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Using Results from a Stratified Random Sampling Program to Describe the Status of Michigan's Stream Resources, 2002–2013

Jan-Michael Hessenauer, Kevin E. Wehrly,
Todd C. Wills, and Troy G. Zorn

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Using Results from a Stratified Random Sampling Program to Describe the Status of Michigan's Stream Resources, 2002–2013

Jan-Michael Hessenauer

Michigan Department of Natural Resources, Lake St. Clair Fisheries Research Station, 33135 South River Road, Harrison Township, Michigan 48045

Kevin E. Wehrly

Michigan Department of Natural Resources and University of Michigan, Institute for Fisheries Research, 400 North Ingalls Street, Room G250, Ann Arbor, Michigan 48109

Todd C. Wills

Michigan Department of Natural Resources, Lake St. Clair Fisheries Research Station, 33135 South River Road, Harrison Township, Michigan 48045

Troy G. Zorn

Michigan Department of Natural Resources, Marquette Fisheries Research Station, 488 Cherry Creek Rd, Marquette, Michigan 49855

INTRODUCTION

The State of Michigan contains more than 10,000 lakes and more than 36,000 miles of streams and rivers (Wills et al. 2015). These diverse aquatic resources encompass everything from groundwater fed headwater streams to large deep lakes. The State's aquatic resources are culturally and ecologically significant, providing recreational opportunities and economic benefit to the people of Michigan. It is the mission of the Michigan Department of Natural Resources (DNR) Fisheries Division to "protect and enhance Michigan's aquatic life and habitats for the benefit of current and future generations" (2018–2022 Fisheries Division Strategic Plan; https://www.michigan.gov/documents/dnr/2018-2022-FisheriesDivision-StrategicPlan-FINAL-WEB_613209_7.pdf (11/20/2018)). This mission is a challenging one given the wide range of human uses and factors influencing aquatic communities which include large scale ecological and climatic changes, landscape development, the extraction of water and other resources, pollution, and the introduction of nonnative and invasive species. To ensure science based management of our aquatic resources considering these diverse user interests and multiple disturbances, the DNR and its partners require information on the current status of aquatic resources and how that status compares to previous conditions.

To provide information to natural resource managers and stakeholders about the current status and trends of aquatic communities, the Michigan DNR Fisheries Division launched the Status and Trends Program (STP) in 2002. The primary objective of the STP is to collect, synthesize and distribute the information that fisheries managers, policy makers, and the public need to address inland aquatic resource management needs (Wills et al. 2015). The specific objectives of the STP are to: (1) collect the information needed to maintain an inventory of inland lake and stream habitat and fish community characteristics statewide; (2) provide reference points for local, regional, and statewide management needs; and (3) to assess the status of, and detect changes to, aquatic communities across the State of Michigan. To address these objectives, the STP conducts surveys of aquatic communities that represent the broad range of habitat types and conditions found in waters across the state.

This report describes the status and distributions of Michigan's stream resources from 2002–2013, with a specific concentration on the second goal of the stream STP to provide reference points for local, regional and statewide management needs. We use the definition of "stream" provided by Wills et al. (2015) to include flowing waters of all sizes. Results from the Lakes STP can be found in a companion report (Wehrly et al. *in prep*). The statewide summaries presented in this report include data collected since the beginning of the STP in 2002. In contrast to the previous Stream STP report (Wills et al. 2015), this document specifically focuses on providing management benchmarks for Michigan's recreationally important stream fisheries resources including stream salmonids (Brook Trout *Salvelinus fontinalis*, Brown Trout *Salmo trutta,* Rainbow Trout *Oncorhynchus mykiss*) and Smallmouth Bass *Micropterus dolomieu* that are derived from the stratified random sampling component of the STP. Summaries of other habitat and fish community data measured at random site surveys are available through an online data viewer, the Stream Evaluator, located at http://www.mcgi.state.mi.us/smdt/ (11/20/2018). Additional species summaries may be found in the appendix of this report. Likewise, local and regional scale trend data on abundance, growth, and survival of recreationally important species collected at STP fixed sampling sites (see below for sampling design) are available using the online Stream Fish Population Trend Viewer located at http://www.mcgi.state.mi.us/fishpop/ (11/20/2018).

The objective of this report is to provide statewide summaries of the associations between various instream habitat attributes, stream size, and temperature, and the occurrence of stream salmonid and Smallmouth Bass populations. These analyses identify habitat characteristics that are important to each species and may be used to identify other suitable stream reaches for each species. This information can be help explain species distribution patterns, differences in fish relative abundance among reaches, and identify stream reaches that are most appropriate to manage for each species. Such information provides the basis for science based management. Additionally, this report seeks to provide natural resource managers and the interested public with baseline information about the typical relative abundance of stream salmonids and Smallmouth Bass, where present, in streams located in three statewide regions of Michigan: the Upper Peninsula, the Northern Lower Peninsula, and the Southern Lower Peninsula (Figure 1). These regions are made up of local fisheries management units based on watershed boundaries (Upper Peninsula: Western Lake Superior, Eastern Lake Superior, Northern Lake Michigan, and a portion of Northern Lake Huron; Northern Lower Peninsula: Central Lake Michigan, Northern Lake Huron; Southern Lower Peninsula: Southern Lake Michigan, Southern Lake Huron, and Lake Erie) and often have similar climates, land use, and other important characteristics.

We begin this report by providing a brief overview of the sampling design, survey methods and analytical techniques used in the stream STP. Next, we summarize the associations between stream characteristics and the presence/absence of stream salmonids and Smallmouth Bass. We discuss the statewide distribution of important habitat variables for stream salmonids and Smallmouth Bass as identified by our analyses. Finally, we conclude by reporting benchmarks for salmonid and Smallmouth Bass growth, density and size at randomly selected sample sites across the regions of Michigan. We present the current status and management benchmarks of Michigan's recreationally important stream fish species from a statewide perspective in nontechnical language, with the intention of providing information to a broad audience including scientists, resource managers, policy makers, and the public. Readers desiring to learn more about individual streams are encouraged to contact their local DNR operations service centers and explore the multiple online data viewers now available.

METHODS

Sampling Design

The sampling design for the stream STP is well described by Wills et al. (2015) and is therefore only briefly summarized here. The stream STP program uses a two tiered sampling approach: random sites and fixed sites. The random site component employs stratified random sampling across the state to characterize the diversity of Michigan's streams and their condition relative to other similar streams. Random sites were selected with sites stratified by DNR fisheries management unit, stream size, and temperature (Table 1). Fixed or index sites are reaches on representative streams supporting populations of salmonids or Smallmouth Bass that are repeatedly sampled using a three year on, three year off rotation. This approach provides high resolution data for documenting trends in abundance, growth, and survival of these recreationally important species. In addition, the network of fixed sites can be used to determine whether changes in fish populations or habitat are similar across Michigan or unique to individual streams. While this report focuses specifically on random site data, fixed site data can be found online using the Stream Fish Population Trend Viewer located at http://www.mcgi.state.mi.us/fishpop/ (11/20/18).

Field Surveys

Fish community data for random sites were collected by DNR Fisheries personnel throughout the state between June 15 and September 15, which is generally a low flow period for Michigan streams. A single upstream pass of each station was electrofished with a tow barge or backpack electrofishing unit in wadeable streams. Station length varied from 500–1,500 feet depending on stream size (Wills et al. 2008). For nonwadeable streams, a single one mile long downstream pass was made with a boat-mounted electrofisher. Total catch and length data were recorded for all fish species encountered during each random site survey to obtain catch-per-effort (CPE, number of fish per mile sampled) as an index of relative abundance. Samples for estimating age and growth were collected from a minimum of 10 fish per inch group for all stream salmonids, Smallmouth Bass, and other species of interest to local fisheries managers.

Habitat sampling occurred as close as possible to the time of fish surveys at random sites. Sampling included measurements of stream width, depth, substrate, and visual assessment of riparian vegetation and bank condition at evenly spaced transects throughout the sampling station. Instream fish habitat, including large woody material and natural and artificial instream structure were quantified for the entire sampling reach. A single measurement of discharge was recorded at the time of habitat sampling, and water temperature was logged hourly from continuously recording data loggers from a minimum period of June 1 to August 31 (Wills et al. 2015).

Data Summaries

IDENTIFYING FISH HABITAT RELATIONSHIPS

Presence and absence maps, percent occurrence by size and temperature strata, Great Lakes access, and catch per effort data (number of fish per mile sampled) were created for all species captured by the STP during 2002–2013 (Appendix A). Classification tree models (Breiman et al. 1984; De'ath and Fabricius 2000) were used to evaluate relationships between stream habitat variables and the presence or absence of stream salmonids and Smallmouth Bass. Classification tree models construct dichotomous trees that repeatedly split sampled stream reaches into groups based on similarity of fish and habitat. Classification trees can be thought of as flow charts describing the most important habitat features, and the cutoffs within these habitat features which describe the presence or absence of the species of interest. These models are ideal for datasets such as the STP that contain large numbers of variables because they do not require data to be normally distributed, and both categorical (e.g., statewide region: Southern Lower Peninsula, Northern Lower Peninsula, Upper Peninsula) and continuous data (e.g., stream width) can be used simultaneously (Breiman et al. 1984; De'ath and Fabricius 2000). Classification tree models have previously been used to describe spatial patterns of occurrence and abundance of fishes in Michigan streams (e.g., Steen et al. 2008; Hessenauer et al. 2019).

Given the large number of stream habitat variables and likely correlations among them, we used a screening process based on variable importance to reduce the number of habitat variables measured in the field for model development. The relative importance of each variable was calculated as the absolute difference of the average value of that variable for sites that contained the species of interest and the average value of that variable for sites that did not contain the species of interest. If that difference was greater than 10% of the observed range of the variable, then that variable was considered potentially important and retained for further analysis (Hessenauer et al. 2019). To further refine the final set of variables included in the analysis, we tested for correlations among variables previously identified as important. When significant correlations ($P<0.05$) were observed, the variable with the higher importance score was included for further analysis. All stream STP strata were included in the final analysis, except for fisheries management unit which were combined into regions as appropriate. These variables were always included because of their importance for describing fish distribution (e.g., temperature and size strata), and to ensure region specific results where possible.

The final set of variables was then analyzed using the randomForest package in program R (Liaw and Wiener 2002; R Core Team 2015). During model development, 2/3 of the data were randomly selected and classified based on a random subset of the variables. The accuracy of these subsequent classifications was tested against the remaining 1/3 of the data that were excluded from in the initial model. This process was repeated 10,000 times resulting in an ordered list of variable importance. Important variables were determined as variables that greatly increase the accuracy of classifications when they were included in the model. A final visual representation of the best classification tree for each species was constructed by entering the highest ranked variables for each species into the ctree function in program R. The ctree function uses conditional inference to test for significant association with the presence or absence variable (Hothorn et al. 2006a, 2006b).

REGIONAL BENCHMARKS

We also assessed whether relative abundance of stream salmonid and Smallmouth Bass (number of fish per mile sampled) differed among three regions: Upper Peninsula, Northern Lower Peninsula, and Southern Lower Peninsula (Figure 1). For this analysis, relative abundance data for each species were pooled by region. We then calculated the upper 75th percentile, the median (middle value), and lower 25th percentile of relative abundance for each species and region and graphically compared these values. Similar statewide statistics were calculated for stream salmonid and Smallmouth Bass by pooling all relative abundance data in the state by species. We consider relative abundance values between the 75th and 25th percentile to represent benchmarks describing the expected or typical range of relative abundance in randomly selected streams where the species of interest was present. Relative abundance values at a particular stream that fall outside these benchmarks represent exceptionally high or low relative abundances. Additionally, benchmarks to assess relative fishing quality were created for Smallmouth Bass, Brook Trout and Brown Trout. Insufficient data prevented calculation of relative fishing quality metrics for Rainbow Trout. These relative fishing quality benchmarks are based on the relative abundance of each sportfish and the relative abundance of quality or legal sized individuals for each species, with the reasoning that: a good fishing location has both a high relative abundance of a species (50th percentile or higher) and a relatively high abundance of quality or legal sized individuals (50th percentile or higher); a fair catch-rate fishing location (Fair: Catch Rate) has high relative abundance of a species, but few quality or legal sized individuals; a fair catch rate but good fish size fishing location (Fair: Size) has a relatively high abundance of quality or legal sized individuals, and finally a poor fishing location has neither a high total relative abundance nor a high relative abundance of quality or legal sized individuals. These categories may indicate potential management needs. For example, a location with many small individuals but few quality or legal sized individuals (classified as Fair: Catch Rate) may have issues associated with food abundance, or mortality. Conversely, a location with relatively large individuals but a relatively low abundance (Fair:Size), may lack spawning or nursery habitat. A poor location may only be marginally suitable for the species. Size thresholds were based on quality size for Smallmouth Bass (11 inches, Gabelhouse 1984), and the legal (harvestable) sizes of Brook Trout (7 inches) and Brown Trout (8 inches) based on the minimum size limits specified by Michigan Type 1 stream regulations. Growth information is presented for regions with sufficient data. Each point on the graph represents an average of the mean weighted length at a given age across all surveys with data present (i.e., a mean of means). The standard error of that estimate is presented for the region as a whole.

RESULTS AND DISCUSSION

Waters Surveyed

A total of 212 randomly chosen stream valley segments (Seelbach et al. 1997) were sampled by the stream STP during the period from 2002–2013. Small stream segments of all temperature classes remain undersampled relative to their abundance in the state (Table 2). However, an excellent distribution of sampling effort among temperature classes (regardless of stream size) has been achieved (Table 2).

Status of Fishery Resources

Across species, the randomForest modeling approach was very successful with predictions of species presence and absence successful for 73–84% of streams (Table 3) depending on species. All models were successful at predicting where species were likely absent with success rates ranging from 86–93%; however, model success at predicting where species were likely to be present were much more variable (success rates from 35% to 75%). This finding is not surprising given our unknown rate of species detection in the field but provides an important starting point for the estimation of species detection rates in the future.

SMALLMOUTH BASS

Smallmouth Bass were detected at 54 of the 212 streams reaches randomly selected for sampling during the period from 2002–2013. Smallmouth Bass were most often detected in random stream reaches located in the eastern portion of the Lower Peninsula, and the western portion of the Upper Peninsula (Figure 2). Among the 54 stream reaches where Smallmouth Bass were detected, 48% were classified as warm and 50% of Smallmouth Bass detections occurred in large or very large stream reaches (Table 4). Additionally, 59% of stream reaches where Smallmouth Bass were detected (corrected for sampling abundance) had access to the Great Lakes (Table A102).

Random forest classification models for Smallmouth Bass indicated that the most important habitat variables associated with Smallmouth Bass occurrence were measures of stream size including the average width and the STP size strata assigned to each stream (Table 5). This is consistent with previous predictive models of Smallmouth Bass densities in Michigan's Lower Peninsula which identified mean July temperature, increasing stream size, occurrence of cobbles and riffles, and lack of silt substrates as positively associated with smallmouth bass occurrence and abundance (Zorn et al. 2004; 2009). Mean July stream temperature, total area of instream structure, and lineal feet of large woody debris with a diameter of 24 inches or greater were also important variables for predicting Smallmouth Bass occurrence. We used stream width and the July stream temperature, the two most important variables in the randomForest model, to generate a final classification tree for Smallmouth Bass streams (Figure 3). The statewide distribution of large streams (Figure 4) closely matches the statewide distribution of Smallmouth Bass (Figure 2).

Across all STP sites where Smallmouth Bass were present, relative abundance was generally highest in the Southern Lower Peninsula and lowest in the Northern Lower Peninsula (Figure 5). Streams with good relative fishing quality (Figure 6) had more than 31 Smallmouth Bass per mile, and about 10 Smallmouth Bass over 11 inches per mile. The Southern Lower Peninsula was the only region that contained sufficient data for the calculation of Smallmouth Bass growth (Figure 7). Growth curves for other regions will be assembled as more data become available; in the meantime, the Southern Lower Peninsula curve provides a valuable benchmark against which other surveys may be compared. Smallmouth Bass grew faster at ages 1 and 2 in the Lake Erie Management Unit compared to the Southern Lake Huron and Southern Lake Michigan management units. No Smallmouth Bass in the Southern Lower Peninsula reached the minimum size limit of 14 inches by age 5.

BROOK TROUT

Brook Trout were present at 71 of the 212 randomly selected reaches sampled during the period from 2002–2013. Brook Trout occurred most often (61%) in small or medium coldwater stream reaches in the Northern Lower Peninsula and Upper Peninsula (Figure 8) and rarely (3%) occurred in warm stream reaches (Table 6). The majority (54%) of Brook Trout detections (corrected for sample abundance) occurred in stream reaches isolated from the Great Lakes (Table A102).

Important predictors of Brook Trout presence or absence based on random forest modelling included July mean temperature, region, average depth of bank undercuts, and percent of tag alder cover in the riparian buffer (Table 5). Zorn et al. (2004; 2009) found increased occurrence and densities of Brook Trout in Lower Peninsula streams occurred in small, cold streams, with high gradients and little urban land use in their watersheds. These two modelling approaches are likely detecting patterns associated with similar drivers, for example both bank undercuts and tag alder cover are likely associated with a lack of urban land uses. The most important variables including predicted July mean temperature and region were used to generate a final classification tree (Figure 9). The statewide distribution of sample sites classified as "Cold" (Figure 10) correlated well with Brook Trout abundance for some statewide regions, but poorly in others, consistent with the patchy distribution of cold, headwater streams in Michigan. The importance of region for predicting Brook Trout abundance, and the patchy overlap between Brook Trout occurrence and coldwater streams likely reflect the historical range and fisheries management practices (e.g., stocking) of this species, and negative interactions between Brook Trout and Brown Trout (Zorn and Wiley 2010).

Brook Trout density was generally highest in streams located in the Northern Lower Peninsula, and lowest in the Southern Lower Peninsula (Figure 11). Streams with good relative fishing quality (Figure 12) had a total relative abundance of more than 148 Brook Trout per mile, and more than 35 Brook Trout over seven inches per mile. Growth curves were calculated for both the Northern Lower Peninsula (Figure 13) and the Upper Peninsula (Figure 14) to age 3 providing regional benchmarks that local managers can use to assess growth in sampled streams. Brook trout growth through age 3 in the Northern Lower Peninsula was very similar between management units while growth in the Upper Peninsula was much more variable. Mean length-at-age of Upper Peninsula Brook trout from ages 1 through 3 was highest in the Northern Lake Michigan Management Unit, followed by the Eastern Lake Superior and Western Lake Superior management units.

BROWN TROUT

Brown Trout were present at 60 of the 212 randomly sampled stream reaches surveyed during the period from 2002–2013, with a concentration along the western coast of the Southern Lower Peninsula and the Northern Lower Peninsula (Figure 15). Brown Trout were found most often (62%) in small or medium cold stream reaches (Table 7). Fifty-four percent of stream reaches where Brown Trout were detected had access to the Great Lakes, when corrected for sample abundance (Table A102).

Important variables associated with the presence and absence of Brown Trout (based on random forest modelling) included July mean stream temperature, region, percent of small cobble substrate, the presence of large coniferous trees in the riparian buffer, and region (Table 5). The most important variables including July mean temperature and region were used to generate the final classification tree (Figure 16). These findings correlate well with those of Zorn et al. (2004, 2009) which indicated that increased occurrence and densities of Brown Trout in Lower Peninsula streams was associated with colder July mean water temperatures, higher base flow yields, increased prevalence of gravel and coarser substrates, a lack of upstream ponds, and coarse textured geology the catchments. Similar to Brook Trout, the statewide distribution of “Cold” stream temperatures (Figure 10) correlated well with Brown Trout abundance for some statewide regions, but poorly in others, suggesting the importance of additional drivers of Brown Trout abundance including local habitat features and variation in geology and topography.

Brown Trout relative abundance was highest in the Southern Lower Peninsula, and lowest in the Upper Peninsula (Figure 17). Streams with good relative fishing quality (Figure 18) had a relative abundance of more than 139 Brown Trout per mile, and a relative abundance of more than 52 Brown Trout over eight inches per mile. Growth curves were calculated for the Southern Lower Peninsula (Figure 19) and Northern Lower Peninsula (Figure 20) through age 4. Brown trout growth in the Northern Lower Peninsula was very similar between management units. Mean length-at-age of age 2 and older Brown Trout in the Southern Lower Peninsula tended to be larger in the Southern Lake Michigan Management Unit compared to the Southern Lake Huron Management Unit.

RAINBOW TROUT

Rainbow Trout were detected at 41 randomly selected stream reaches, with concentrations near the Great Lakes coasts in the western and Northern Lower Peninsula, and along the northern coast of the Upper Peninsula (Figure 21). Rainbow Trout were found most often in small and medium cold stream reaches (Table 8; 58% of detections). Additionally, the majority of sites containing Rainbow Trout (81%) had direct access to the Great Lakes (Table A102) when corrected for sampling abundance, which is not surprising given the life history of this species.

Random forest classification of important variables associated with the presence and absence or Rainbow Trout included Great Lakes access, July mean stream temperature, region, stream size strata, and percent of small cobble substrate (Table 5). We used Great Lakes access, stream region, July mean temperature, and the percentage of small cobble substrate to generate a final classification tree (Figure 22). Statewide distribution of streams with Great Lakes access (Figure 23) correlated well with stream reaches where Rainbow Trout were observed, which is not surprising since stream dwelling Rainbow Trout may be juvenile steelhead (offspring from adfluvial rainbow trout). Consistent with our modelling efforts, Zorn et al. (2004; 2009) found that in Michigan's Lower Peninsula, Rainbow Trout densities were positively associated with high baseflow yields, abundant riffle habitats, moderate stream size, coarse geological deposits in watersheds, and Great Lakes access.

Of all randomly selected reaches that contained Rainbow Trout, the highest median relative abundance occurred in the Northern Lower Peninsula. However, median relative abundance for all three regions was near the statewide median (Figure 24). Relative fishing quality was not estimated for Rainbow Trout because relatively few streams contained large individuals. This is likely result of the time period when STP surveys are conducted not overlapping with the presence of adult Steelhead in the rivers. Growth curves were estimated for the Southern Lower Peninsula (Figure 25), Northern Lower Peninsula (Figure 26), and Upper Peninsula (Figure 27) through age 3 providing benchmarks for local fisheries managers to evaluate the growth of Rainbow Trout. Sample size limitations prevented full growth curves from being calculated in the Southern Lake Huron Management Unit (Southern Lower Peninsula) and Eastern Lake Superior Management Unit (Upper Peninsula). Rainbow Trout growth in the Northern Lower Peninsula was similar between the Central Lake Michigan and Northern Lake Huron management units.

INTERPRETATION AND DISCUSSION

Not surprisingly, July mean stream temperature was among the most important variables for all species analyzed. Stream temperature was the most important variable for Brook Trout and Brown Trout, second most important variable for Rainbow Trout, and the third most important variable for Smallmouth Bass. Temperature is a well known driver of stream fish distribution (Wehrly et al. 2003; Wehrly et al. 2007; Lyons et al. 2010) and may be an increasingly important determinant of fishery quality with expected climatic changes (Lyons et al. 2010; Carlson et al. 2017). Next to catchment area, July mean temperature was the most frequently significant variable in predictive models for 68 species of stream fishes in Michigan's Lower Peninsula (Zorn et al. 2004), and the most frequent significant variable in Michigan-based models for 82 fish species (Steen et al. 2008). Interestingly, for all four species considered, large-scale landscape and or climatic features tended to be the single most important variable for classification of a stream as likely to contain (or not contain) one of the four species analyzed here. It should, however, be noted that correlations between stream characteristics and the presence or absence and densities of species of interest do not imply causation or process without additional information.

The importance of large-scale landscape or climatic features highlights the need to consider the landscape context of a stream reach when interpreting survey data and developing management strategies at the site scale (Wiley et al. 1997). This is often a challenge for fisheries management because of a tendency to focus on local channel features when managing a stream reach. The tendency to focus on local features is logical, because management actions such as habitat enhancement, regulations, and fish stocking typically occur at the local scale. Local habitat features are indeed important drivers of species presence and absence, and our analysis of four key Michigan stream sport fishes found at least one and often multiple local features in the top five most important variables. This is generally consistent with other modelling work conducted on these species (Zorn et al. 2004, 2009; Steen et al. 2008). However, expectations of management actions need to consider not just local features, but landscape-scale drivers such as land use, temperature, hydrology, connectivity, and water quality, which ultimately constrain the potential of a reach for each fish species. It should also be noted that our analysis was based on the presence and absence of Smallmouth Bass and stream salmonids. Local features are likely strong drivers of abundance and growth at individual sites.

The predictive ability of the implemented classification tree approach showed commonalities among the four species studied. For each species, the overall ability of the individual random forest classification models to accurately predict species presence and absence was good, ranging from 73% to 84% (see Table 3). However, across all species the majority of error was associated with predicting species presence, such that model accuracy (defined as the model predicting a stream segment to contain the species of interest, and the species of interest being detected as part of the status and trends survey) ranged from a low of 35% (Rainbow Trout) to a high of 75% (Brook Trout). This result highlights several important challenges when conducting single species analyses using STP data. First, with the exception of some very broadly distributed species, most species are not detected at the majority of sites. This results in more data associated with species absence than species presence, which may lead to better predictions of absence then presence. Zorn et al. (2004) noted this, and Steen et al. (2008) attempted to address this shortcoming. Second, the failure of an individual survey to detect a species does not necessarily mean that the species is not present at that location. Rather, the species may have simply been missed by the survey or may occur at a site during the spring and fall when sampling does not occur. Such detection errors result in an underestimate of error rates for sites where a species of interest is predicted to be absent, and an overestimate of error rates for sites where a species of interest is predicted to be present. This concern was explicitly considered when developing electrofishing station lengths for stream STP surveys. Following, Lyons' (1992) guideline for species detection on wadeable stream electrofishing surveys, station lengths for small, medium, and large rivers were generally 35 times the mean width of the channel at low flow or longer. Likewise, habitat survey protocols were identified for the stream STP had levels of precision defined from previous studies (Simonson et al. 1994; Wang et al. 1996). Still, efforts to evaluate the detection probability of individual species by the STP sampling protocols would be of great benefit to the STP as a whole. Finally, it is important to note that the current modelling efforts did not include consideration of an individual streams stocking history. Stream salmonids have been extensively stocked throughout the state, and this has certainly influenced the locations where they are currently present or absent. Certainly, for naturalized stream salmonids (Brown Trout - statewide, Rainbow Trout - statewide, and Brook Trout in most of the Lower Peninsula), the current distribution must be directly related to stocking history, or connectivity to waters that were stocked. This stocking history may influence model accuracy when attempting to predict presence for an individual stream and species. Unlike the salmonids discussed in this publication, Smallmouth Bass were extensively stocked by the state from 1880–1945, only occasionally afterwards to 1980, and by the federal government until at least 1939 in lakes and streams but not since that time. Model accuracy for predicting streams where Smallmouth Bass were present fell in the middle of the range observed for stream salmonids (Table 3), which likely emphasizes (for this species) the sources of error described above.

CONCLUSIONS

The STP has three primary goals: (1) collect the information needed to maintain an inventory of inland lake and stream habitat and fish community characteristics statewide; (2) provide reference points for local, regional, and statewide management needs; and (3) to assess the status of, and detect changes to, aquatic communities across the State of Michigan. To date, the program has detected over 100 species of stream fishes and maps of their distributions can be found in the appendix of this report. These distributional maps are contemporary compliments to existing resources (e.g., Bailey et al. 2004), but have the advantage of being assembled through a single standardized sampling regime. Distributions of key stream habitat features important to stream salmonids and Smallmouth Bass as identified by random forest classification trees are also available as are a wide variety of other habitat features by request. The current report provides stream salmonid and Smallmouth Bass density reference points for managers at both the regional and statewide scale. Likewise, classification trees generated for stream salmonids and Smallmouth Bass provide managers and the interested public with key habitat features and stream characteristics associated with the presence and absence of each species and can be used to assess whether a species is likely to occur in a given stretch of stream. A fishing relative fishing quality index was created for popular sport fishes with sufficient data that should allow managers to quickly assess the fishery potential of a stream based on total abundance and abundance of quality or legal sized fish, while also suggesting potential management actions, though further assessment of a stream is warranted before management action is undertaken. Finally, random site data allowed for the comparison of growth rates in stream salmonids and Smallmouth Bass for some regions. As the fish population trend viewer (http://www.mcgi.state.mi.us/fishpop/) (11/20/18) will continue to provide managers and the interested public with data on a variety of metrics for stream salmonids and Smallmouth Bass at fixed sites, the ability to inventory and develop benchmarks for Michigan's aquatic resources will improve and increase in value to fisheries managers as the Michigan Status and Trends Program random stream sampling continues.

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Figures

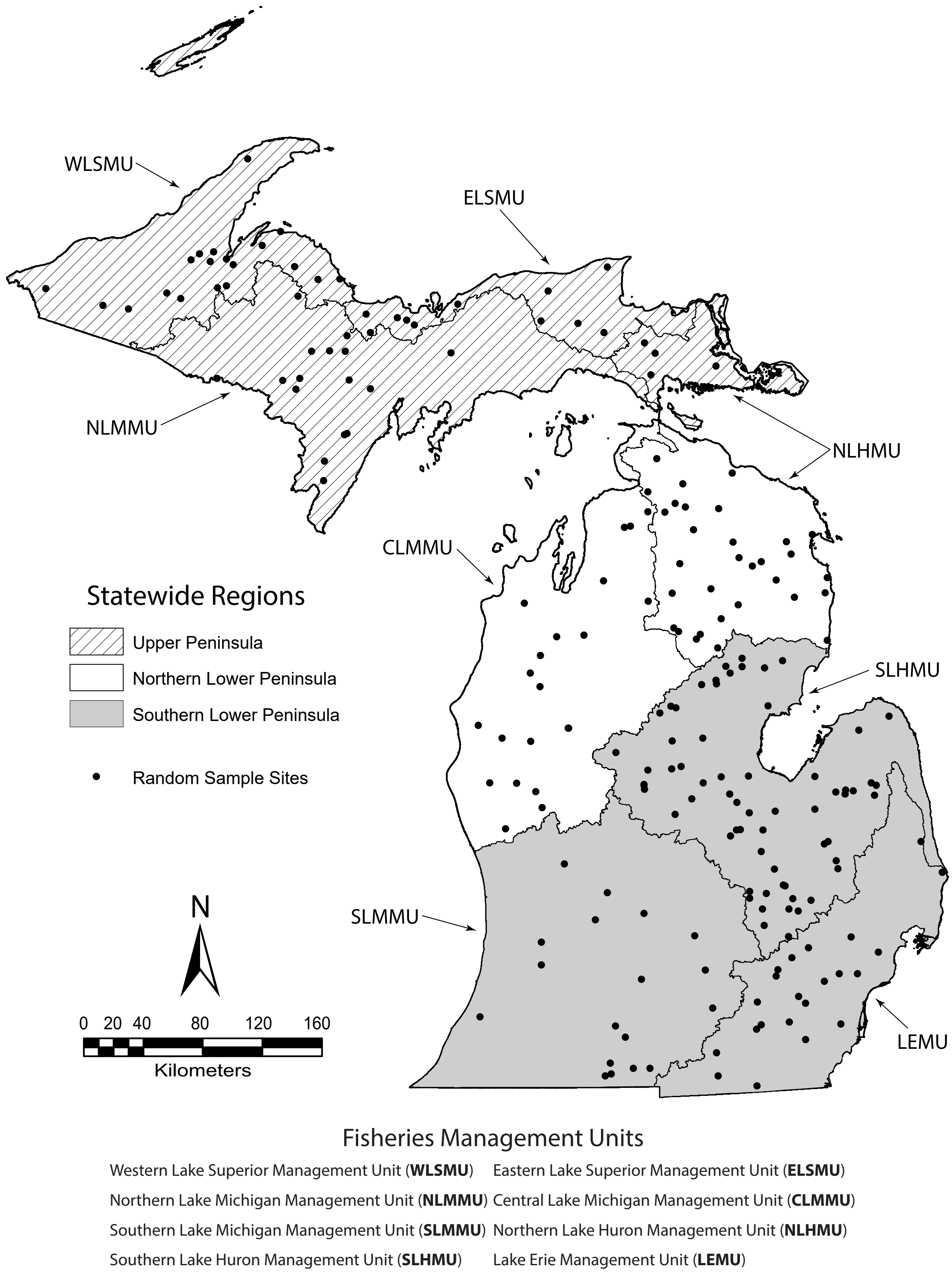

FIGURE 1. Random sample sites (dots) across three statewide regions, the Upper Peninsula, Northern Lower Peninsula, and Southern Lower Peninsula. Boundaries for individual fisheries management units are shown. Note that the Northern Lake Huron fisheries management unit covers both the far eastern Upper Peninsula and northeast Lower Peninsula and has been split into the appropriate regions.

