.49863
# Individuals	0.4751	-0.46088	-0.31053	-0.60366	0.62127	0.2543
% Sensitive Minnows	0.11973	-0.13994	0.095589	-0.29862	0.30681	0.10069
% <i>L. auritus</i>	-0.17352	0.040907	0.13458	0.36953	-0.22102	-0.42876

Table 12. Pearson correlation coefficients between assemblage variables and land use or habitat data. Values that are significant at $p < 0.05$ are bolded. Data used includes all samples from 2010 and 2011.

	% Forest	%Agriculture	% Urban	% Pine monoculture
Similarity	0.1772	-0.3014	-0.0224	0.1687
Stream Order	-0.1355	-0.0045	0.1627	-0.2788
Sp. Richness	-0.1200	0.0004	0.1225	-0.1045
# Individuals	-0.2082	0.1693	0.0736	-0.1728
% Sensitive minnows	-0.1846	0.1484	0.1157	0.1327
% <i>L. auritus</i>	0.1596	-0.2054	-0.1306	0.2384
% <i>L. cyanellus</i>	0.3241	-0.3731	-0.1299	0.4651
% Homogenous sp	0.1662	-0.1317	-0.1072	-0.1063
% Centrarchid sp	0.0294	-0.1162	0.0674	0.3412

Table 13. Species detected in this study listed under the flow dependent spawning guild that best represents their life history strategy.

Prefer Low Flow	Prefer Moderate Flow	Prefer High Flow
<i>Notemigonus crysoleucas</i>	<i>Ichthyomyzon gagei</i>	<i>Campostoma pauciradii</i>
<i>Semotilus thoreauianus</i>	<i>Cyprinella venusta</i>	<i>Cyprinella callitaenia</i>
<i>Ameiurus natalis</i>	<i>Hybopsis winchelli</i>	<i>Luxilus zonistius</i>
<i>Ameiurus nebulosus</i>	<i>Notropis maculatus</i>	<i>Lythrurus atrapiculus</i>
<i>Ictalurus punctatus</i>	<i>Notropis texanus</i>	<i>Nocomis leptocephalus</i>
<i>Noturus gyrinus</i>	<i>Opsopoedus emiliae</i>	<i>Notropis ammophilus</i>
<i>Esox americanus</i>	<i>Erimyzon oblongus</i>	<i>Notropis amplamala</i>
<i>Esox niger</i>	<i>Minytrema melanops</i>	<i>Notropis cummingsae</i>
<i>Aphredoderus sayanus</i>	<i>Ameiurus brunneus</i>	<i>Notropis hypsilepis</i>
<i>Fundulus olivaceus</i>	<i>Labidesthes sicculus</i>	<i>Notropis longirostris</i>
<i>Gambusia holbrooki</i>	<i>Elassoma zonatum</i>	<i>Pteronotropis euryzonus</i>
<i>Lepomis auritus</i>	<i>Micropterus coosae</i>	<i>Hypentelium etowanum</i>
<i>Lepomis cyanellus</i>	<i>Perca flavescens</i>	<i>Scartomyzon lachneri</i>
<i>Lepomis gulosus</i>	<i>Percina nigrofasciata</i>	<i>Noturus leptacanthus</i>
<i>Lepomis macrochirus</i>		<i>Micropterus cataractae</i>
<i>Lepomis megalotis</i>		<i>Etheostoma edwini</i>
<i>Lepomis microlophus</i>		<i>Etheostoma parvipinne</i>
<i>Lepomis miniatus</i>		<i>Etheostoma swaini</i>
<i>Micropterus henshalli</i>		
<i>Micropterus punctulatus</i>		
<i>Micropterus salmoides</i>		
<i>Pomoxis nigromaculatus</i>		

Table. 14. Percent of each spawning guild present in 2009, 2010, and 2011 in five frequently disturbed sites in the Uchee Creek System.

Site number (2011)	26	31	32	33	36
High flow species	0%	4%	0%	9%	0%
Moderate flow species	0%	10%	0%	9%	15%
Low flow species	100%	86%	100%	82%	85%
Site number (2010)	26	31	32	33	36
High flow species	0%	0%	11%	23%	0%
Moderate flow species	10%	0%	14%	13%	17%
Low flow species	90%	100%	75%	65%	75%
Site number (2009)	26	31	32	33	36
High flow species	0%	10%	0%	0%	0%
Moderate flow species	0%	0%	0%	0%	0%
Low flow species	100%	90%	100%	100%	100%

Table 15. Select species and their abundances from several samples for Wacoochee Creek site 12. The flow requirement for successful recruitment in each species is also reported.

SITE 12	1970	1995	2006	2009	2010	2011	Spawning needs
<i>Campostoma paucradii</i>	3	7	2	9	4	2	High Flow
<i>Cyprinella venusta</i>	0	32	25	14	13	5	Moderate
<i>Hybopsis winchelli</i>	2	56	2	0	2	0	High Flow
<i>Lythrurus atrapiculus</i>	57	3	0	0	0	0	High Flow
<i>Notropis hypsilepis</i>	175	0	0	0	6	18	High Flow
<i>Scartomyzon lachneri</i>	0	14	2	4	4	0	High Flow
<i>Lepomis auritus</i>	0	23	2	19	14	29	Low Flow
<i>Lepomis cyanellus</i>	0	5	1	5	5	25	Low Flow
<i>Percina nigrofasciata</i>	0	13	43	7	30	32	Moderate

Table 16. Select species and their abundances from several samples for Wacoochee Creek site 13. The flow requirement for successful recruitment in each species is also reported.

SITE 13	1969	1995	2005	2009	2010	2011	Spawning needs
<i>Cyprinella venusta</i>	0	1	0	0	1	0	Moderate
<i>Hybopsis winchelli</i>	1	18	0	0	46	0	High Flow
<i>Luxilus zonistius</i>	33	47	52	70	70	5	High Flow
<i>Lythrurus atrapiculus</i>	49	8	0	0	0	0	High Flow
<i>Nocomis leptocephalus</i>	2	5	0	6	18	0	High Flow
<i>Notropis amplamala</i>	24	42	2	31	38	21	High Flow
<i>Notropis longirostris</i>	67	48	0	45	56	77	High Flow
<i>Lepomis auritus</i>	27	16	7	4	19	2	Low Flow
<i>Percina nigrofasciata</i>	5	13	0	24	25	4	Moderate

Table 17. Select species and their abundances from several samples for Little Uchee Creek site 16. The flow requirement for successful recruitment in each species is also reported.

SITE 16	1995	2006	2009	2010	2011	Spawning needs
<i>Campostoma paucradii</i>	16	9	7	24	15	High Flow
<i>Cyprinella venusta</i>	35	6	25	25	18	Moderate
<i>Hybopsis winchelli</i>	19	0	0	3	5	High Flow
<i>Notropis amplamala</i>	7	3	16	6	4	High Flow
<i>Notropis hypsilepis</i>	0	0	0	1	2	High Flow
<i>Hypentelium etowanum</i>	7	0	3	4	1	High Flow
<i>Lepomis auritus</i>	11	4	17	22	40	Low Flow
<i>Lepomis macrochirus</i>	14	11	39	21	7	Low Flow
<i>Percina nigrofasciata</i>	75	20	36	47	27	Moderate

Table 18. Pearson correlation coefficients between the percent of fish in each spawning guild per sample and land use at the corresponding sample sites. Coefficients were calculated for all sites and then broken into the Uchee System, and Halawakee and Wacoochee systems to identify regional trends. Bolded values are significant at $p < 0.05$.

ALL SITES	% High flow	% Moderate flow	% Low flow
% Forest	-0.1465	0.0918	0.0328
% Agriculture	0.0943	-0.1403	0.0323
% Urban	0.0933	-0.0748	0.0027
% Pine monoculture	0.1757	-0.1811	0.0352
UCHEE & LITTLE UCHEE	% High flow	% Moderate flow	% Low flow
% Forest	0.0542	-0.0680	0.0456
% Agriculture	-0.1774	-0.0210	0.0688
% Urban	0.0978	0.0428	-0.0668
% Pine monoculture	0.1366	-0.23686	0.1511
HALAWAKEE & WACOOCHEE	% High flow	% Moderate flow	% Low flow
% Forest	-0.2802	0.5960	-0.0517
% Agriculture	0.2361	-0.5187	0.0519
% Urban	0.1621	-0.6714	0.2022
% Pine monoculture	-0.2579	0.2336	0.1178

Table 19. Length at maturity for all species caught in 2009, 2010, and 2011.

Species	Length at maturity (mm)
<i>Campostoma paucradii</i>	100
<i>Cyprinella venusta</i>	65
<i>Hybopsis winchelli</i>	50
<i>Luxilus zonistius</i>	60
<i>Lythrurus atrapiculus</i>	30
<i>Nocomis leptocephalus</i>	70
<i>Notemigonus chrysoleucas</i>	50
<i>Notropis amplamala</i>	30
<i>Notropis baileyi</i>	50
<i>Notropis cummingsae</i>	30
<i>Notropis hypsilepis</i>	40
<i>Notropis longirostris</i>	35
<i>Notropis texanus</i>	35
<i>Semotilus thoreauianus</i>	65
<i>Erimyzon oblongus</i>	127
<i>Hypentelium etowanum</i>	230
<i>Scartomyzon lachneri</i>	300
<i>Ameiurus brunneus</i>	254
<i>Ameiurus natalis</i>	152
<i>Esox americanus</i>	178
<i>Aphredoderus sayanus</i>	60
<i>Labidesthes sicculus</i>	60
<i>Fundulus olivaceus</i>	56
<i>Gambusia holbrooki</i>	30
<i>Lepomis auritus</i>	152
<i>Lepomis cyanellus</i>	102
<i>Lepomis gulosus</i>	152
<i>Lepomis macrochirus</i>	152
<i>Lepomis megalotis</i>	127
<i>Lepomis miniatus</i>	152
<i>Micropterus salmoides</i>	300
<i>Etheostoma parvipinne</i>	35
<i>Percina nigrofasciata</i>	40

Fig. 1. Study sites located in the Halawakee, Wacoochee, Uchee, Little Uchee, and Ihagee Creek systems, Chattahoochee River Drainage, AL.

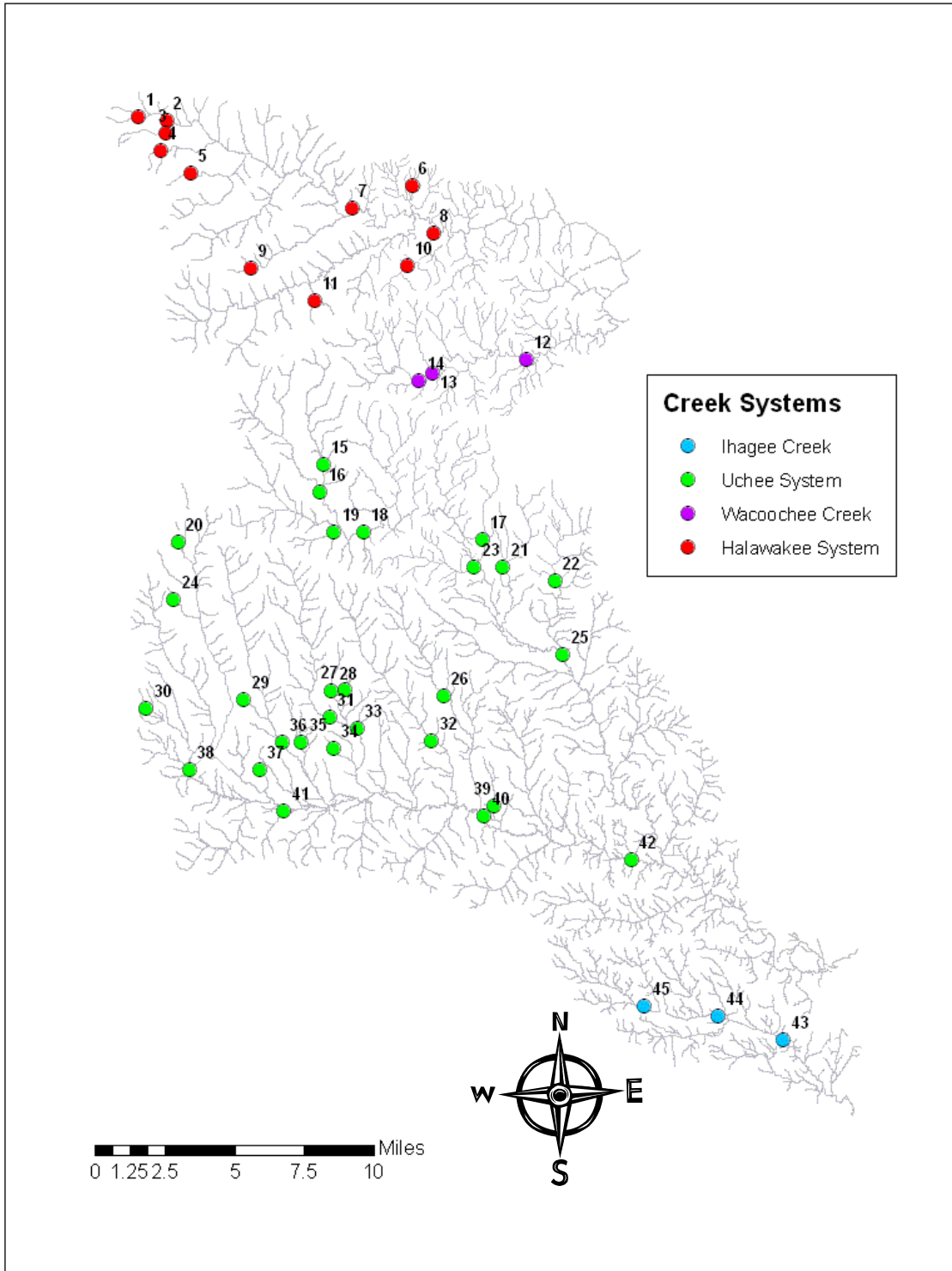


Fig. 2. Hydrographs using yearly average and monthly data displaying discharge in cubic feet per second beginning in 1947 and ending in 2010. Data is from a USGS gauge on Uchee Creek at Fort Mitchell, AL.

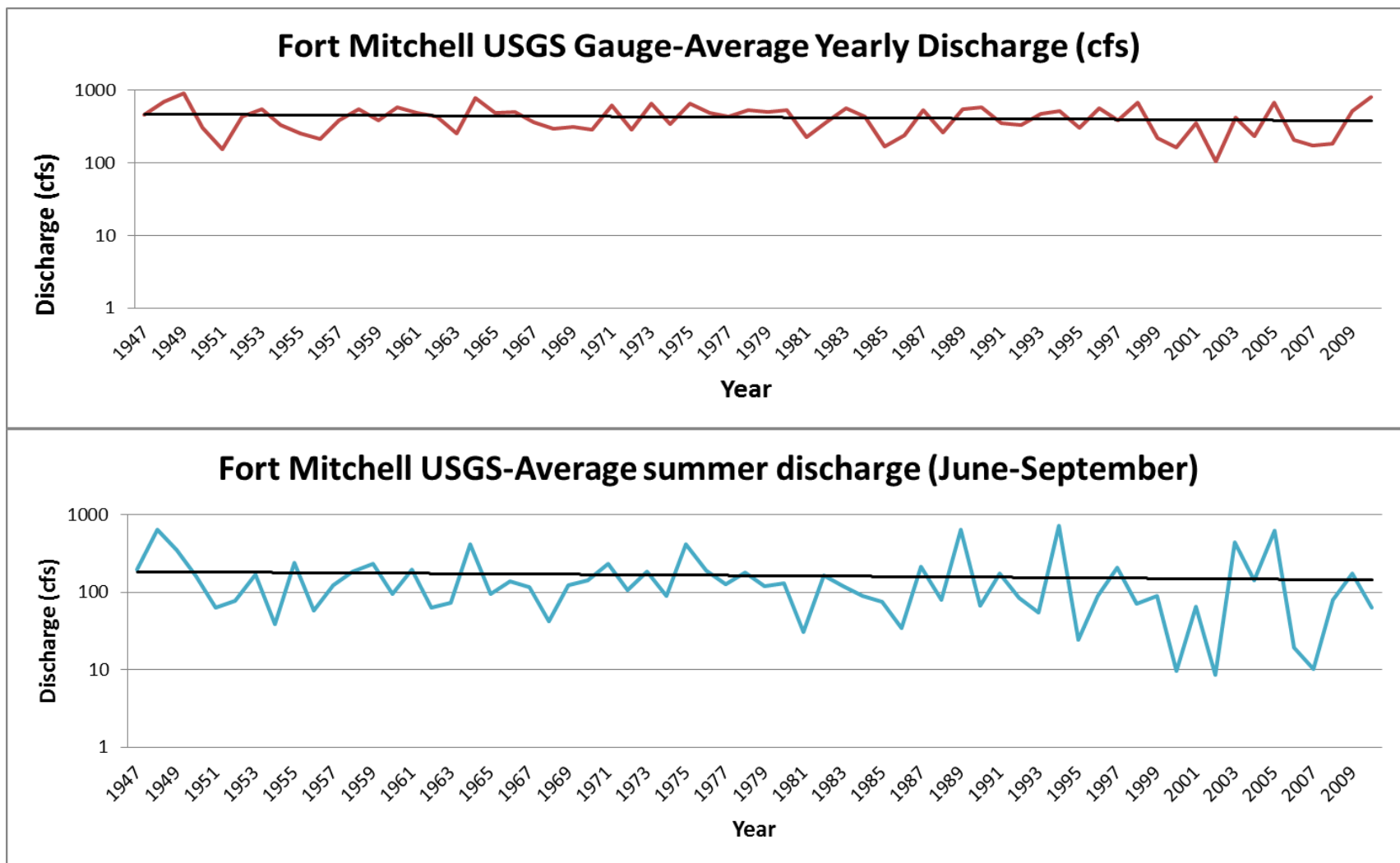


Fig. 3. Average yearly discharge and average similarity of assemblages across the study area for 1968-1978, 1995, 2004-2006, 2009, and 2010. Points correspond to average similarity between sampled assemblages from each time period.