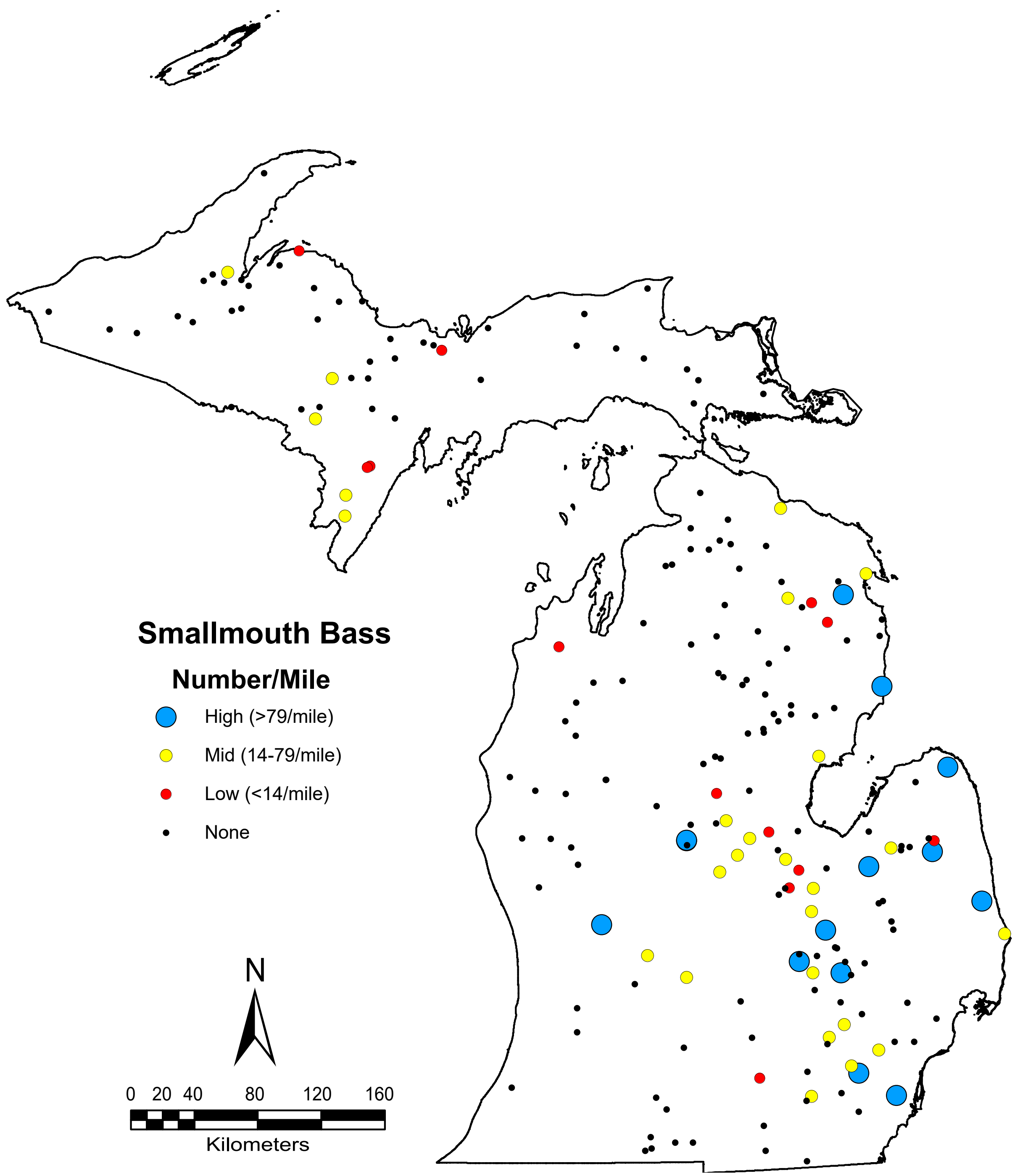

FIGURE 2. Statewide distribution of random sites sampled for Smallmouth Bass from 2002–2013. The "High" relative abundance sites (large blue circles) represent the 4th quartile of the data, the "Mid" sites (medium yellow circles) represent the 2nd and 3rd quartiles of the data, the "Low" relative abundance sites (small red circles) represent the 1st quartile of the data, and the "None" sites (very small black dots) represent locations where Smallmouth Bass were not detected.

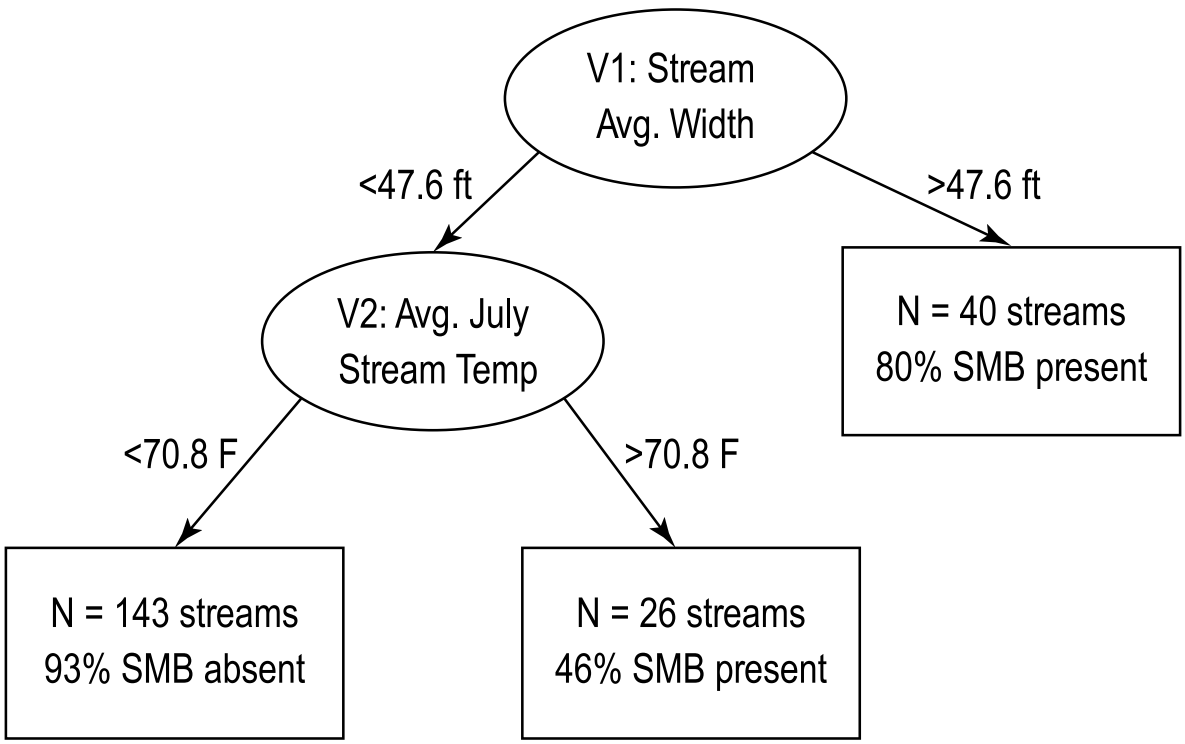

FIGURE 3. Classification tree for variables associated with the presence and absence of Smallmouth Bass (SMB), average width in feet (V1) and average July stream temperature (V2). Terminal groups are rectangles and give sample size (N) and the percentage of streams sampled that have Smallmouth Bass present or absent.

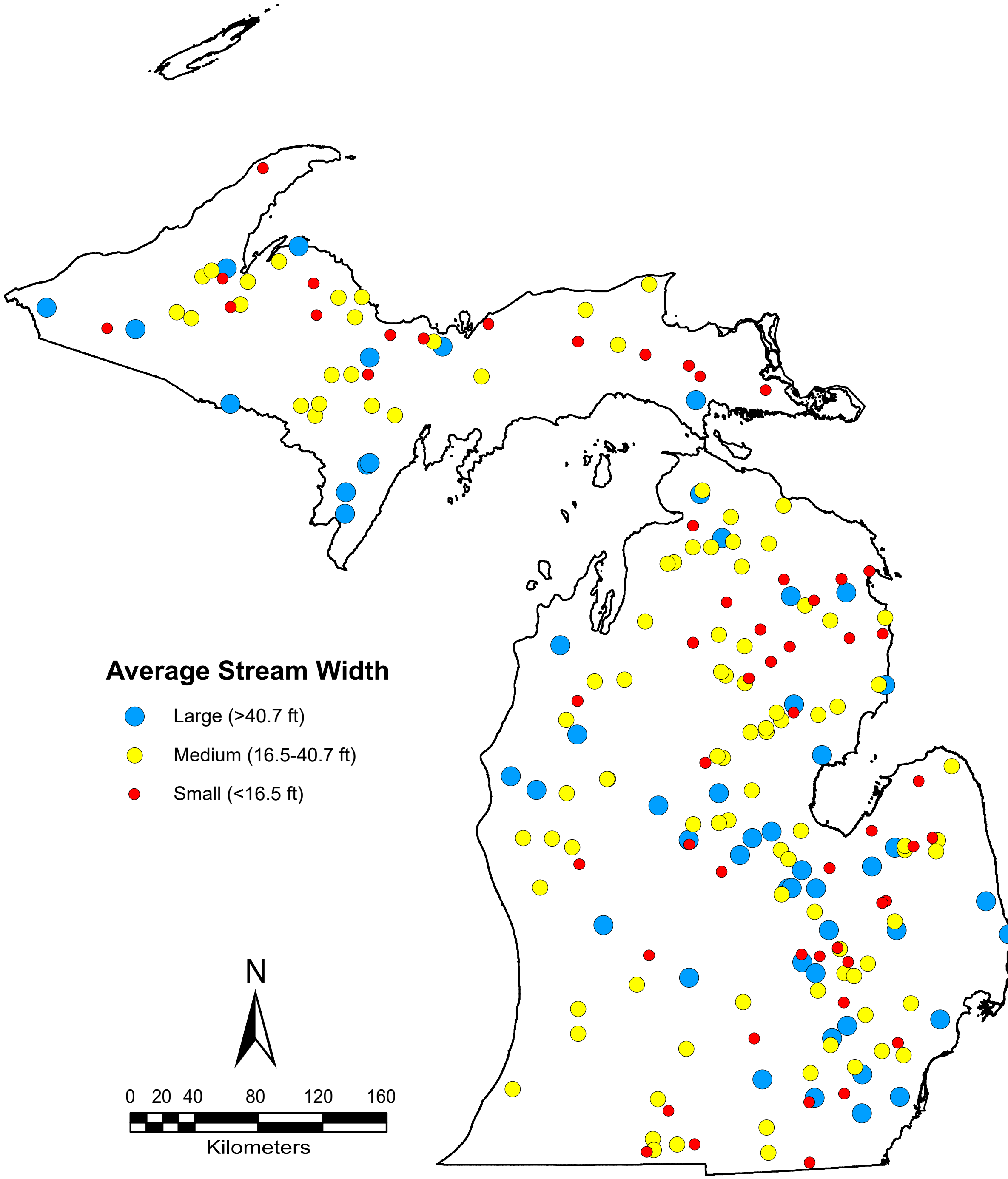

FIGURE 4. Statewide distribution of average stream widths, the most important variable predicting Smallmouth Bass occurrence based on random forest modeling. The first quartile (narrowest 25% of streams) is labeled small (red circles), the second and third quartiles are labeled medium (yellow circles), and the fourth quartile (widest 25% of streams) is labeled large (blue circles).

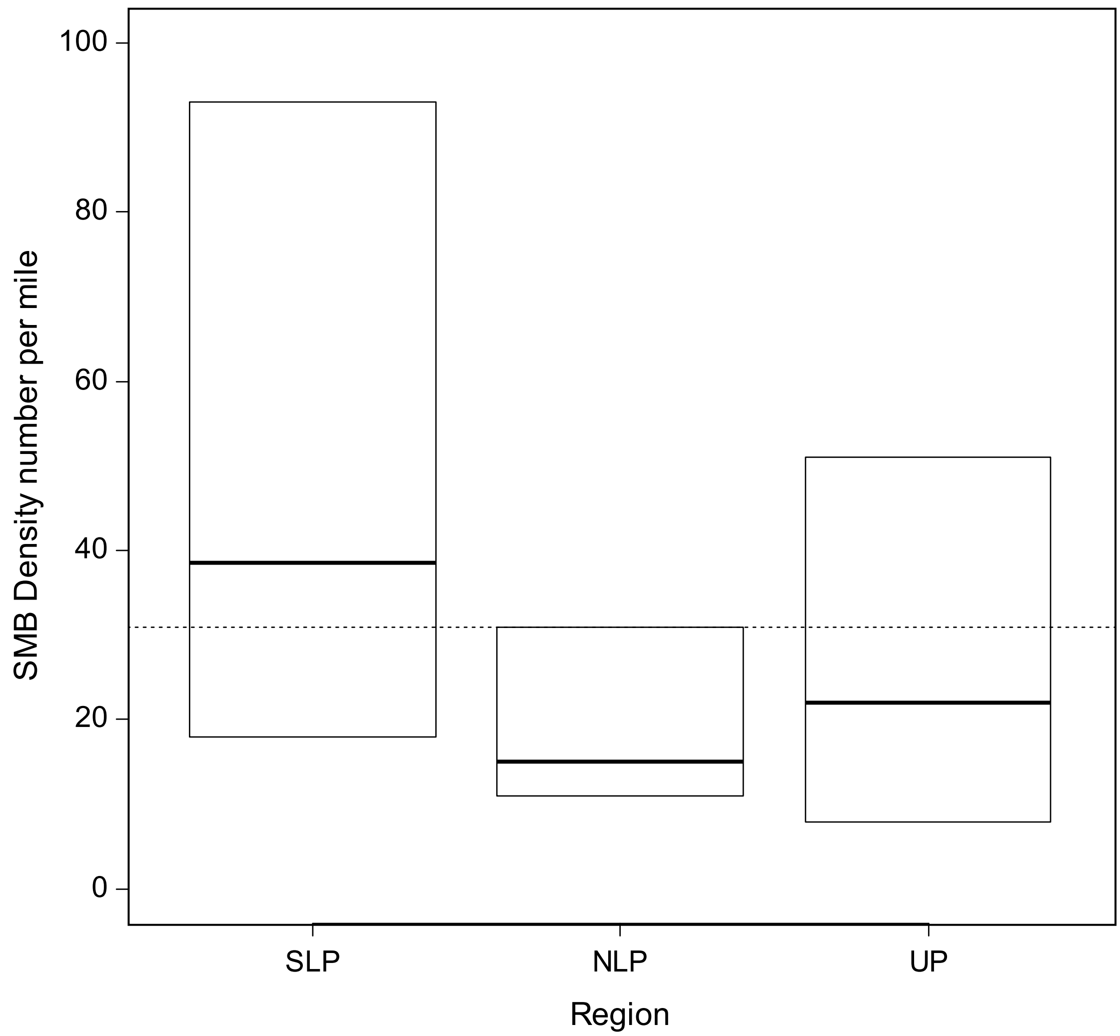

FIGURE 5. Box plot of Smallmouth Bass (SMB) relative abundance for Southern Lower Peninsula (SLP), Northern Lower Peninsula (NLP) and Upper Peninsula (UP) sites where Smallmouth Bass were detected. The top of each box represents the 3rd quartile, the solid line within each box represents the median, and the bottom of the box represents the 1st quartile of the data. The dashed line represents the overall statewide median of Smallmouth Bass relative abundance at all sites where Smallmouth Bass were present.

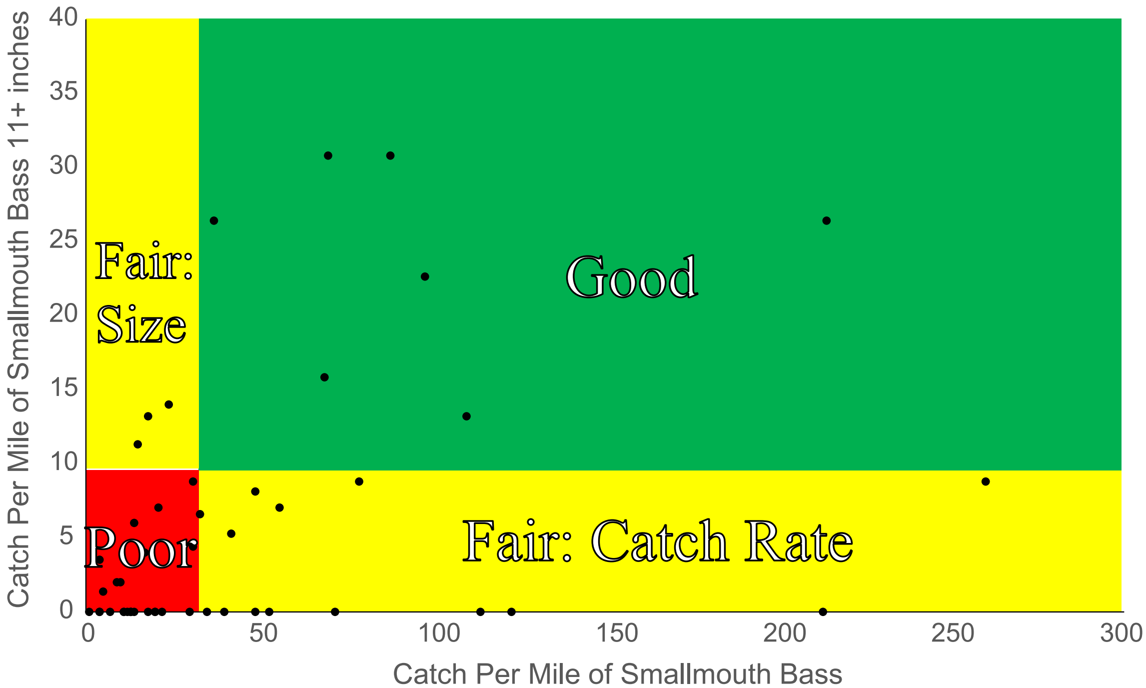

FIGURE 6. Relative fishing quality for Michigan Smallmouth Bass streams sampled at random locations. The relative fishing quality is based on both the overall relative abundance and the relative abundance of quality-sized (11 inches, Gabelhouse 1984) individuals as follows: a “good” fishing location has both a high relative abundance of Smallmouth Bass (50th percentile or higher) and a relatively high abundance of quality-sized individuals (50th percentile or higher); a “fair: catch rate” fishing location a high relative abundance or individuals; a “fair: size” location has a relatively high abundance of quality-sized individuals; and a “poor” fishing location has neither a high total relative abundance nor a high relative abundance of quality-sized individuals. Individual survey points are shown as black dots.

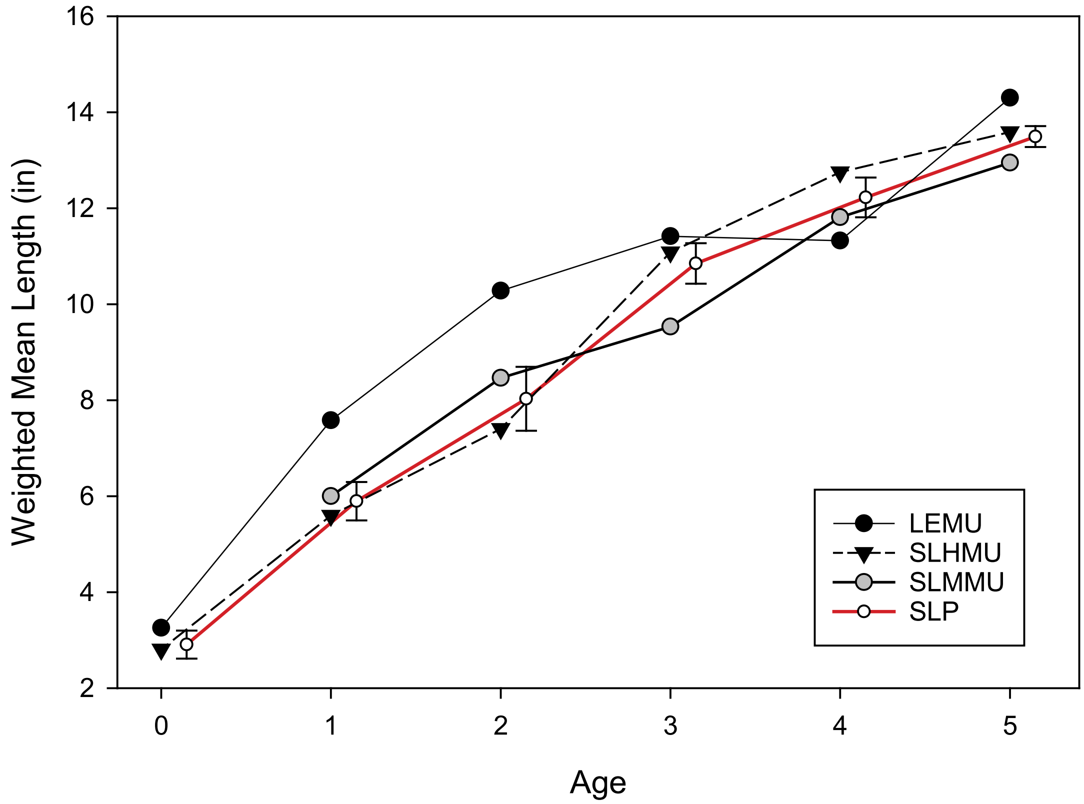

FIGURE 7. Mean weighted length-at-age for Smallmouth Bass sampled at random sites in the Southern Lower Peninsula (SLP; the only region where sufficient length at age data were available), and corresponding management units (Lake Erie: LEMU, Southern Lake Huron, SLHMU, and Southern Lake Michigan (SLMMU). Error bars represent the mean ± one standard error, and are shown only for the SLP.

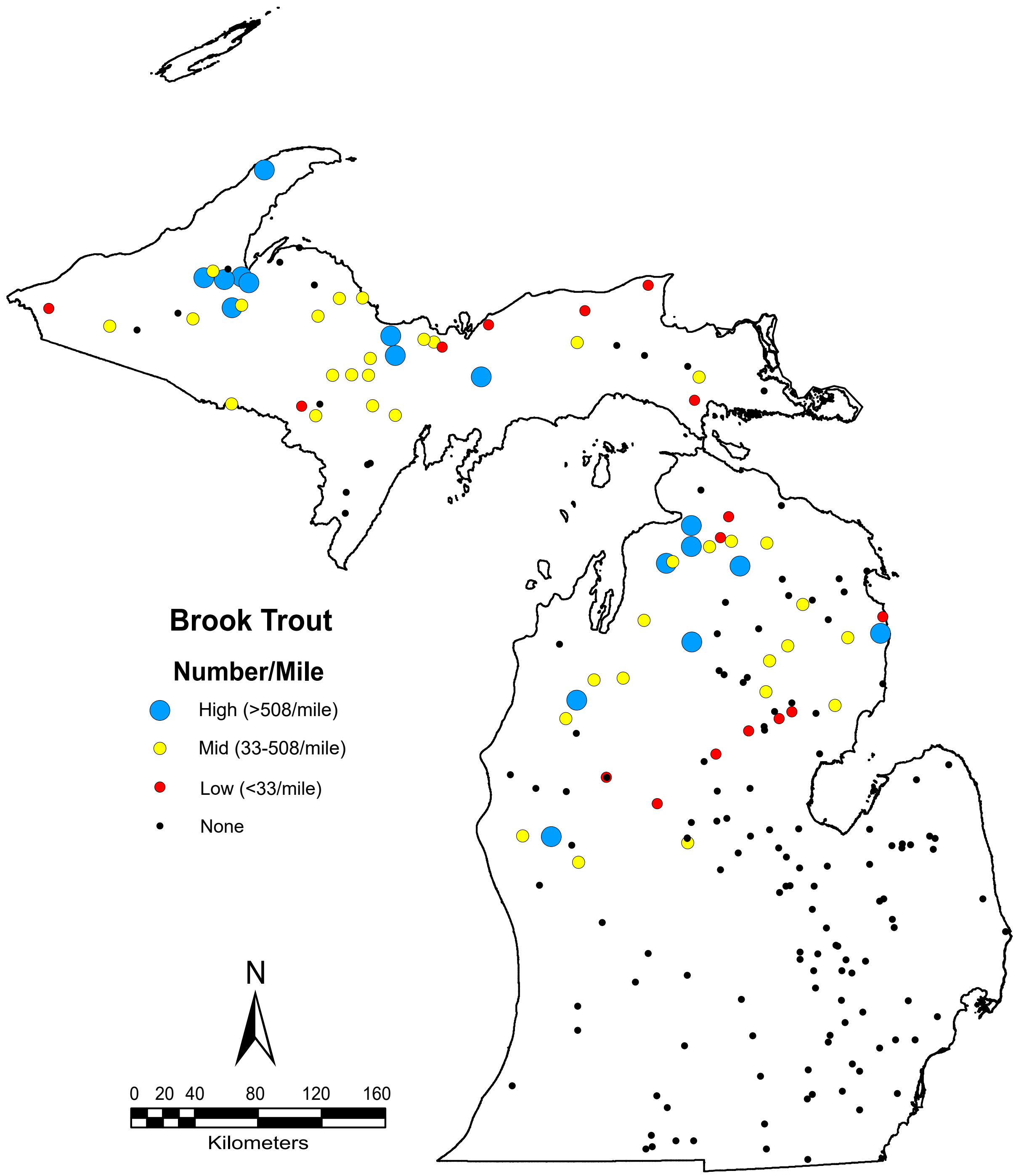

FIGURE 8. Statewide distribution of random sites sampled for Brook Trout from 2002–2013. The “High” relative abundance sites (large blue circles) represent the 4th quartile of the data, the “Mid” sites (medium yellow circles) represent the 2nd and 3rd quartiles of the data, the “Low” relative abundance sites (small red circles) represent the 1st quartile of the data, and the “None” sites (very small black dots) represent locations where Brook Trout were not detected.

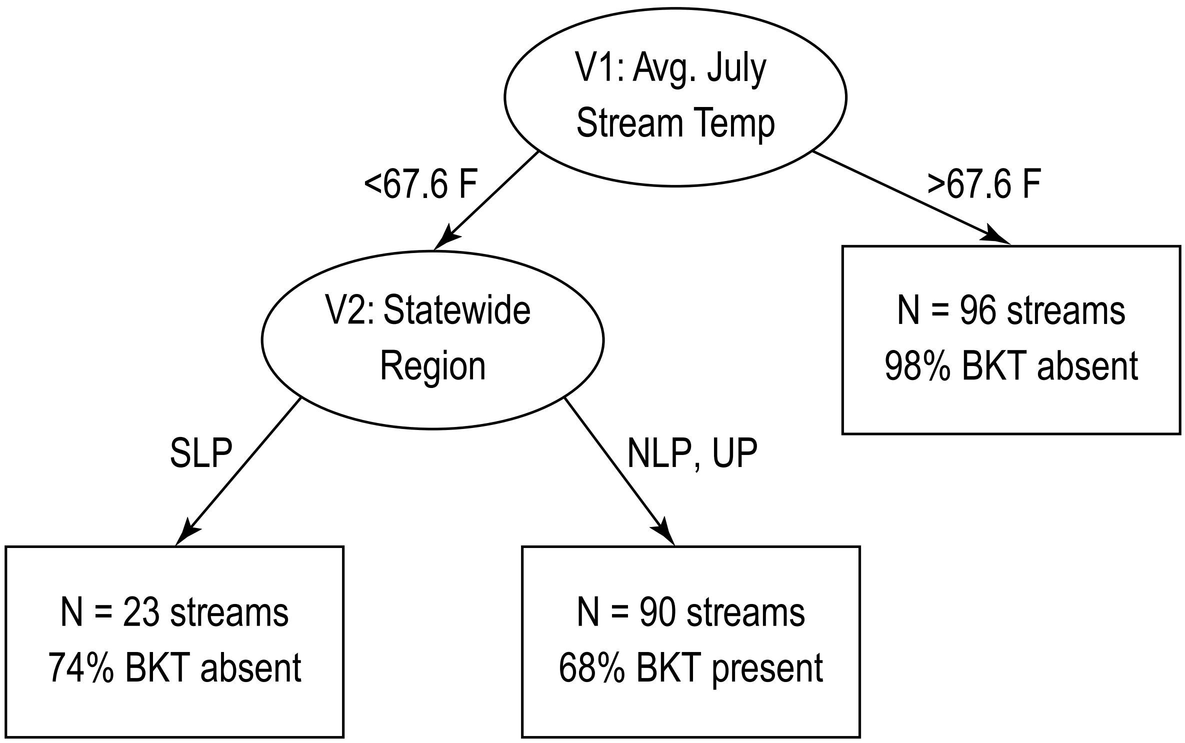

FIGURE 9. Classification tree for variables associated with the presence and absence of Brook Trout (BKT), average July stream temperature (V1) and region (V2). The regions are Southern Lower Peninsula (SLP), Northern Lower Peninsula (NLP), and Upper Peninsula(UP). Terminal groups are rectangles and give sample size (N) and the percentage of streams sampled with Brook Trout present or absent.

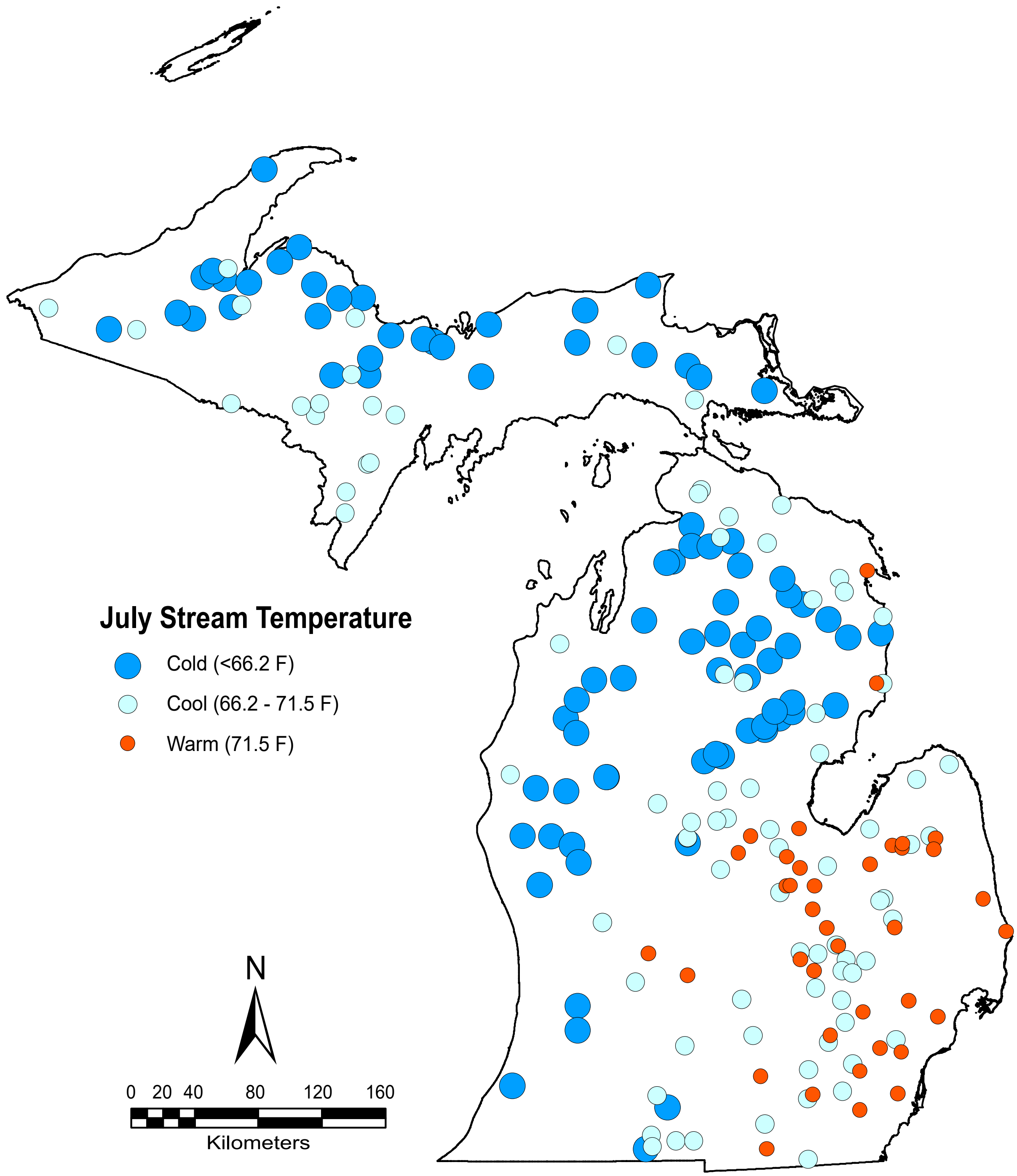

FIGURE 10. Statewide distribution of mean July temperature, the most important variable for predicting the occurrence of Brook Trout and Brown Trout as determined from random forest modeling, for randomly-sampled cold (large blue circles), cool (medium blue circles) and warm water (small red circles) streams.

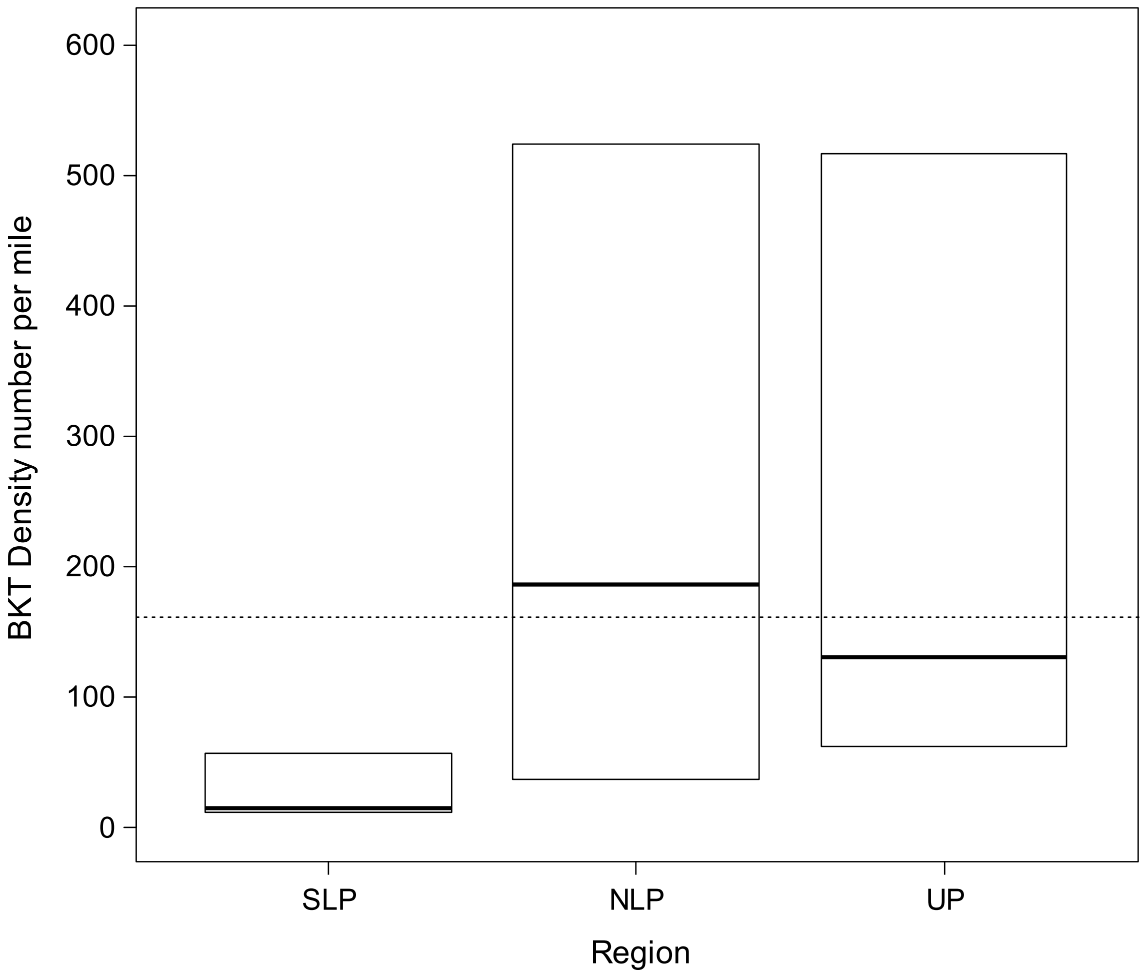

FIGURE 11. Box plot of Brook Trout (BKT) relative abundance for Southern Lower Peninsula (SLP), Northern Lower Peninsula (NLP) and Upper Peninsula (UP) sites where Brook Trout were detected. The top of each box represents the 3rd quartile, the solid line within each box represents the median, and the bottom of the box represents the 1st quartile of the data. The dashed line represents the overall statewide median of Brook Trout relative abundance at all sites where Brook Trout were present.