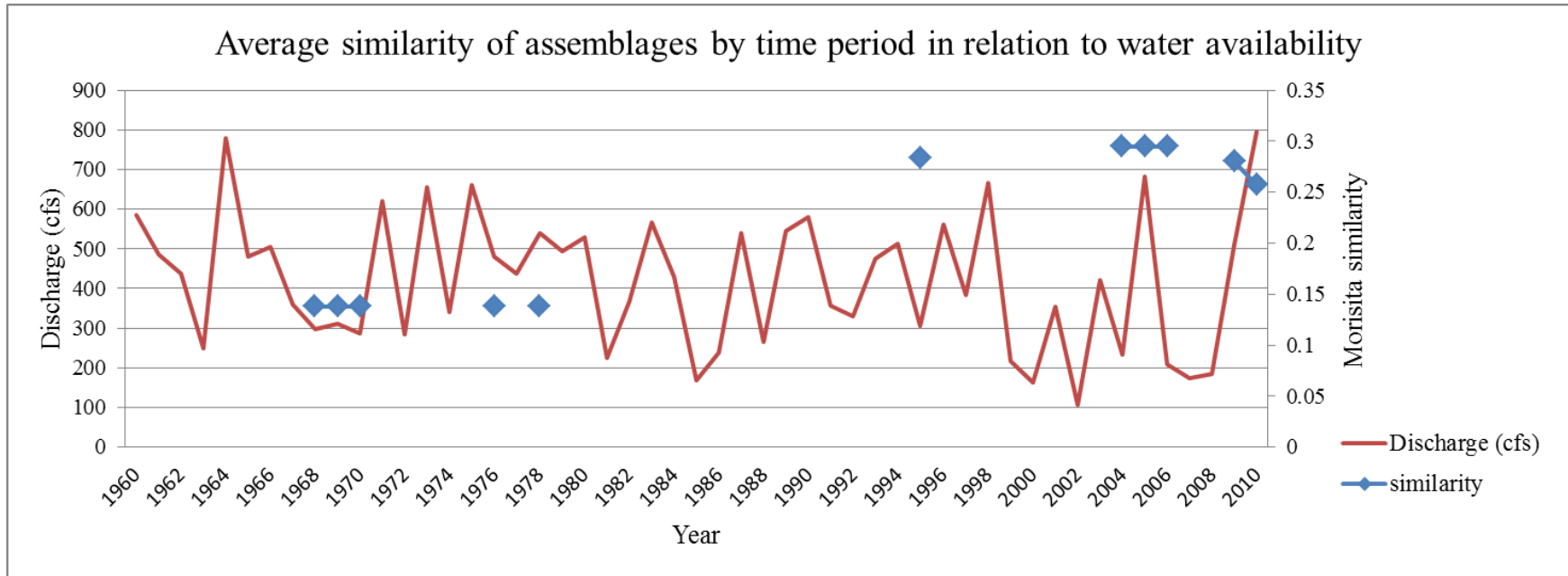


Fig. 4. Graph of combined water usage estimates for Lee and Russell Counties Alabama for 1985, 1995, and 2005. Data were downloaded from USGS and are only used to portray rough estimates of water usage and demand.

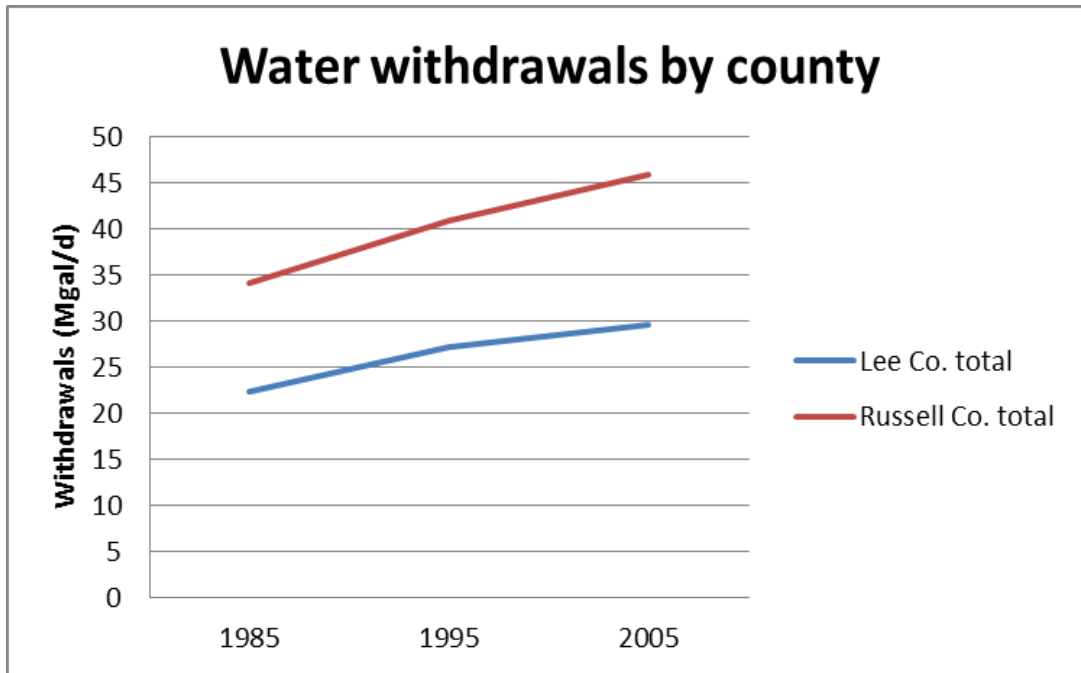


Fig. 5. Population growth in Lee and Russell Counties, Alabama between 1990 and 2010 according to United States Census data.

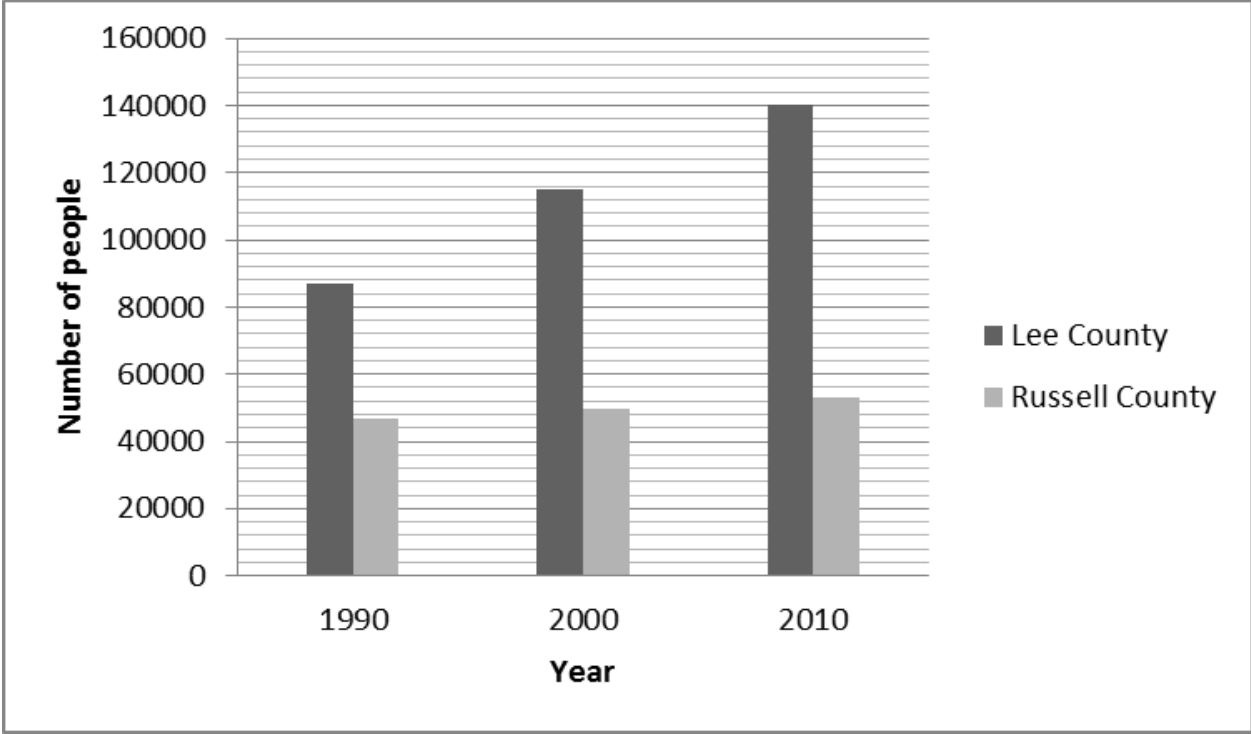


Fig. 6. Multidimensional scaling representation of Morisita similarity among three different sites on Wacoochee Creek (cross = site 12, square = site 13, asterisk = site 14) over six different time periods.

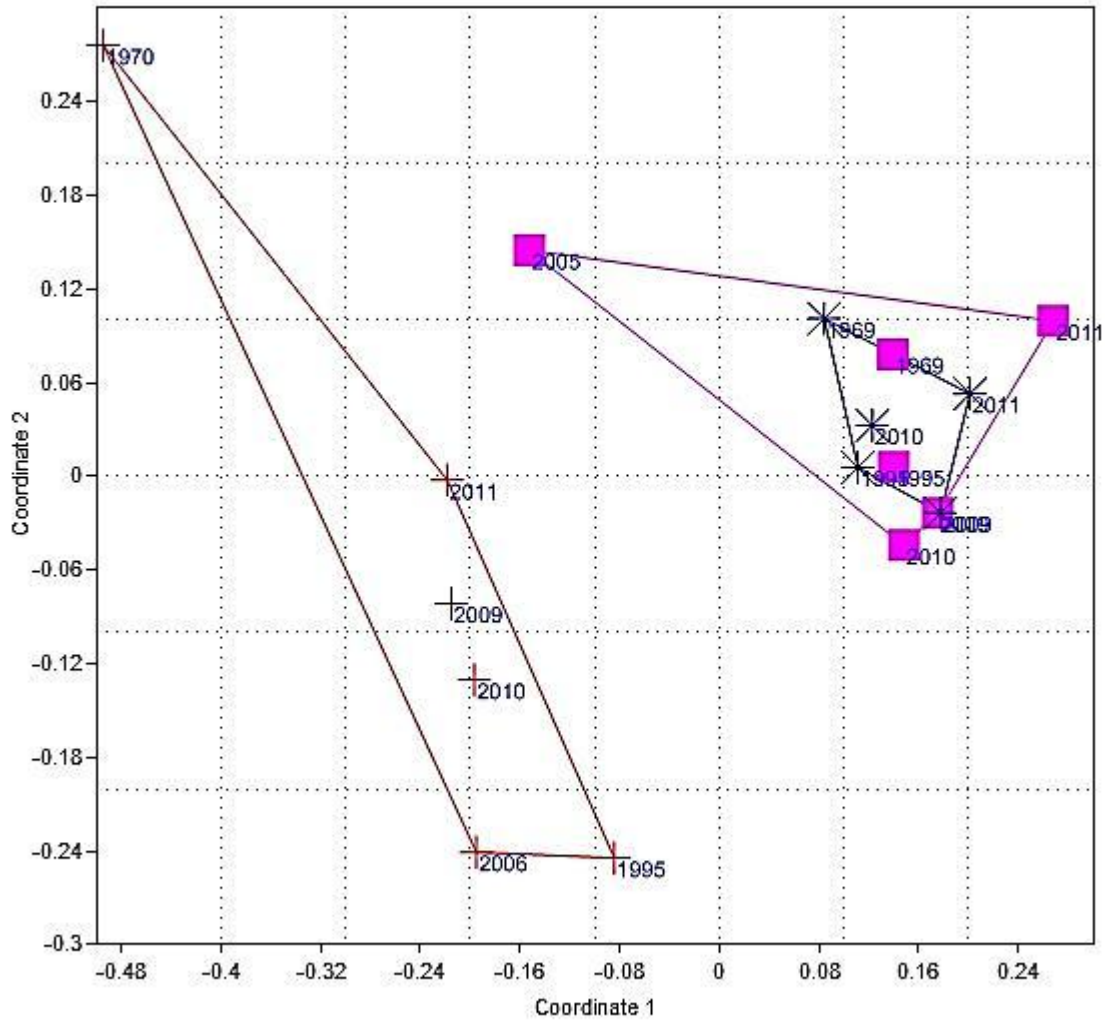


Fig. 7. Multidimensional scaling representation of Morisita similarity among three different creeks (Uch=Uchee Creek site 38, LU = Little Uchee site 16, Wac = Wacoochee site 12, Hal = Halawakee site 7) over three different time periods (2010, 2006/4, 1995).