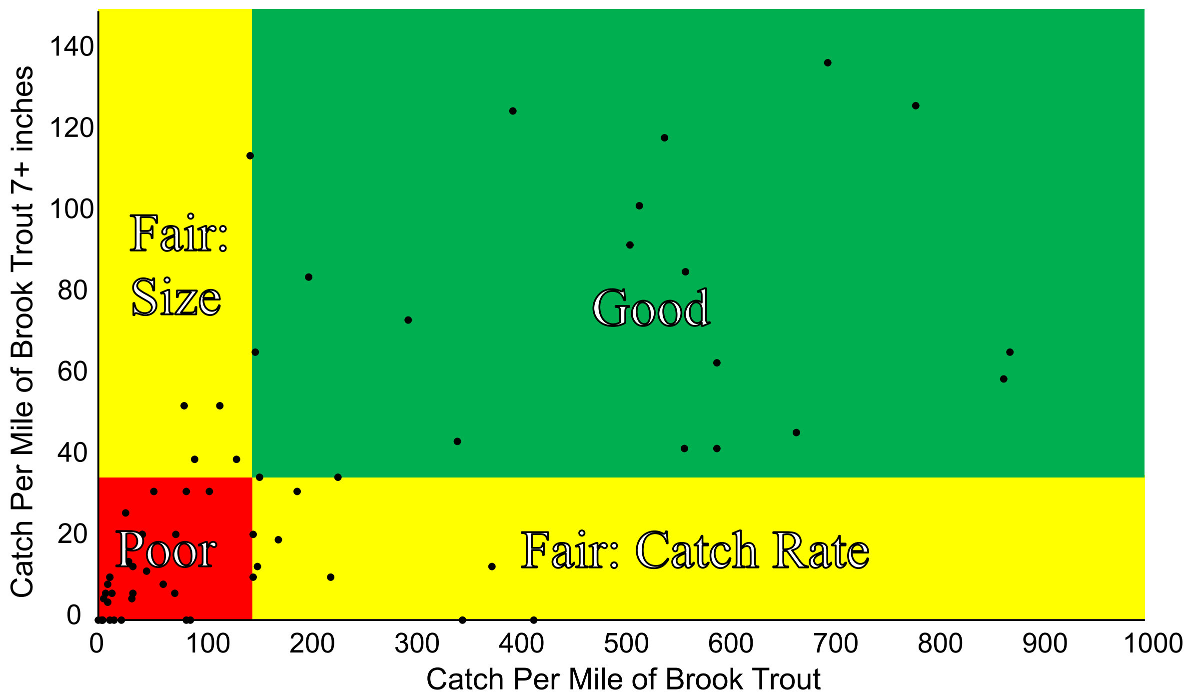

FIGURE 12. Relative fishing quality for Michigan Brook Trout streams sampled at random locations. The relative fishing quality is based on both the overall relative abundance and the relative abundance of legal-sized (7 inches) individuals as determined from the minimum size limits under Michigan Type 1 stream regulations as follows: a "good" fishing location has both a high relative abundance of Brook Trout (50th percentile or higher) and a relatively high abundance of legal-sized individuals (50th percentile or higher); a "fair: catch rate" fishing location has a high relative abundance; a "fair: size" location has a relatively high abundance of legal-sized individuals; and a "poor" fishing location has neither a high total relative abundance nor a high relative abundance of legal-sized individuals. Individual survey points are shown as black dots.

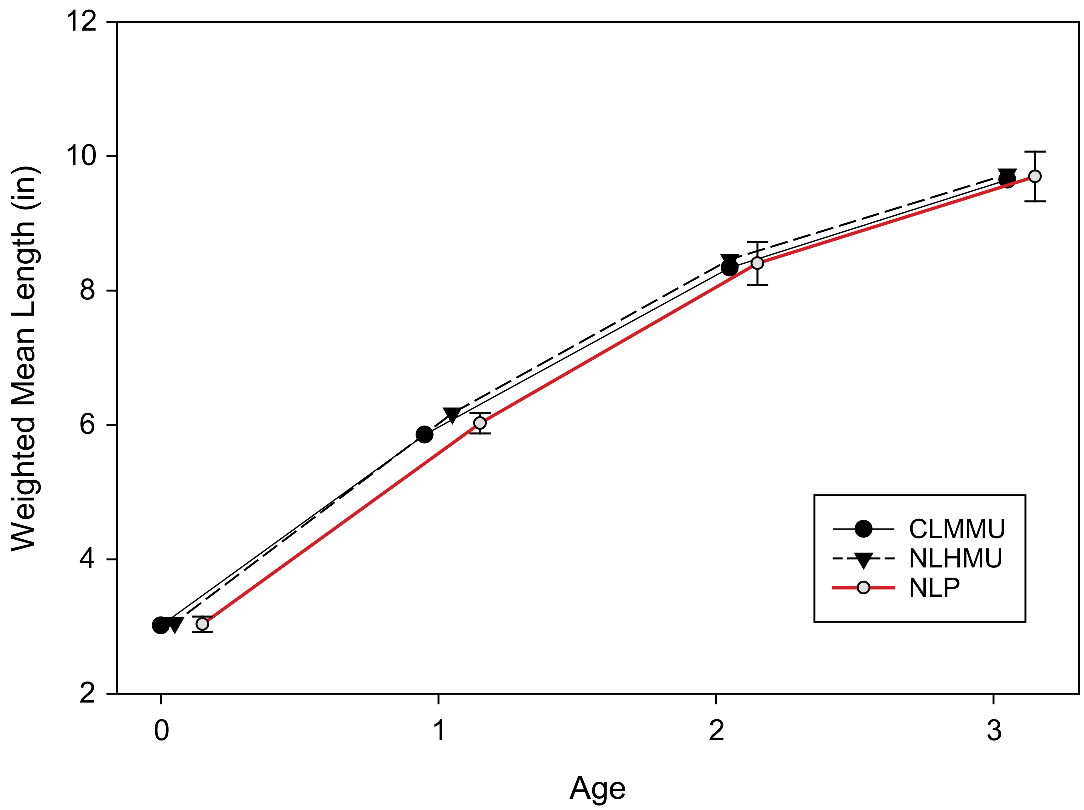

FIGURE 13. Trends in mean weighted length-at-age for Brook Trout sampled at random sites in the Northern Lower Peninsula and corresponding management units (Central Lake Michigan: CLMMU, Northern Lake Huron: NLHMU). Error bars represent the mean ± one standard error.

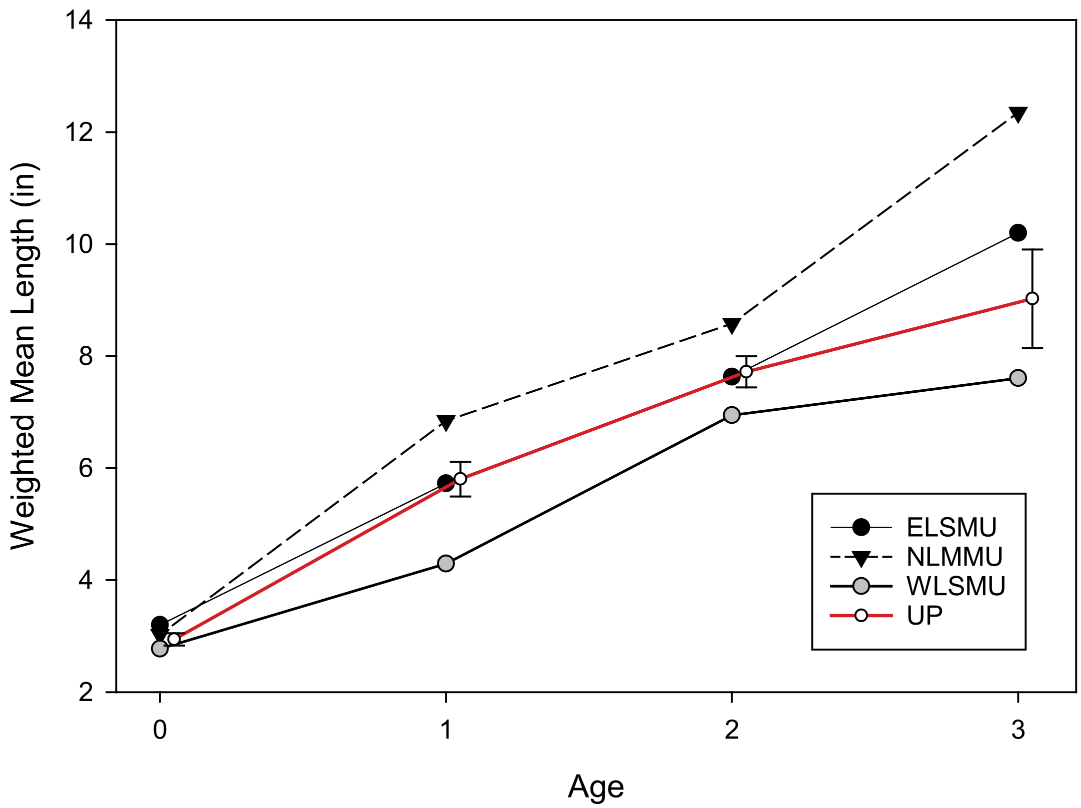

FIGURE 14. Trends in mean weighted length-at-age for Brook Trout sampled at random sites in the Upper Peninsula and corresponding management units (Eastern Lake Superior: ELSMU, Northern Lake Michigan: NLMMU, Western Lake Superior: WLSMU). Error bars represent the mean ± one standard error.

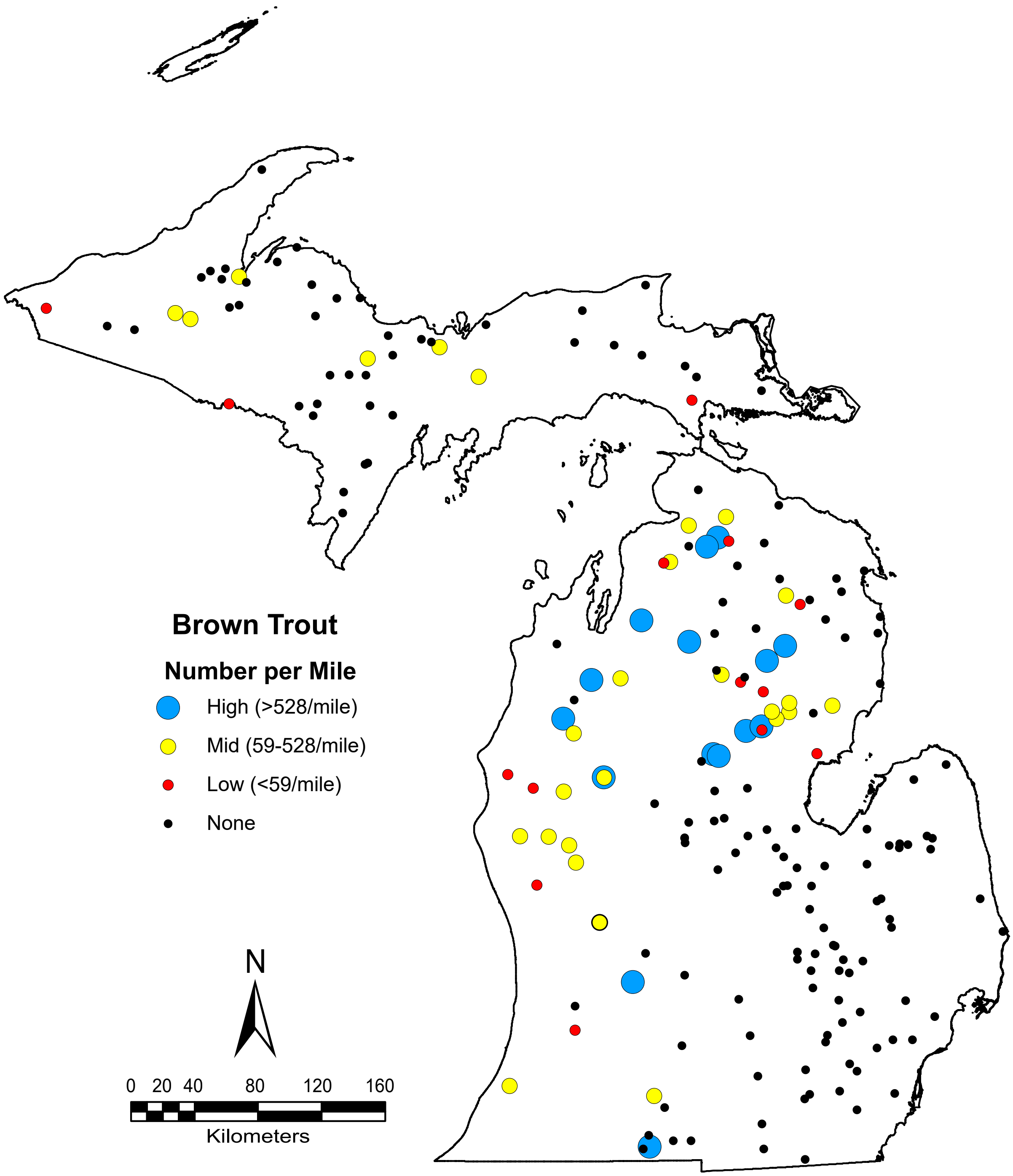

FIGURE 15. Statewide distribution of random sites sampled for Brown Trout from 2002–2013. The "High" relative abundance sites (large blue circles) represent the 4th quartile of the data, the "Mid" sites (medium yellow circles) represent the 2nd and 3rd quartiles of the data, the "Low" relative abundance sites (small red circles) represent the 1st quartile of the data, and the "None" sites (very small black dots) represent locations where Brown Trout were not detected.

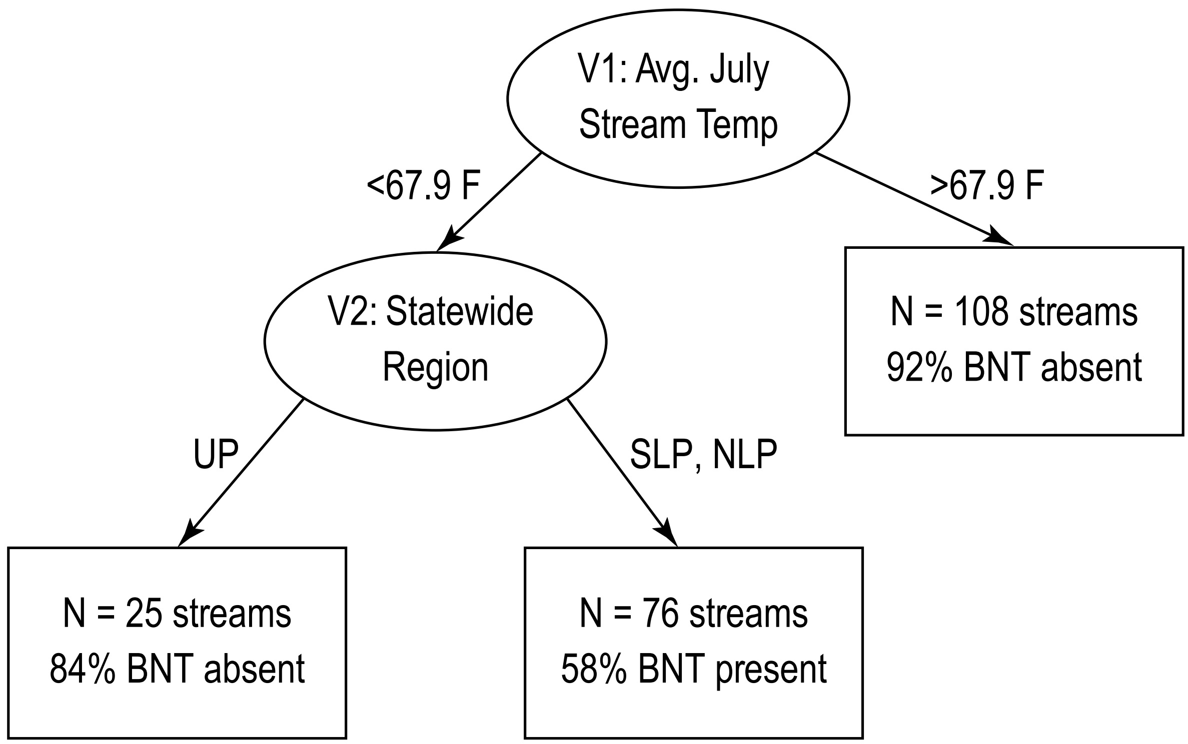

FIGURE 16. Classification tree for variables associated with the presence and absence of Brown Trout (BNT), average July stream temperature (V1) and region (V2). The regions are Southern Lower Peninsula (SLP), Northern Lower Peninsula (NLP), and Upper Peninsula(UP). Terminal groups are rectangles and give sample size (N) and the percentage of streams sampled with BrownTrout present or absent.

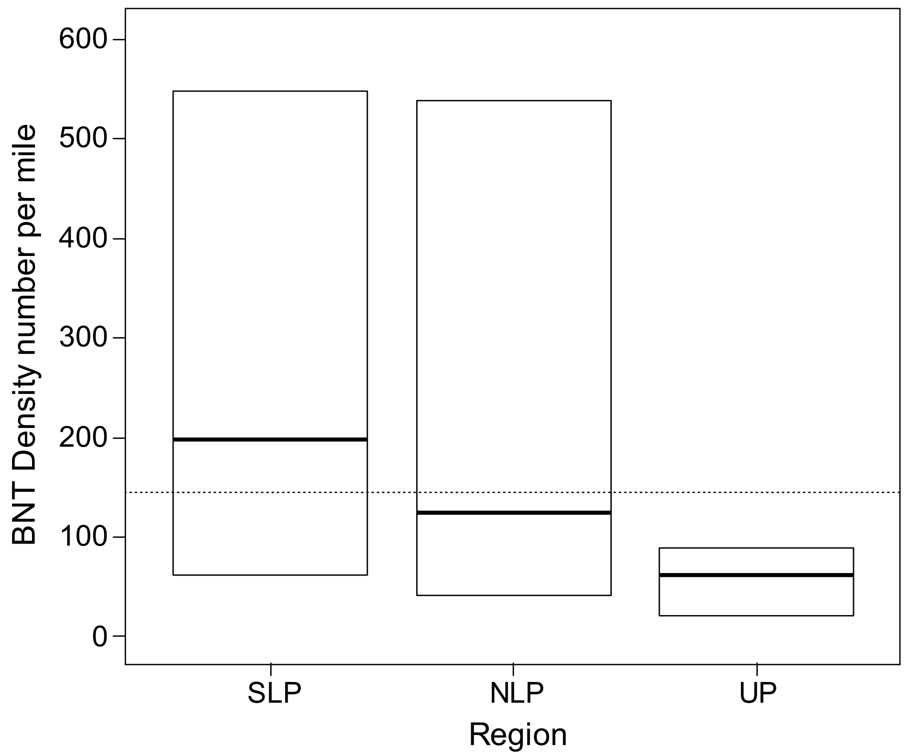

FIGURE 17. Box plot of Brown Trout (BNT) relative abundance for Southern Lower Peninsula (SLP), Northern Lower Peninsula (NLP) and Upper Peninsula (UP) sites where Brown Trout were detected. The top of each box represents the 3rd quartile, the solid line within each box represents the median, and the bottom of the box represents the 1st quartile of the data. The dashed line represents the overall statewide median of Brown Trout relative abundance at all sites where Brown Trout were present.

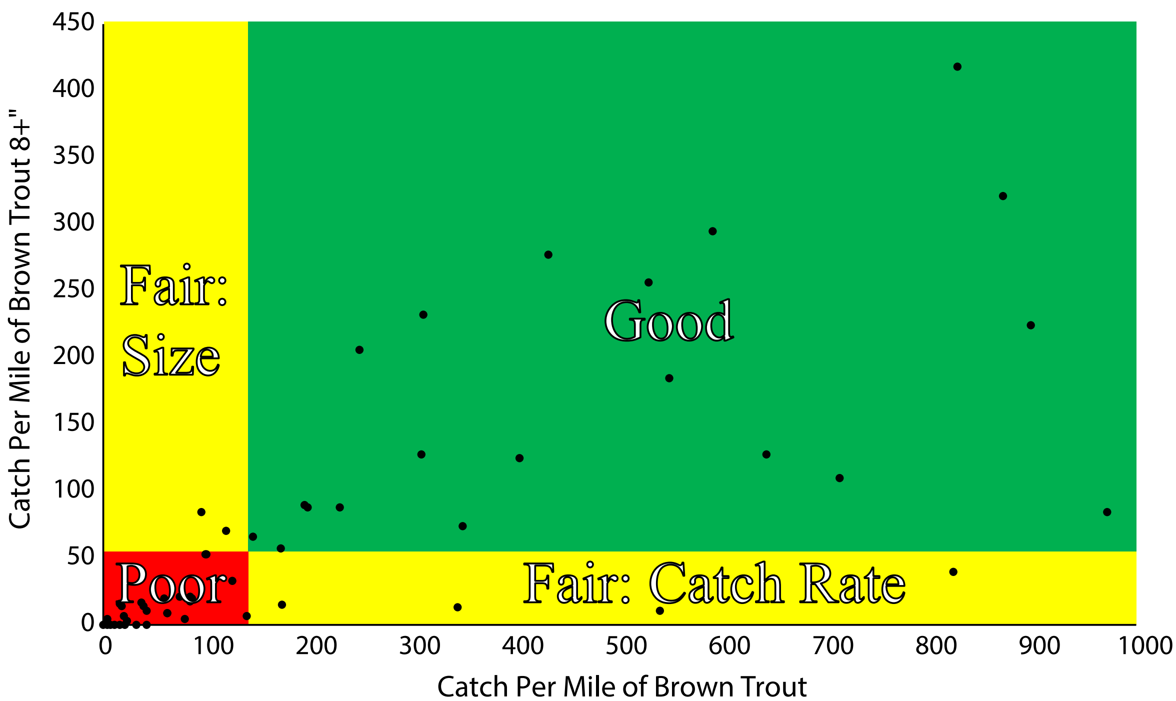

FIGURE 18. Relative fishing quality for Michigan Brown Trout streams sampled at random locations. The relative fishing quality is based on both the overall relative abundance and the relative abundance of legal-sized (8 inches) individuals as determined from the minimum size limits under Michigan Type 1 stream regulations as follows: a "good" fishing location has both a high relative abundance of Brook Trout (50th percentile or higher) and a relatively high abundance of legal-sized individuals (50th percentile or higher); a "fair: catch rate" fishing location has a high relative abundance; a "fair: size" location has a relatively high abundance of legal-sized individuals; and a "poor" fishing location has neither a high total relative abundance nor a high relative abundance of legal-sized individuals. Individual survey points are shown as black dots.

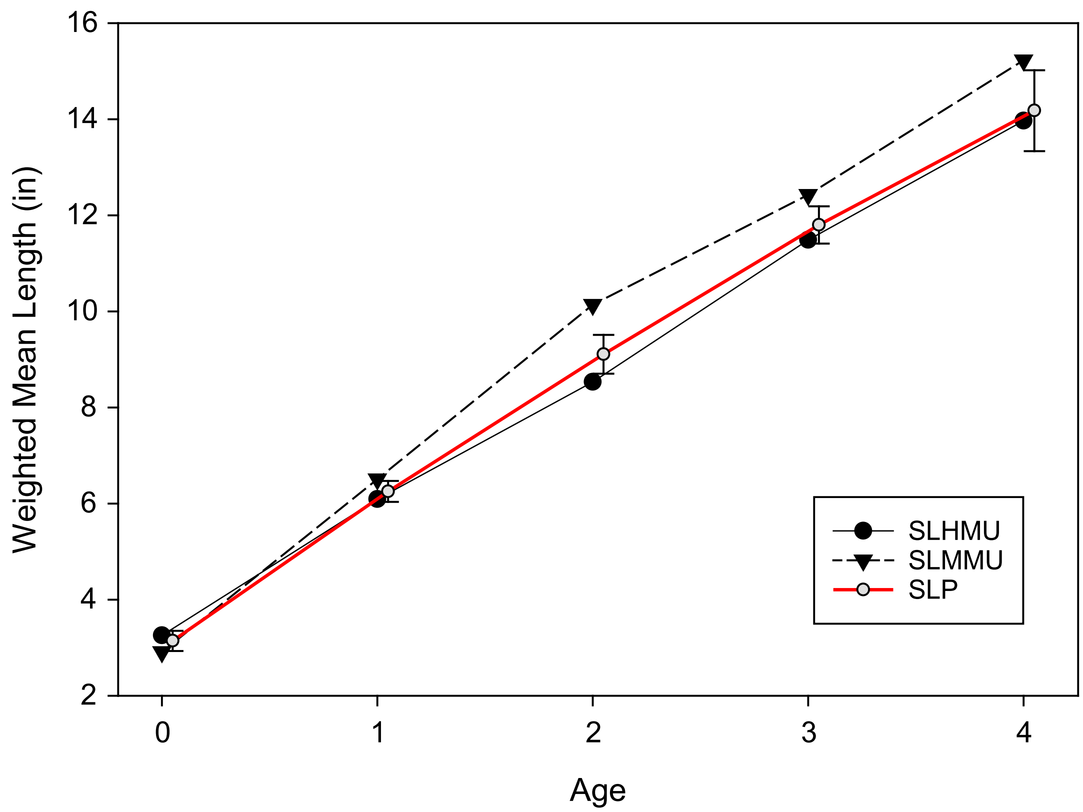

FIGURE 19. Weighted length-at-age for Brown Trout sampled at random sites in the Southern Lower Peninsula, and corresponding fisheries management units (Southern Lake Huron: SLHMU, and Southern Lake Michigan: SLMMU). Error bars represent the mean ± the standard error.

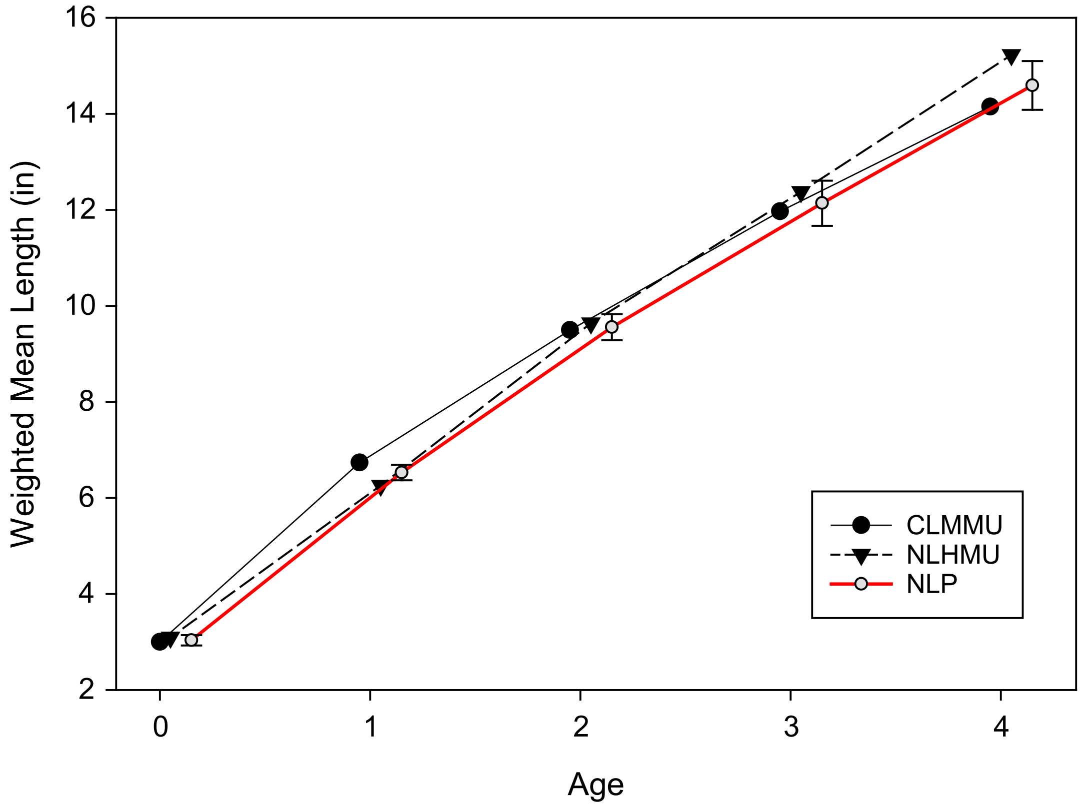

FIGURE 20. Mean weighted length-at-age for Brown Trout sampled at random sites in the Northern Lower Peninsula, and corresponding fisheries management units (Central Lake Michigan: CLMMU, Northern Lake Huron: NLHMU). Error bars represent the mean ± the standard error.

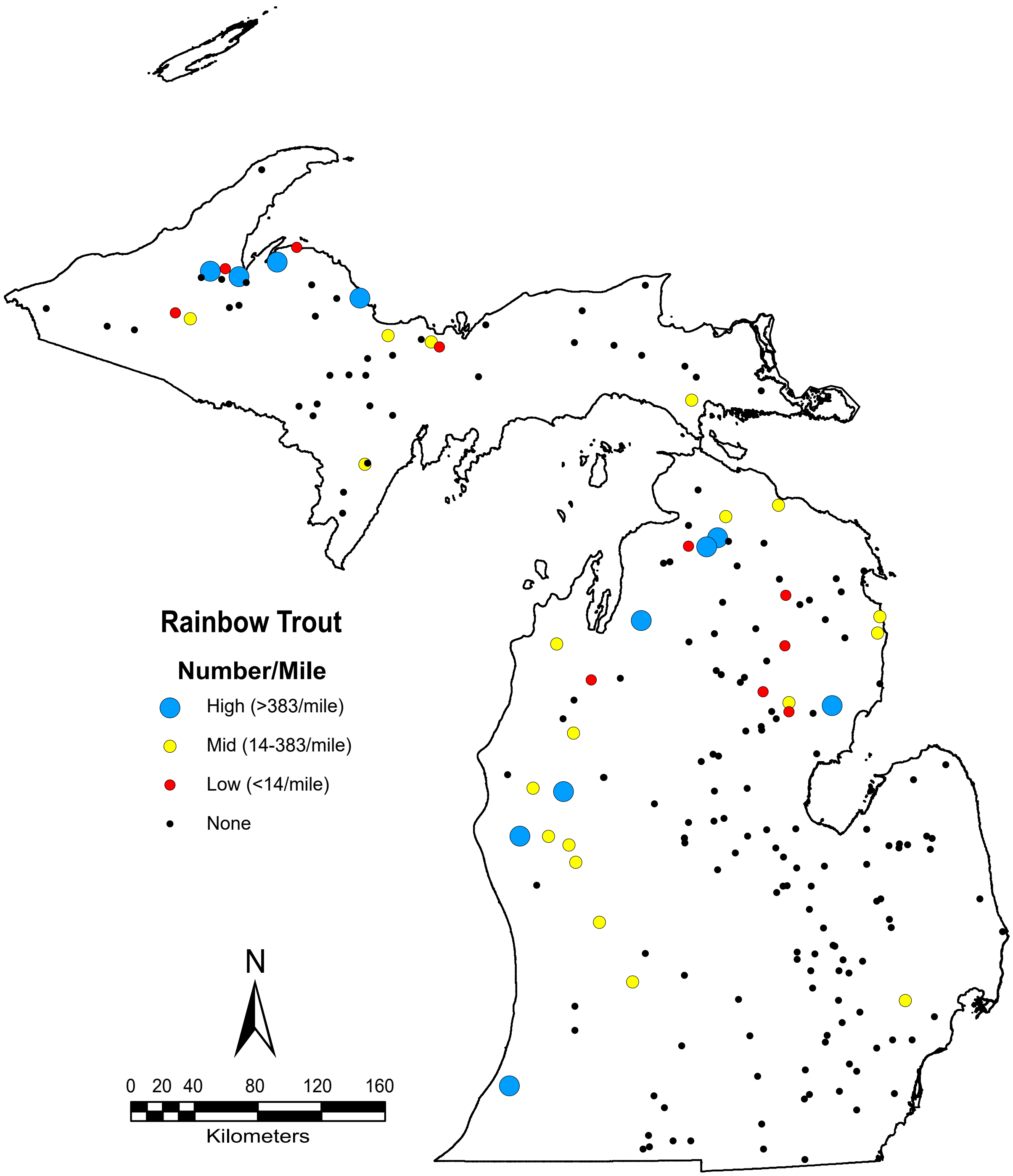

FIGURE 21. Statewide distribution of random sites sampled for Rainbow Trout from 2002–2013. The "High" relative abundance sites (large blue circles) represent the 4th quartile of the data, the "Mid" sites (medium yellow circles) represent the 2nd and 3rd quartiles of the data, the "Low" relative abundance sites (small red circles) represent the 1st quartile of the data, and the "None" sites (very small black dots) represent locations where Rainbow Trout were not detected.

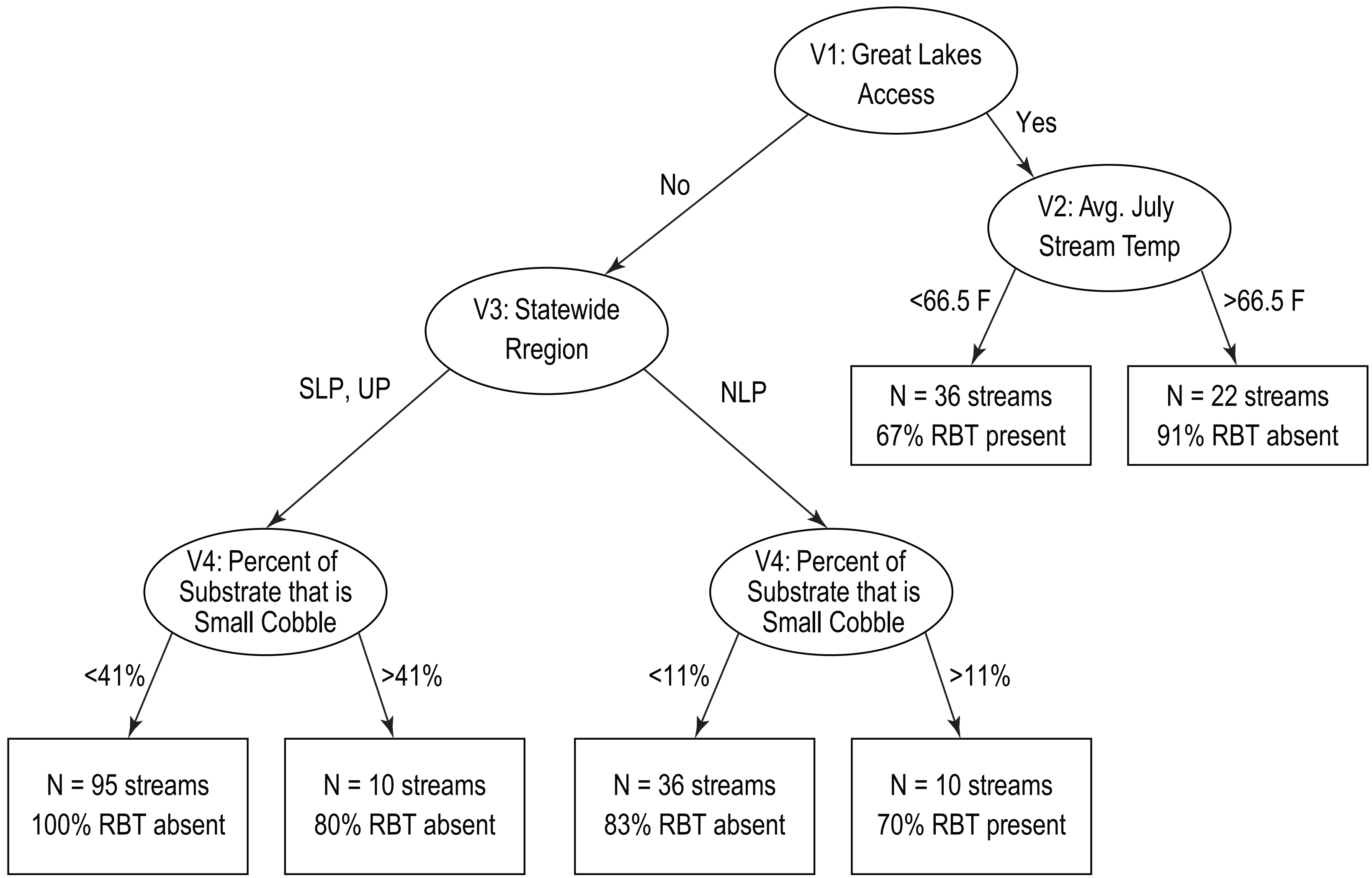

FIGURE 22. Classification tree for variables associated with the presence and absence of Rainbow Trout (RBT), Great Lakes access (V1), average July stream temperature (V2), region (V3), and percent of substrate composed of small cobble (V4). The regions are Southern Lower Peninsula (SLP), Northern Lower Peninsula (NLP), and Upper Peninsula(UP). Terminal groups are rectangles and give sample size (N) and the percentage of streams with Rainbow Trout present or absent.

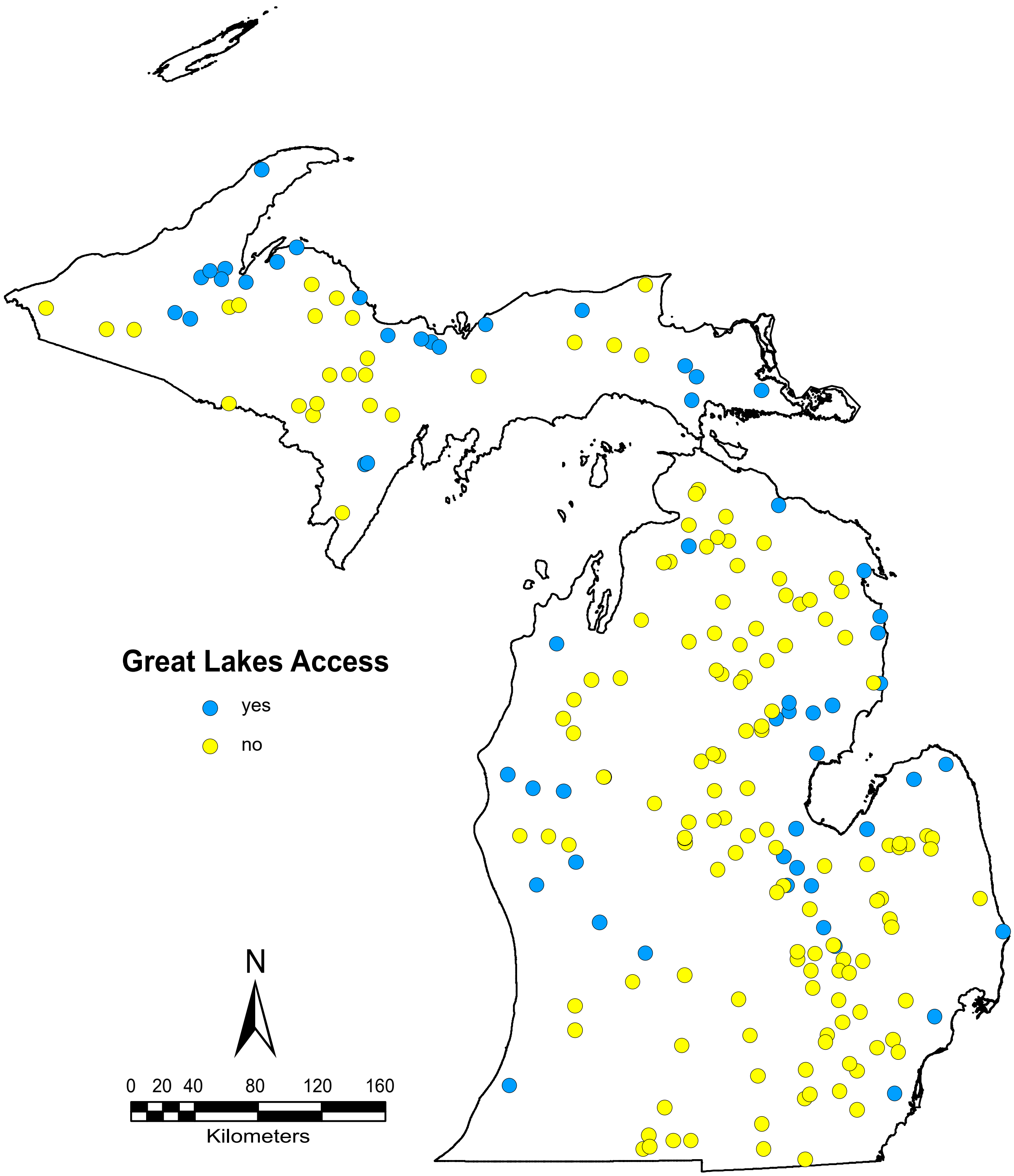

FIGURE 23. Statewide distribution of randomly-sampled streams with (blue circles, yes) and without (yellow circles, no) Great Lakes access, the most important variable from random forest modeling predicting Rainbow Trout occurrence.

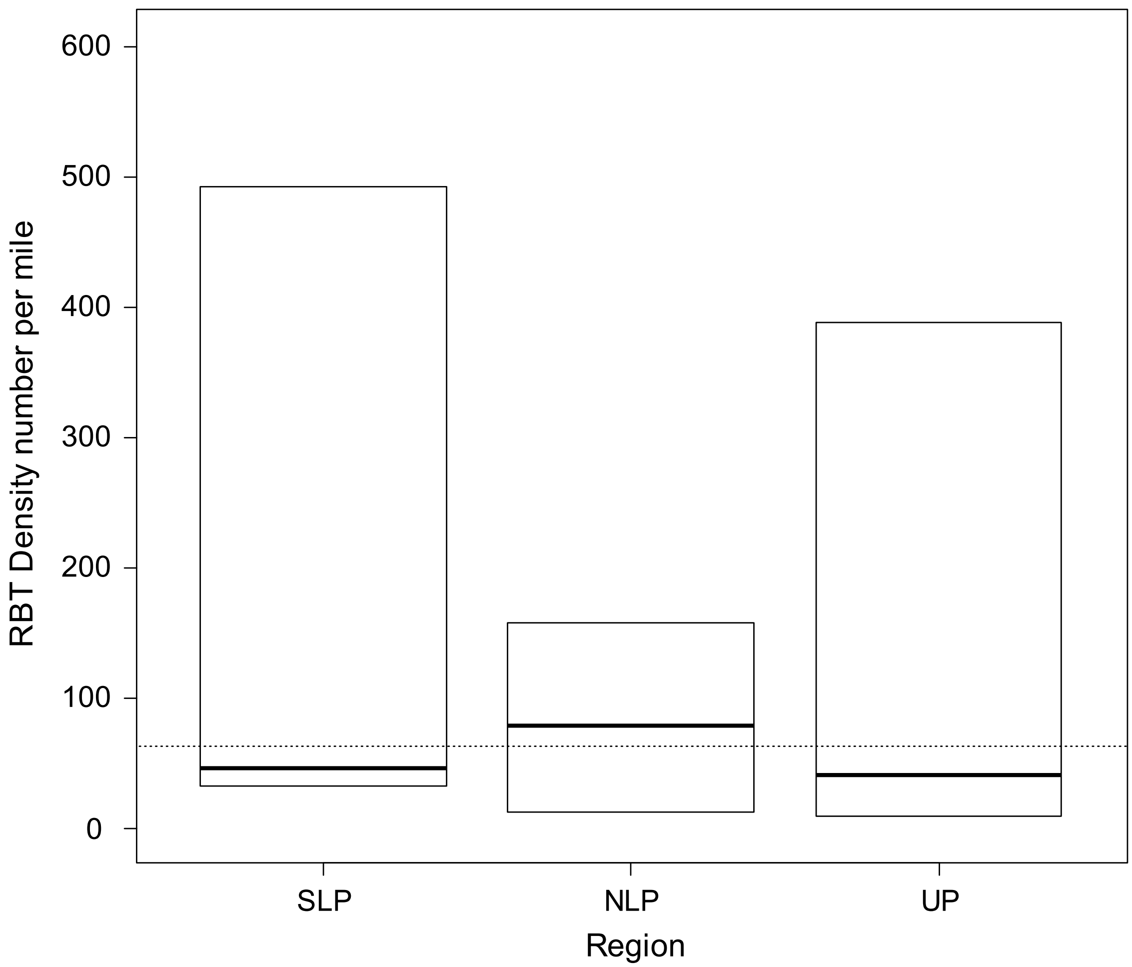

FIGURE 24. Box plot of Rainbow Trout (RBT) relative abundance for Southern Lower Peninsula (SLP), Northern Lower Peninsula (NLP) and Upper Peninsula (UP) sites where Rainbow Trout were detected. The top of each box represents the 3rd quartile, the solid line within each box represents the median, and the bottom of the box represents the 1st quartile of the data. The dashed line represents the overall statewide median of Rainbow Trout relative abundance at all sites where Rainbow Trout were present.

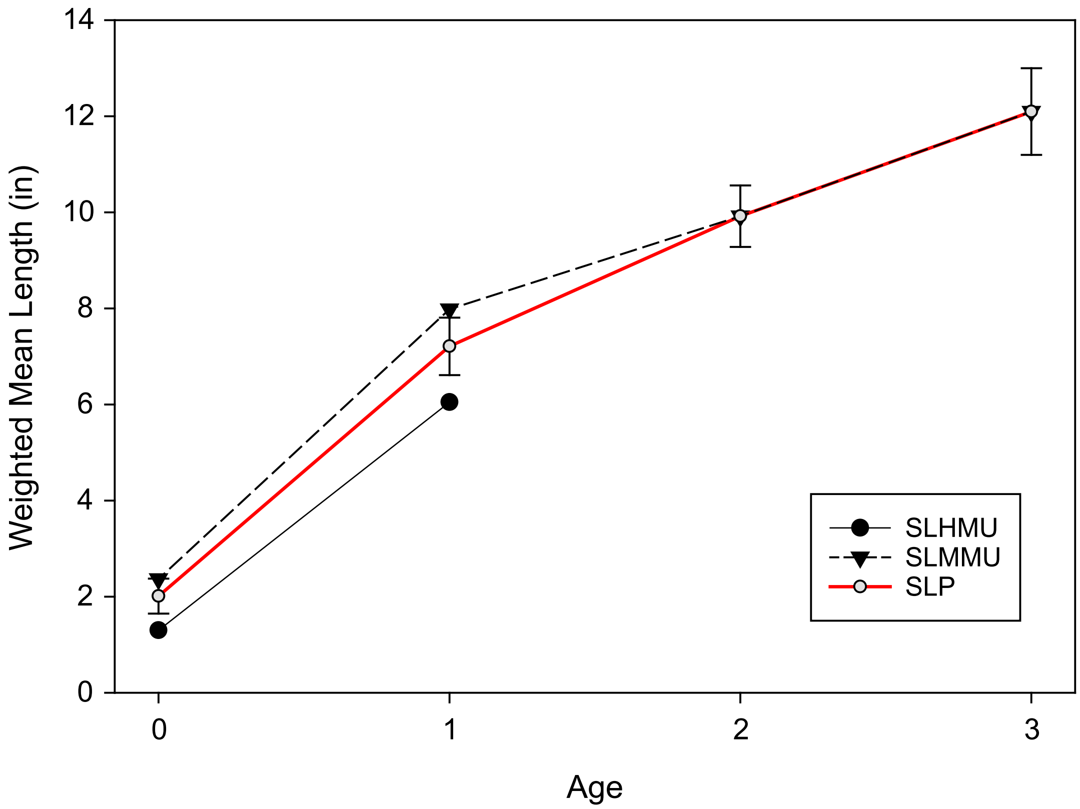

FIGURE 25. Mean weighted length-at-age for Rainbow Trout sampled at random sites in the Southern Lower Peninsula, and corresponding fisheries management units (Southern Lake Huron: SLHMU, Southern Lake Michigan: SLMMU). Error bars represent the mean ± the standard error.

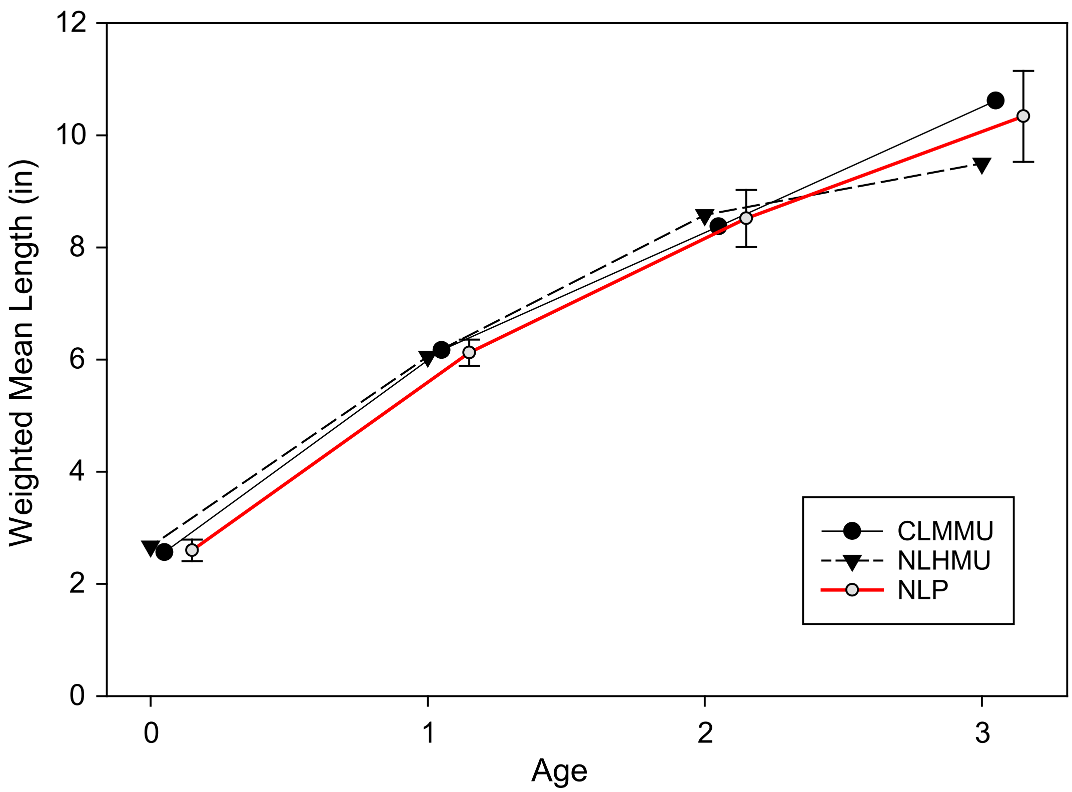

FIGURE 26. Mean weighted length-at-age for Rainbow Trout sampled at random sites in the Northern Lower Peninsula, and corresponding fisheries management units (Central Lake Michigan: CLMMU, Northern Lake Huron: NLHMU). Error bars represent the mean ± the standard error.

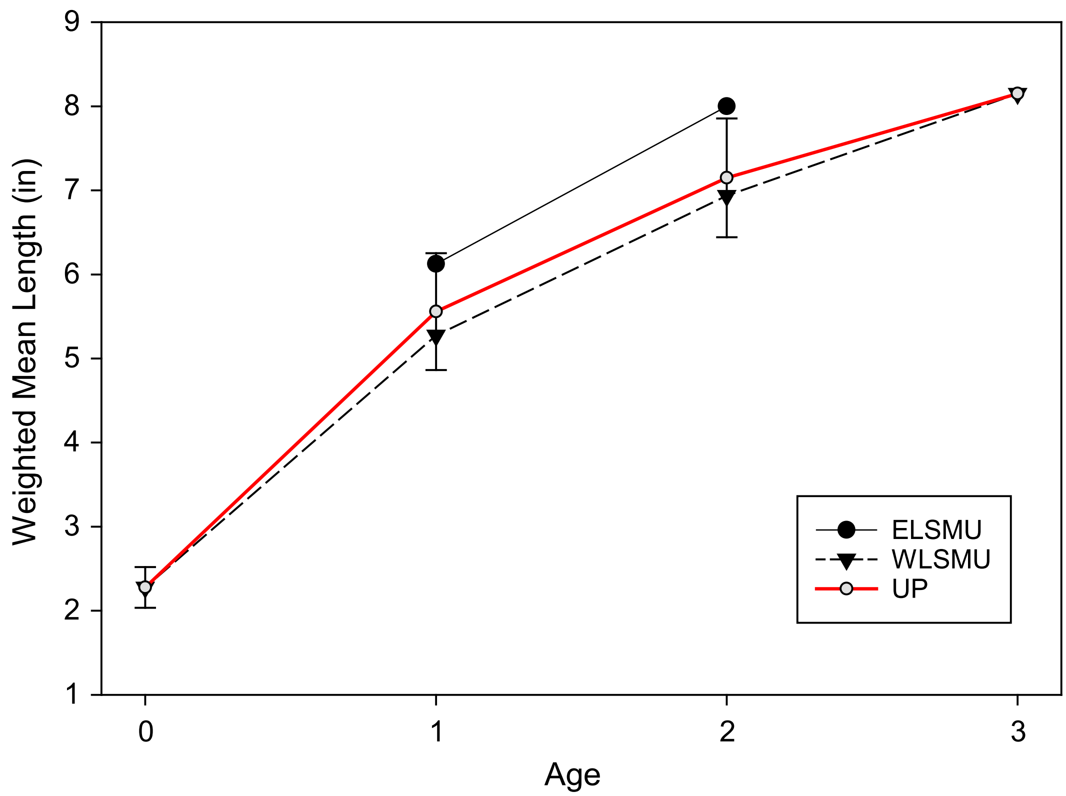

FIGURE 27. Mean weighted length-at-age for Rainbow Trout sampled at random sites in the Upper Peninsula, and corresponding fisheries management units (Eastern Lake Superior: ELSMU, Western Lake Superior: WLSMU). Error bars represent the mean ± the standard error.

TABLES

TABLE 1. Description of stream size and temperature strata used to allocate sampling effort. Stream size is characterized by area of the upstream watershed (mi^2) and temperature is based on mean July water temperature (°F).

Strata	Value range
Size	
Small	<40 mi^2
Medium	40–179 mi^2
Large	180–620 mi^2
Very Large	>620 mi^2
Temperature	
Cold	<66.2 °F
Cool	66.2–71.5 °F
Warm	>71.5 °F

TABLE 2. Summary of randomly chosen stream valley segments sampled among stream size, temperature classes, and Great Lakes access. The number in parentheses represents the total number of valley segments available statewide.

	Temperature class			Great Lakes access	
Size class	Cold	Cool	Warm	No	Yes
Small	43 (579)	29 (595)	17 (278)	66 (1,021)	23 (431)
Medium	30 (127)	37 (197)	19 (97)	62 (289)	24 (132)
Large	3 (21)	12 (82)	7 (42)	16 (109)	6 (36)
Very large	1 (1)	3 (39)	11 (49)	7 (48)	8 (41)
Grand total	77 (728)	81 (913)	54 (466)	151 (1,467)	61 (640)

TABLE 3. Success rates of random forest models for Smallmouth Bass, Brook Trout, Brown Trout and Rainbow Trout. Success rate is the percentage of stream reaches where each species was detected (Present) or not detected (Absent) that were correctly predicted by the random forest model for that species. The total success rate (Overall) represents the total percentage of all stream reaches where the random forest model correctly predicted presence or absence.

	Stream reaches (%)		
Species	Present	Absent	Overall
Smallmouth Bass	52	93	84
Brook Trout	75	86	82
Brown Trout	37	88	73
Rainbow Trout	35	93	81

TABLE 4. Percent occurrence of Smallmouth Bass by stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each strata are given at the bottom of each row and column, respectively, with grand total given in the lower diagonal. Data are not corrected based on sampling effort.

	Stream temperature (%)			
Size	Cold	Cool	Warm	Total N
Small	2	2	2	3
Medium	6	24	15	24
Large	0	17	11	15
Very Large	0	2	20	12
Total N	4	24	26	54

TABLE 5. The five most important stream features predicting the occurrence of Smallmouth Bass, Brook Trout, Brown Trout, and Rainbow Trout based on randomForest classification.

	Species			
Variable	Smallmouth Bass	Brook Trout	Brown Trout	Rainbow Trout
1	Avg. stream width	July stream temp.	July stream temp.	Great Lakes access
2	STP size strata	Region	% small cobble substrate	July stream temp.
3	July stream temp.	Avg. undercut depth	% of large conifer cover	Region
4	Total area structure	% of tag alder cover	Region	STP size strata
5	Total area large woody debris	% of run-type habitat	Great Lakes access	% small cobble substrate

TABLE 6. Percent occurrence of Brook Trout by stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each strata are given at the bottom of each row and column, respectively, with grand total given in the lower diagonal. Data are not corrected based on sampling effort.

	Stream temperature (%)			
Size	Cold	Cool	Warm	Total N
Small	37	17	3	40
Medium	24	14	0	27
Large	3	1	0	3
Very large	1	0	0	1
Total N	46	23	2	71

TABLE 7. Percent occurrence of Brown Trout by stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each strata are given at the bottom of each row and column, respectively, with grand total given in the lower diagonal. Data are not corrected based on sampling effort.

	Stream temperature (%)			
Size	Cold	Cool	Warm	Total N
Small	30	5	3	23
Medium	32	15	0	28
Large	5	7	0	7
Very large	2	2	0	2
Total N	41	17	2	60

TABLE 8. Percent (%) occurrence of Rainbow Trout by stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each strata are given at the bottom of each row and column, respectively, with grand total given in the lower diagonal. Data are not corrected based on sampling effort.

	Stream temperature (%)			
Size	Cold	Cool	Warm	Total N
Small	24	5	3	13
Medium	34	17	3	22
Large	0	12	0	5
Very large	2	0	0	1
Total N	25	14	2	41

APPENDIX A

Maps of the distribution of all species detected by the Stream Status and Trends Program (Figures A1-A101).

Species occurrence based on stream size and temperature (Tables A1-A101).

Note: Percentages in these tables are rounded to the nearest whole number, therefore totals may not sum to 100. Percentages represent raw data not corrected for sampling effort.

Species occurrence based on whether the sampling site had Great Lakes Access (Table A102).

Species catch per effort for each statewide region where it occurred (Table A103).

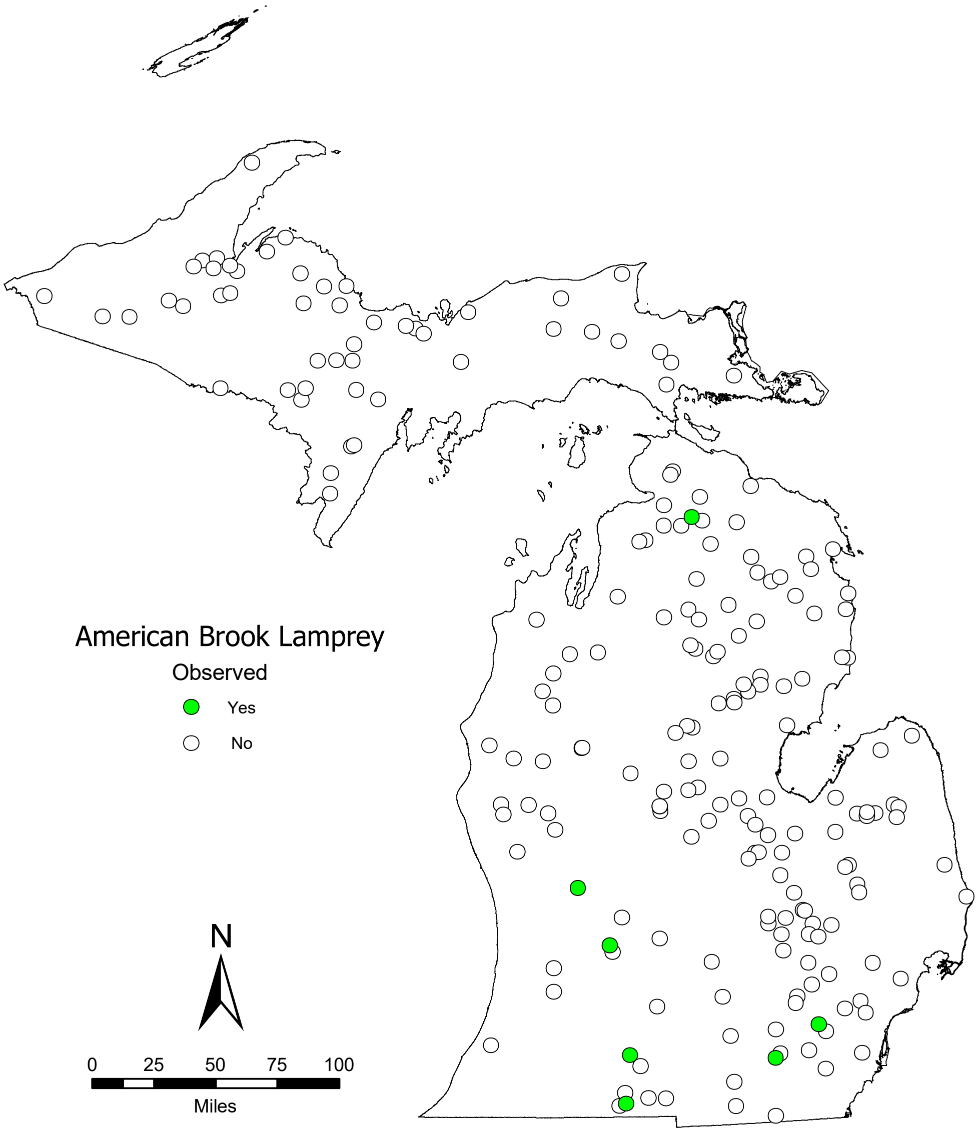

FIGURE A1. Map of distribution of American Brook Lamprey *Lampetra appendix* at randomly sampled sites.

TABLE A1. Percentage of American Brook Lamprey *Lampetra appendix* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	29	0	2
Medium	29	43	0	5
Large	0	0	0	0
Very Large	0	0	0	0
Total N	2	5	0	7

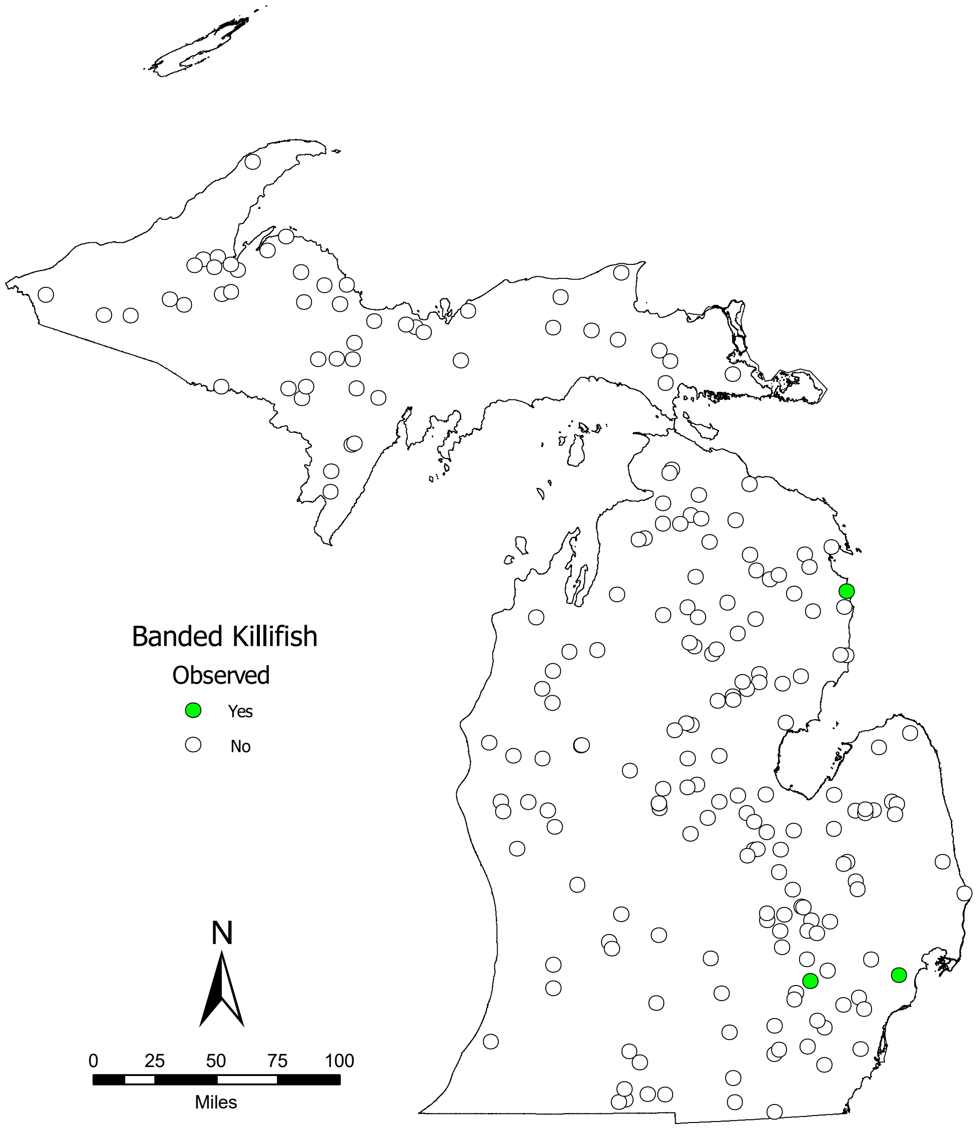

FIGURE A2. Map of distribution of Banded Killifish *Fundulus diaphanus* at randomly sampled sites.