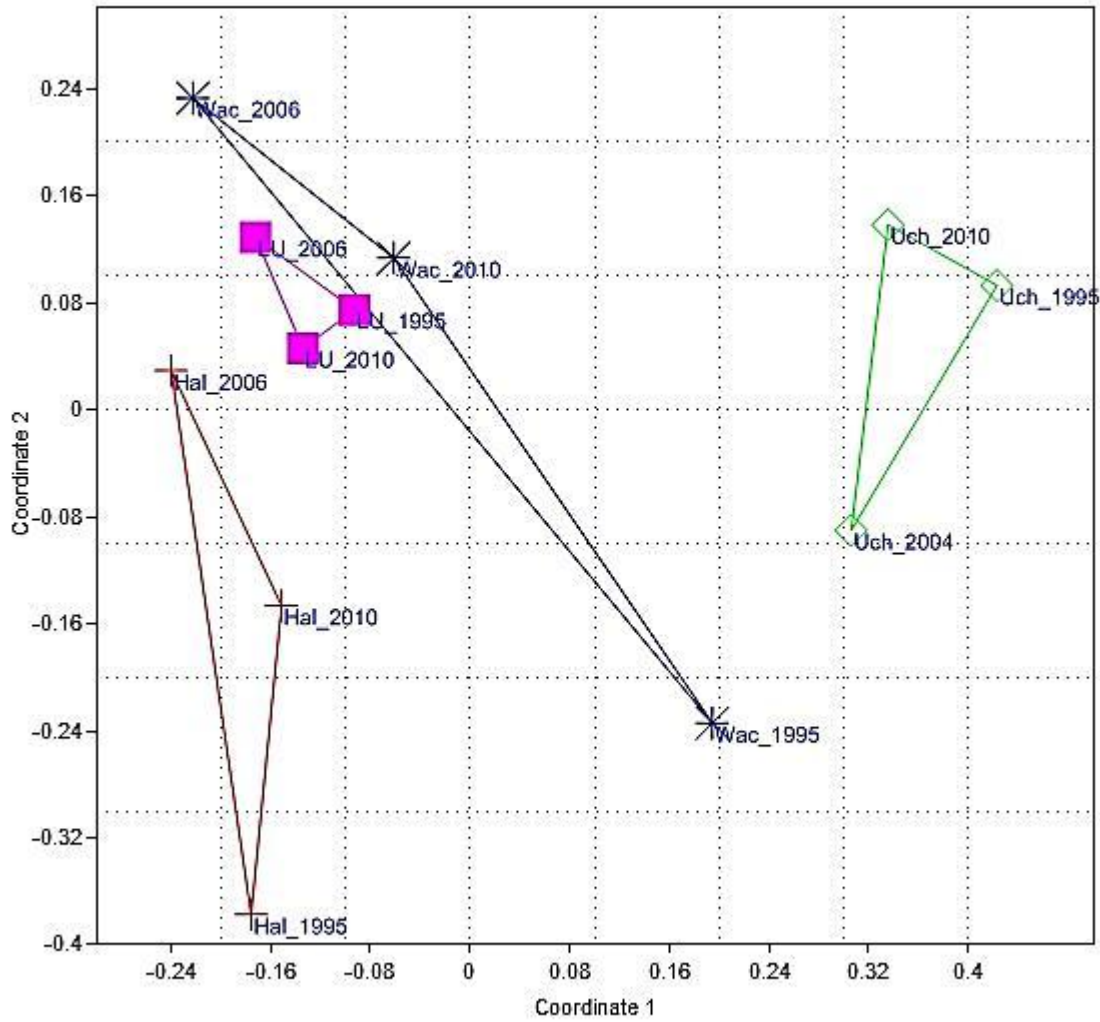


Fig. 8. Multidimensional scaling representation of Morisita similarity among three different frequently disturbed sites (26, 31, 32) in the Uchee Creek system over four different time periods (2011, 2010, 2009, 2004).

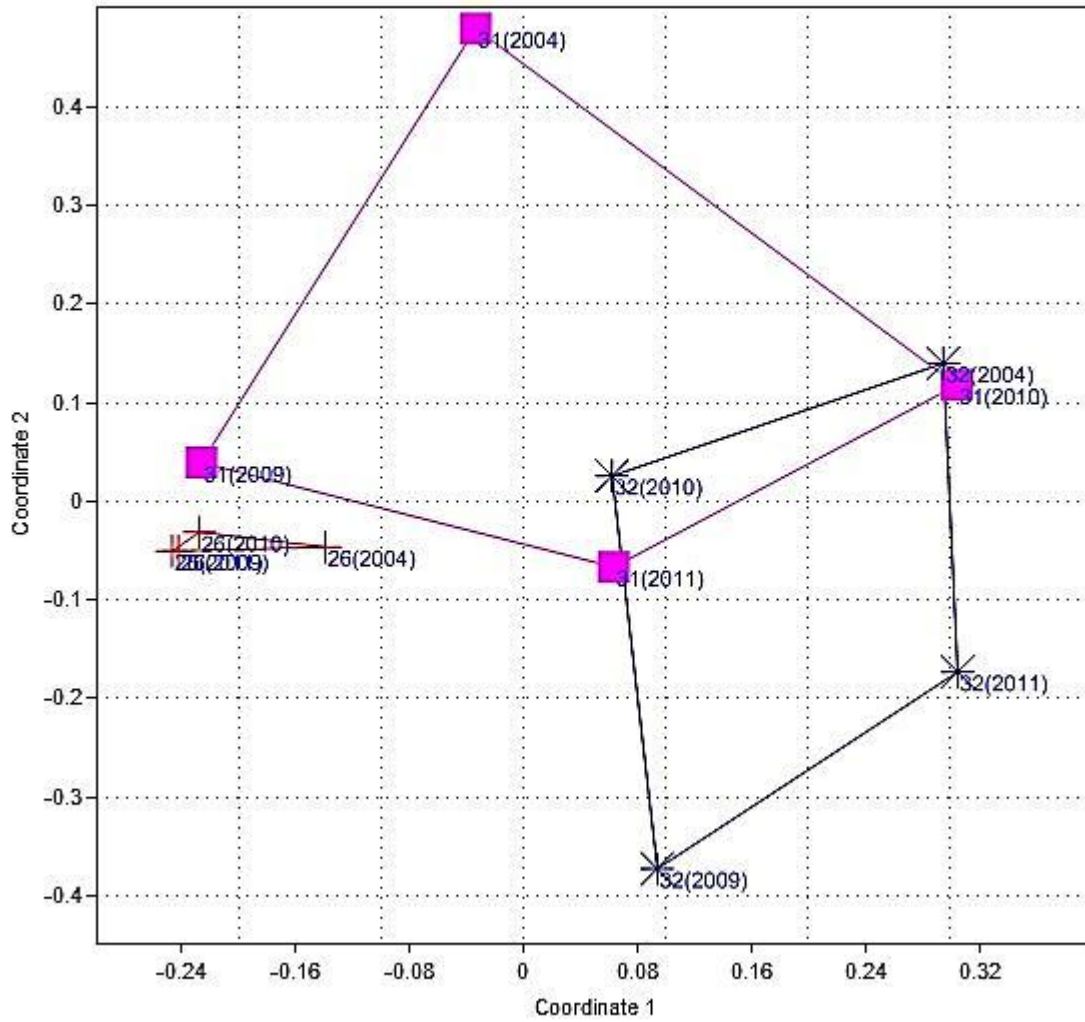


Fig. 9. Correspondence Analysis showing species association with years across a large timescale for seventeen stream sites. All species in plot composed >5% of combined yearly assemblages. *Hybopsis winchelli*= H_winch, *Notropis texanus*=N_tex, *Luxilus zonistius*=L_zon, *Lepomis macrochirus* =L_macr, *Lepomis auritus*=L_aur, *Notropis longirostris*=N_long, *Notropis amplamala*=N_ampla, *Percina nigrofasciata*=P_nigr, *Cyprinella venusta*=C_ven, *Campostoma pauciradii*=C_pauc, *Notropis hypsilepis*=N_hyps, *Lythrurus atrapiculus*=L_atra, *Notropis cummingsae*=N_cumming, and *Semotilus thoreauianus*=S_thor.

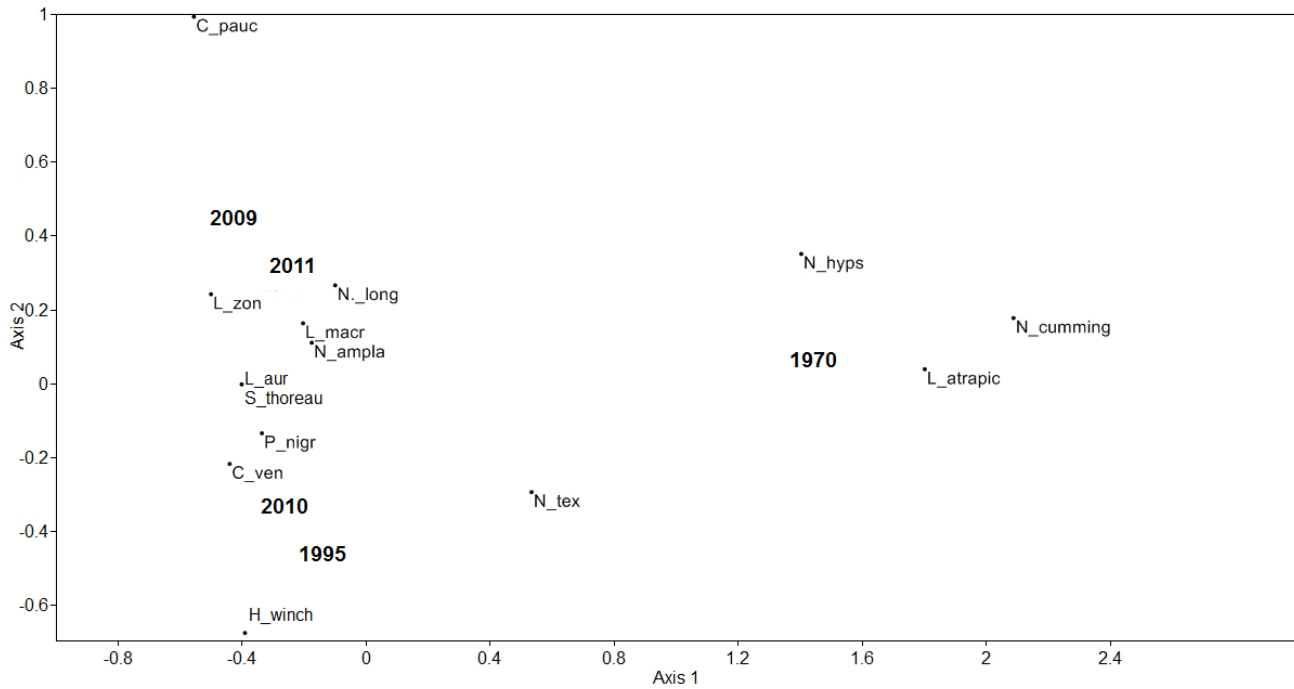


Fig. 10. Correspondence Analysis showing species association with years across a short timescale for seventeen stream sites. All species in plot composed >5% of combined yearly assemblages. *Hybopsis winchelli*= H_winch, *Notropis texanus*=N_tex, *Luxilus zonistius*=L_zon, *Lepomis macrochirus* =L_macr, *Lepomis auritus*=L_aur, *Notropis longirostris*=N_long, *Notropis amplamala*=N_ampla, *Percina nigrofasciata*=P_nigr, *Cyprinella venusta*=C_ven, *Campostoma pauciradii*=C_pauc, *Notropis hypsilepis*=N_hyps, *Lythrurus atrapiculus*=L_atra, *Notropis cummingsae*=N_cumming, and *Semotilus thoreauianus*=S_thor.

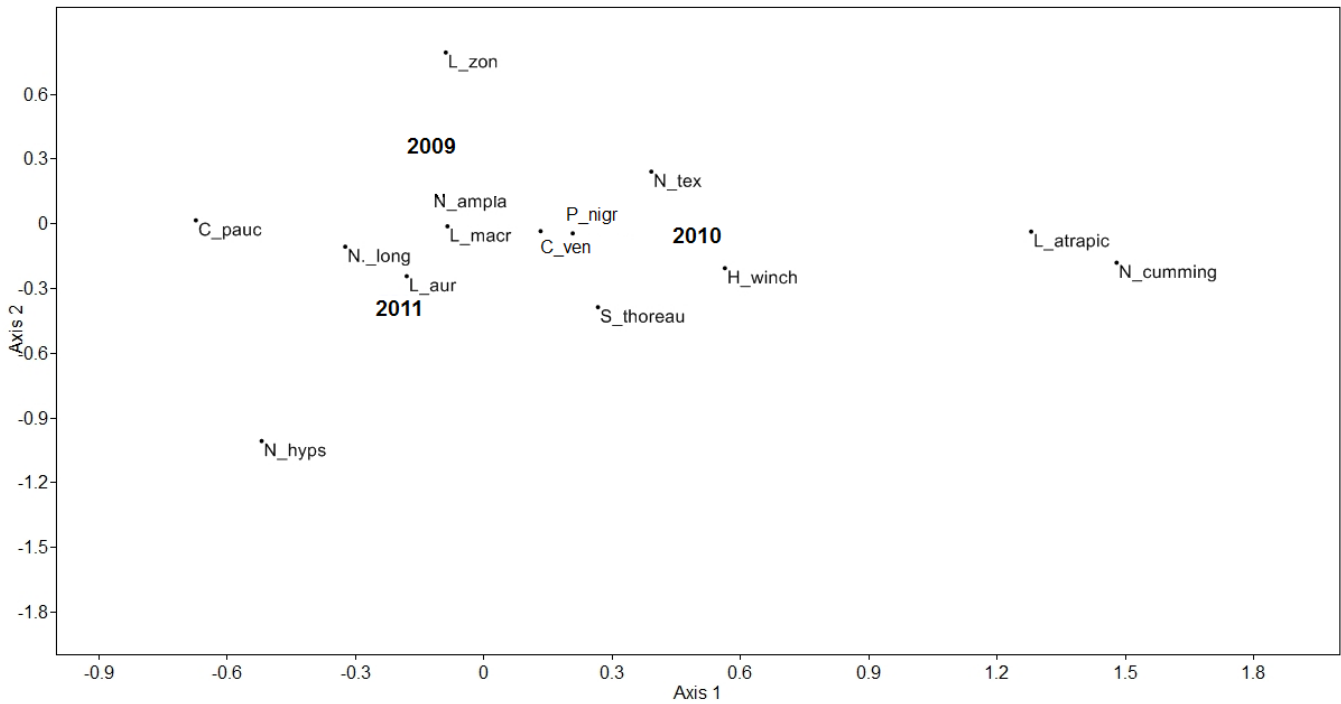


Fig. 11. Boxplot of USGS daily discharge data at Uchee Creek at Fort Mitchell, AL for water years beginning in 1960 and ending in 2010. Each box represents 5 water years labeled by beginning of first water year and ending of 5th water year. Boxes display 25th percentile, median, and 75th percentiles as well as the 95% Confidence Level and outliers

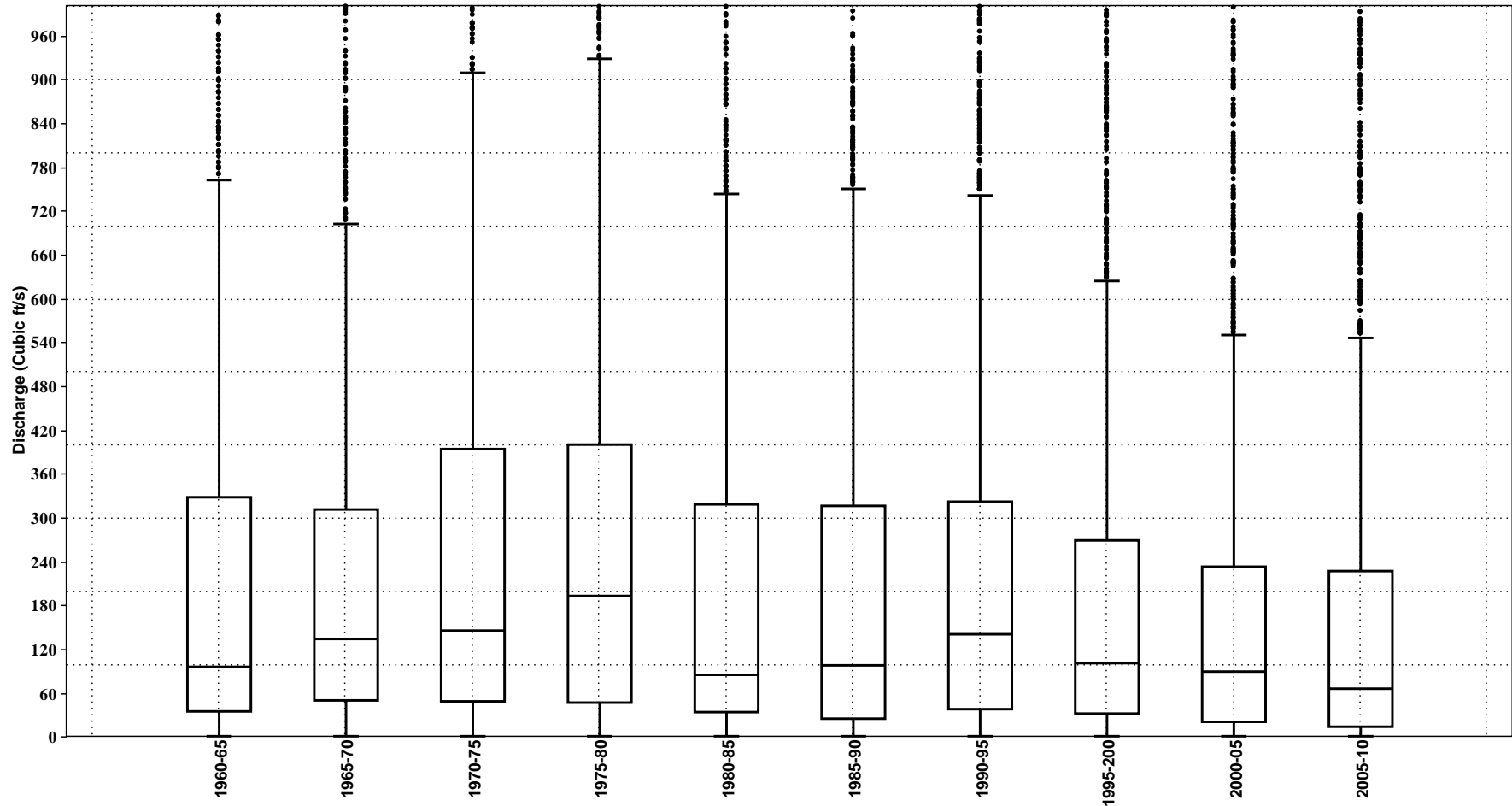


Fig. 12. Bar charts of land use in the Halawakee, Wacoochee, Uchee, and Little Uchee Creek watersheds.

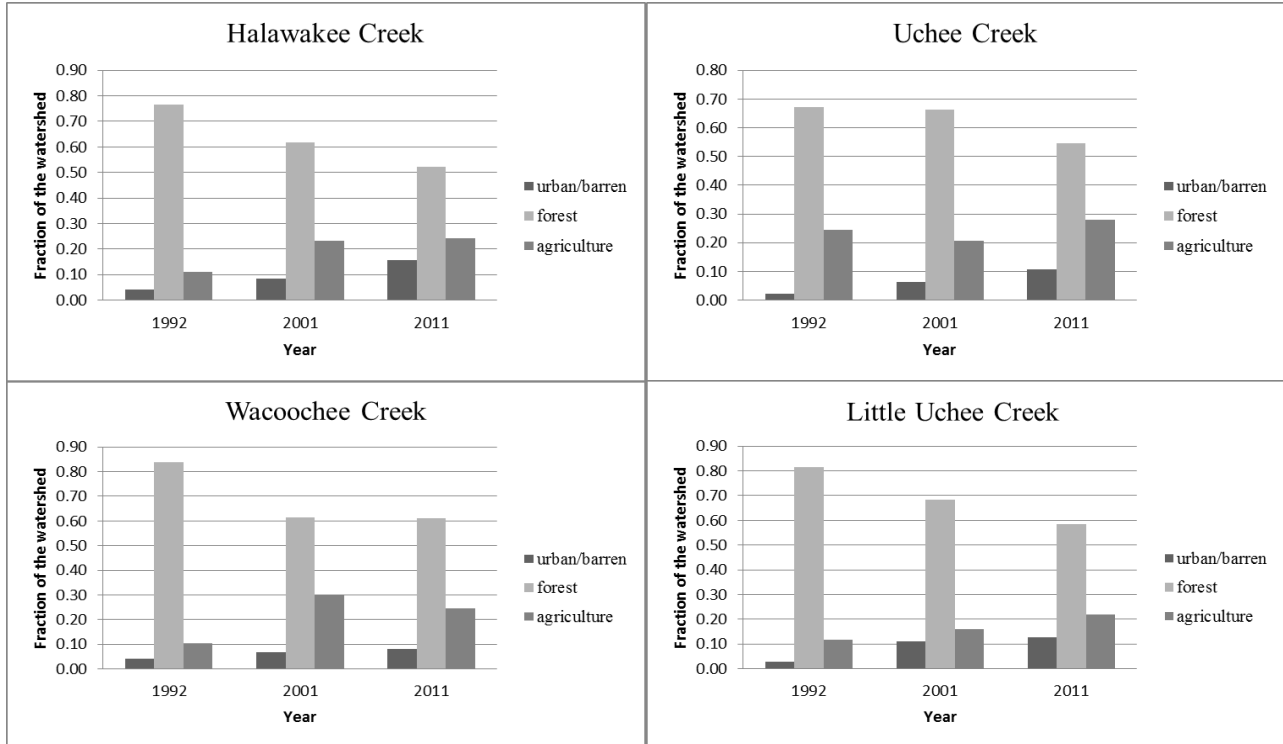


Fig. 13. Map showing pine monoculture intensity by huc 12 watershed. Watersheds darker in color have higher percentages of pine monoculture while lighter colors represent lower percentages of pine monoculture. Study sites are also included and labeled.

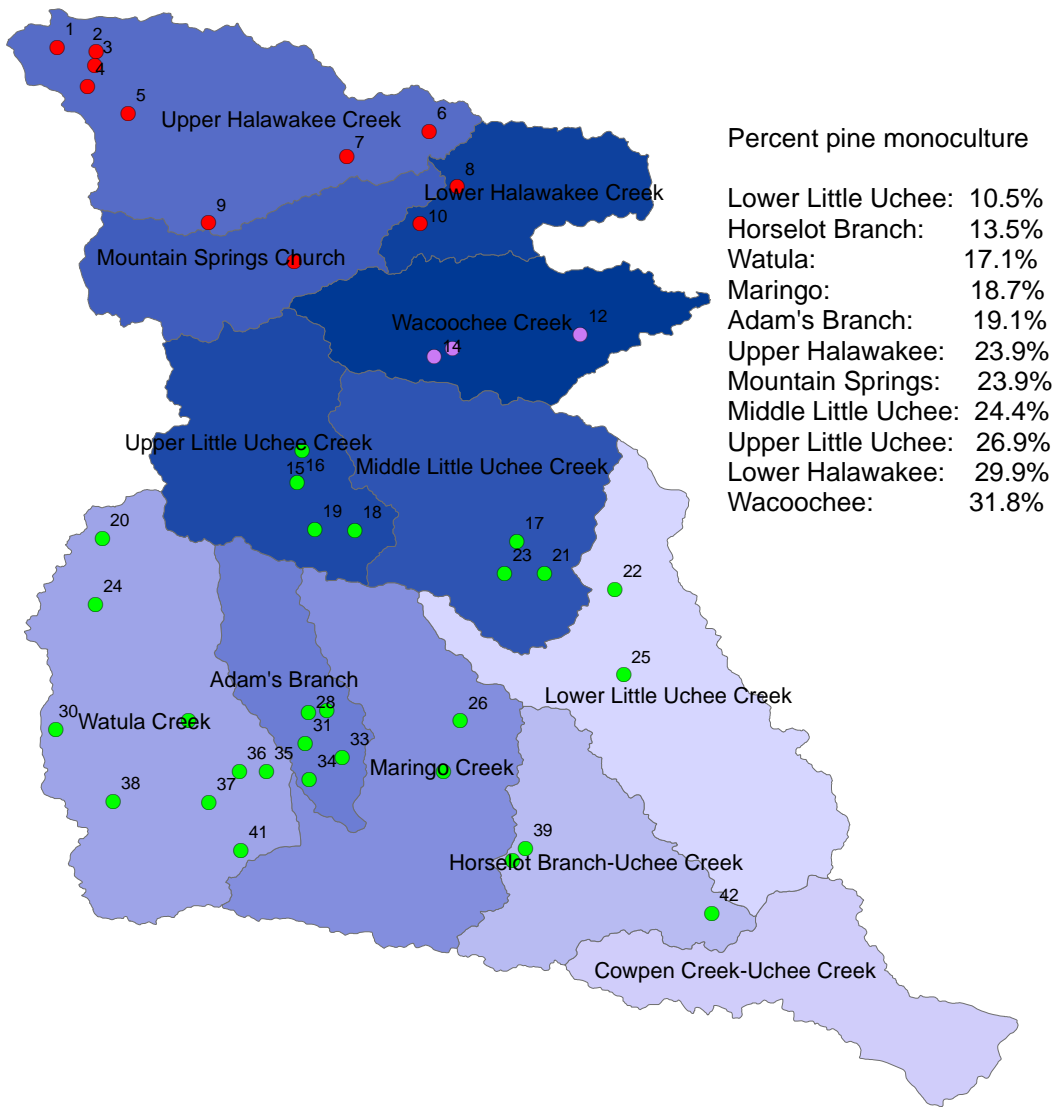


Fig. 14. Linear regression showing the relationship between assemblage similarity (Morisita Index) by site and the percent of agriculture land use within a 2km buffer upstream of the corresponding sites. Assemblage similarity and percent agriculture showed a weak, yet significant negative relationship ($p < 0.05$).

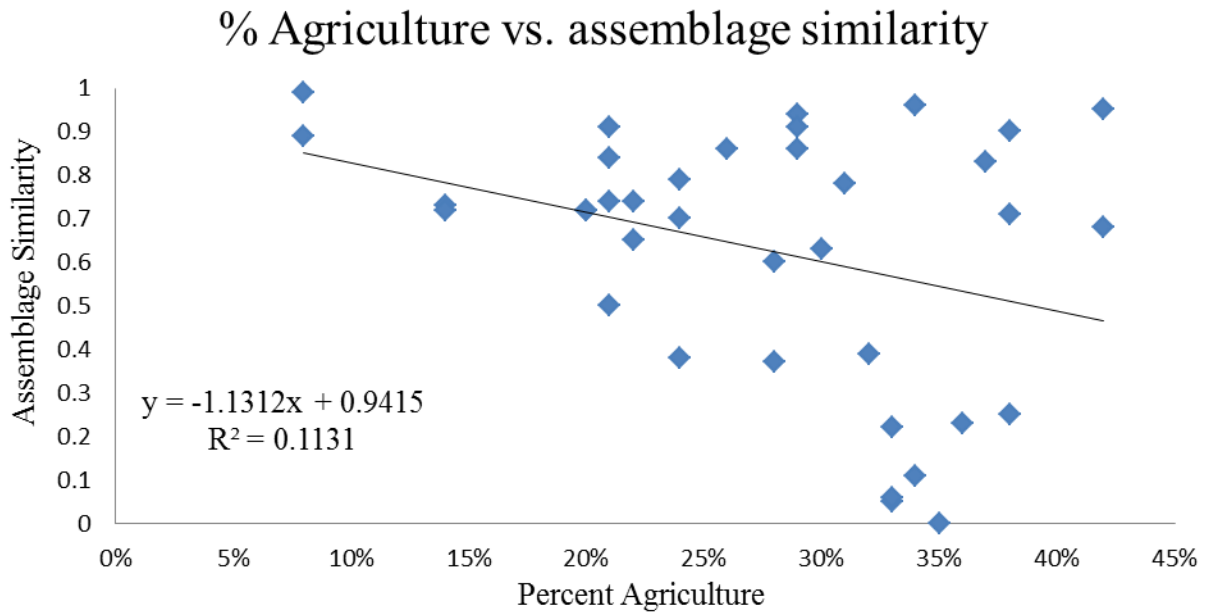


Fig. 15. Linear regression showing the relationship between assemblage similarity (Morisita Index) by site and the percent of forest land use within a 2km buffer upstream of the corresponding sites. Assemblage similarity and percent forest showed a weak, non significant positive relationship ($p = 0.22$).

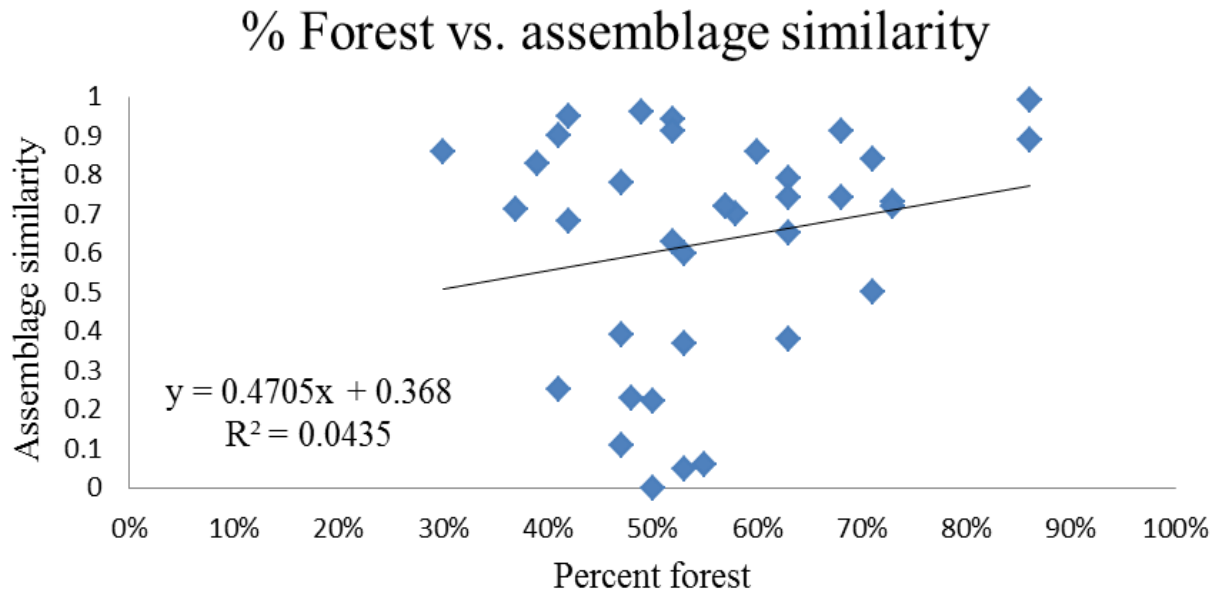


Fig. 16. Linear regression showing the relationship between assemblage similarity (Morisita Index) by site and the percent of pine monoculture within a 2km buffer upstream of the corresponding sites. Assemblage similarity and percent pine monoculture showed a weak, non significant positive relationship ($p = 0.58$).

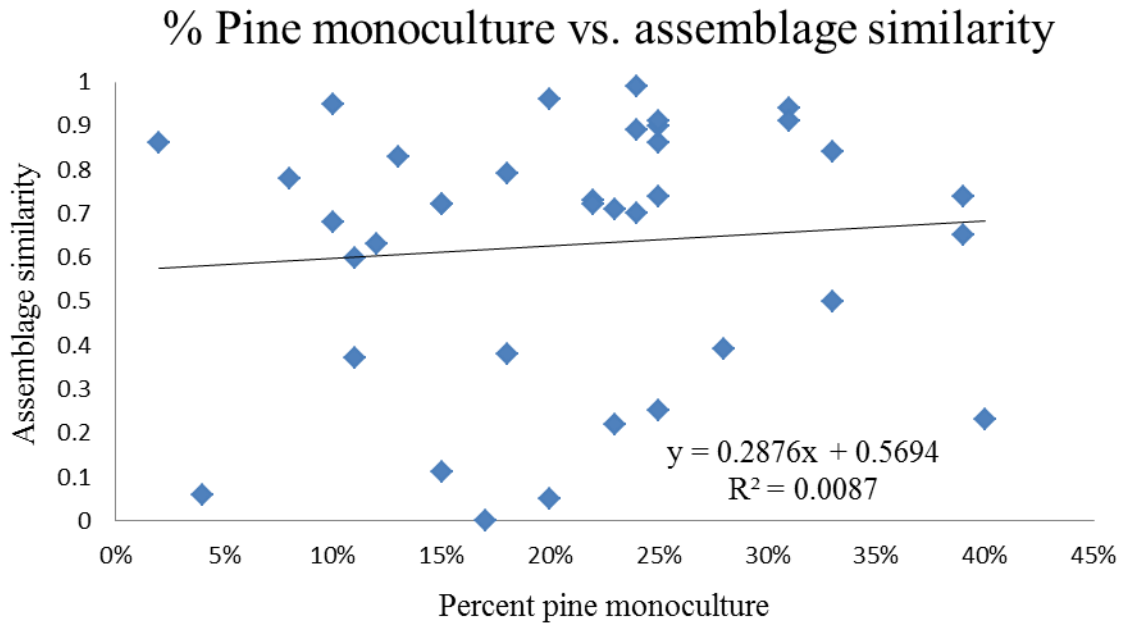


Fig. 17. Linear regression showing the relationship between assemblage similarity (Morisita Index) by site and the percent of urban land use within a 2km buffer upstream of the corresponding sites. Assemblage similarity and percent urban land use showed a weak, non significant negative relationship ($p = 0.78$).