TABLE A2. Percentage of Banded Killifish *Fundulus diaphanus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	33	0	33	2
Large	0	33	0	1
Very Large	0	0	0	0
Total N	1	1	1	3

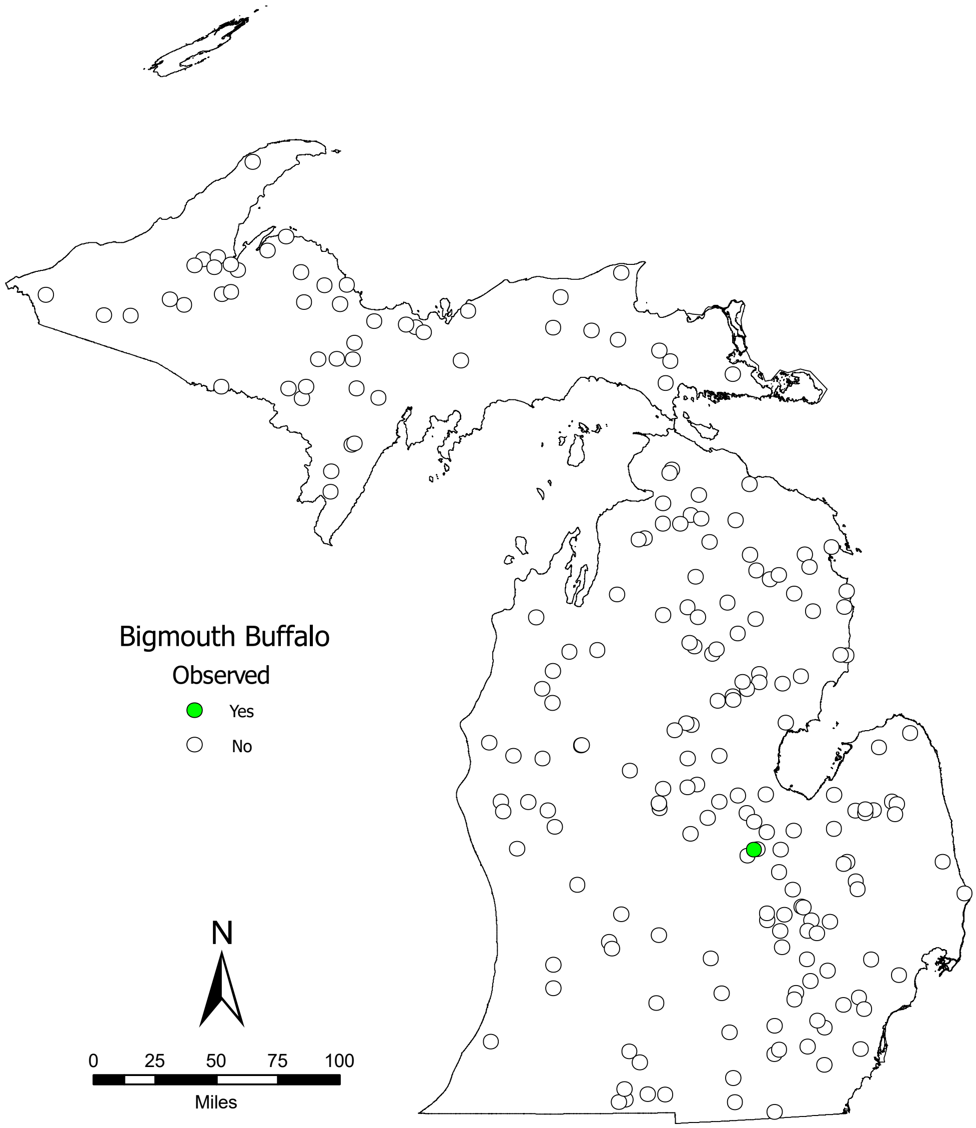

FIGURE A3. Map of distribution of Bigmouth Buffalo *Ictiobus cyprinellus* at randomly sampled sites.

TABLE A3. Percentage of Bigmouth Buffalo *Ictiobus cyprinellus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	100	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	0	1	1

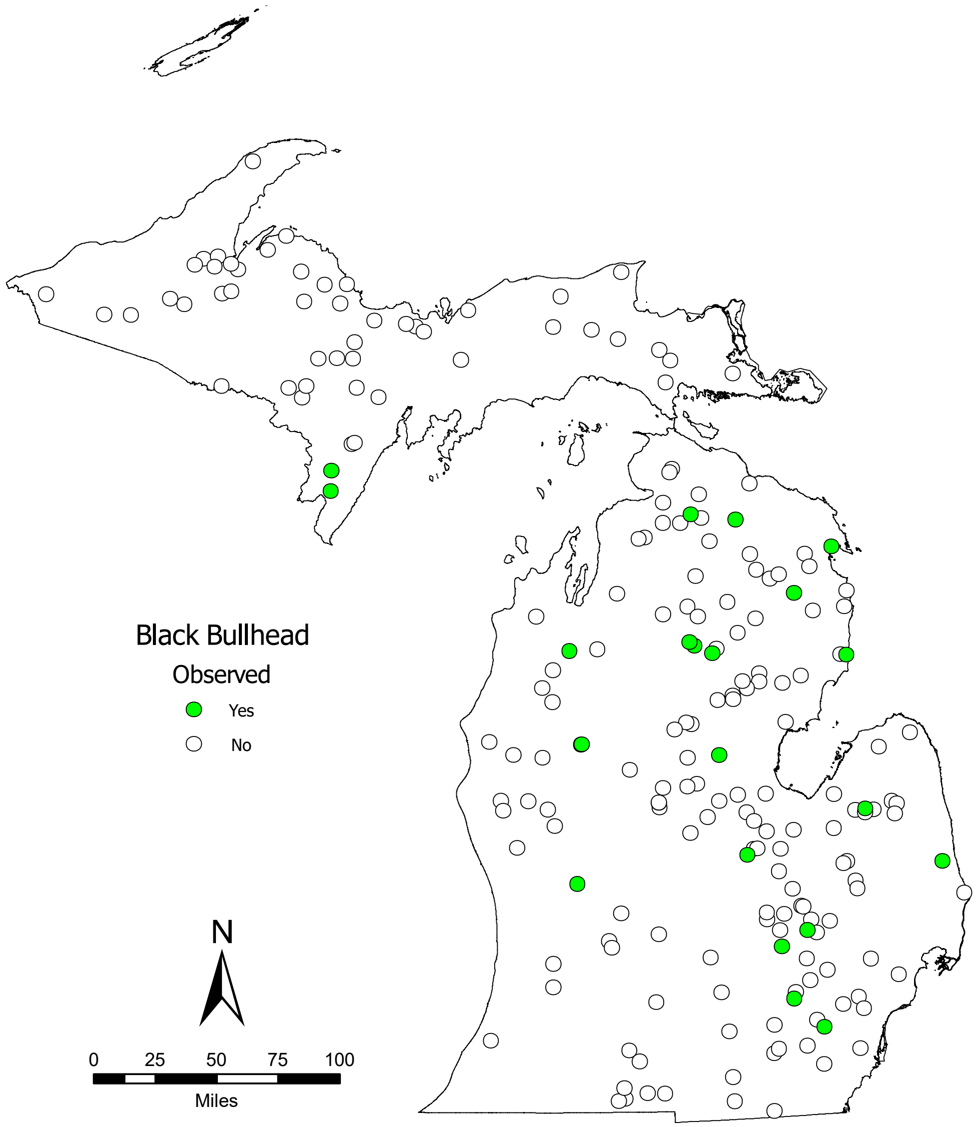

FIGURE A4. Map of distribution of Black Bullhead *Ameiurus melas* at randomly sampled sites.

TABLE A4. Percentage of Black Bullhead *Ameiurus melas* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	5	5	10	4
Medium	29	29	5	13
Large	0	5	5	2
Very Large	0	0	10	2
Total N	7	8	6	21

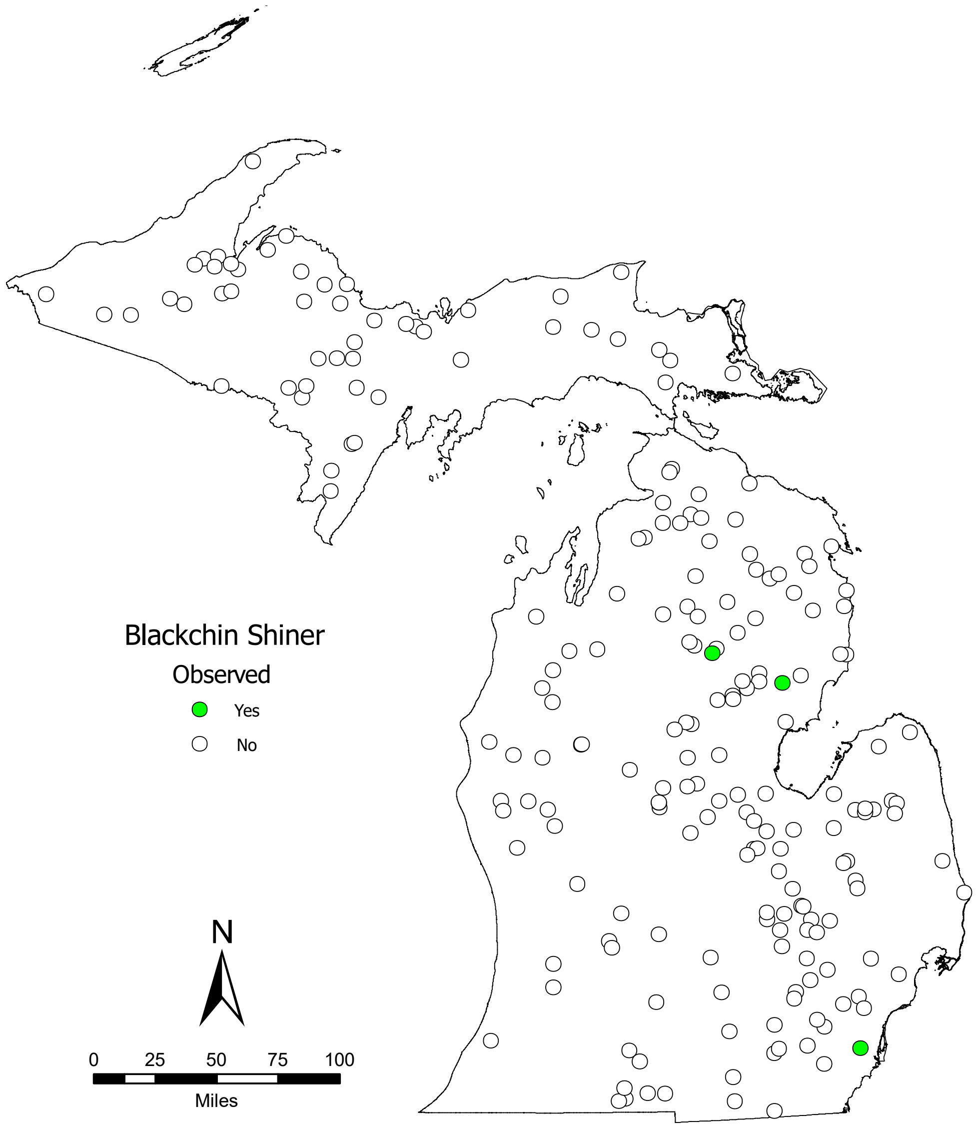

FIGURE A5. Map of distribution of Blackchin Shiner *Notropis heterodon* at randomly sampled sites.

TABLE A5. Percentage of Blackchin Shiner *Notropis heterodon* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	33	33	2
Large	0	0	0	0
Very Large	0	0	33	1
Total N	0	1	2	3

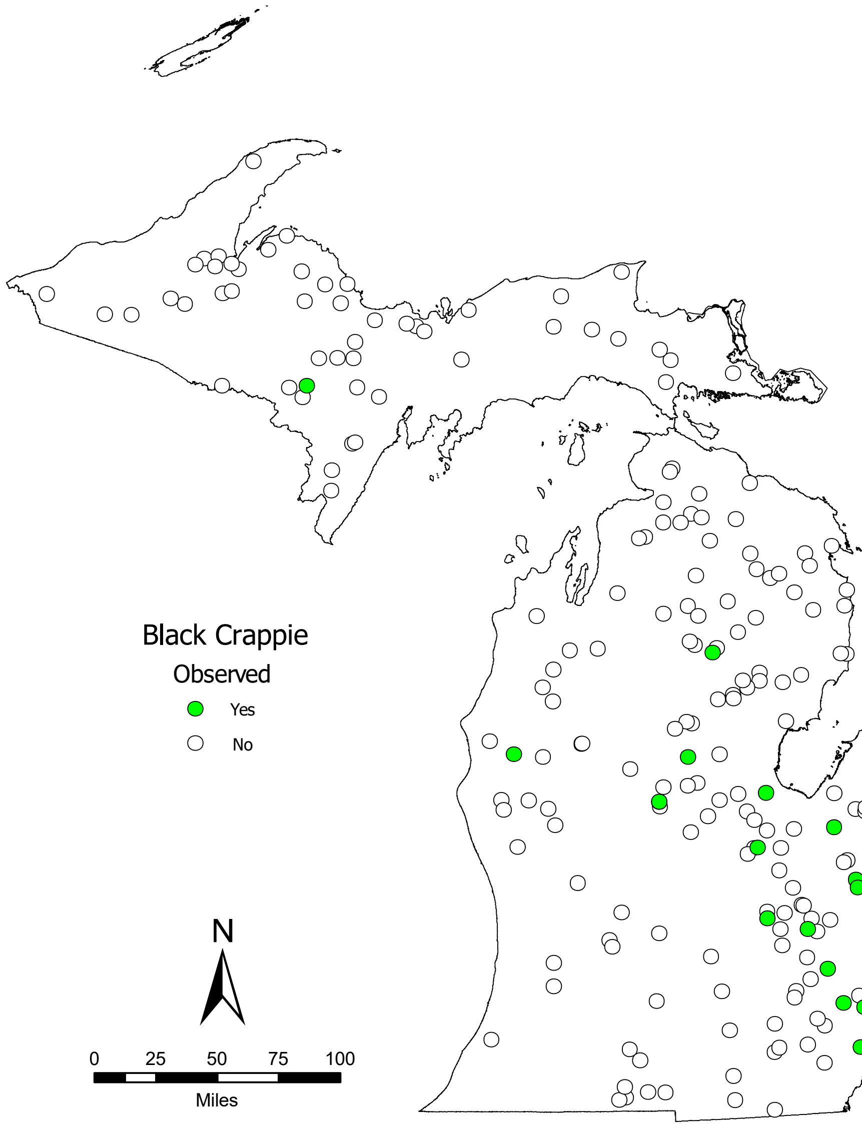

FIGURE A6. Map of distribution of Black Crappie *Pomoxis nigromaculatus* at randomly sampled sites.

TABLE A6. Percentage of Black Crappie *Pomoxis nigromaculatus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	6	0	1
Medium	6	35	12	9
Large	0	12	12	4
Very Large	0	0	18	3
Total N	1	9	7	17

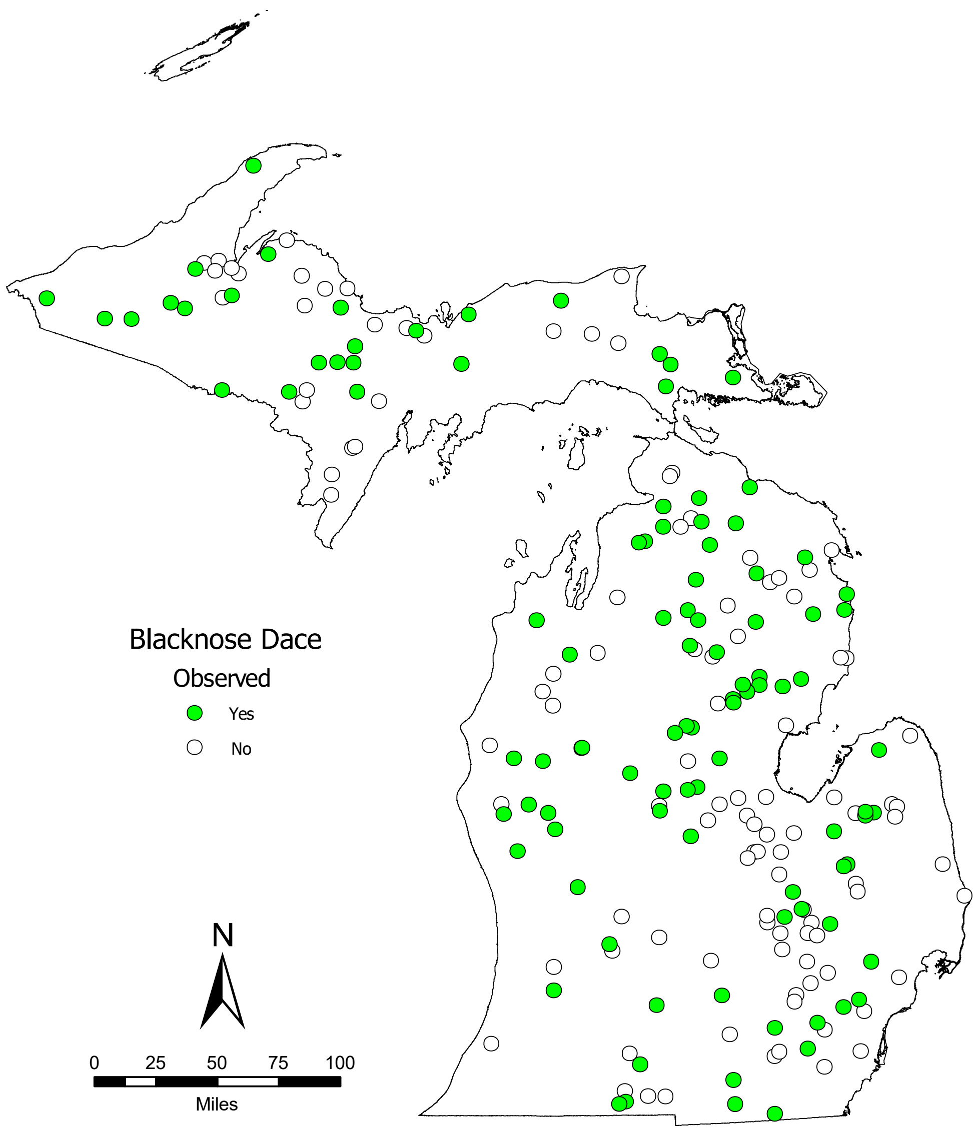

FIGURE A7. Map of distribution of Blacknose Dace *Rhinichthys atratulus* at randomly sampled sites.

TABLE A7. Percentage of Blacknose Dace *Rhinichthys atratulus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	27	18	9	56
Medium	20	13	4	39
Large	2	4	0	6
Very Large	1	0	2	3
Total N	52	37	15	104

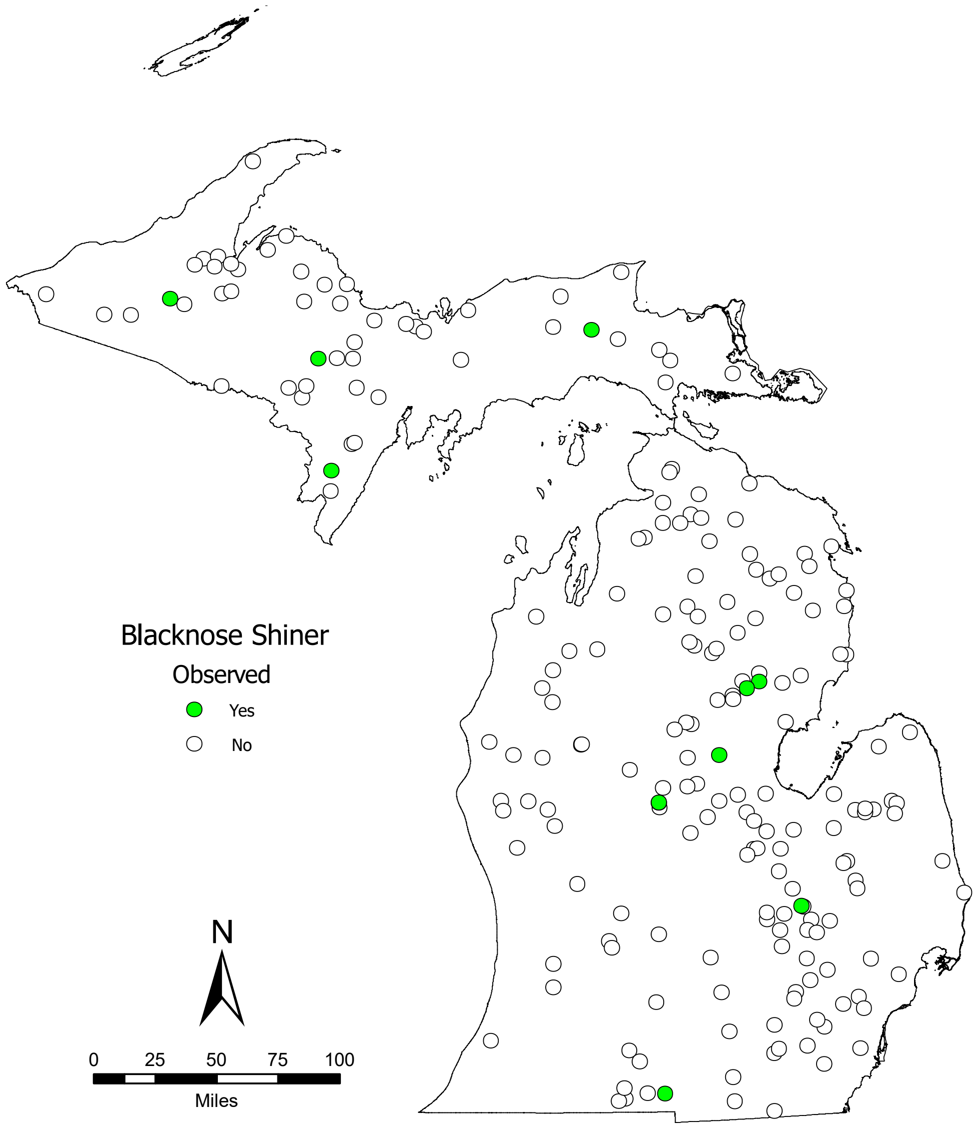

FIGURE A8. Map of distribution of Blacknose Shiner *Notropis heterolepis* at randomly sampled sites.

TABLE A8. Percentage of Blacknose Shiner *Notropis heterolepis* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	10	30	4
Medium	0	40	0	4
Large	0	10	0	1
Very Large	0	10	0	1
Total N	0	7	3	10

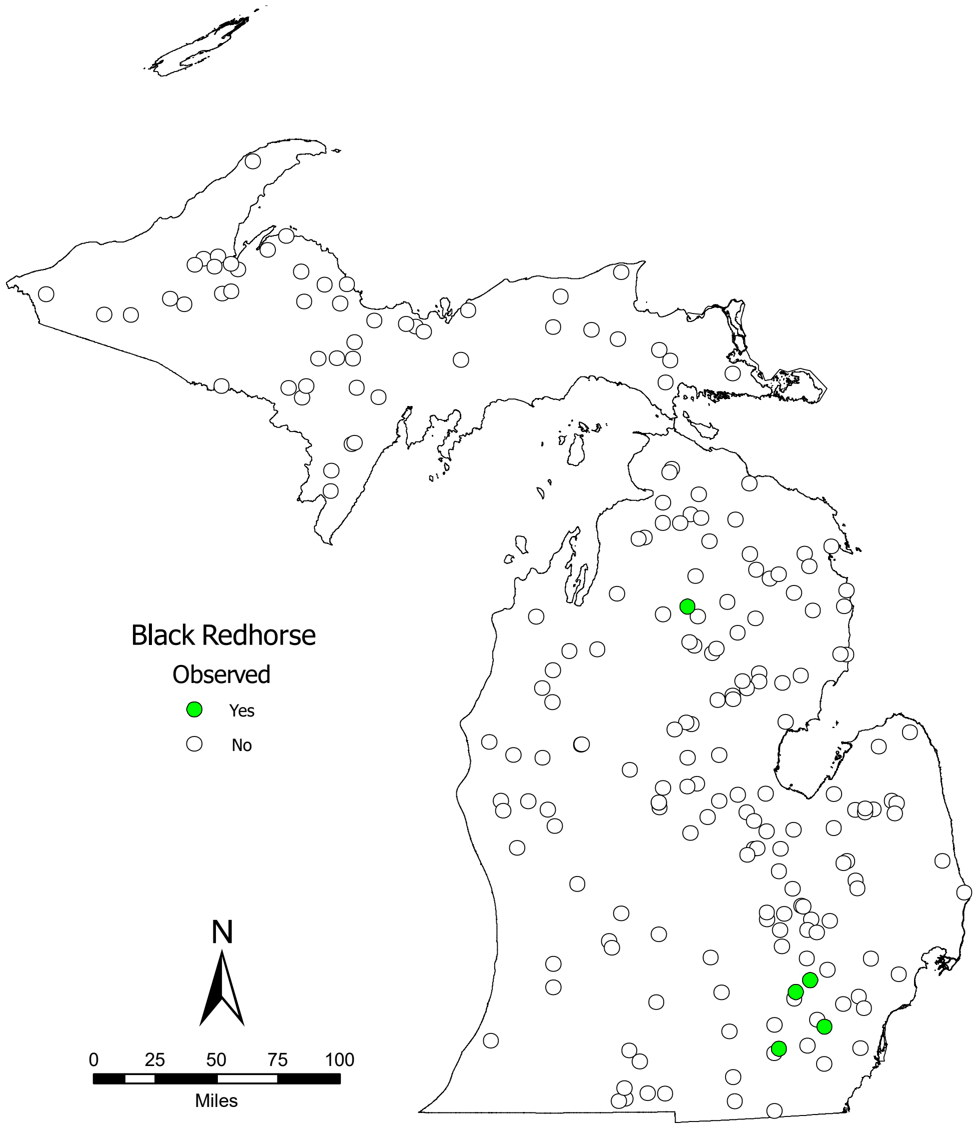

FIGURE A9. Map of distribution of Black Redhorse *Moxostoma duquesnei* at randomly sampled sites. Black Redhorse is a Michigan species of special concern.

TABLE A9. Percentage of Black Redhorse *Moxostoma duquesnei* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	20	0	20	2
Large	0	20	20	2
Very Large	0	0	20	1
Total N	1	1	3	5

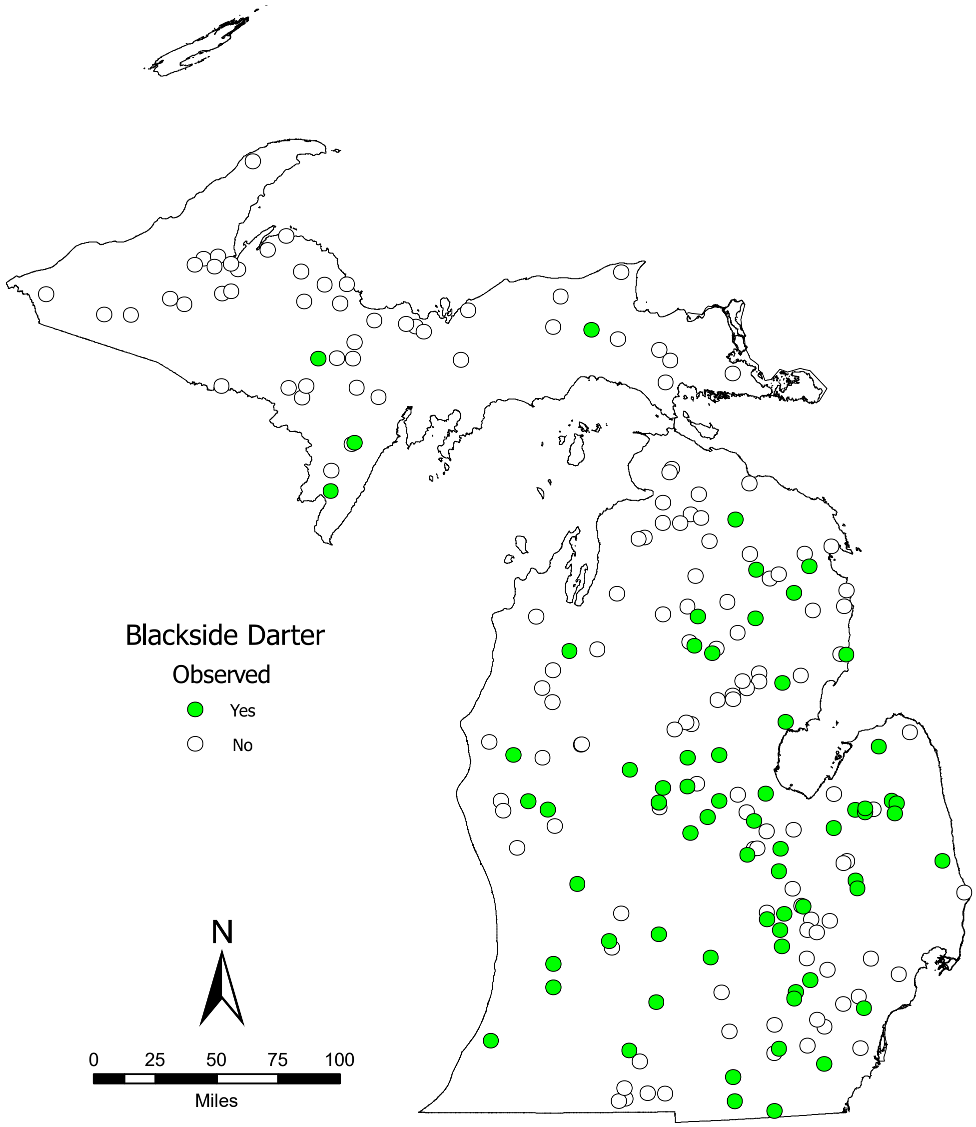

FIGURE A10. Map of distribution of Blackside Darter *Percina maculata* at randomly sampled sites.

TABLE A10. Percentage of Blackside Darter *Percina maculata* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	4	10	10	17
Medium	9	22	18	33
Large	0	12	7	13
Very Large	1	1	4	5
Total N	10	31	27	68

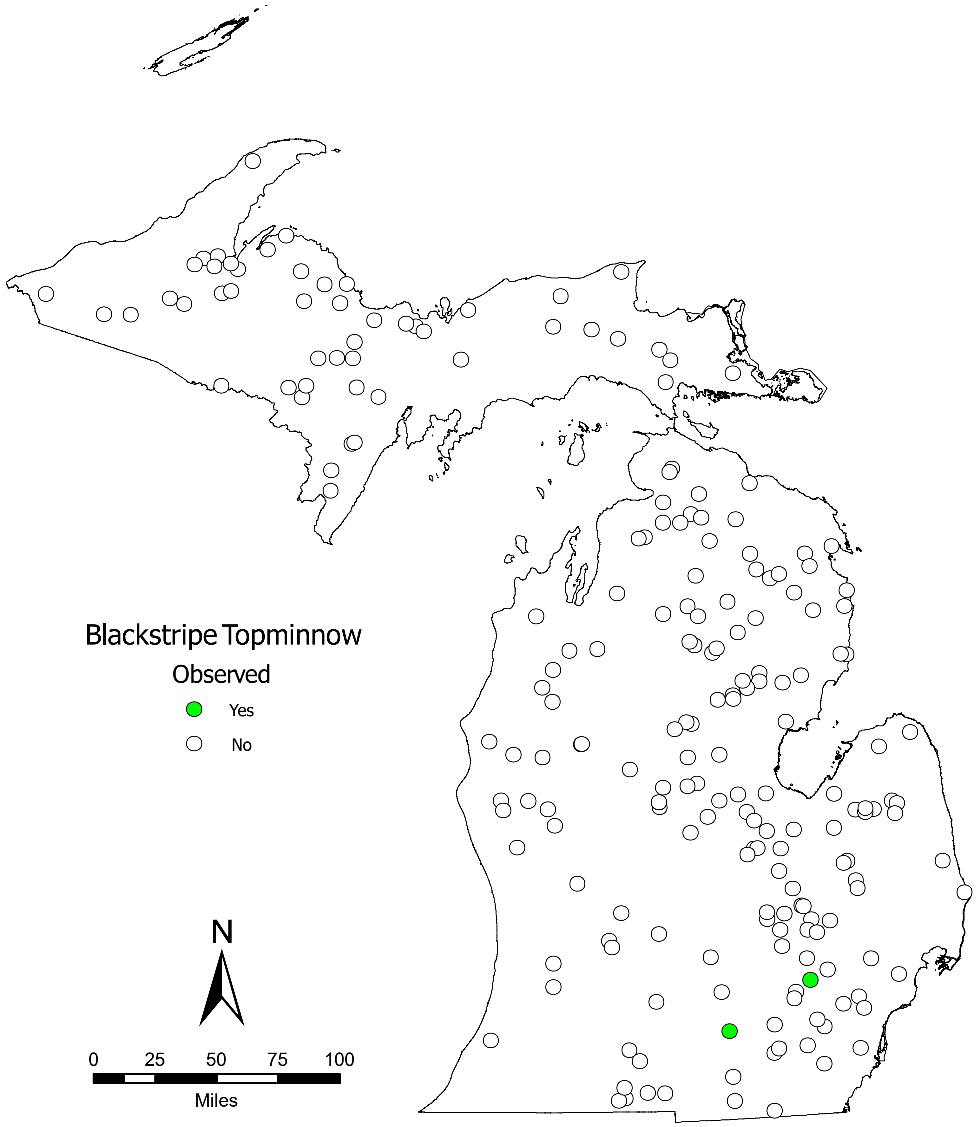

FIGURE A11. Map of distribution of Blackstripe Topminnow *Fundulus notatus* at randomly sampled sites.