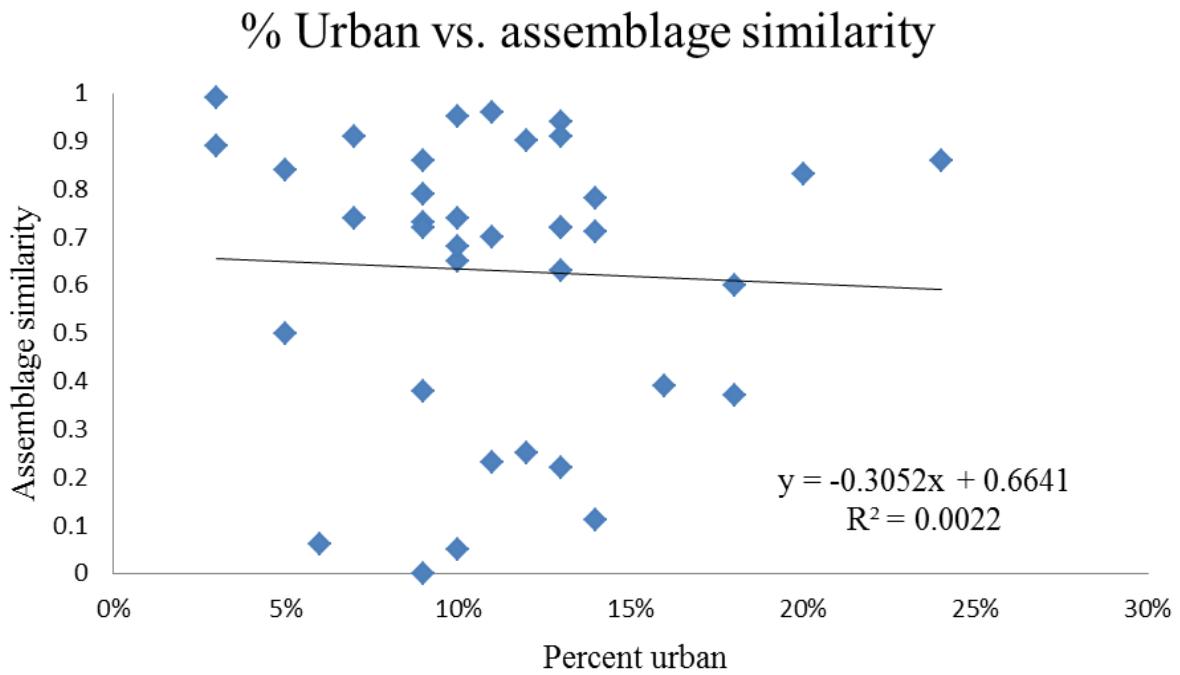


Fig. 18. Linear regression displaying the relationship between average water velocity and percent of individuals within an assemblage that are classified as high flow species. Data used is from sites one through forty two, 2010 and 2011. The relationship between average flow and percent high flow individuals in an assemblage is weakly positive and not significant ($p = 0.18$).

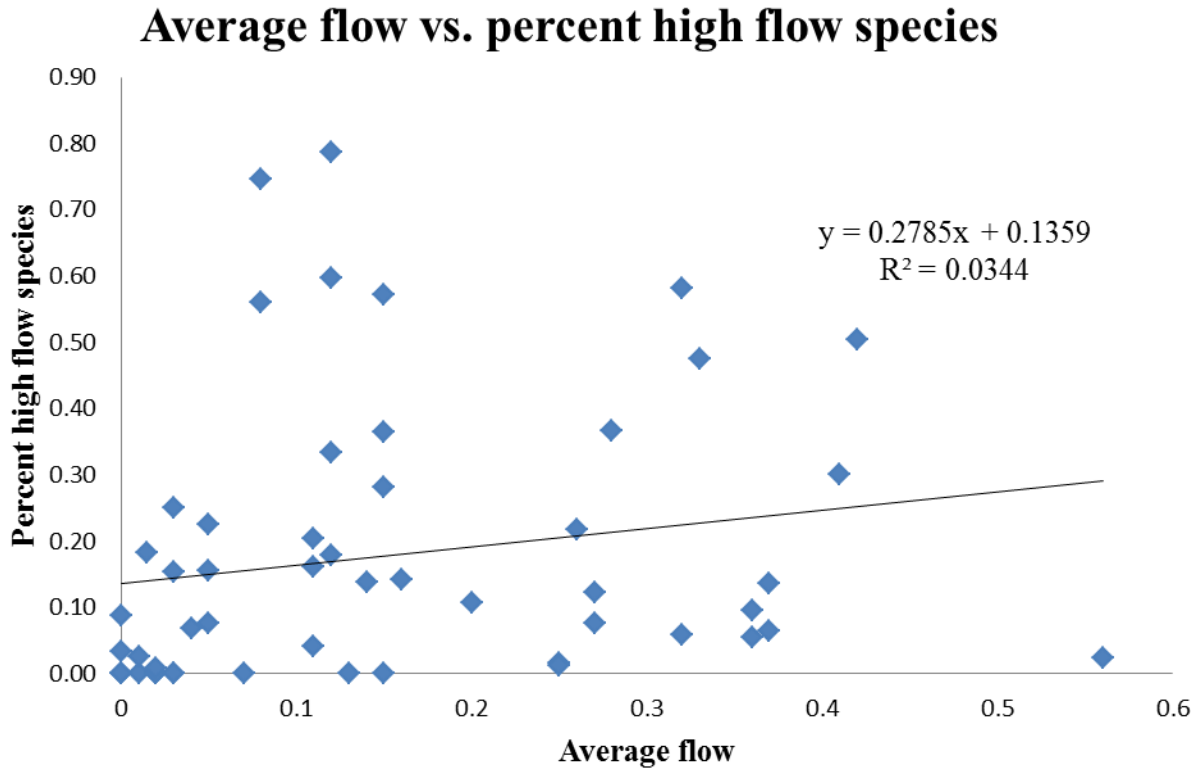


Fig. 19. Linear regression displaying the relationship between average water velocity and percent of individuals within an assemblage that are classified as moderate flow species. Data used is from sites one through forty two, 2010 and 2011. The relationship between average flow and percent moderate flow individuals in an assemblage is both positive and significant ($p < 0.05$).

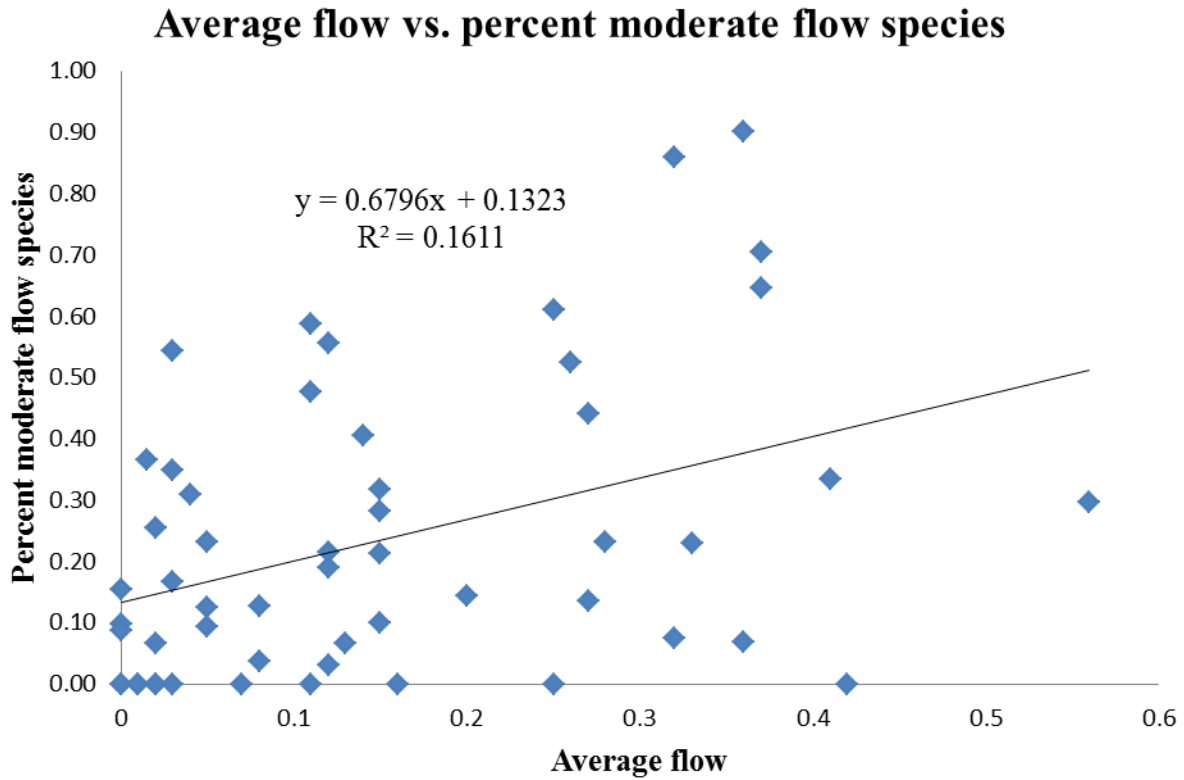
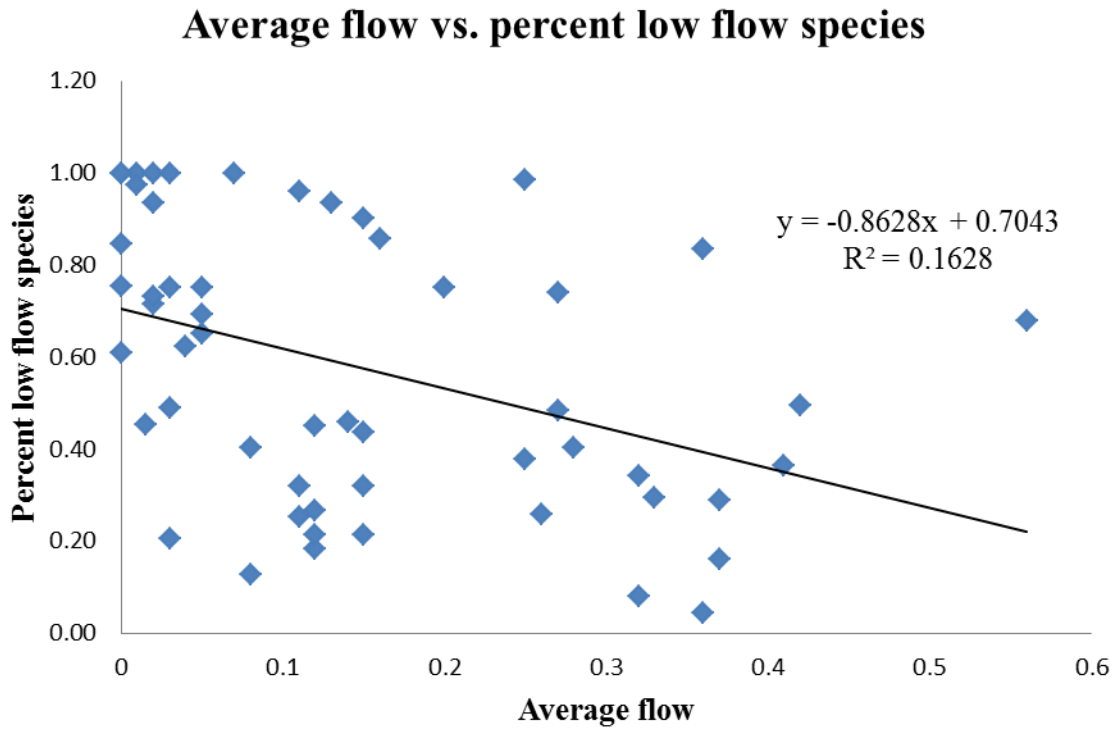


Fig. 20. Linear regression displaying the relationship between average water velocity and percent of individuals within an assemblage that are classified as low flow species. Data used is from sites one through forty two, 2010 and 2011. The relationship between average flow and percent low flow individuals in an assemblage is both negative and significant ($p < 0.05$).



Appendix 1. Locality and collection date information for all sites.

Site #	Longitude	Latitude	Project Sample Dates	Previous Sample Dates	Road Crossing	Stream
1	-85.3872	32.7459	6/10/10	none	Lee Co. 173	Halawakee Creek
2	-85.3696	32.7437	6/10/10	7/19/2005	Chambers Co. 174	Halawakee Creek
3	-85.3703	32.7376	6/10/10	none	Lee Co. 174	Trib. Halawakee
4	-85.3736	32.7280	6/10/10	none	Lee Co. 174	Trib. Halawakee
5	-85.3551	32.7160	6/10/10	9/8/1995	Lee Co. 389	Trib. Halawakee
6	-85.2190	32.7080	6/22/10	5/21/1995	Lee Co. 262	Trib. Halawakee
7	-85.2562	32.6965	6/22/10	7/27/06, 7/18/05, 12/4/01, 8/16/95, 10/11/91	Lee Co. 390	Halawakee Creek
8	-85.2063	32.6828	6/22/10	8/4/09, 6/13/06	Lee Co. Rd. 259	Halawakee Creek
9	-85.3188	32.6664	6/11/10	none	Lee Co. 161	Little Halawakee
10	-85.2230	32.6659	6/18/10	none	Lee Co.158	Trib. Halawakee
11	-85.2801	32.6490	6/11/10	none	Lee Co. 158	Trib. Halawakee
12	-85.1506	32.6161	6/10/11, 6/17/10	6/16/09, 8/2/06, 6/13/95, 10/13/70	Lee Rd. 279	Wacoochee Creek
13	-85.2083	32.6096	5/26/11, 6/17/10	6/16/09, 8/4/05, 4/22/95, 11/5/69, 11/16/69	Lee Co. Rd. 252	Wacoochee creek
14	-85.2166	32.6061	5/26/11, 6/17/10	6/16/09, 4/22/95, 11/6/69, 10/26/69	Lee Co. 254	Wacoochee Creek
15	-85.2765	32.5633	6/9/10	5/19/04, 6/14/95	Lee Co. 145	Phelps Creek
16	-85.2786	32.5491	5/27/11, 6/14/10	6/2/09, 8/2/06, 5/21/95	Lee Co. Rd. 144	Little Uchee Creek
17	-85.1793	32.5223	6/15/10	6/21/04, 6/13/95	Lee Co. 245	Peters Creek
18	-85.2526	32.5275	5/27/11, 6/14/10	6/2/09, 5/22/06, 6/15/04, 5/21/95	Lee Co. Rd. 175	Little Uchee Creek
19	-85.2707	32.5279	6/17/10	10/3/53, 10/17/53	Lee Co. 138	Flake Creek
20	-85.3668	32.5237	6/1/11, 6/9/10	7/7/09, 6/15/04, 7/8/76	Lee Co. Rd. 757	Watula Creek
21	-85.1668	32.5081	5/31/11, 6/15/10	7/7/09, 6/18/04, 5/18/95	Lee Co. 240	Whites Creek
22	-85.1349	32.5005	5/31/11, 6/15/10	6/2/09, 6/18/04, 5/20/95	Lee Co. 240	Hospilika Creek
23	-85.1848	32.5081	5/31/11, 6/15/10	6/2/09, 6/22/04	Lee Co. Rd. 206	Little Uchee Creek
24	-85.3700	32.4939	6/9/10	7/8/1976	Lee Co. 42	Trib. Watula Creek
25	-85.1310	32.4620	6/24/10	7/15/04, 10/24/1971	Russell Co. Hwy 80	Little Uchee Creek
26	-85.2048	32.4412	6/1/11, 6/8/10	7/7/09, 5/25/04	Russell Co. Rd. 27	Island Creek
27	-85.2653	32.4456	6/9/10	3/10/2001	Russell Co. Hwy 80	Adam's Branch

Appendix 1 (continued).

Site			Project Sample		Road Crossing	Stream
#	Longitude	Latitude	Dates	Previous Sample Dates		
28	-85.2736	32.4450	6/9/10	3/10/01, 4/27/1980	Russell Co. Hwy 80	Adam's Branch
29	-85.3278	32.4411	6/9/10	3/10/01, 6/16/95, 5/17/1977	Russell Co. Hwy 80	Trib. Snake Creek
30	-85.3879	32.4375	6/9/10	8/5/1976	Lee Co. Hwy 80	Trib. Uchee Creek
31	-85.2751	32.4311	6/1/11, 6/8/10	6/8/09, 6/4/04	Russell Co. Rd 32	Adam's Branch
32	-85.2125	32.4180	6/1/11, 6/8/10	7/7/09, 5/25/04	Russell Co. Rd. 27	Maringo Creek
33	-85.2583	32.4248	6/1/11, 6/23/10	6/8/2009	Russell Co. Rd 33	Adam's Branch
34	-85.2731	32.4146	6/9/10	10/4/1955	Russell Co. Rd 33	Adam's Branch
35	-85.2926	32.4184	6/8/10	5/27/2004	Russell Co. Rd. 72	Snake Creek
36	-85.3048	32.4185	6/16/11, 6/8/10	7/7/2009	Lee Co. Rd. 72	Snake Creek
37	-85.3186	32.4043	7/13/10	3/17/2001	Russell Co. Rd 32	Uchee Trib.
38	-85.3619	32.4047	6/18/10	5/21/04, 5/20/95, 4/16/78, 7/19/77	Lee Co. State rt. 51	Uchee Creek
39	-85.1754	32.3834	6/23/10	10/1/1955	Russell Co. rt. 169	Trib. Uchee Creek
40	-85.1812	32.3782	6/23/10	7/15/04, 3/27/99, 6/14/95, 11/4/68	Russell Co. rt. 169	Uchee Creek
41	-85.3042	32.3825	6/23/10	4/11/00, 10/11/91	Russell Co. Rd. 65	Uchee Creek
42	-85.0911	32.3541	6/24/10	5/20/2004	Russell Co. Rd. 137	Uchee Creek

Appendix 2. Species abundance data for all samples from 1953 through 2011.

Site # (year)	1(10)	2(10)	2(05)	3(10)	4(10)	5(10)	5(95)	6(10)	6(95)	7(10)	7(06)	7(05)	7(01)
<i>Ichthyomyzon gagei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Amia calva</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Campostoma paucradii</i>	5	0	0	0	10	0	5	10	10	2	2	5	4
<i>Cyprinella callitaenia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	0	0	1	0	0	0	3	0	0	8	2	1	6
<i>Hybopsis winchelli</i>	0	0	0	0	0	0	3	0	0	1	1	14	56
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	36	38	0	0	2	2
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nocomis leptcephalus</i>	0	0	0	0	0	0	0	10	3	0	0	5	1
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis ammophilus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	2	0	0	0	0	0	8	0	0	0	0	0	16
<i>Notropis baileyi</i>	0	0	0	0	0	0	0	1	22	11	2	1	40
<i>Notropis cummingsae</i>	0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	0	0	0	9	0	0	1	0	0	7
<i>Notropis texanus</i>	0	2	0	0	0	0	0	0	0	0	0	1	0
<i>Opsopoedus emiliae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pteronotropis euryzonus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	34	1	0	0	59	9	0	56	38	0	0	0	0
<i>Erimyzon oblongus</i>	2	0	0	0	8	1	0	0	0	0	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	1	3	3	2	1
<i>Minytrema melanops</i>	0	0	0	0	0	0	3	0	0	0	0	0	0
<i>Moxostoma poecilurum</i>	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	0	0	0	1	3
<i>Ameiurus brunneus</i>	0	0	1	0	0	0	1	0	0	0	1	0	0
<i>Ameiurus natalis</i>	2	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus nebulosus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ictalurus punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Noturus gyrinus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 (continued).

Site # (year)	7(95)	7(91)	8(10)	8(06)	9(10)	10(10)	11(10)	12(11)	12(10)	12(09)	12(06)	12(95)	12(70)
<i>Ichthyomyzon gagei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Amia calva</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Campostoma paucradii</i>	0	1	2	0	13	5	24	2	4	9	2	7	3
<i>Cyprinella callitaenia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	7	38	0	0	0	0	0	5	13	14	25	32	0
<i>Hybopsis winchelli</i>	16	0	0	3	11	16	15	0	2	0	2	56	2
<i>Luxilus zonistius</i>	4	0	0	0	13	13	0	0	0	1	0	3	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	0	0	0	0	0	0	3	57
<i>Nocomis leptocephalus</i>	5	1	0	0	13	1	0	0	0	0	0	8	0
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis ammophilus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	4	1	0	0	0	1	2	2	0	0	0	0	0
<i>Notropis baileyi</i>	54	69	0	0	37	8	22	0	0	0	0	0	0
<i>Notropis cummingsae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	18	6	0	0	0	175
<i>Notropis longirostris</i>	1	2	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis texanus</i>	0	0	0	0	0	0	0	3	5	11	0	0	0
<i>Opsopoedus emiliae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pteronotropis euryzonus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	0	0	0	0	35	2	16	0	0	0	0	0	0
<i>Erimyzon oblongus</i>	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Hypentelium etowanum</i>	6	2	0	0	9	1	3	1	0	0	0	0	0
<i>Minytrema melanops</i>	1	0	0	0	0	0	0	0	1	0	0	0	0
<i>Moxostoma poecilurum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	4	0	0	0	0	0	0	0	4	4	2	14	0
<i>Ameiurus brunneus</i>	3	4	11	0	0	0	0	6	0	7	3	1	0
<i>Ameiurus natalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus nebulosus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ictalurus punctatus</i>	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Noturus gyrinus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 (continued).

Site # (year)	7(95)	7(91)	8(10)	8(06)	9(10)	10(10)	11(10)	12(11)	12(10)	12(09)	12(06)	12(95)	12(70)
<i>Noturus leptacanthus</i>	5	9	0	0	0	0	0	0	0	0	0	0	0
<i>Esox americanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox niger</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Labidesthes sicculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Fundulus olivaceus</i>	3	7	0	2	0	0	8	0	0	0	0	0	0
<i>Gambusia holbrooki</i>	0	1	0	0	0	0	0	1	0	1	0	0	0
<i>Lepomis auritus</i>	26	11	10	15	10	11	5	29	14	19	2	23	0
<i>Lepomis cyanellus</i>	8	1	1	0	2	19	0	25	5	5	1	5	0
<i>Lepomis cyanellus x macrochirus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis gulosus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis macrochirus</i>	13	5	4	1	2	0	2	1	2	0	0	9	0
<i>Lepomis megalotis</i>	3	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis microlophus</i>	0	0	0	0	0	0	0	1	0	0	0	0	0
<i>Lepomis miniatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus cataractae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus coosae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus henshalli</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus punctulatus</i>	0	2	0	1	0	0	0	0	0	0	1	0	0
<i>Micropterus salmoides</i>	0	0	38	0	1	1	5	0	1	0	0	0	0
<i>Pomoxis nigromaculatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma edwini</i>	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Etheostoma parvipinne</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma swaini</i>	1	2	0	0	0	0	7	0	0	0	0	0	0
<i>Etheostoma whipplei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Perca flavescens</i>	1	0	2	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	19	26	11	0	0	3	12	32	30	7	43	13	0
<i>Elassoma zonatum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
# species	20	17	10	6	11	13	13	13	12	10	9	12	4
# individuals	184	182	81	23	146	82	122	126	87	78	81	174	237

Appendix 2 (continued).

Site # (year)	13(11)	13(10)	13(09)	13(05)	13(95)	13(69)	14(11)	14(10)	14(09)	14(95)	14(69)	15(10)	15(04)
<i>Ichthyomyzon gagei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Amia calva</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Campostoma paucradii</i>	0	11	6	0	8	21	10	6	6	11	0	7	19
<i>Cyprinella callitaenia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	0	1	0	0	1	0	0	1	0	3	0	0	0
<i>Hybopsis winchelli</i>	0	46	0	0	18	1	14	27	15	12	2	9	1
<i>Luxilus zonistius</i>	5	70	52	0	47	33	6	22	57	47	12	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	8	49	0	20	0	9	30	0	1
<i>Nocomis leptcephalus</i>	0	18	6	0	5	2	2	1	7	4	2	0	0
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis ammophilus</i>	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	21	38	31	2	42	24	40	45	26	38	76	12	39
<i>Notropis baileyi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis cummingsae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	1	0	0	0	1	0	0
<i>Notropis longirostris</i>	77	56	45	0	48	67	53	33	39	40	32	0	0
<i>Notropis texanus</i>	0	0	10	0	0	0	0	0	0	4	0	0	0
<i>Opsopoedus emiliae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pteronotropis euryzonus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	16	34	6	1	1	8	0	0	3	0	0	7	22
<i>Erimyzon oblongus</i>	0	0	0	0	0	0	0	0	0	0	0	10	5
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	0	0	0	7	2
<i>Minytrema melanops</i>	0	0	0	0	2	0	0	8	0	1	0	0	0
<i>Moxostoma poecilurum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	9	0	0	8	0	4	4	0	0
<i>Ameiurus brunneus</i>	0	0	0	0	0	0	0	0	1	4	0	0	0
<i>Ameiurus natalis</i>	0	3	0	0	0	0	1	1	1	0	0	0	1
<i>Ameiurus nebulosus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ictalurus punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Noturus gyrinus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 (continued).

Site # (year)	13(11)	13(10)	13(09)	13(05)	13(95)	13(69)	14(11)	14(10)	14(09)	14(95)	14(69)	15(10)	15(04)
<i>Noturus leptacanthus</i>	0	0	0	0	0	0	0	0	0	0	0	0	2
<i>Esox americanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox niger</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Labidesthes sicculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Fundulus olivaceus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Gambusia holbrooki</i>	2	2	1	0	0	1	5	0	0	0	2	5	0
<i>Lepomis auritus</i>	2	19	4	7	16	27	5	20	8	27	24	8	24
<i>Lepomis cyanellus</i>	3	8	1	2	15	8	1	5	6	18	1	9	4
<i>Lepomis cyanellus x macrochirus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis gulosus</i>	0	0	0	0	1	0	0	0	0	3	0	0	1
<i>Lepomis macrochirus</i>	1	4	2	0	13	30	7	18	4	28	1	13	11
<i>Lepomis megalotis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis microlophus</i>	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Lepomis miniatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus cataractae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus coosae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus henshalli</i>	0	2	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus punctulatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Micropterus salmoides</i>	0	0	0	0	0	2	0	4	0	2	1	0	0
<i>Pomoxis nigromaculatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma edwini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma parvipinne</i>	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Etheostoma swaini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma whipplei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Perca flavescens</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	4	25	24	0	13	5	5	7	10	11	20	8	32
<i>Elassoma zonatum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
# species	9	15	12	5	16	15	13	16	13	18	14	12	15
# individuals	131	337	188	13	247	279	150	226	183	266	208	96	165

Appendix 2 (continued).

Site # (year)	15(95)	16(11)	16(10)	16(09)	16(06)	16(95)	17(10)	17(04)	17(95)	18(11)	18(10)	18(09)	18(06)
<i>Ichthyomyzon gagei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Amia calva</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Campostoma paucradii</i>	3	15	24	7	9	16	2	6	11	26	8	12	6
<i>Cyprinella callitaenia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	2	18	25	25	6	35	0	0	0	29	7	4	19
<i>Hybopsis winchelli</i>	24	5	3	0	0	19	0	0	0	2	0	1	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	3	0	0	1	0	0	0	0	0	0	0	0	0
<i>Nocomis leptocephalus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis ammophilus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	3	4	6	16	3	7	0	0	0	1	0	0	0
<i>Notropis baileyi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis cummingsae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis hypsilepis</i>	0	2	1	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis texanus</i>	0	0	0	22	0	0	0	0	0	0	9	13	1
<i>Opsopoedus emiliae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pteronotropis euryzonus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	1	16	8	3	0	2	119	17	264	4	4	0	3
<i>Erimyzon oblongus</i>	0	0	1	1	0	1	0	0	0	0	0	0	0
<i>Hypentelium etowanum</i>	6	1	4	3	0	7	0	0	0	2	1	0	1
<i>Minytrema melanops</i>	4	0	0	1	0	2	0	0	0	0	0	0	0
<i>Moxostoma poecilurum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	1	2	0	0	0	0	0	0	0
<i>Ameiurus brunneus</i>	0	0	6	4	1	2	0	0	2	11	6	5	7
<i>Ameiurus natalis</i>	0	3	0	0	0	0	1	3	0	1	0	0	0
<i>Ameiurus nebulosus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ictalurus punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Noturus gyrinus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 (continued).

Site # (year)	15(95)	16(11)	16(10)	16(09)	16(06)	16(95)	17(10)	17(04)	17(95)	18(11)	18(10)	18(09)	18(06)
<i>Noturus leptacanthus</i>	0	0	0	1	0	6	0	0	0	0	1	1	0
<i>Esox americanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox niger</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Labidesthes sicculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Fundulus olivaceus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Gambusia holbrooki</i>	0	2	2	0	0	0	0	0	0	0	0	0	0
<i>Lepomis auritus</i>	24	40	22	17	4	11	0	0	0	24	6	1	6
<i>Lepomis cyanellus</i>	12	0	1	0	3	9	0	0	0	0	0	0	2
<i>Lepomis cyanellus x macrochirus</i>	4	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis gulosus</i>	0	1	0	2	0	6	0	0	0	1	0	1	0
<i>Lepomis macrochirus</i>	6	7	21	39	11	14	0	0	0	13	2	5	2
<i>Lepomis megalotis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis microlophus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis miniatus</i>	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Lepomis punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus cataractae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus coosae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus henshalli</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus punctulatus</i>	0	0	1	0	0	0	0	0	0	0	0	0	1
<i>Micropterus salmoides</i>	0	1	0	1	0	0	0	0	0	0	1	0	0
<i>Pomoxis nigromaculatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma edwini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma parvipinne</i>	0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Etheostoma swaini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma whipplei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Perca flavescens</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	9	27	47	36	20	75	0	0	0	48	35	19	47
<i>Elassoma zonatum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
# species	13	15	15	17	9	17	3	3	3	12	13	10	11
# individuals	101	143	172	182	58	215	122	26	277	162	81	73	95

Appendix 2 (continued).

Site # (year)	18(04)	18(95)	19(10)	19(53)	20(11)	20(10)	20(09)	20(04)	21(11)	21(10)	21(09)	21(04)	21(95)
<i>Ichthyomyzon gagei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Amia calva</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Campostoma paucradii</i>	9	9	0	0	0	0	0	0	10	8	9	12	8
<i>Cyprinella callitaenia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	27	13	0	0	0	0	0	0	0	0	0	0	0
<i>Hybopsis winchelli</i>	1	8	0	55	0	0	0	0	0	0	0	0	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	0	0	0	0	0	0	1	1
<i>Nocomis leptocephalus</i>	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis ammophilus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	1	2	0	72	0	0	0	0	3	2	14	3	28
<i>Notropis baileyi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis cummingsae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	2	0	0	0	0	0	0	1	0	1
<i>Notropis texanus</i>	2	0	0	0	0	0	0	0	0	0	0	0	0
<i>Opsopoedus emiliae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pteronotropis euryzonus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	3	0	14	16	15	14	11	4	0	1	1	0	5
<i>Erimyzon oblongus</i>	0	0	4	0	0	0	0	2	0	0	0	0	0
<i>Hypentelium etowanum</i>	0	10	0	0	0	0	0	0	0	0	0	0	0
<i>Minytrema melanops</i>	0	0	0	0	0	0	0	0	0	0	2	2	0
<i>Moxostoma poecilurum</i>	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	2	2	0	6	0	0	0	0	4	6	13	6	5
<i>Ameiurus brunneus</i>	0	2	0	0	0	0	0	0	0	0	0	0	4
<i>Ameiurus natalis</i>	2	0	1	0	0	2	2	0	0	1	0	0	0
<i>Ameiurus nebulosus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ictalurus punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Noturus gyrinus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 (continued).