TABLE A11. Percentage of Blackstripe Topminnow *Fundulus notatus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	100	0	2
Very Large	0	0	0	0
Total N	0	2	0	2

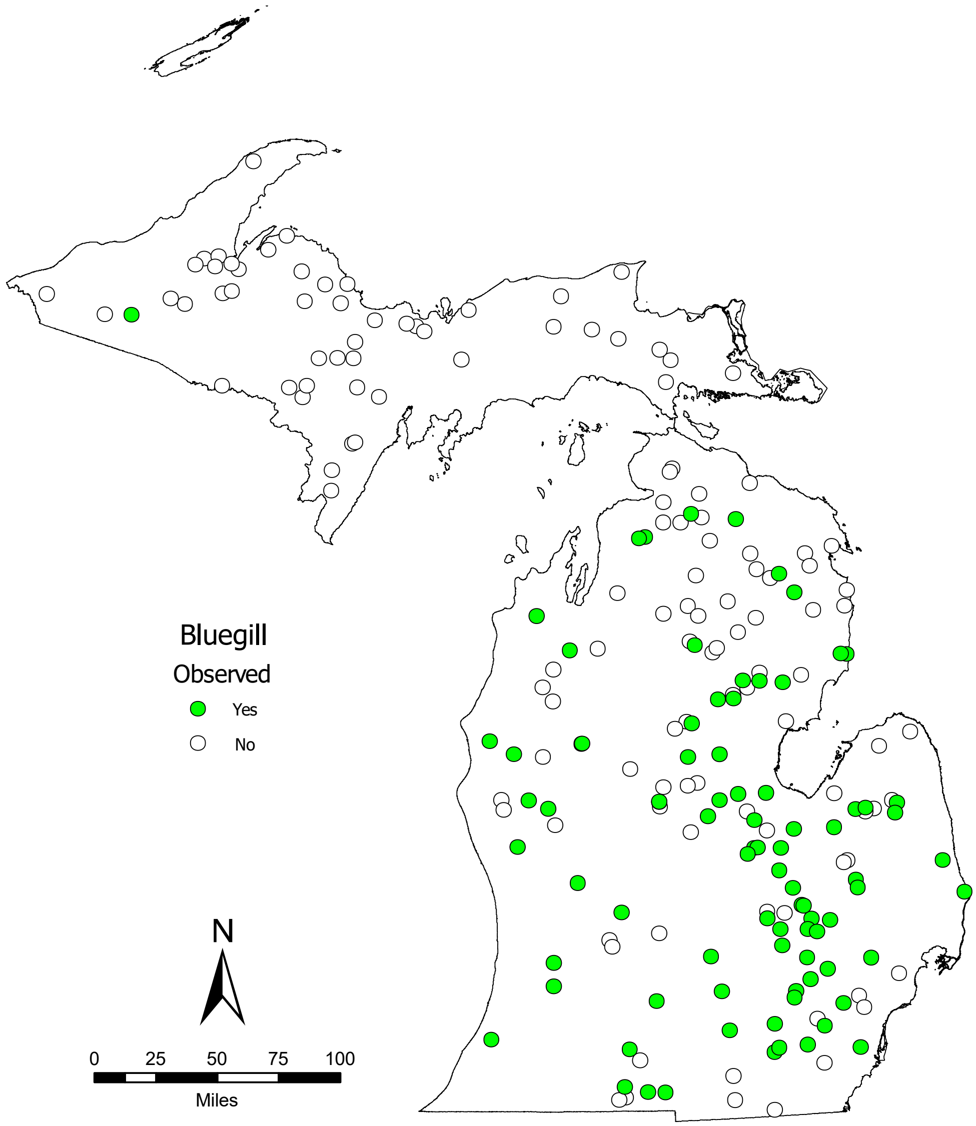

FIGURE A12. Map of distribution of Bluegill *Lepomis macrochirus* at randomly sampled sites.

TABLE A12. Percentage of Bluegill *Lepomis macrochirus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	12	9	9	26
Medium	13	18	12	36
Large	0	8	7	13
Very Large	0	2	9	10
Total N	21	32	32	85

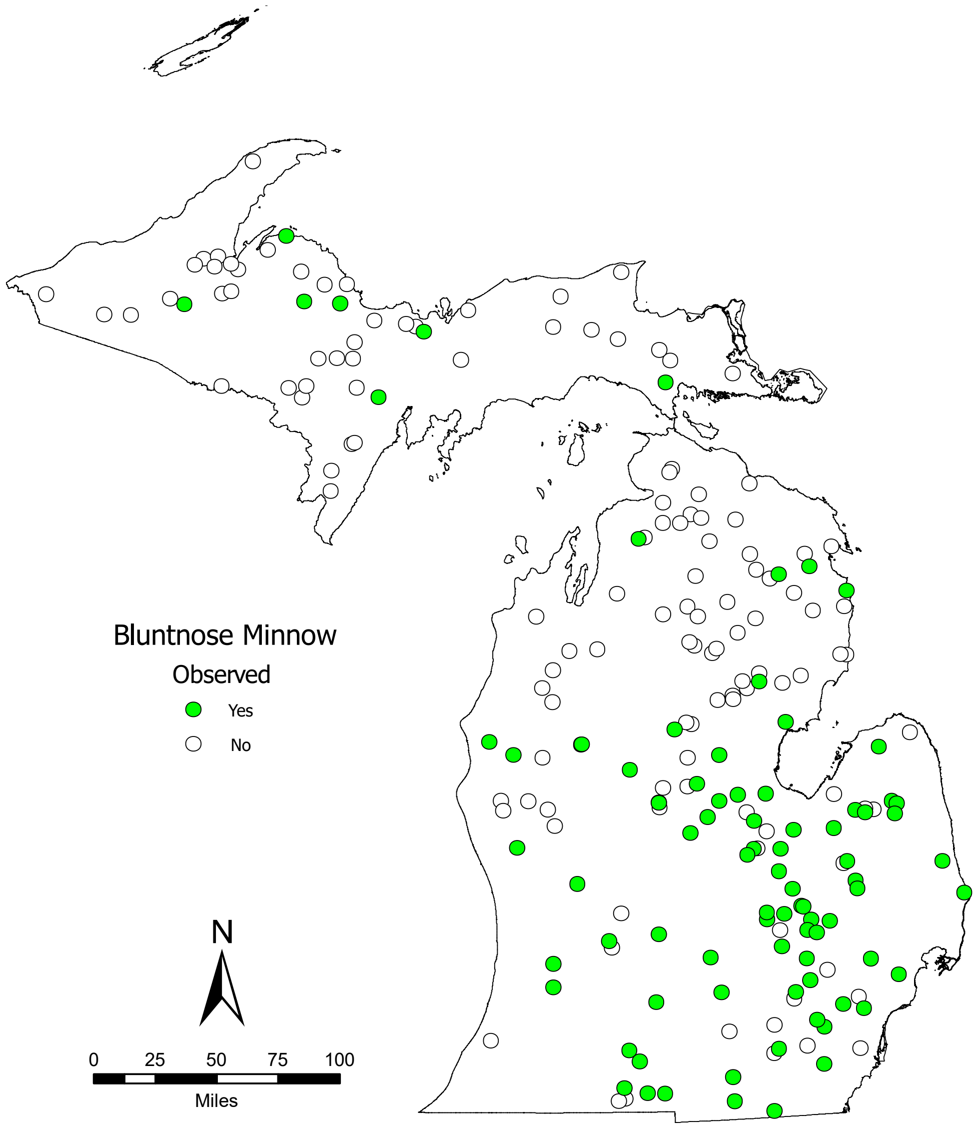

FIGURE A13. Map of distribution of Bluntnose Minnow *Pimephales notatus* at randomly sampled sites.

TABLE A13. Percentage of Bluntnose Minnow *Pimephales notatus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	10	13	15	32
Medium	5	19	15	33
Large	0	7	6	11
Very Large	0	1	8	8
Total N	12	34	38	84

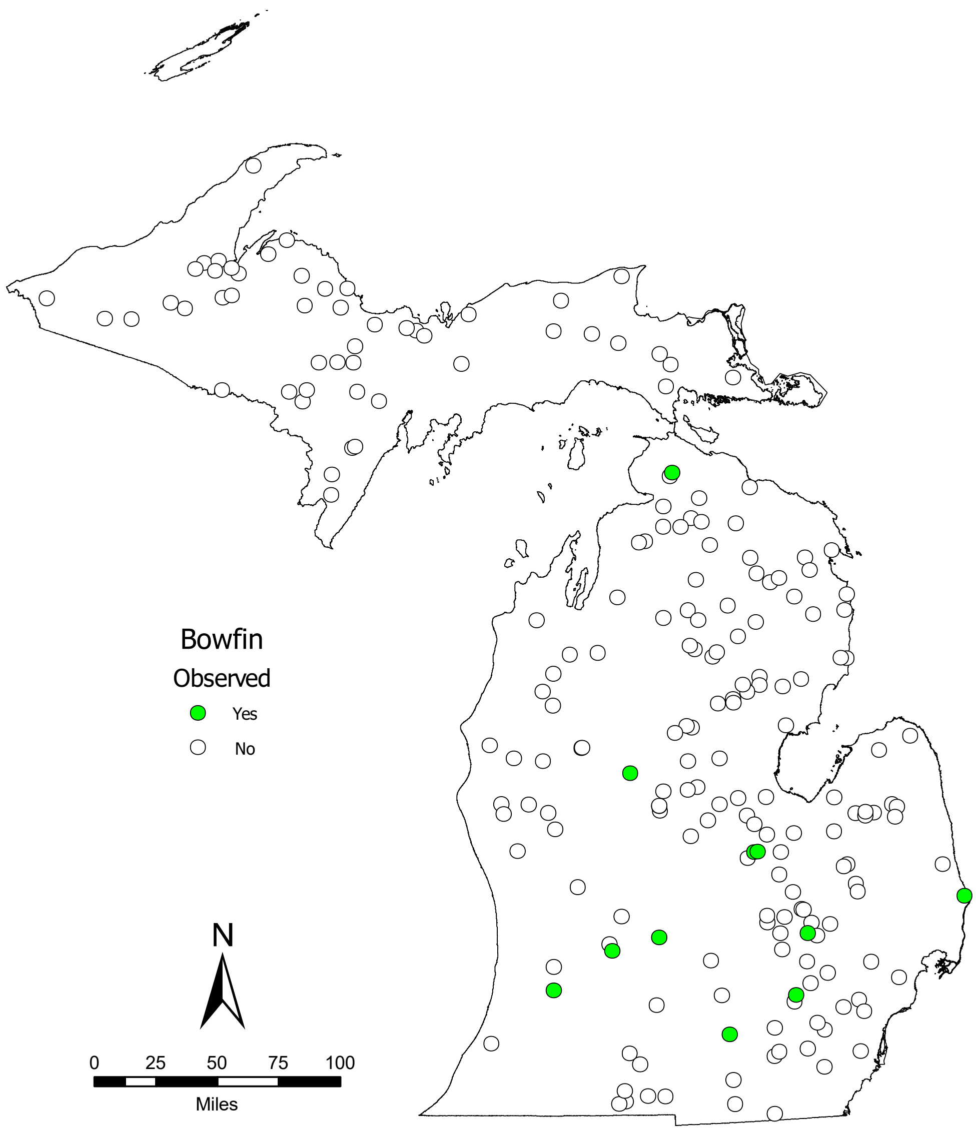

FIGURE A14. Map of distribution of Bowfin *Amia calva* at randomly sampled sites.

TABLE A14. Percentage of Bowfin *Amia calva* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	9	9	0	2
Medium	0	27	9	4
Large	0	9	18	3
Very Large	0	0	18	2
Total N	1	5	5	11

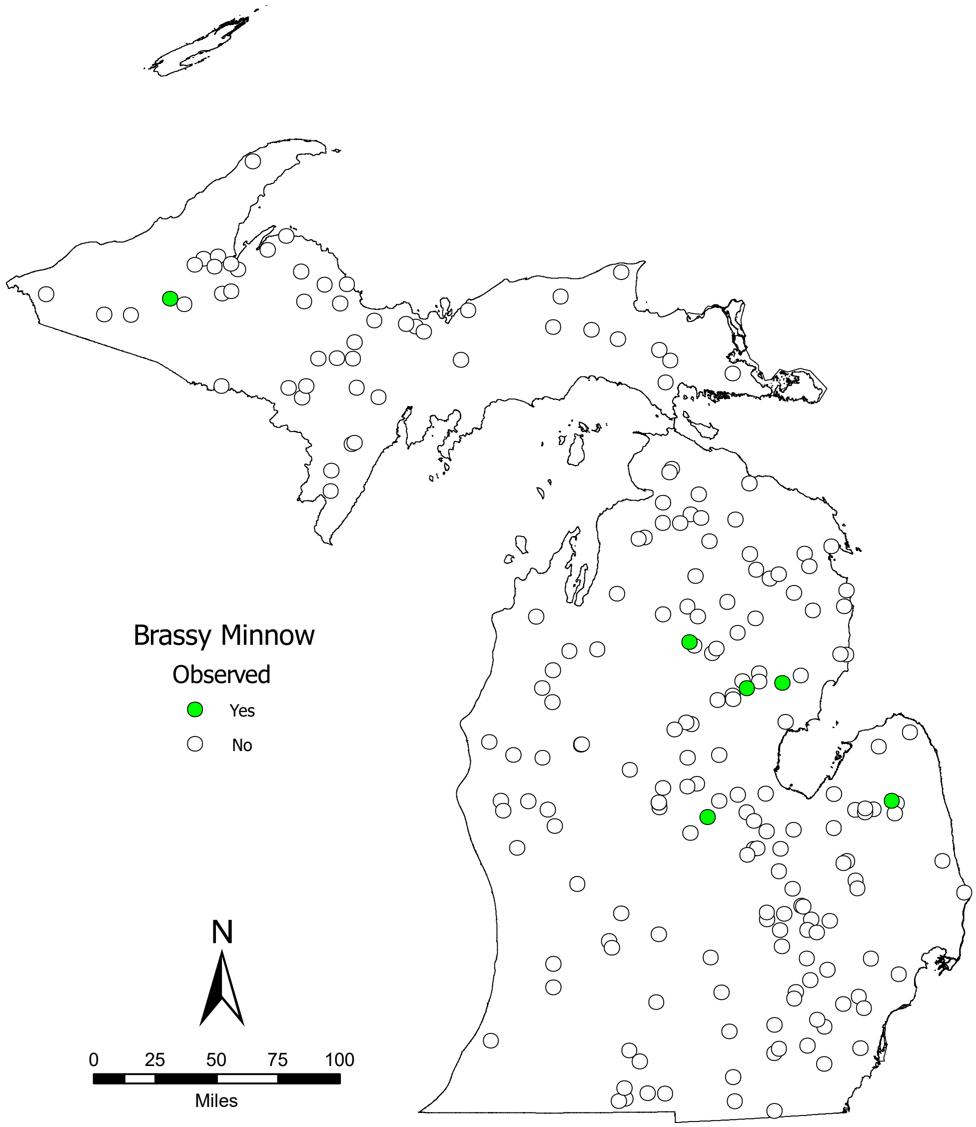

FIGURE A15. Map of distribution of Brassy Minnow *Hybognathus hankinsoni* at randomly sampled sites.

TABLE A15. Percentage of Brassy Minnow *Hybognathus hankinsoni* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	17	1
Medium	17	33	17	4
Large	0	0	17	1
Very Large	0	0	0	0
Total N	1	2	3	6

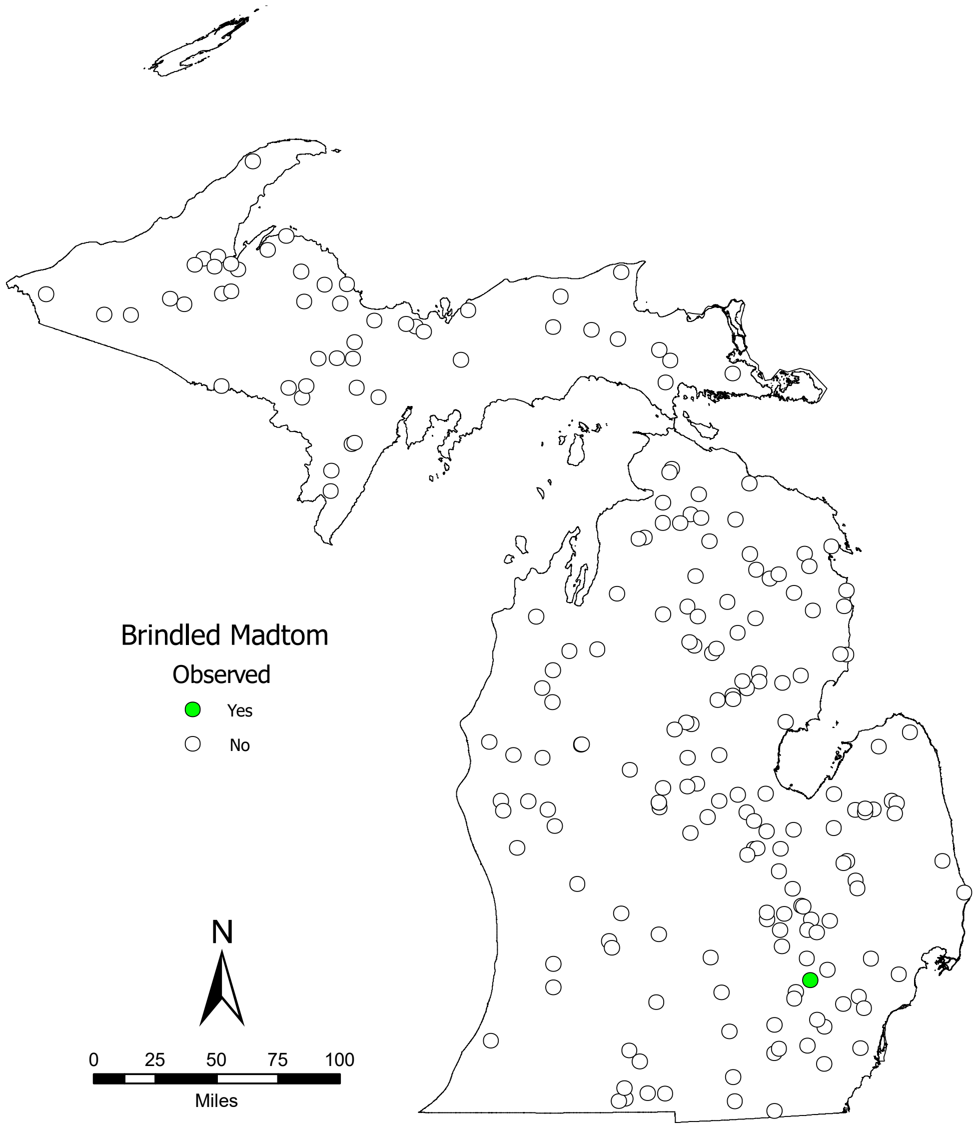

FIGURE A16. Map of distribution of Brindled Madtom *Noturus miurus* at randomly sampled sites. Brindled Madtom is a Michigan species of special concern.

TABLE A16. Percentage of Brindled Madtom *Noturus miurus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	100	0	1
Very Large	0	0	0	0
Total N	0	1	0	1

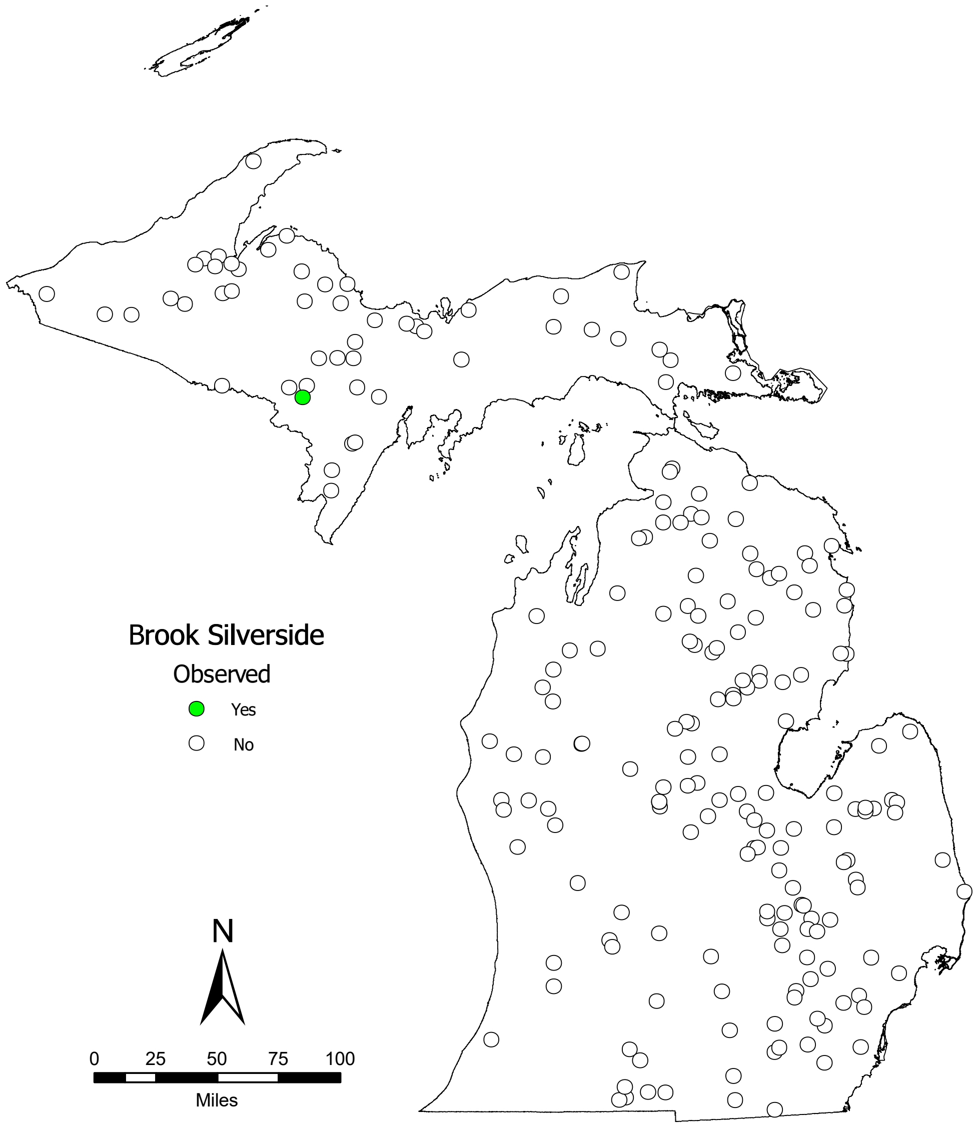

FIGURE A17. Map of distribution of Brook Silverside *Labidesthes sicculus* at randomly sampled sites.

TABLE A17. Percentage of Brook Silverside *Labidesthes sicculus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	100	0	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	1	0	1

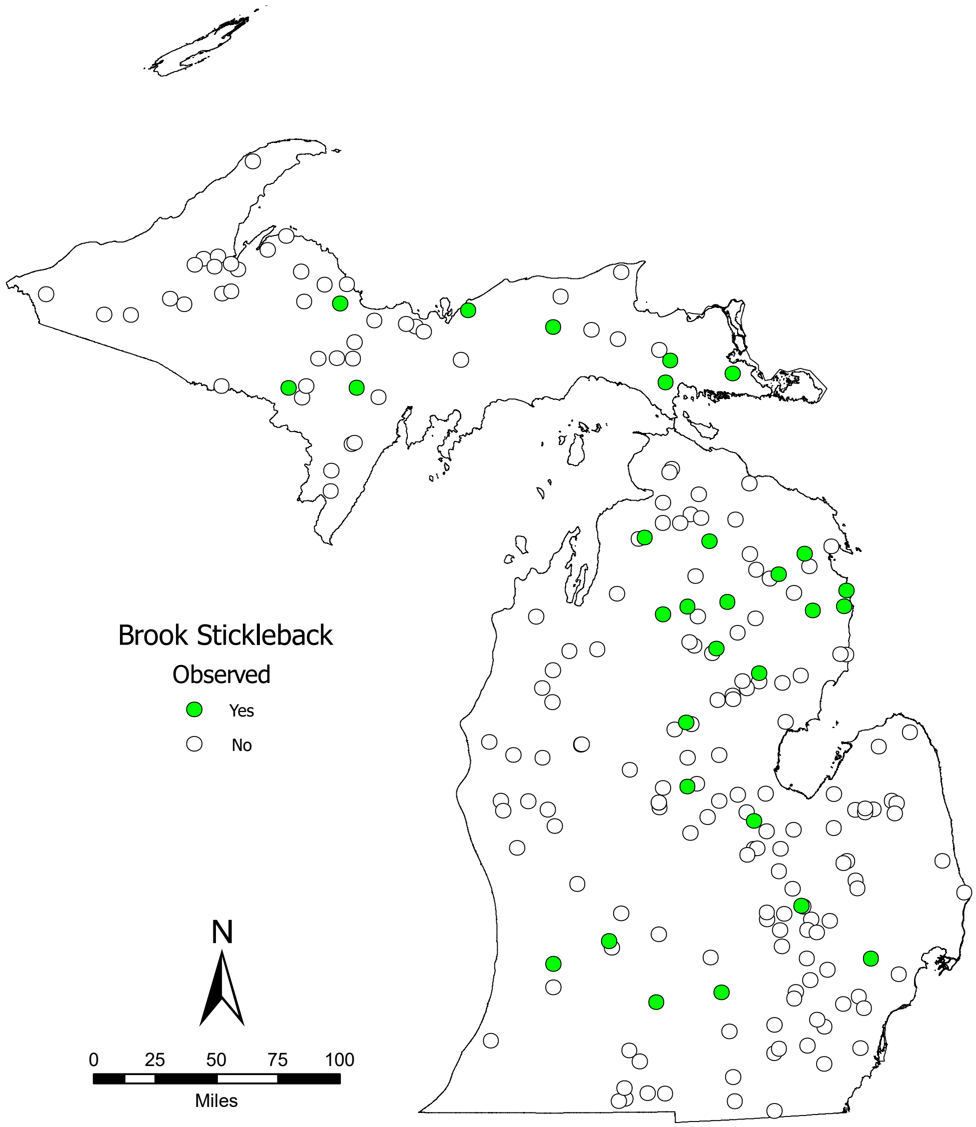

FIGURE A18. Map of distribution of Brook Stickleback *Culaea inconstans* at randomly sampled sites.

TABLE A18. Percentage of Brook Stickleback *Culaea inconstans* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	28	17	10	16
Medium	17	10	10	11
Large	3	3	0	2
Very Large	0	0	0	0
Total N	14	9	6	29

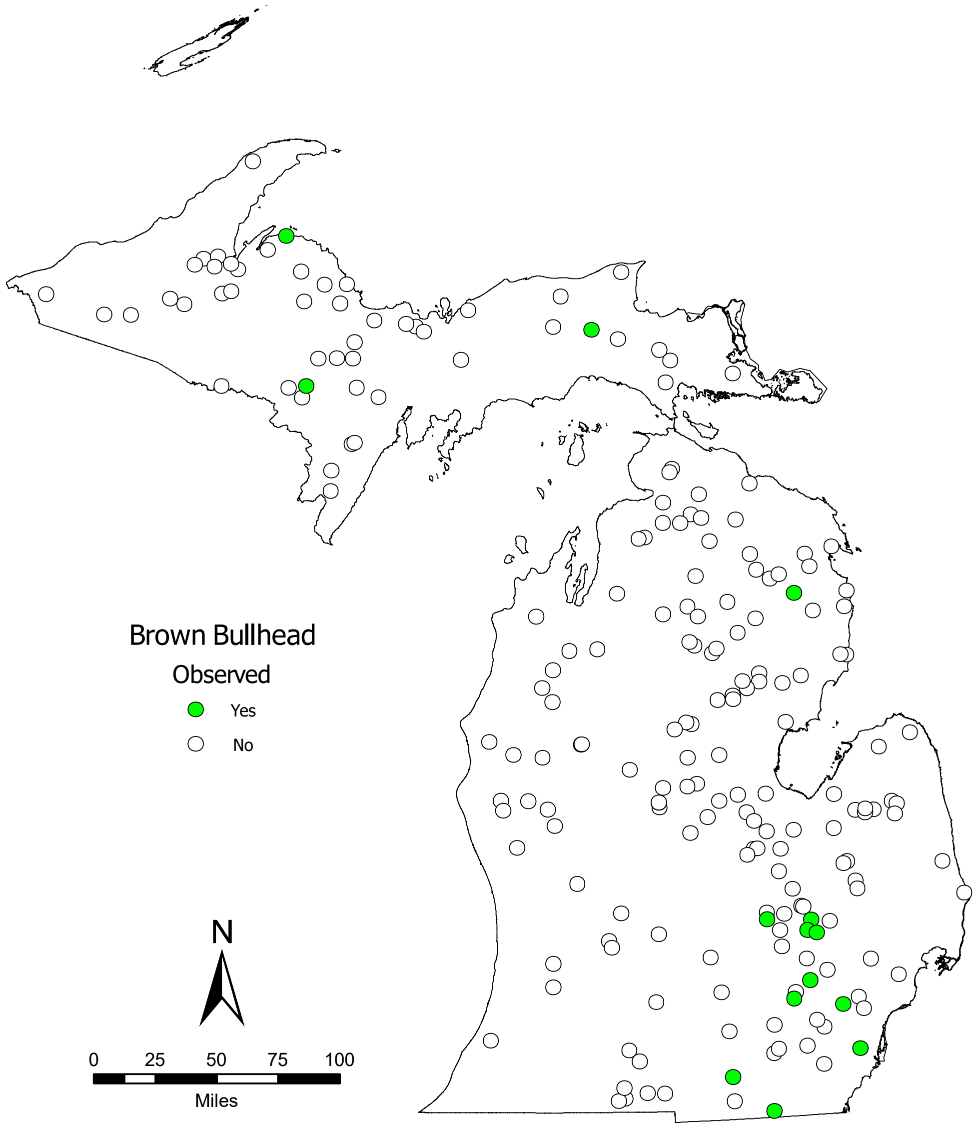

FIGURE A19. Map of distribution of Brown Bullhead *Ameiurus nebulosus* at randomly sampled sites.

TABLE A19. Percentage of Brown Bullhead *Ameiurus nebulosus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	14	14	4
Medium	14	29	0	6
Large	0	7	7	2
Very Large	0	7	7	2
Total N	2	8	4	14

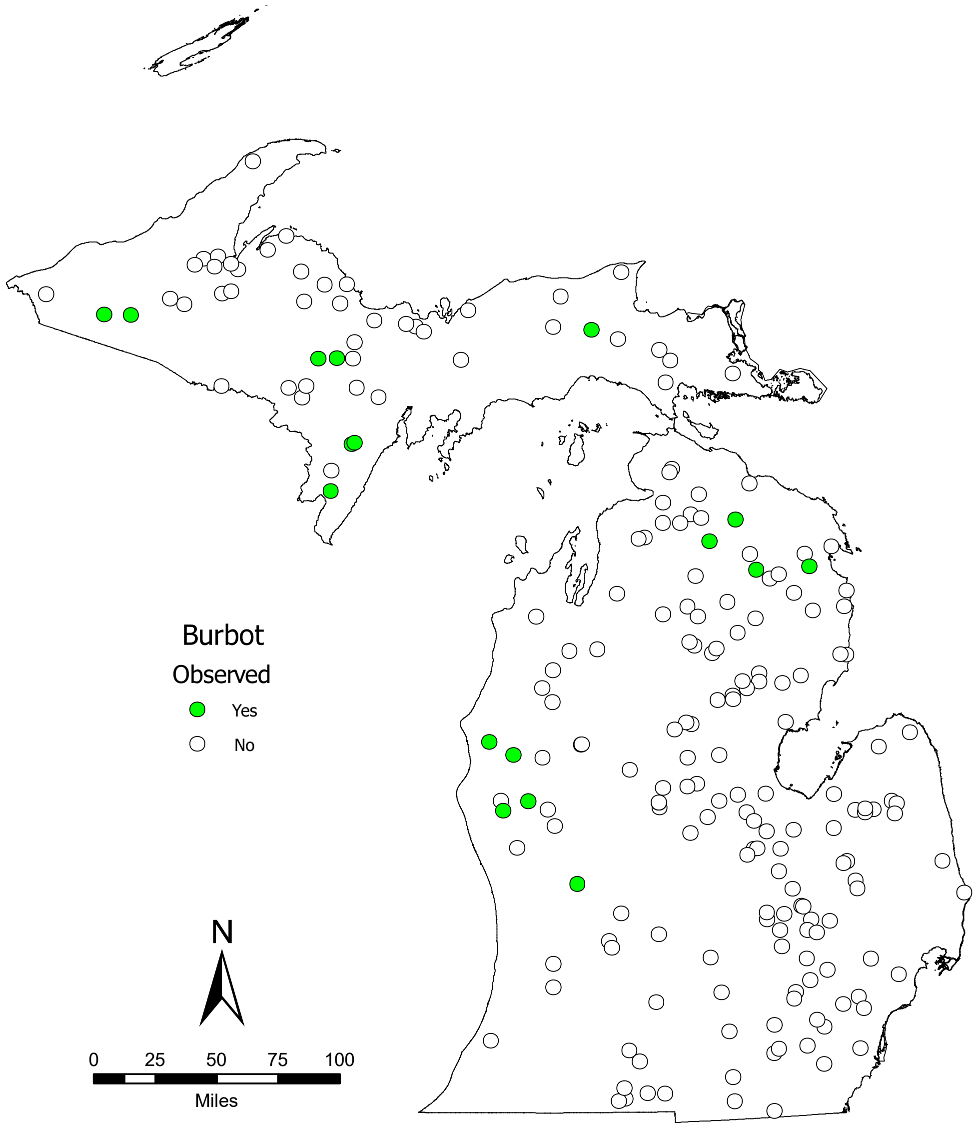

FIGURE A20. Map of distribution of Burbot *Lota lota* at randomly sampled sites.