Site # (year)	18(04)	18(95)	19(10)	19(53)	20(11)	20(10)	20(09)	20(04)	21(11)	21(10)	21(09)	21(04)	21(95)
<i>Noturus leptacanthus</i>	1	0	1	4	0	0	0	0	0	0	0	0	0
<i>Esox americanus</i>	0	0	0	0	0	2	3	0	0	0	0	0	0
<i>Esox niger</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	0	0	0	2	1	0	1	0	0	0	0	0
<i>Labidesthes sicculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Fundulus olivaceus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Gambusia holbrooki</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis auritus</i>	9	9	0	0	0	0	0	0	17	6	8	11	38
<i>Lepomis cyanellus</i>	0	1	1	0	0	1	0	0	1	3	3	0	31
<i>Lepomis cyanellus x macrochirus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis gulosus</i>	0	0	0	0	2	1	0	0	0	0	0	0	0
<i>Lepomis macrochirus</i>	10	2	2	0	6	3	6	1	4	1	6	2	4
<i>Lepomis megalotis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis microlophus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis miniatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus cataractae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus coosae</i>	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus henshalli</i>	0	0	0	0	0	0	0	0	0	2	0	0	0
<i>Micropterus punctulatus</i>	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus salmoides</i>	0	1	0	0	0	0	0	0	1	0	5	0	0
<i>Pomoxis nigromaculatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma edwini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma parvipinne</i>	0	0	1	1	0	4	0	0	0	0	0	0	0
<i>Etheostoma swaini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma whipplei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Perca flavescens</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	22	39	2	5	0	0	0	0	11	14	14	3	27
<i>Elassoma zonatum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
# species	14	13	8	10	4	8	4	4	8	10	11	8	11
# individuals	91	99	26	163	25	28	24	8	51	44	76	40	152

Appendix 2 (continued).

Site # (year)	22(11)	22(10)	22(09)	22(04)	22(95)	23(11)	23(10)	23(09)	23(04)	24(10)	24(76)	25(10)	25(04)
<i>Ichthyomyzon gagei</i>	0	0	0	2	3	0	0	0	1	DRY	0	0	0
<i>Amia calva</i>	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Campostoma paucradii</i>	0	4	0	2	0	0	0	0	5	0	0	0	0
<i>Cyprinella callitaenia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	0	0	0	0	3	89	35	4	26	0	0	14	5
<i>Hybopsis winchelli</i>	11	7	0	1	36	11	1	1	0	0	0	1	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	1	1	0	0	0	0	0	25	4	0
<i>Nocomis leptocephalus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis ammophilus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	5	7	0	2	39	0	0	0	1	0	0	8	0
<i>Notropis baileyi</i>	0	0	0	0	0	0	0	0	0	0	4	0	0
<i>Notropis cummingsae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	1	0	0	0	0	0	0	0	0	1
<i>Notropis longirostris</i>	1	4	0	9	50	57	0	0	0	0	6	4	0
<i>Notropis texanus</i>	21	35	0	0	60	16	4	0	7	0	42	18	7
<i>Opsopoedus emiliae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pteronotropis euryzonus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	0	7	0	1	0	0	0	0	1	0	0	0	0
<i>Erimyzon oblongus</i>	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	11	7	6	2	0	0	2	0
<i>Minytrema melanops</i>	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Moxostoma poecilurum</i>	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	3	2	1	0	0	0	0
<i>Ameiurus brunneus</i>	0	0	0	0	0	1	3	2	4	0	0	1	0
<i>Ameiurus natalis</i>	2	0	1	5	0	0	0	0	0	0	0	1	0
<i>Ameiurus nebulosus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ictalurus punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	3	0
<i>Noturus gyrinus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 (continued).

Site # (year)	22(11)	22(10)	22(09)	22(04)	22(95)	23(11)	23(10)	23(09)	23(04)	24(10)	24(76)	25(10)	25(04)
<i>Noturus leptacanthus</i>	0	1	0	2	13	0	1	0	3	0	0	9	3
<i>Esox americanus</i>	0	0	0	1	1	0	0	0	0	0	0	0	0
<i>Esox niger</i>	0	1	0	1	2	0	0	0	0	0	1	0	0
<i>Aphredoderus sayanus</i>	0	0	0	2	1	0	1	0	1	0	0	0	0
<i>Labidesthes sicculus</i>	1	2	0	0	0	10	1	0	2	0	2	0	7
<i>Fundulus olivaceus</i>	3	6	1	3	4	3	0	0	1	0	7	4	1
<i>Gambusia holbrooki</i>	0	0	0	0	0	10	0	0	0	0	0	0	0
<i>Lepomis auritus</i>	12	7	5	0	40	11	16	12	8	0	3	14	6
<i>Lepomis cyanellus</i>	8	0	1	1	18	0	1	0	0	0	0	0	0
<i>Lepomis cyanellus x macrochirus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis gulosus</i>	5	0	2	1	0	0	1	0	1	0	0	0	1
<i>Lepomis macrochirus</i>	38	38	6	4	6	1	13	10	0	0	0	10	8
<i>Lepomis megalotis</i>	14	6	1	18	17	33	35	2	10	0	0	11	14
<i>Lepomis microlophus</i>	0	0	0	0	0	0	0	0	1	0	0	1	2
<i>Lepomis miniatus</i>	0	0	1	0	0	0	0	0	1	0	0	0	0
<i>Lepomis punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus cataractae</i>	0	0	0	0	0	3	0	0	0	0	0	0	0
<i>Micropterus coosae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus henshalli</i>	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus punctulatus</i>	0	0	0	2	0	0	3	0	0	0	0	0	2
<i>Micropterus salmoides</i>	0	4	1	0	1	0	0	0	1	0	3	0	0
<i>Pomoxis nigromaculatus</i>	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma edwini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma parvipinne</i>	3	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma swaini</i>	0	5	0	1	1	0	0	0	0	0	0	10	15
<i>Etheostoma whipplei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Perca flavescens</i>	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Percina nigrofasciata</i>	8	18	1	9	15	27	19	6	36	0	1	55	22
<i>Elassoma zonatum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
# species	15	17	10	22	19	14	17	9	21	0	10	19	16
# individuals	133	153	20	70	311	283	145	45	114	0	94	170	96

Appendix 2 (continued).

Site # (year)	25(71)	26(11)	26(10)	26(09)	26(04)	27(10)	27(01)	28(10)	28(01)	28(80)	29(10)	29(01)	29(95)
<i>Ichthyomyzon gagei</i>	0	0	0	0	0	0	0	2	11	0	DRY	DRY	0
<i>Amia calva</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Campostoma paucradii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella callitaenia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hybopsis winchelli</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nocomis leptocephalus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	17	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis ammophilus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis baileyi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis cummingsae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis texanus</i>	1	0	1	0	0	0	0	0	0	0	0	0	31
<i>Opsopoedus emiliae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pteronotropis euryzonus</i>	0	0	0	0	0	0	0	44	57	44	0	0	2
<i>Semotilus thoreauianus</i>	0	0	0	4	1	5	0	22	47	2	0	0	6
<i>Erimyzon oblongus</i>	0	0	0	0	1	0	0	1	2	0	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Minytrema melanops</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Moxostoma poecilurum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus brunneus</i>	0	0	0	0	0	0	0	0	0	0	0	0	8
<i>Ameiurus natalis</i>	0	0	0	0	5	0	0	0	0	0	0	0	0
<i>Ameiurus nebulosus</i>	4	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ictalurus punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Noturus gyrinus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 (continued).

Site # (year)	25(71)	26(11)	26(10)	26(09)	26(04)	27(10)	27(01)	28(10)	28(01)	28(80)	29(10)	29(01)	29(95)
<i>Noturus leptacanthus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox americanus</i>	0	0	1	2	2	4	0	3	0	0	0	0	6
<i>Esox niger</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	1	1	1	0	0	0	6	0	0	0	0	6
<i>Labidesthes sicculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Fundulus olivaceus</i>	0	0	0	0	0	0	0	0	0	0	0	0	15
<i>Gambusia holbrooki</i>	71	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis auritus</i>	0	0	0	0	0	0	0	0	0	0	0	0	23
<i>Lepomis cyanellus</i>	30	3	0	0	0	0	0	0	0	0	0	0	3
<i>Lepomis cyanellus x macrochirus</i>	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Lepomis gulosus</i>	6	4	0	0	0	0	0	0	0	0	0	0	2
<i>Lepomis macrochirus</i>	54	19	7	25	6	0	0	0	0	0	0	0	10
<i>Lepomis megalotis</i>	0	4	0	1	0	0	0	0	0	0	0	0	8
<i>Lepomis microlophus</i>	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis miniatus</i>	0	0	0	0	0	0	0	2	7	0	0	0	0
<i>Lepomis punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	13
<i>Micropterus cataractae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus coosae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus henshalli</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus punctulatus</i>	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>Micropterus salmoides</i>	0	1	0	2	0	0	0	0	0	0	0	0	0
<i>Pomoxis nigromaculatus</i>	3	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma edwini</i>	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Etheostoma parvipinne</i>	0	0	0	0	0	0	0	2	0	0	0	0	0
<i>Etheostoma swaini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma whipplei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Perca flavescens</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	0	0	0	0	3	0	0	0	0	0	0	0	5
<i>Elassoma zonatum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
# species	10	6	4	6	7	2	1	8	5	2	0	0	16
# individuals	208	32	10	35	19	9	1	82	124	46	0	0	140

Appendix 2 (continued).

Site # (year)	29(77)	30(10)	30(76)	31(11)	31(10)	31(09)	31(04)	32(11)	32(10)	32(09)	32(04)	33(11)	33(10)
<i>Ichthyomyzon gagei</i>	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Amia calva</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Campostoma paucradii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella callitaenia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hybopsis winchelli</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	7	0	0	0	0	0	0	0	0	0	0
<i>Nocomis leptocephalus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	0	0	7	0	0	1	0	0	0	0	5	0
<i>Notropis ammophilus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Notropis baileyi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis cummingsae</i>	141	0	9	0	0	0	30	0	3	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis texanus</i>	313	0	65	0	0	0	25	0	0	0	0	1	2
<i>Opsopoedus emiliae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pteronotropis euryzonus</i>	12	0	28	2	0	0	1	0	0	0	0	2	9
<i>Semotilus thoreauianus</i>	0	38	0	13	0	0	0	0	0	0	0	0	0
<i>Erimyzon oblongus</i>	0	0	0	0	0	0	4	0	0	0	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Minytrema melanops</i>	0	0	0	5	0	0	0	0	1	0	0	1	0
<i>Moxostoma poecilurum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus brunneus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus natalis</i>	2	3	0	5	2	0	3	0	0	0	3	0	4
<i>Ameiurus nebulosus</i>	0	5	0	0	0	0	0	0	0	0	0	0	0
<i>Ictalurus punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Noturus gyrinus</i>	0	0	0	0	0	0	1	0	0	0	0	0	0

Appendix 2 (continued).

Site # (year)	29(77)	30(10)	30(76)	31(11)	31(10)	31(09)	31(04)	32(11)	32(10)	32(09)	32(04)	33(11)	33(10)
<i>Noturus leptacanthus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox americanus</i>	2	1	0	12	1	0	10	3	7	2	4	7	5
<i>Esox niger</i>	0	0	3	0	0	0	0	0	0	0	2	0	0
<i>Aphredoderus sayanus</i>	2	18	2	2	2	2	0	0	7	0	16	1	7
<i>Labidesthes sicculus</i>	1	0	32	0	0	0	19	0	0	0	0	0	0
<i>Fundulus olivaceus</i>	0	0	9	4	2	0	1	1	1	0	3	3	2
<i>Gambusia holbrooki</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis auritus</i>	0	0	8	0	0	0	0	1	0	3	0	0	0
<i>Lepomis cyanellus</i>	0	0	0	0	0	0	0	1	0	0	0	0	0
<i>Lepomis cyanellus x macrochirus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis gulosus</i>	0	2	2	0	0	3	2	0	1	0	0	1	0
<i>Lepomis macrochirus</i>	0	3	0	9	0	4	3	0	5	1	0	2	6
<i>Lepomis megalotis</i>	0	0	0	0	0	0	0	0	0	3	1	0	0
<i>Lepomis microlophus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis miniatus</i>	0	0	5	0	0	0	7	0	0	0	1	0	2
<i>Lepomis punctatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus cataractae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus coosae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus henshalli</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus punctulatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus salmoides</i>	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Pomoxis nigromaculatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma edwini</i>	0	0	11	0	0	0	0	0	0	0	2	0	0
<i>Etheostoma parvipinne</i>	0	3	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma swaini</i>	0	0	9	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma whipplei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Perca flavescens</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	0	0	14	0	0	0	0	0	3	0	2	0	3
<i>Elassoma zonatum</i>	0	0	10	1	0	0	4	0	0	0	0	0	0
# species	7	8	16	11	4	4	14	4	8	4	9	9	9
# individuals	473	73	215	61	7	10	111	6	28	9	34	23	40

Appendix 2 (continued).

Site # (year)	33(09)	34(10)	35(10)	35(04)	36(11)	36(10)	36(09)	37(10)	38(10)	38(04)	38(95)	38(78)	39(10)
<i>Ichthyomyzon gagei</i>	0	0	0	0	0	0	0	1	0	0	0	2	0
<i>Amia calva</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Campostoma paucradii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella callitaenia</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	0	0	0	0	0	0	0	0	0	0	0	5	0
<i>Hybopsis winchelli</i>	0	0	0	0	0	0	0	0	46	19	60	5	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	0	0	0	0	0	0	203	0
<i>Nocomis leptocephalus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	0	14	0	0	1	7	1	0	0	0	11	0
<i>Notropis ammophilus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	0	0	0	0	0	0	0	0	14	7	14	5	0
<i>Notropis baileyi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis cummingsae</i>	0	0	0	0	0	0	0	0	2	0	1	154	1
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	0	0	0	0	0	0	0	3	8	0
<i>Notropis texanus</i>	0	0	0	9	0	0	0	7	74	6	102	44	0
<i>Opsopoedus emiliae</i>	0	0	0	0	0	0	0	0	0	0	0	2	0
<i>Pteronotropis euryzonus</i>	0	0	0	14	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	0	7	0	6	0	0	1	0	0	0	2	1	3
<i>Erimyzon oblongus</i>	0	3	0	0	0	1	0	2	4	3	2	1	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Minytrema melanops</i>	0	0	0	0	0	0	0	1	5	0	0	0	0
<i>Moxostoma poecilurum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus brunneus</i>	0	0	0	0	0	0	0	1	0	0	4	0	0
<i>Ameiurus natalis</i>	0	2	0	7	0	0	0	21	3	6	0	0	0
<i>Ameiurus nebulosus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ictalurus punctatus</i>	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Noturus gyrinus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2 (continued).

Site # (year)	33(09)	34(10)	35(10)	35(04)	36(11)	36(10)	36(09)	37(10)	38(10)	38(04)	38(95)	38(78)	39(10)
<i>Noturus leptacanthus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox americanus</i>	1	5	0	4	1	0	2	8	1	0	0	0	0
<i>Esox niger</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	1	6	0	23	1	1	0	3	0	1	1	0	0
<i>Labidesthes sicculus</i>	0	0	0	0	2	0	0	9	3	2	0	0	0
<i>Fundulus olivaceus</i>	0	0	0	0	0	0	0	32	16	0	20	85	5
<i>Gambusia holbrooki</i>	0	0	17	0	0	0	0	10	1	0	0	0	0
<i>Lepomis auritus</i>	0	0	9	3	2	4	2	12	17	12	48	1	0
<i>Lepomis cyanellus</i>	0	0	0	0	0	0	1	3	1	1	0	10	5
<i>Lepomis cyanellus x macrochirus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis gulosus</i>	0	3	5	0	2	2	2	5	4	3	1	0	3
<i>Lepomis macrochirus</i>	0	1	1	0	5	2	4	32	10	9	17	0	15
<i>Lepomis megalotis</i>	0	0	0	0	0	0	0	26	15	23	20	0	4
<i>Lepomis microlophus</i>	0	0	0	0	0	0	0	0	0	2	0	0	0
<i>Lepomis miniatus</i>	0	0	3	8	0	0	2	6	9	6	0	0	0
<i>Lepomis punctatus</i>	0	0	0	0	0	0	0	0	0	0	2	0	0
<i>Micropterus cataractae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus coosae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micropterus henshalli</i>	0	0	0	0	0	0	0	0	0	0	0	0	2
<i>Micropterus punctulatus</i>	0	0	0	0	0	0	0	0	0	0	0	11	0
<i>Micropterus salmoides</i>	0	0	0	1	0	0	0	0	3	3	2	0	0
<i>Pomoxis nigromaculatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma edwini</i>	0	0	0	4	0	0	0	0	2	1	0	0	0
<i>Etheostoma parvipinne</i>	0	5	0	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma swaini</i>	0	0	0	0	0	0	0	2	0	0	3	0	0
<i>Etheostoma whipplei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Perca flavescens</i>	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	0	0	0	25	0	0	0	34	46	14	37	6	0
<i>Elassoma zonatum</i>	0	0	0	0	0	1	0	0	0	0	0	0	0
# species	1	8	6	11	6	7	7	20	20	18	18	17	8
# individuals	2	32	49	104	13	12	21	216	276	119	339	554	38

Appendix 2 (continued).