TABLE A20. Percentage of Burbot *Lota lota* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	18	0	0	3
Medium	29	12	12	9
Large	0	18	0	3
Very Large	0	12	0	2
Total N	8	7	2	17

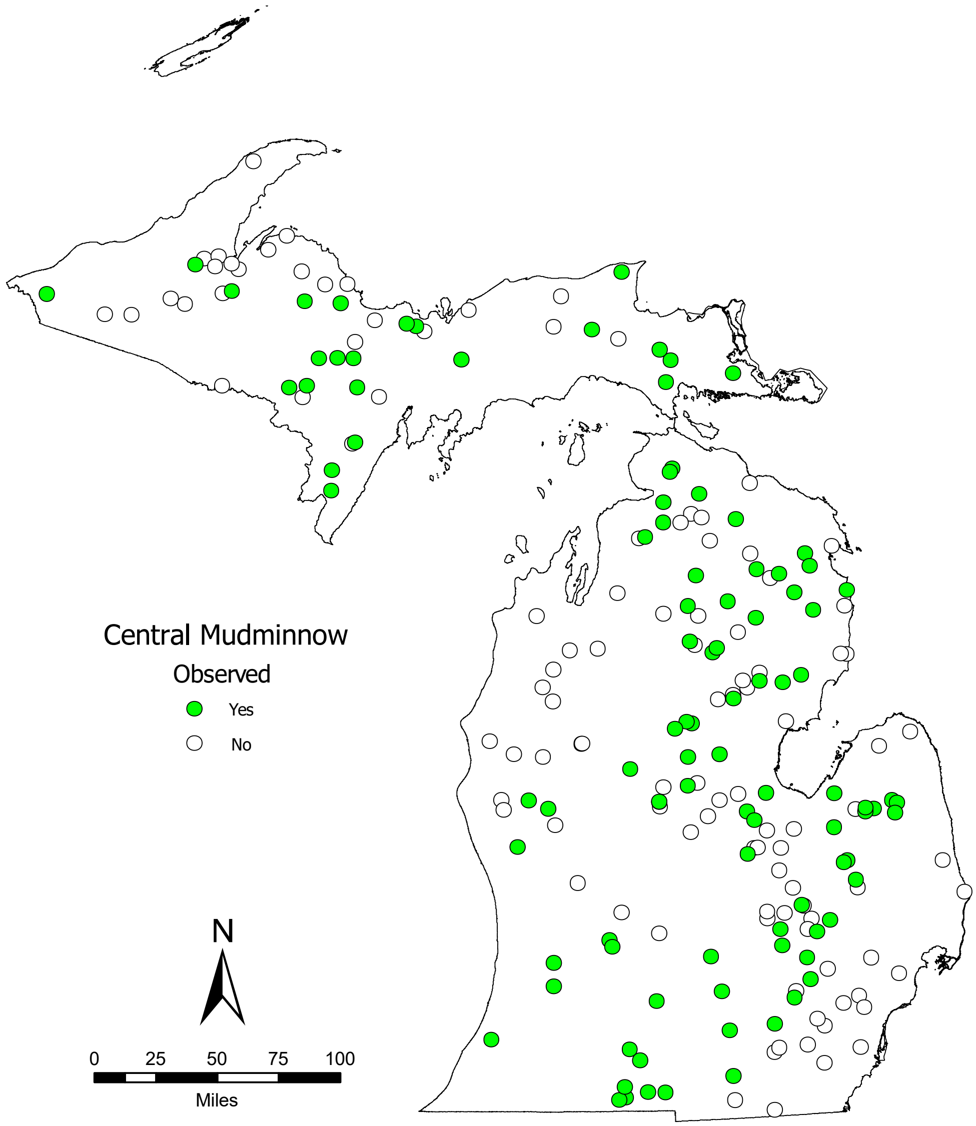

FIGURE A21. Map of distribution of Central Mudminnow *Umbra limi* at randomly sampled sites.

TABLE A21. Percentage of Central Mudminnow *Umbra limi* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	20	17	11	48
Medium	15	20	10	45
Large	0	6	0	6
Very Large	0	1	1	2
Total N	35	44	22	101

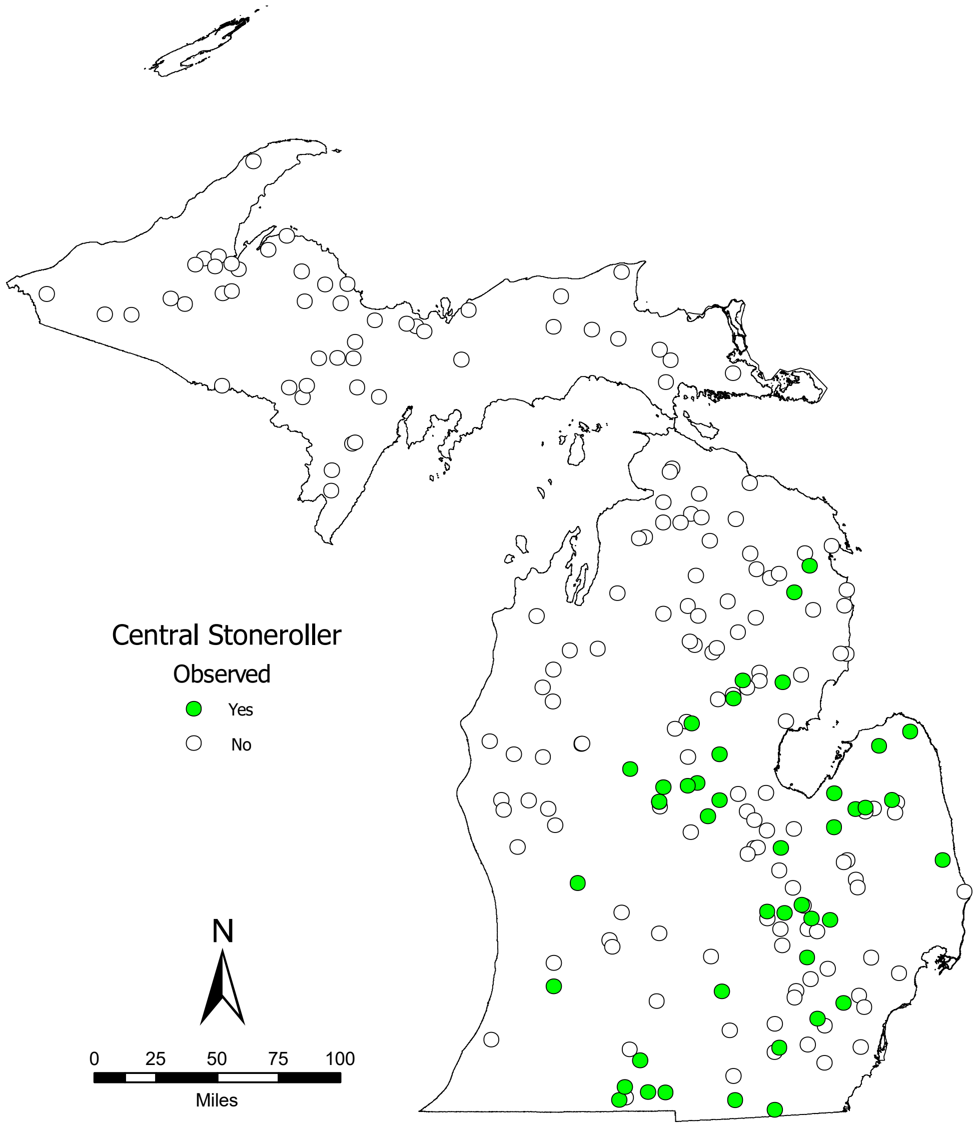

FIGURE A22. Map of distribution of Central Stoneroller *Campostoma anomalum* at randomly sampled sites.

TABLE A22. Percentage of Central Stoneroller *Campostoma anomalum* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	5	14	23	18
Medium	12	14	14	17
Large	0	7	7	6
Very Large	0	0	5	2
Total N	7	15	21	43

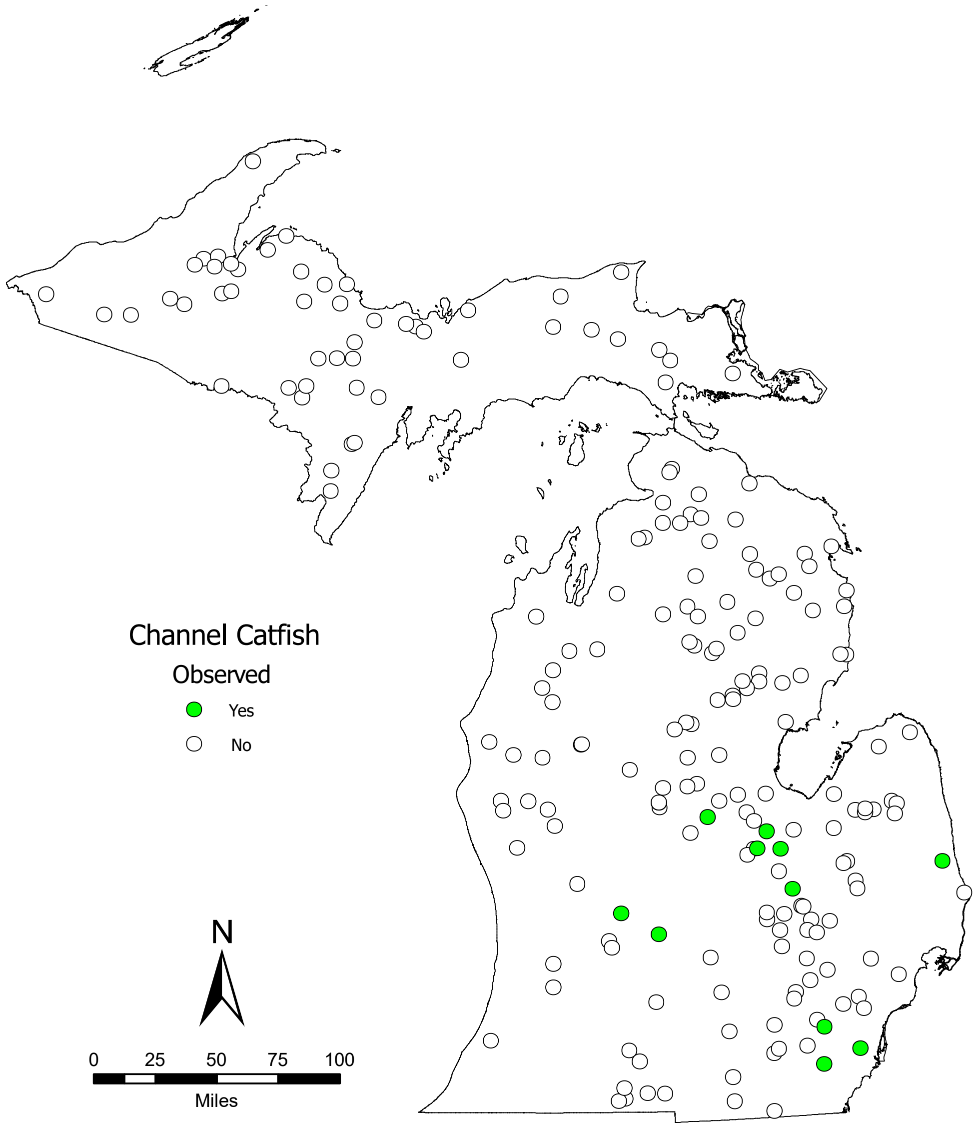

FIGURE A23. Map of distribution of Channel Catfish *Ictalurus punctatus* at randomly sampled sites.

TABLE A23. Percentage of Channel Catfish *Ictalurus punctatus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	9	1
Large	0	0	27	3
Very Large	0	0	64	7
Total N	0	0	11	11

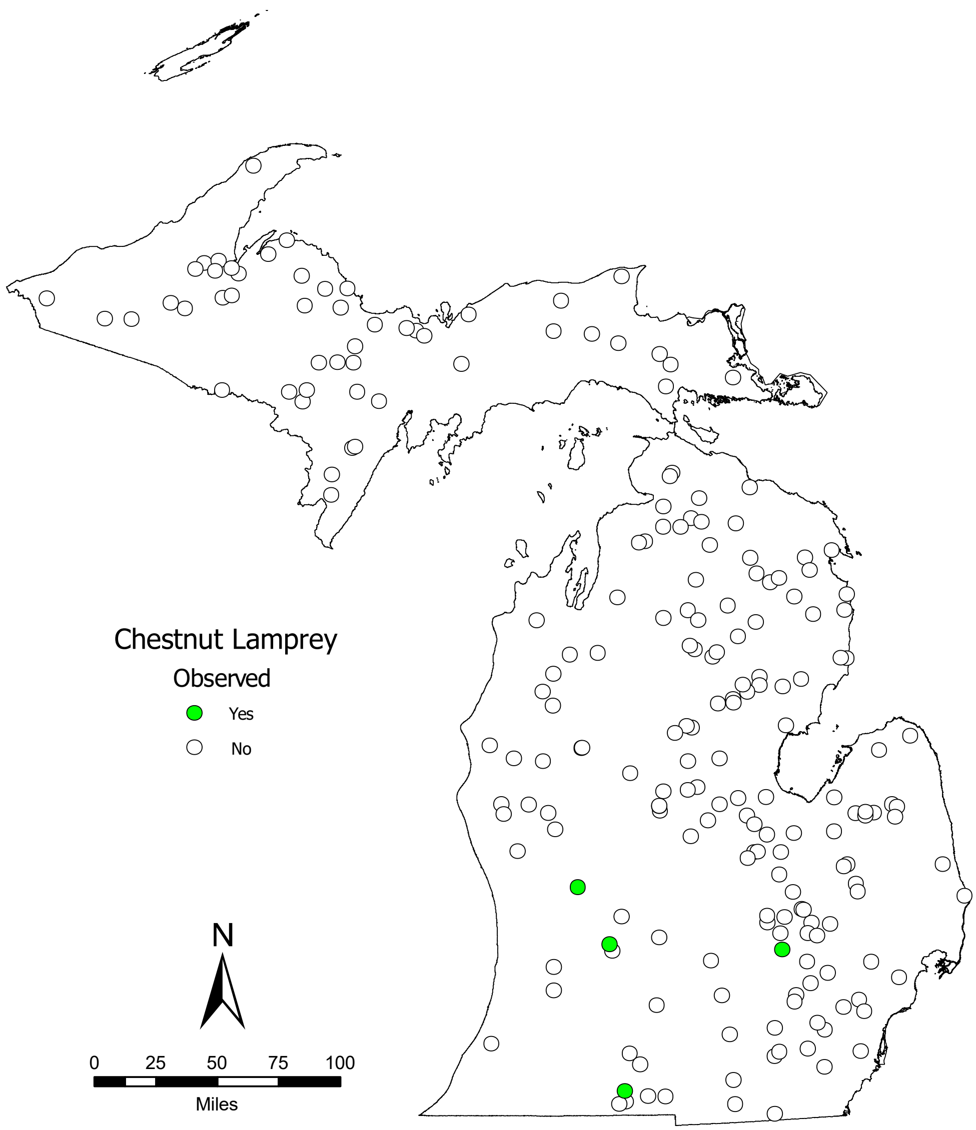

FIGURE A24. Map of distribution of Chestnut Lamprey *Ichthyomyzon castaneus* at randomly sampled sites.

TABLE A24. Percentage of Chestnut Lamprey *Ichthyomyzon castaneus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	25	1
Medium	25	25	25	3
Large	0	0	0	0
Very Large	0	0	0	0
Total N	1	1	2	4

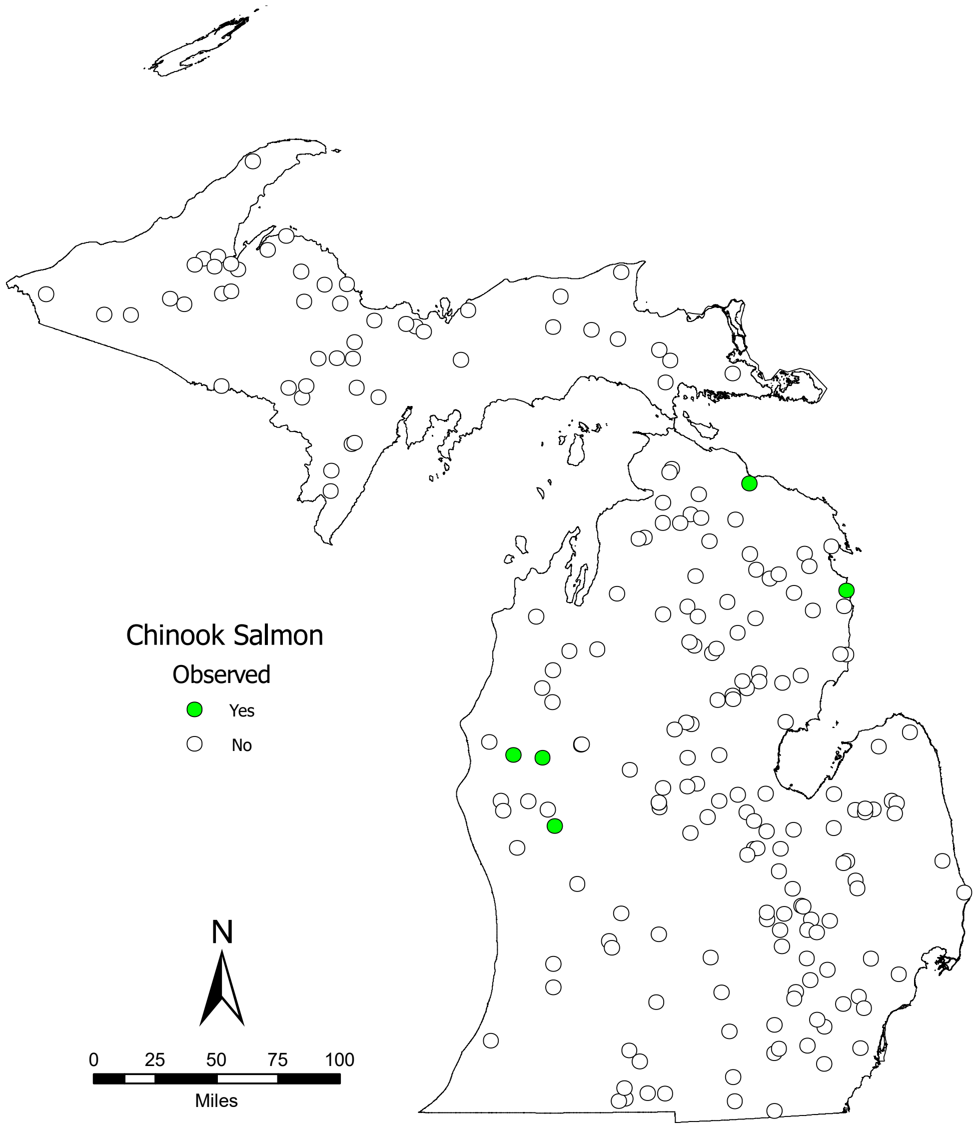

FIGURE A25. Map of distribution of Chinook Salmon *Oncorhynchus tshawytscha* at randomly sampled sites.

TABLE A25. Percentage of Chinook Salmon *Oncorhynchus tshawytscha* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	20	0	0	1
Medium	40	20	0	3
Large	0	20	0	1
Very Large	0	0	0	0
Total N	3	2	0	5

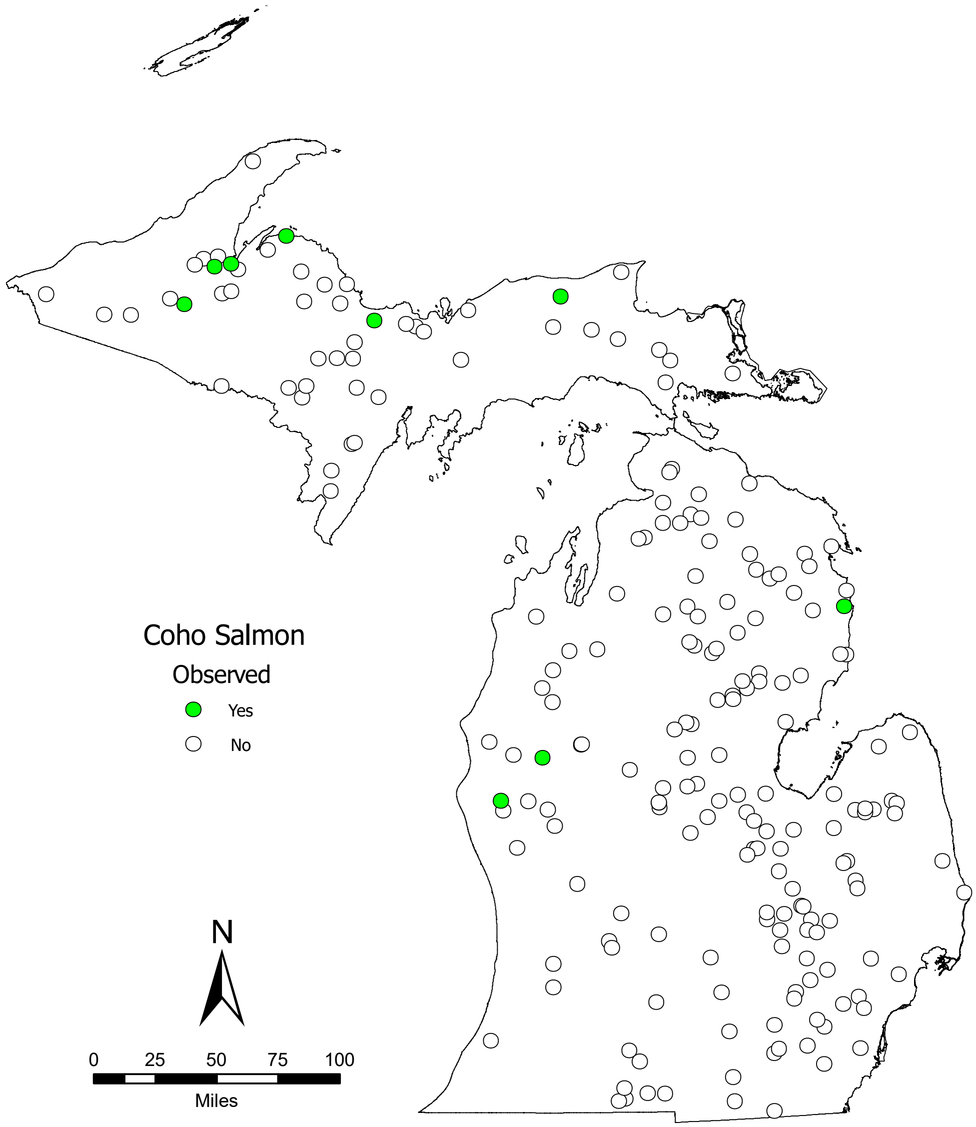

FIGURE A26. Map of distribution of Coho Salmon *Oncorhynchus kisutch* at randomly sampled sites.

TABLE A26. Percentage of Coho Salmon *Oncorhynchus kisutch* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	56	0	0	5
Medium	22	22	0	4
Large	0	0	0	0
Very Large	0	0	0	0
Total N	7	2	0	9

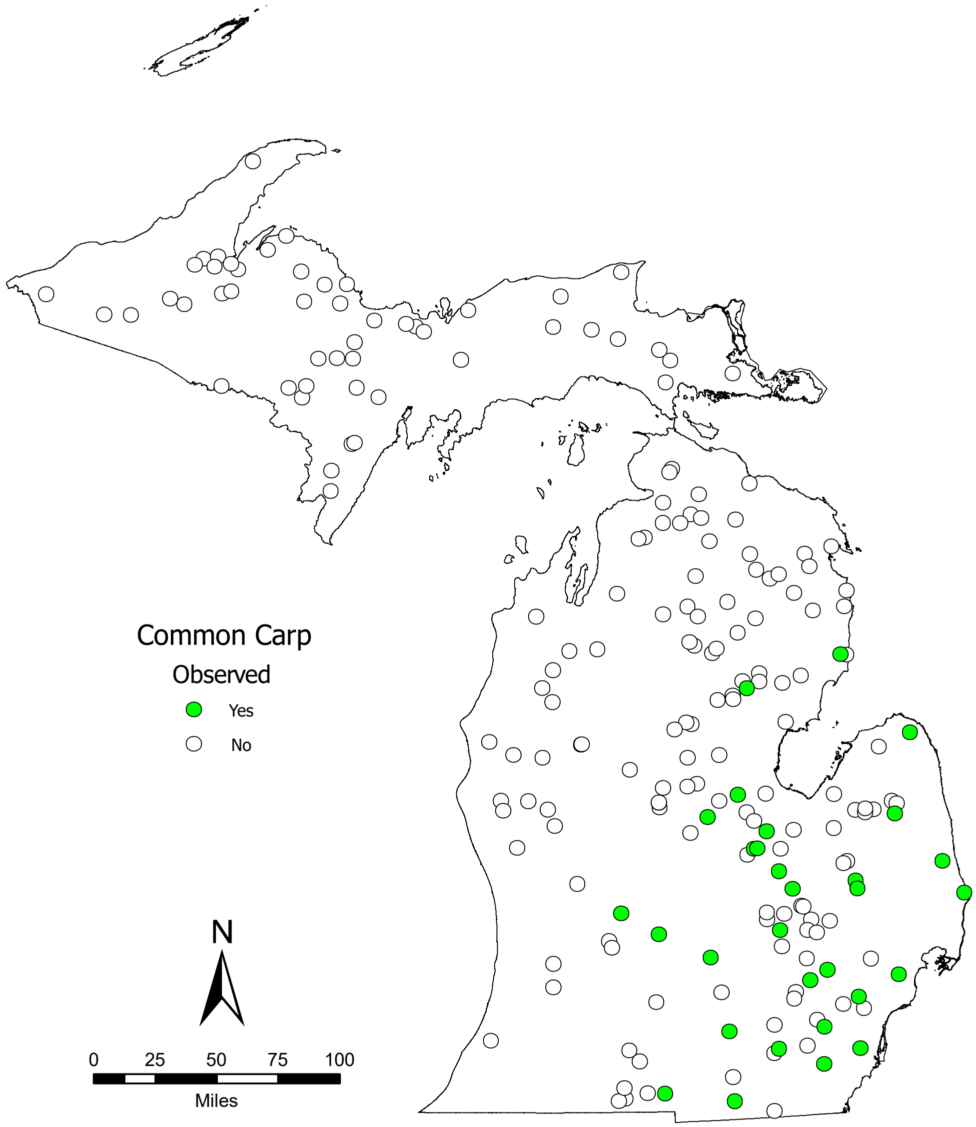

FIGURE A27. Map of distribution of Common Carp *Cyprinus carpio* at randomly sampled sites.

TABLE A27. Percentage of Common Carp *Cyprinus carpio* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	10	3	4
Medium	0	13	27	12
Large	0	7	10	5
Very Large	0	3	27	9
Total N	0	10	20	30

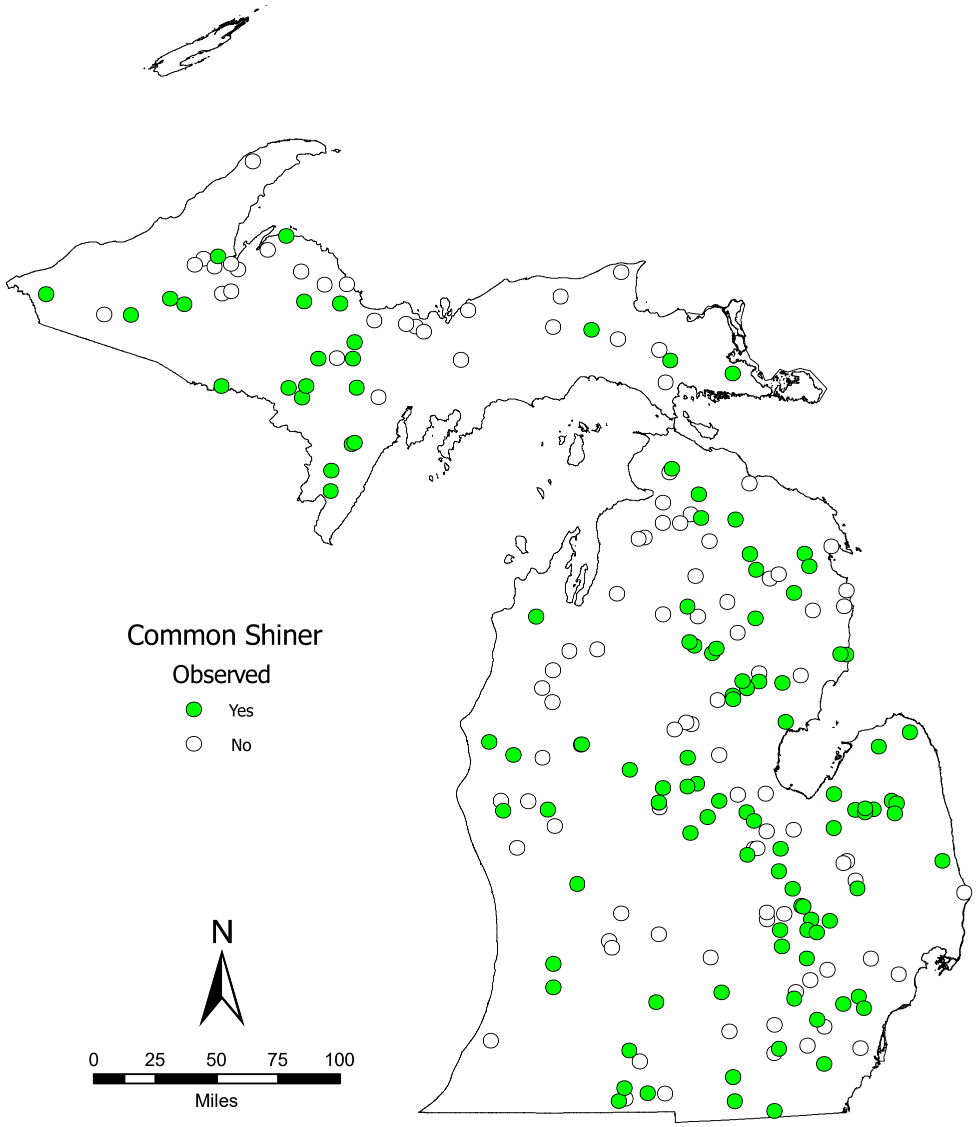

FIGURE A28. Map of distribution of Common Shiner *Luxilus cornutus* at randomly sampled sites.

TABLE A28. Percentage of Common Shiner *Luxilus cornutus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	6	15	10	34
Medium	15	24	14	57
Large	1	7	3	12
Very Large	0	3	3	6
Total N	24	53	32	109

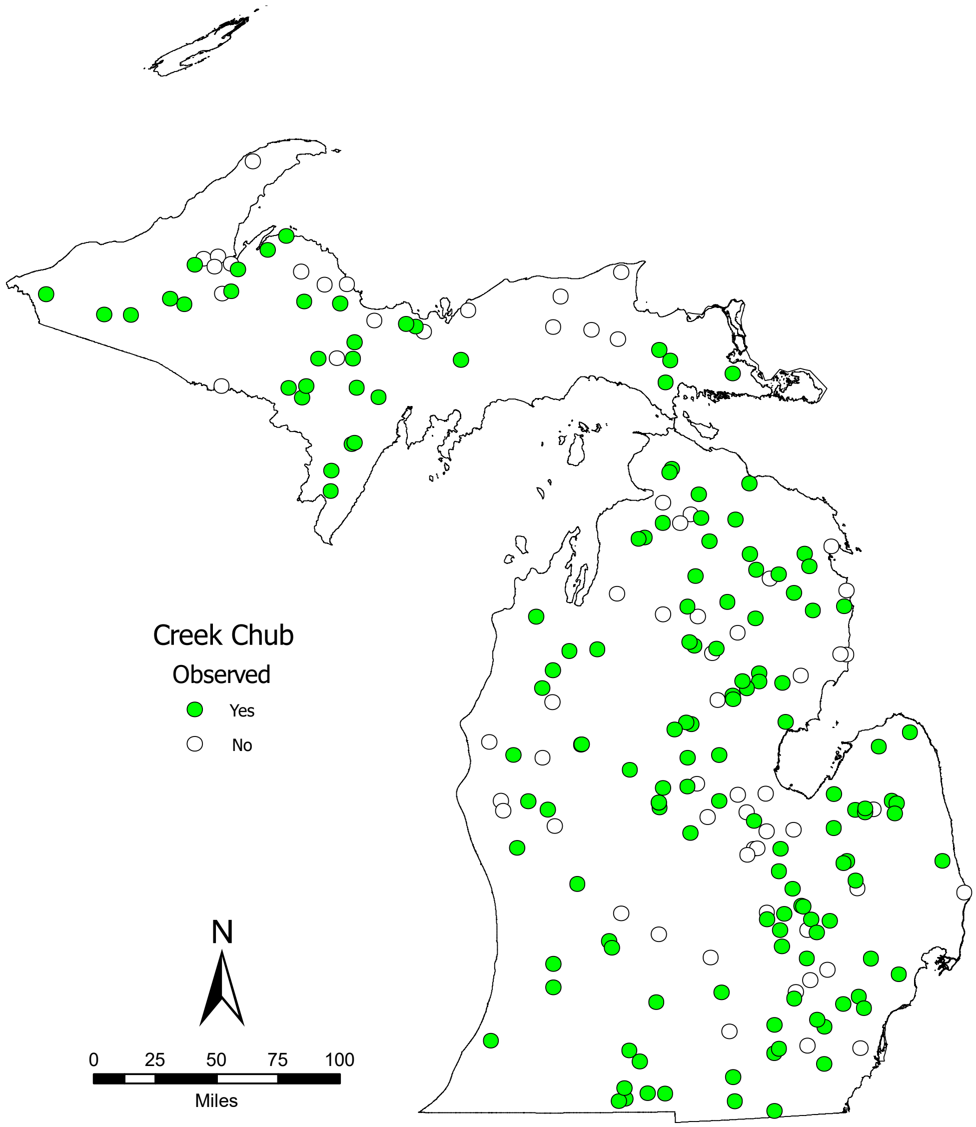

FIGURE A29. Map of distribution of Creek Chub *Semotilus atromaculatus* at randomly sampled sites.