Site # (year)	39(55)	40(10)	40(04)	40(99)	40(95)	40(68)	41(10)	41(00)	41(91)	42(10)
<i>Ichthyomyzon gagei</i>	0	0	1	0	1	0	0	0	0	0
<i>Amia calva</i>	0	0	0	0	0	0	0	0	0	0
<i>Campostoma paucradii</i>	0	0	0	0	0	0	0	0	0	3
<i>Cyprinella callitaenia</i>	0	0	0	0	0	1	0	0	0	0
<i>Cyprinella venusta</i>	0	69	7	130	86	90	3	4	84	117
<i>Hybopsis winchelli</i>	0	17	9	1	3	1	0	1	0	1
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	8	0	2	0	0
<i>Nocomis leptocephalus</i>	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	1	0	0	0	0	0	0	0	0
<i>Notropis ammophilus</i>	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	0	0	0	5	3	6	0	0	2	1
<i>Notropis baileyi</i>	0	0	0	0	0	0	0	4	0	0
<i>Notropis cummingsae</i>	0	0	12	0	4	4	0	0	9	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	7	4	10	28	53	0	0	38	4
<i>Notropis texanus</i>	0	44	15	26	179	53	18	0	239	11
<i>Opsopoedus emiliae</i>	0	0	0	0	1	4	0	0	2	0
<i>Pteronotropis euryzonus</i>	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	0	0	0	1	0	0	0	0	0	0
<i>Erimyzon oblongus</i>	0	0	0	0	0	0	0	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	0	2
<i>Minytrema melanops</i>	0	0	1	0	0	1	1	1	0	0
<i>Moxostoma poecilurum</i>	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus brunneus</i>	0	1	1	0	1	0	0	0	0	8
<i>Ameiurus natalis</i>	0	0	4	0	0	0	2	0	2	0
<i>Ameiurus nebulosus</i>	0	0	0	0	0	0	0	0	0	0
<i>Ictalurus punctatus</i>	0	0	0	0	0	0	0	0	0	4
<i>Noturus gyrinus</i>	0	0	0	0	0	0	0	0	1	0

Appendix 2 (continued).

Site # (year)	39(55)	40(10)	40(04)	40(99)	40(95)	40(68)	41(10)	41(00)	41(91)	42(10)
<i>Noturus leptacanthus</i>	0	4	1	0	9	3	1	0	23	7
<i>Esox americanus</i>	0	1	1	1	0	0	0	0	0	0
<i>Esox niger</i>	0	0	1	0	1	1	0	2	2	0
<i>Aphredoderus sayanus</i>	0	0	3	0	5	0	2	0	24	0
<i>Labidesthes sicculus</i>	10	0	2	5	5	57	2	8	0	0
<i>Fundulus olivaceus</i>	54	4	3	10	2	33	6	3	21	1
<i>Gambusia holbrooki</i>	0	1	0	0	20	39	3	0	13	0
<i>Lepomis auritus</i>	0	5	5	5	2	4	30	0	0	7
<i>Lepomis cyanellus</i>	0	0	1	0	0	0	0	0	0	0
<i>Lepomis cyanellus x macrochirus</i>	0	0	0	0	0	0	0	0	0	0
<i>Lepomis gulosus</i>	0	0	0	0	0	0	7	1	0	0
<i>Lepomis macrochirus</i>	0	3	0	0	0	2	21	0	15	1
<i>Lepomis megalotis</i>	0	6	9	7	7	0	13	2	34	2
<i>Lepomis microlophus</i>	0	0	0	0	0	0	0	0	0	0
<i>Lepomis miniatus</i>	0	0	0	1	0	0	4	0	0	0
<i>Lepomis punctatus</i>	0	0	0	0	0	0	0	0	1	0
<i>Micropterus cataractae</i>	1	0	0	0	0	0	0	0	0	0
<i>Micropterus coosae</i>	0	0	0	0	0	0	0	0	0	0
<i>Micropterus henshalli</i>	0	3	0	0	0	0	0	0	0	0
<i>Micropterus punctulatus</i>	0	0	0	0	9	0	0	0	0	0
<i>Micropterus salmoides</i>	0	0	0	1	2	5	0	0	4	1
<i>Pomoxis nigromaculatus</i>	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma edwini</i>	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma parvipinne</i>	0	0	0	0	0	0	0	0	0	0
<i>Etheostoma swaini</i>	0	6	3	13	8	8	2	0	10	3
<i>Etheostoma whipplei</i>	0	0	0	0	0	0	0	0	0	0
<i>Perca flavescens</i>	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	0	118	20	20	73	32	118	0	118	191
<i>Elassoma zonatum</i>	0	0	0	0	0	0	0	0	3	0
# species	3	16	20	15	21	20	16	10	20	17
# individuals	65	290	103	136	449	405	233	28	645	364

Appendix 3. Species abundance data for five sites sampled three times in the summer of 2011 for detectability analysis.

Sample	13A	13B	13C	16A	16B	16C	20A	20B	20C	21A	21B	21C	22A	22B	22C
Date	5/26	6/10	7/14	5/27	6/6	7/14	6/1	7/8	7/14	5/31	7/8	7/14	5/31	6/10	7/8
<i>C. paucradii</i>	0	0	6	14	15	21	0	0	0	10	20	18	0	3	0
<i>C. venusta</i>	0	0	0	8	18	2	0	0	0	0	0	0	0	0	0
<i>H. winchelli</i>	0	0	0	8	5	6	0	0	0	0	0	0	11	11	4
<i>L. zonistius</i>	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>L. atrapiculus</i>	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0
<i>N. leptocephalus</i>	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
<i>N. chrysoleucas</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>N. amplamala</i>	0	21	17	0	4	12	0	0	0	3	2	10	5	3	5
<i>N. hypsilepis</i>	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
<i>N. longirostris</i>	18	77	71	0	0	0	0	0	0	0	0	0	1	0	0
<i>N. texanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	21	27	4
<i>S. thoreauianus</i>	1	16	9	1	16	30	15	11	15	0	0	0	0	5	6
<i>E. oblongus</i>	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0
<i>H. etowanum</i>	0	0	0	2	1	5	0	0	0	0	0	0	0	0	1
<i>M. poecilurum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>S. lachneri</i>	0	0	0	0	0	0	0	0	0	4	1	1	0	0	0
<i>A. brunneus</i>	0	0	0	1	0	5	0	0	0	0	0	0	0	0	0
<i>A. natalis</i>	0	0	0	1	3	0	0	0	1	0	0	0	2	1	0
<i>N. leptacanthus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>E. americanus</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
<i>A. sayanus</i>	0	0	0	0	0	0	2	0	6	0	0	0	0	0	1
<i>L. sicculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0

Appendix 3 (continued).

Sample	13A	13B	13C	16A	16B	16C	20A	20B	20C	21A	21B	21C	22A	22B	22C
Date	5/26	6/10	7/14	5/27	6/6	7/14	6/1	7/8	7/14	5/31	7/8	7/14	5/31	6/10	7/8
<i>F. olivaceous</i>	0	0	0	0	0	0	0	0	0	0	0	0	3	9	3
<i>G. holbrooki</i>	1	2	7	3	2	5	0	0	0	0	0	0	0	0	0
<i>L. auritus</i>	1	2	0	22	40	17	0	0	0	17	11	7	12	11	6
<i>L. cyanellus</i>	1	3	0	1	0	1	0	2	0	1	0	0	8	4	7
<i>L. gulosus</i>	0	0	0	1	1	0	2	0	1	0	0	0	5	2	6
<i>L. macrochirus</i>	2	1	2	5	7	5	6	0	0	4	1	2	38	31	11
<i>L. megalotis</i>	0	0	0	0	0	0	0	0	0	0	0	0	14	36	11
<i>L. miniatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>M. henshalli</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
<i>M. salmoides</i>	0	0	0	0	1	0	0	0	0	1	3	3	0	0	0
<i>P. nigromaculatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>E. parvipinne</i>	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
<i>P. nigrofasciata</i>	0	4	2	22	27	6	0	0	0	11	19	19	8	10	2
# species	6	10	9	13	15	13	4	3	4	8	7	7	15	17	15
# individuals	24	131	133	89	143	124	25	14	23	51	57	60	133	157	69

Appendix 4. Length data for 14 sites sampled in 2009, 2010, and 2011, divided into juveniles (J) and adults (A) based on length at maturity. The number reported is the number of individuals in that sample that fall either above or below the length at maturity for that species.

	2009		2010		2011		2009		2010		2011		2009	
	12(J)	12(A)	12(J)	12(A)	12(J)	12(A)	13(J)	13(A)	13(J)	13(A)	13(J)	13(A)	14(J)	14(A)
<i>Campostoma pauciradii</i>	9	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	2	12	6	7	0	0	0	0	0	0	0	0	0	0
<i>Hybopsis winchelli</i>	0	0	0	0	0	0	0	0	6	40	0	0	0	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	52	19	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	0	0	0	0	0	0	0	31	0	38	14	7	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	12	6	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	0	0	0	24	21	6	50	19	58	0	0
<i>Notropis texanus</i>	0	10	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	0	0	0	0	0	0	6	0	24	10	16	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Minytrema melanops</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus brunneus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus natalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox americanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis auritus</i>	20	0	14	0	29	0	0	0	0	0	0	0	0	0
<i>Lepomis cyanellus</i>	3	2	0	0	22	3	0	0	0	0	0	0	0	0
<i>Lepomis macrochirus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis megalotis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	2	5	13	17	11	21	0	0	0	25	0	0	0	0

Appendix 4 (continued).

	2010		2011		2009		2010		2011		2009		2010	
	14(J)	14(A)	14(J)	14(A)	16(J)	16(A)	16(J)	16(A)	16(J)	16(A)	18(J)	18(A)	18(J)	18(A)
<i>Campostoma pauciradii</i>	0	0	0	0	7	0	23	1	14	1	11	1	5	3
<i>Cyprinella venusta</i>	0	0	0	0	9	14	7	18	10	8	0	0	3	4
<i>Hybopsis winchelli</i>	11	16	0	14	0	0	0	0	0	0	0	0	0	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	20	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	0	45	2	38	0	16	0	0	0	0	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	2	31	6	47	0	0	0	0	0	0	0	0	0	0
<i>Notropis texanus</i>	0	0	0	0	0	22	0	0	0	0	0	13	2	7
<i>Semotilus thoreauianus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Minytrema melanops</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus brunneus</i>	0	0	0	0	0	0	0	0	0	0	0	0	6	0
<i>Ameiurus natalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox americanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis auritus</i>	20	0	0	0	17	0	22	0	40	0	0	0	24	0
<i>Lepomis cyanellus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis macrochirus</i>	18	0	0	0	39	0	21	0	7	0	0	0	0	0
<i>Lepomis megalotis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	0	0	0	0	2	34	7	41	5	22	0	18	0	35

Appendix 4 (continued).

	2011		2009		2010		2011		2009		2010		2011	
	18(J)	18(A)	20(J)	20(A)	20(J)	20(A)	20(J)	20(A)	21(J)	21(A)	21(J)	21(A)	21(J)	21(A)
<i>Campostoma pauciradii</i>	26	0	0	0	0	0	0	0	9	1	6	2	10	0
<i>Cyprinella venusta</i>	9	20	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hybopsis winchelli</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	0	0	0	0	0	0	0	0	0	14	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis texanus</i>	0	40	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	0	0	2	9	6	8	4	11	0	0	0	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Minytrema melanops</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	13	0	6	0	0	0
<i>Ameiurus brunneus</i>	11	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus natalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox americanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis auritus</i>	0	0	0	0	0	0	0	0	8	0	6	0	17	0
<i>Lepomis cyanellus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis macrochirus</i>	0	0	6	0	0	0	6	0	0	0	0	0	0	0
<i>Lepomis megalotis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	0	48	0	0	0	0	0	0	1	13	5	9	0	11

Appendix 4 (continued).

	2009		2010		2011		2009		2010		2011		2009	
	22(J)	22(A)	22(J)	22(A)	22(J)	22(A)	23(J)	23(A)	23(J)	23(A)	23(J)	23(A)	26(J)	26(A)
<i>Campostoma pauciradii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	0	0	0	0	0	0	3	2	29	6	87	3	0	0
<i>Hybopsis winchelli</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis amplamala</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	0	0	0	0	0	0	0	38	20	0	0
<i>Notropis texanus</i>	0	0	0	35	0	20	0	0	0	0	0	16	0	0
<i>Semotilus thoreauianus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	6	0	0	0	0	0	0	0
<i>Minytrema melanops</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus brunneus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus natalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox americanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis auritus</i>	5	0	0	0	0	0	12	0	16	0	0	0	0	0
<i>Lepomis cyanellus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis macrochirus</i>	6	0	37	1	0	38	10	0	13	0	0	0	0	0
<i>Lepomis megalotis</i>	0	0	0	0	13	1	0	0	35	0	33	0	0	0
<i>Percina nigrofasciata</i>	0	0	0	18	0	0	0	6	1	19	21	6	0	0

Appendix 4 (continued).

	2010		2011		2009		2010		2011		2009		2010	
	26(J)	26(A)	26(J)	26(A)	31(J)	31(A)	31(J)	31(A)	31(J)	31(A)	32(J)	32(A)	32(J)	32(A)
<i>Campostoma pauciradii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hybopsis winchelli</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	0	0	7	0	0	0	0
<i>Notropis amplamala</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis texanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	0	0	0	0	0	0	0	0	5	8	0	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Minytrema melanops</i>	0	0	0	0	0	0	0	0	5	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus brunneus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus natalis</i>	0	0	0	0	0	0	0	0	5	0	0	0	7	0
<i>Esox americanus</i>	0	0	0	0	0	0	0	0	12	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	7
<i>Lepomis auritus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis cyanellus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis macrochirus</i>	7	0	21	0	0	0	0	0	9	0	0	0	5	0
<i>Lepomis megalotis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	3

Appendix 4 (continued).

	2011		2009		2010		2011		2009		2010		2011	
	32(J)	32(A)	33(J)	33(A)	33(J)	33(A)	33(J)	33(A)	36(J)	36(A)	36(J)	36(A)	36(J)	36(A)
<i>Campostoma pauciradii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyprinella venusta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hybopsis winchelli</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Luxilus zonistius</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lythrurus atrapiculus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notemigonus chrysoleucas</i>	0	0	0	0	0	0	0	4	0	0	0	0	0	0
<i>Notropis amplamala</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis hypsilepis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis longirostris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Notropis texanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Semotilus thoreauianus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hypentelium etowanum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Minytrema melanops</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scartomyzon lachneri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus brunneus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ameiurus natalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Esox americanus</i>	0	0	0	0	0	0	6	1	0	0	0	0	0	0
<i>Aphredoderus sayanus</i>	0	0	0	0	0	7	0	0	0	0	0	0	0	0
<i>Lepomis auritus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis cyanellus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lepomis macrochirus</i>	0	0	0	0	6	0	0	0	0	0	0	0	5	0
<i>Lepomis megalotis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Percina nigrofasciata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0