TABLE A29. Percentage of Creek Chub *Semotilus atromaculatus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	22	16	10	69
Medium	14	19	10	63
Large	0	5	2	11
Very Large	0	0	3	4
Total N	53	59	35	147

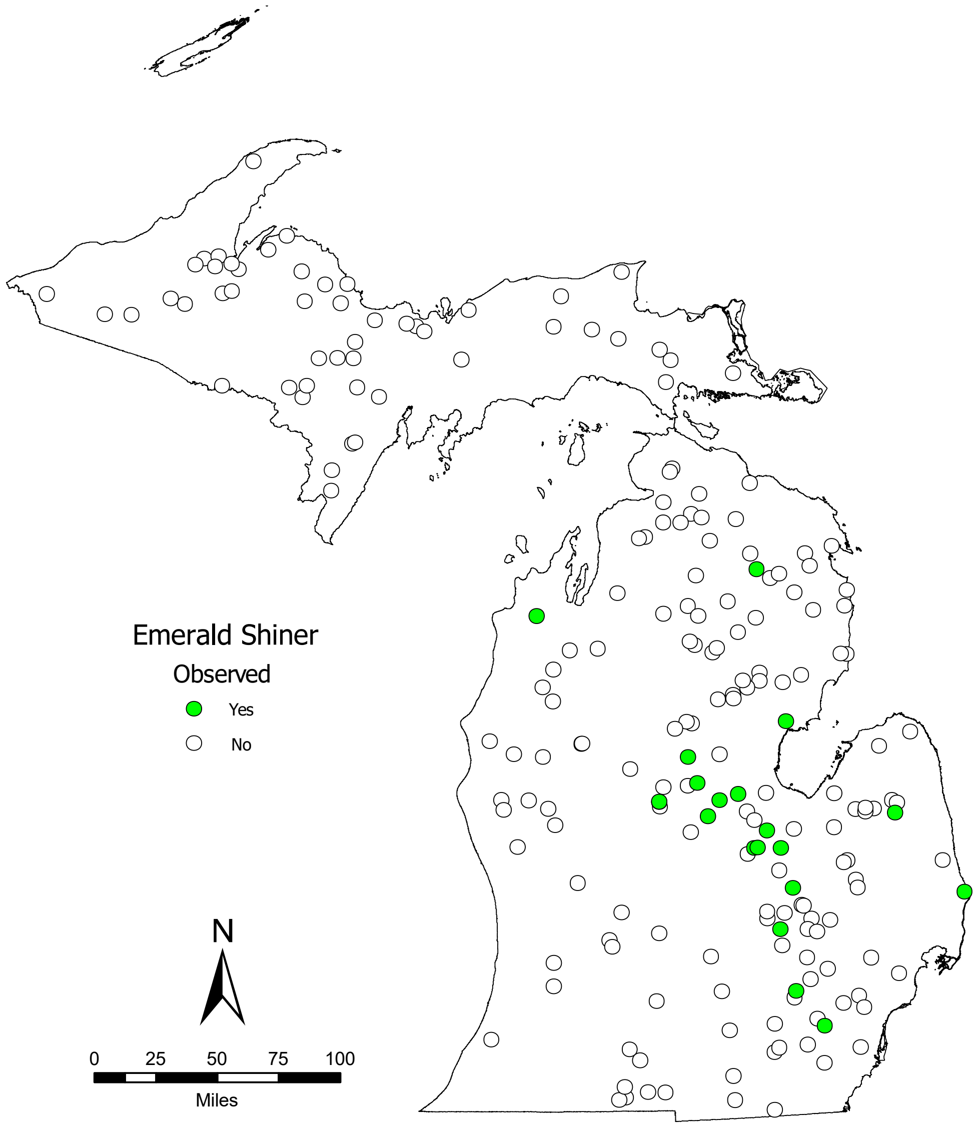

FIGURE A30. Map of distribution of Emerald Shiner *Notropis atherinoides* at randomly sampled sites.

TABLE A30. Percentage of Emerald Shiner *Notropis atherinoides* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	16	16	6
Large	0	16	21	7
Very Large	0	0	32	6
Total N	0	6	13	19

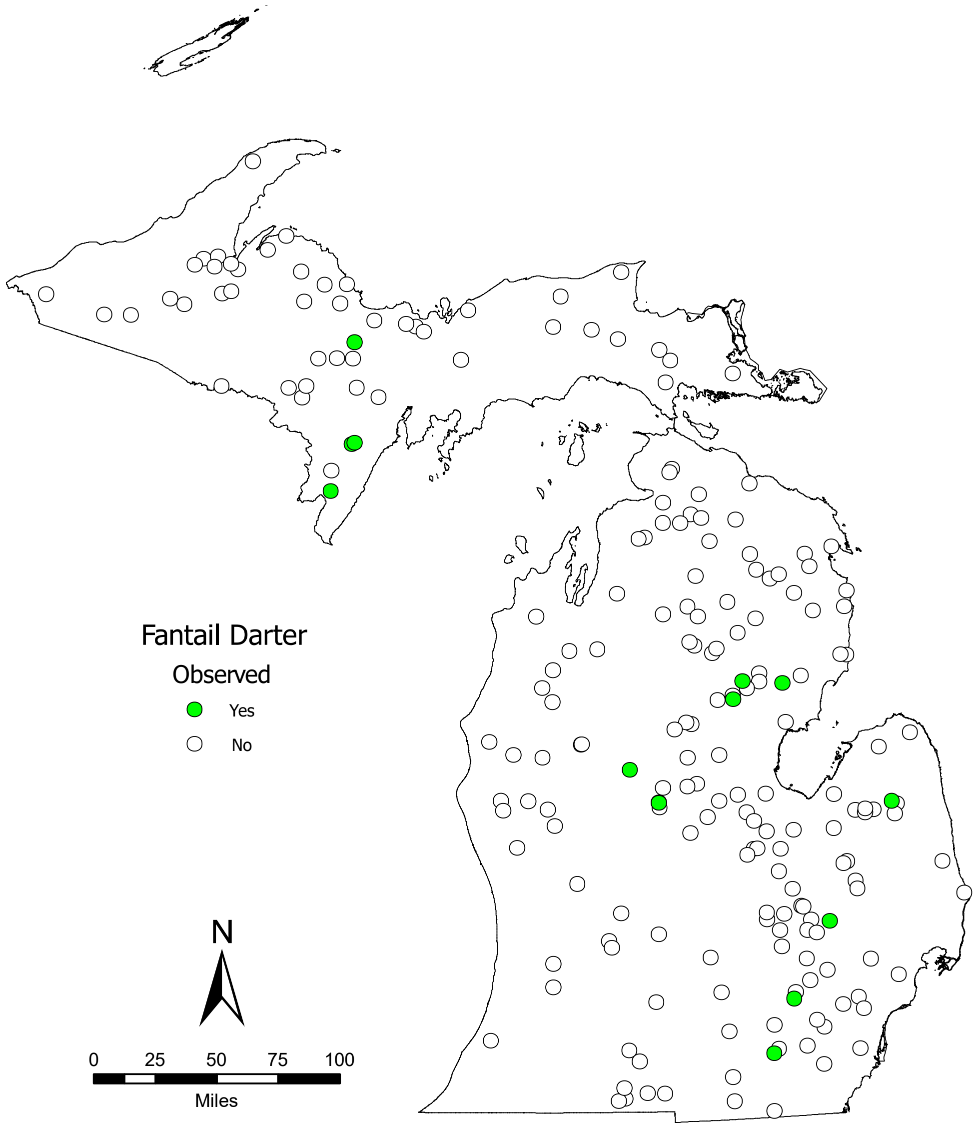

FIGURE A31. Map of distribution of Fantail Darter *Etheostoma flabellare* at randomly sampled sites.

TABLE A31. Percentage of Fantail Darter *Etheostoma flabellare* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	15	15	8	5
Medium	23	8	23	7
Large	0	8	0	1
Very Large	0	0	0	0
Total N	5	4	4	13

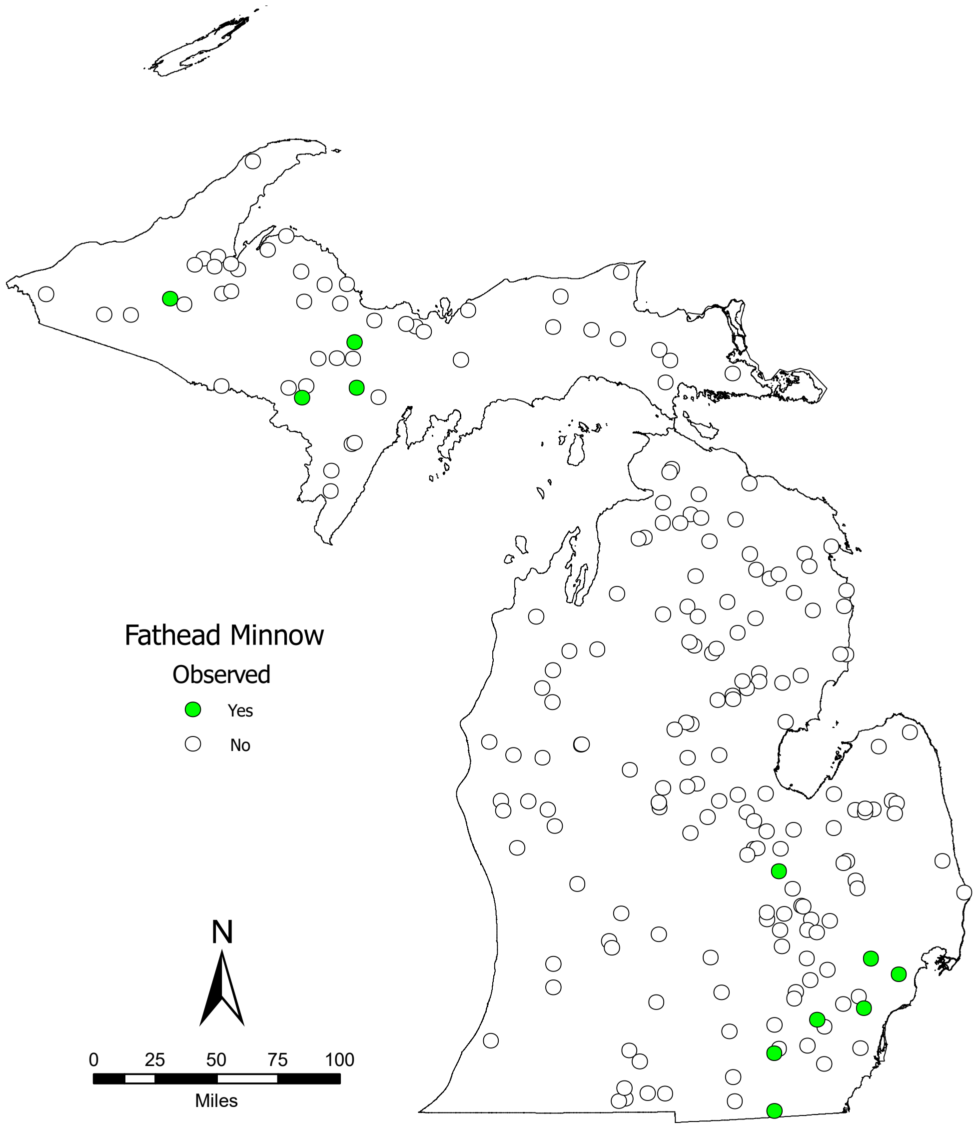

FIGURE A32. Map of distribution of Fathead Minnow *Pimephales promelas* at randomly sampled sites.

TABLE A32. Percentage of Fathead Minnow *Pimephales promelas* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	27	9	4
Medium	9	18	27	6
Large	0	9	0	1
Very Large	0	0	0	0
Total N	1	6	4	11

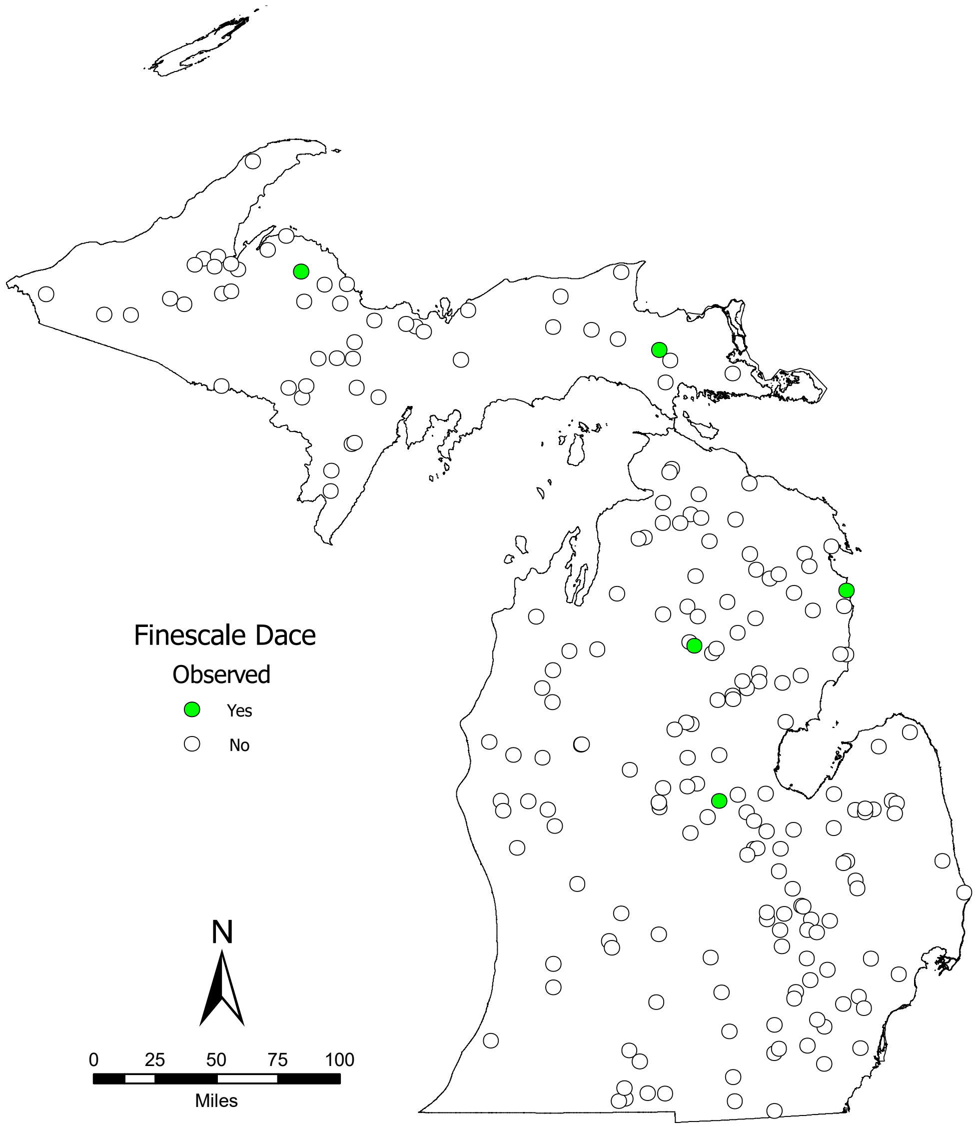

FIGURE A33. Map of distribution of Finescale Dace *Phoxinus neogaeus* at randomly sampled sites.

TABLE A33. Percentage of Finescale Dace *Phoxinus neogaeus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	20	0	0	2
Medium	20	20	0	2
Large	0	0	20	1
Very Large	0	0	0	0
Total N	2	1	1	5

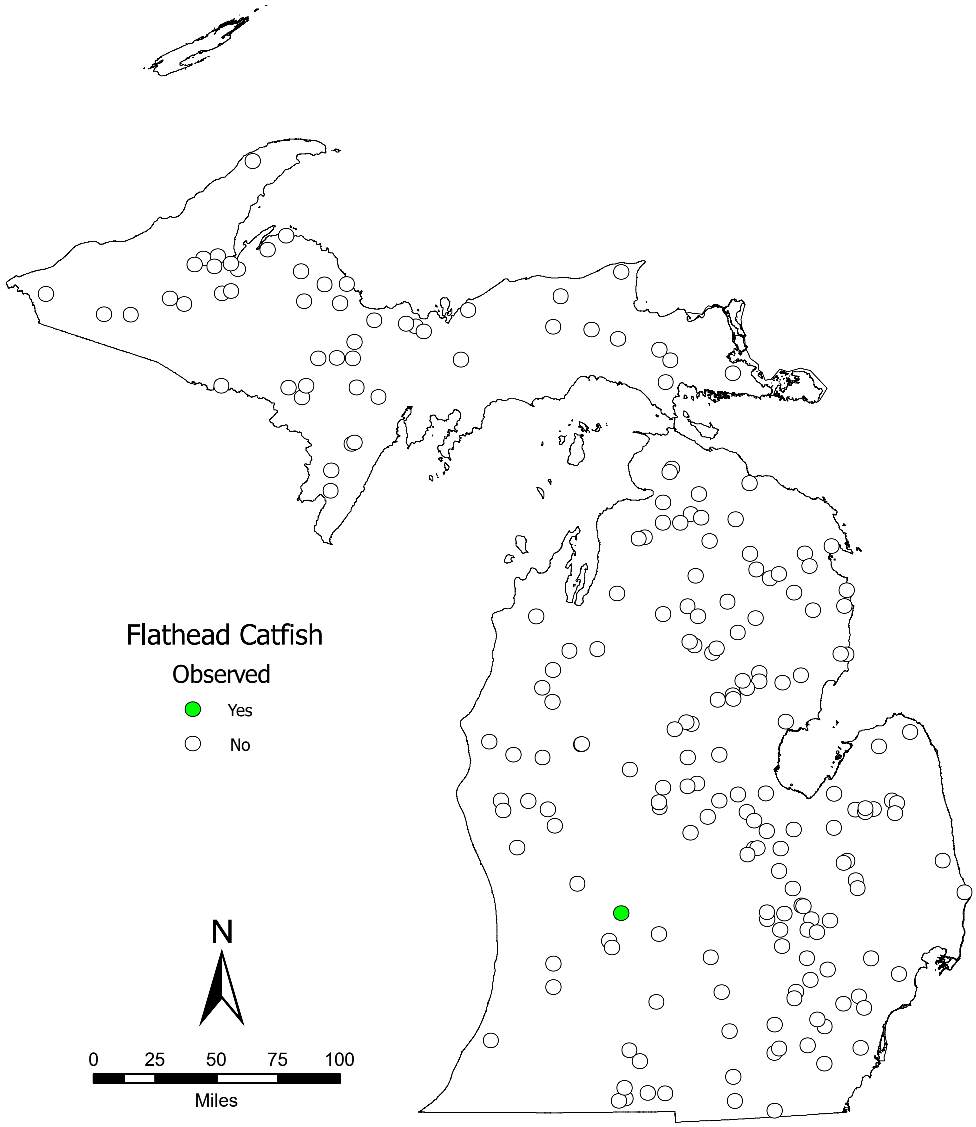

FIGURE A34. Map of distribution of Flathead Catfish *Pylodictis olivaris* at randomly sampled sites.

TABLE A34. Percentage of Flathead Catfish *Pylodictis olivaris* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	100	1
Total N	0	0	1	1

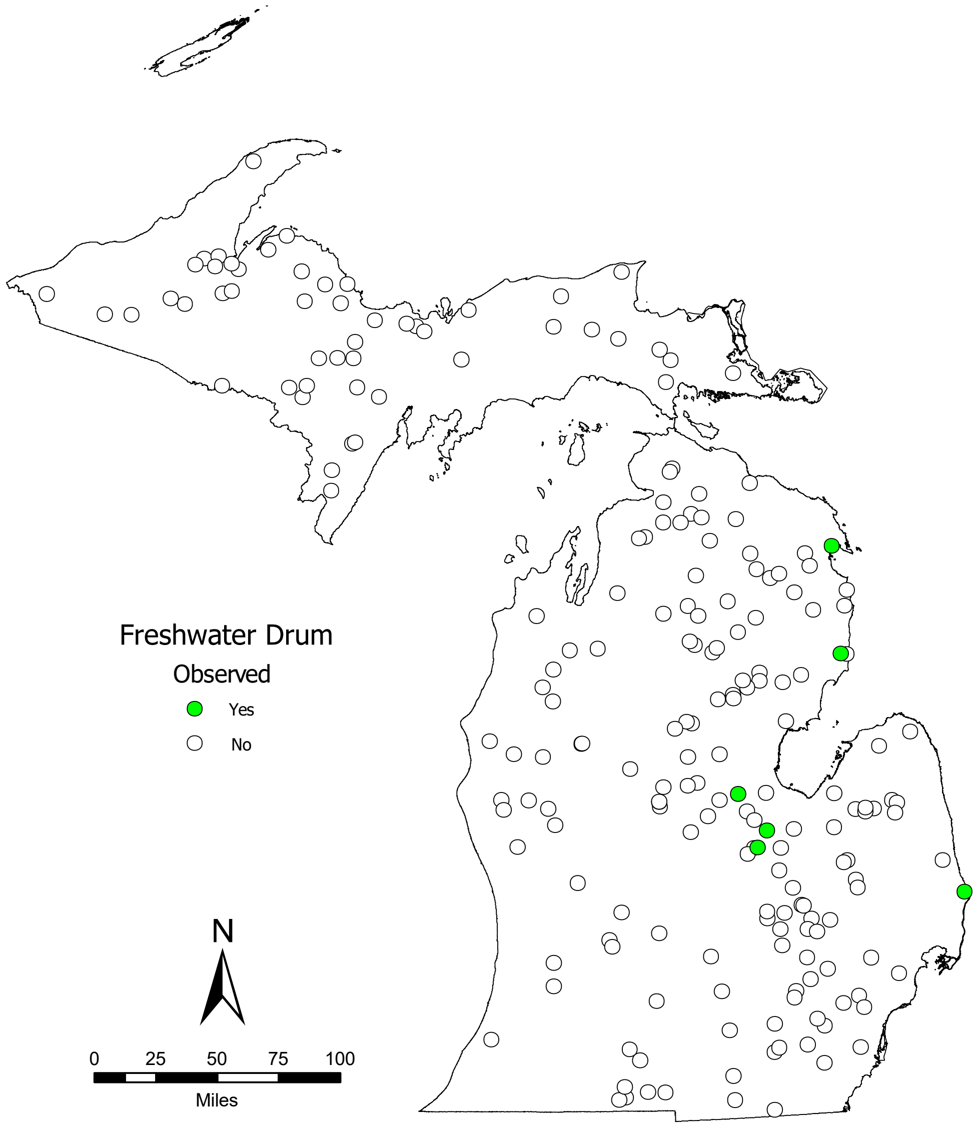

FIGURE A35. Map of distribution of Freshwater Drum *Aplodinotus grunniens* at randomly sampled sites.

TABLE A35. Percentage of Freshwater Drum *Aplodinotus grunniens* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	17	1
Very Large	0	17	67	5
Total N	0	1	5	6

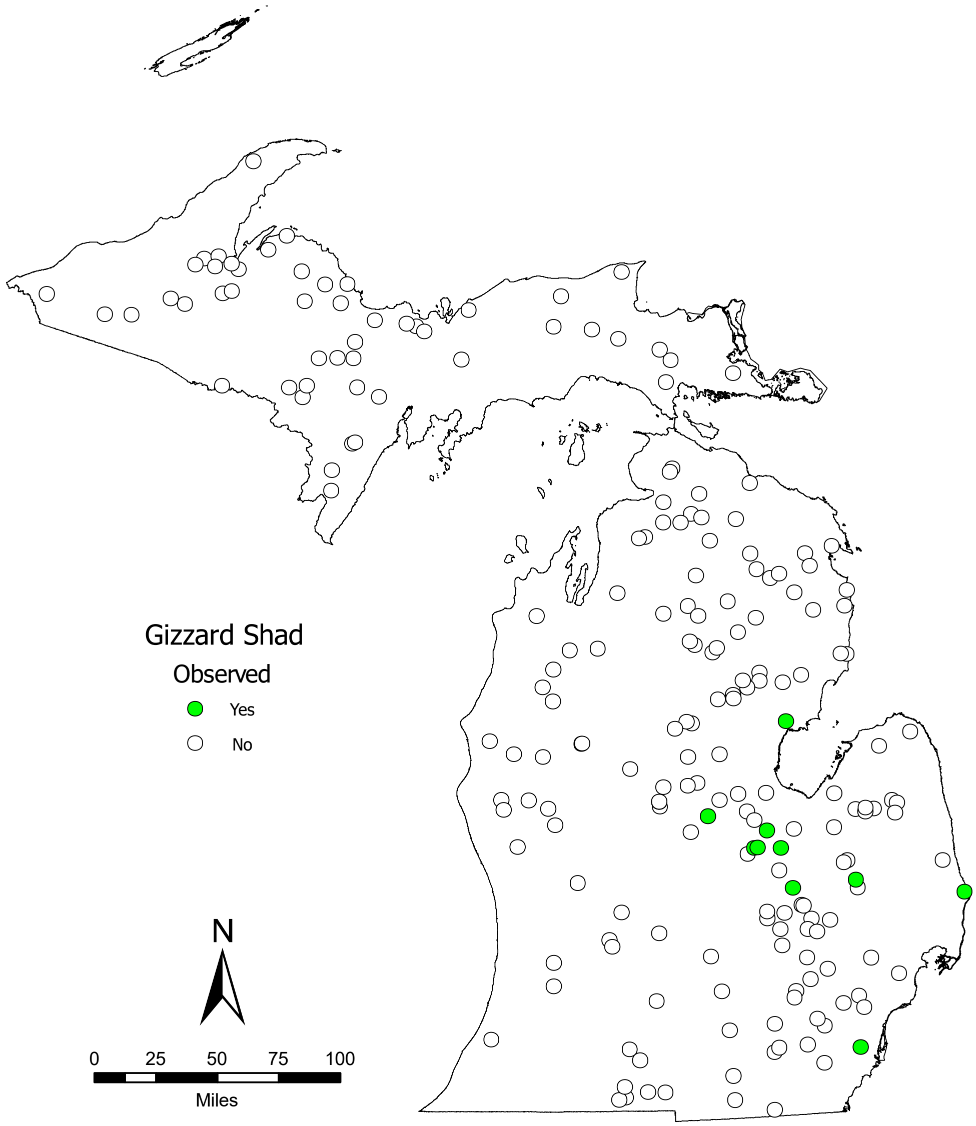

FIGURE A36. Map of distribution of Gizzard Shad *Dorosoma cepedianum* at randomly sampled sites.

TABLE A36. Percentage of Gizzard Shad *Dorosoma cepedianum* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	10	0	1
Medium	0	0	10	1
Large	0	10	20	3
Very Large	0	0	50	5
Total N	0	2	8	10

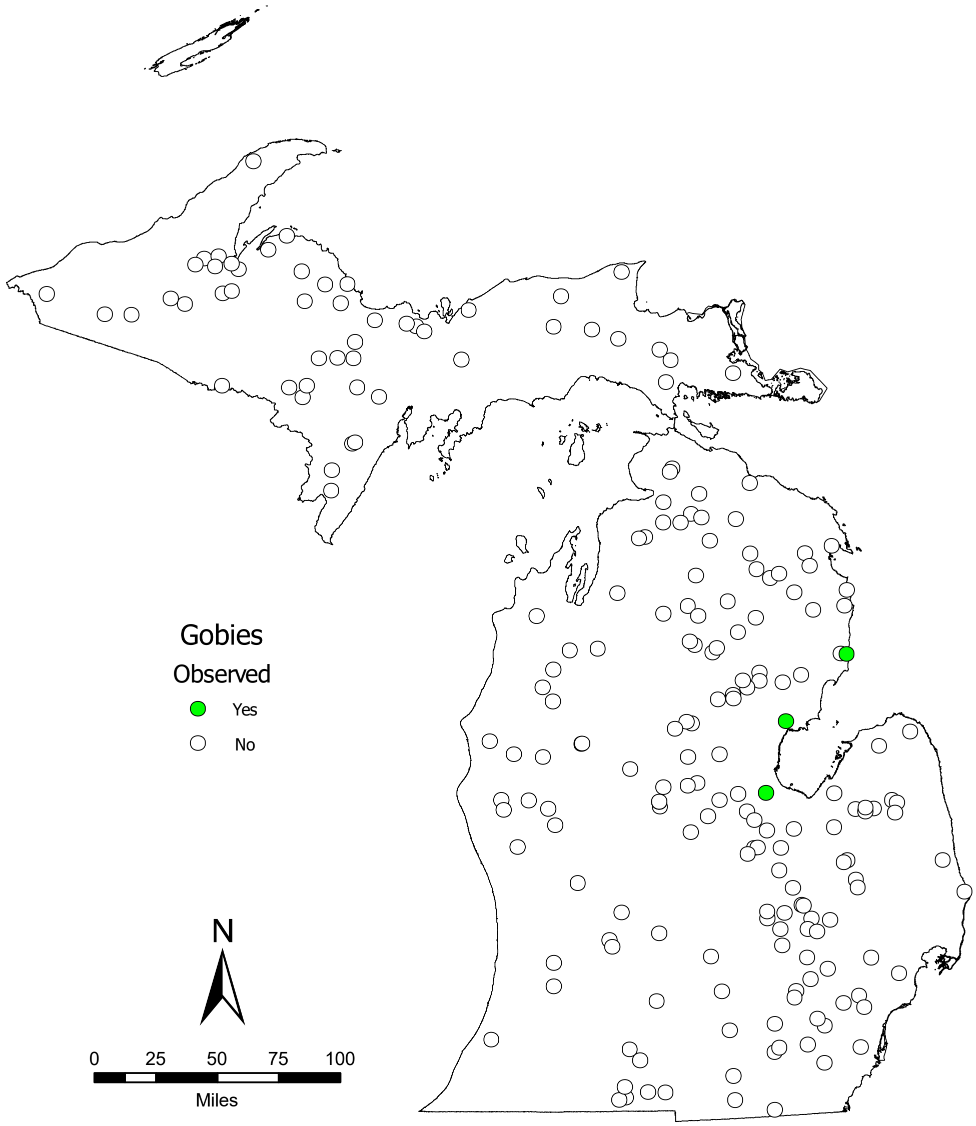

FIGURE A37. Map of distribution of Gobies *Gobiidae (*family) at randomly sampled sites.

TABLE A37. Percentage of Gobies *Gobiidae (*family) occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	33	1
Large	0	67	0	2
Very Large	0	0	0	0
Total N	0	2	1	3

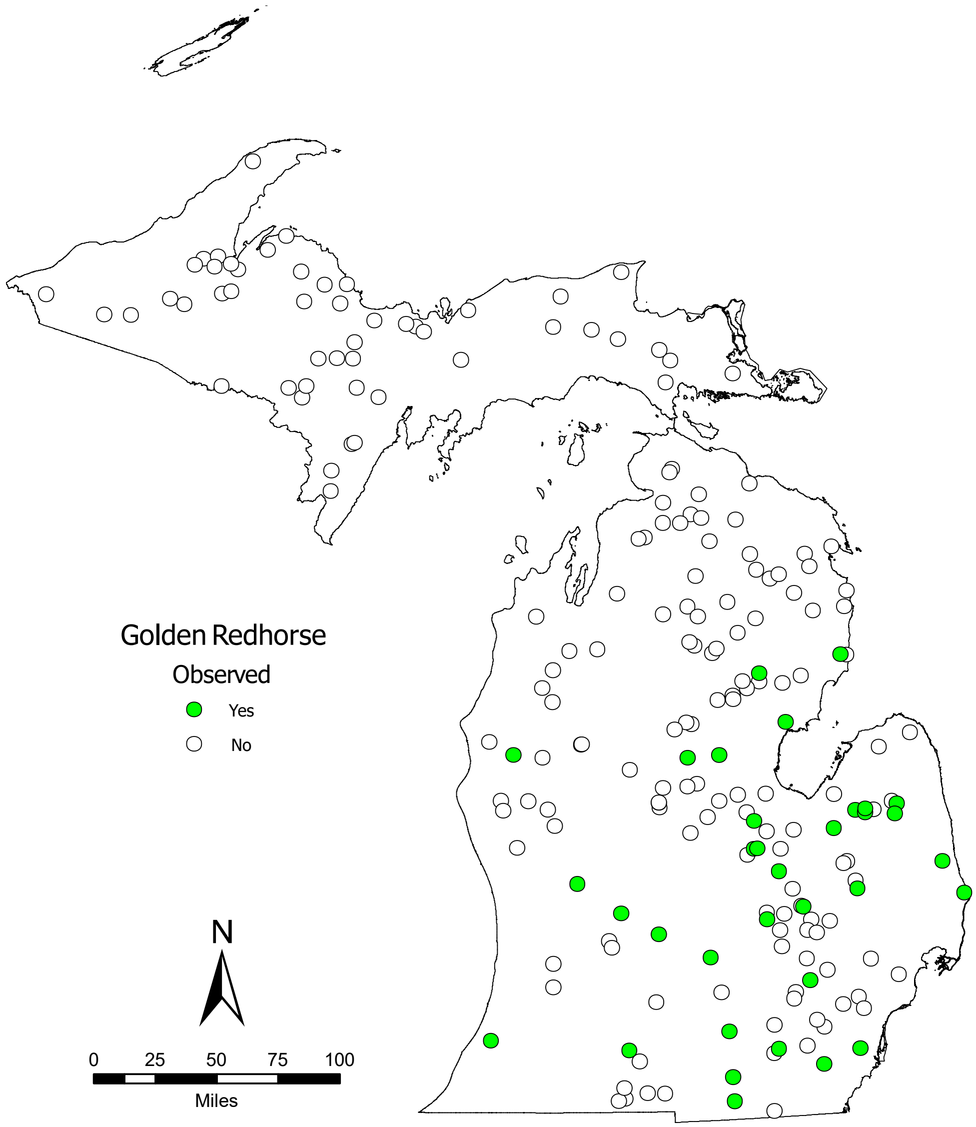

FIGURE A38. Map of distribution of Golden Redhorse *Moxostoma erythrurum* at randomly sampled sites.

TABLE A38. Percentage of Golden Redhorse *Moxostoma erythrurum* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	3	6	3	4
Medium	6	24	21	17
Large	0	12	9	7
Very Large	0	3	15	6
Total N	3	15	16	34

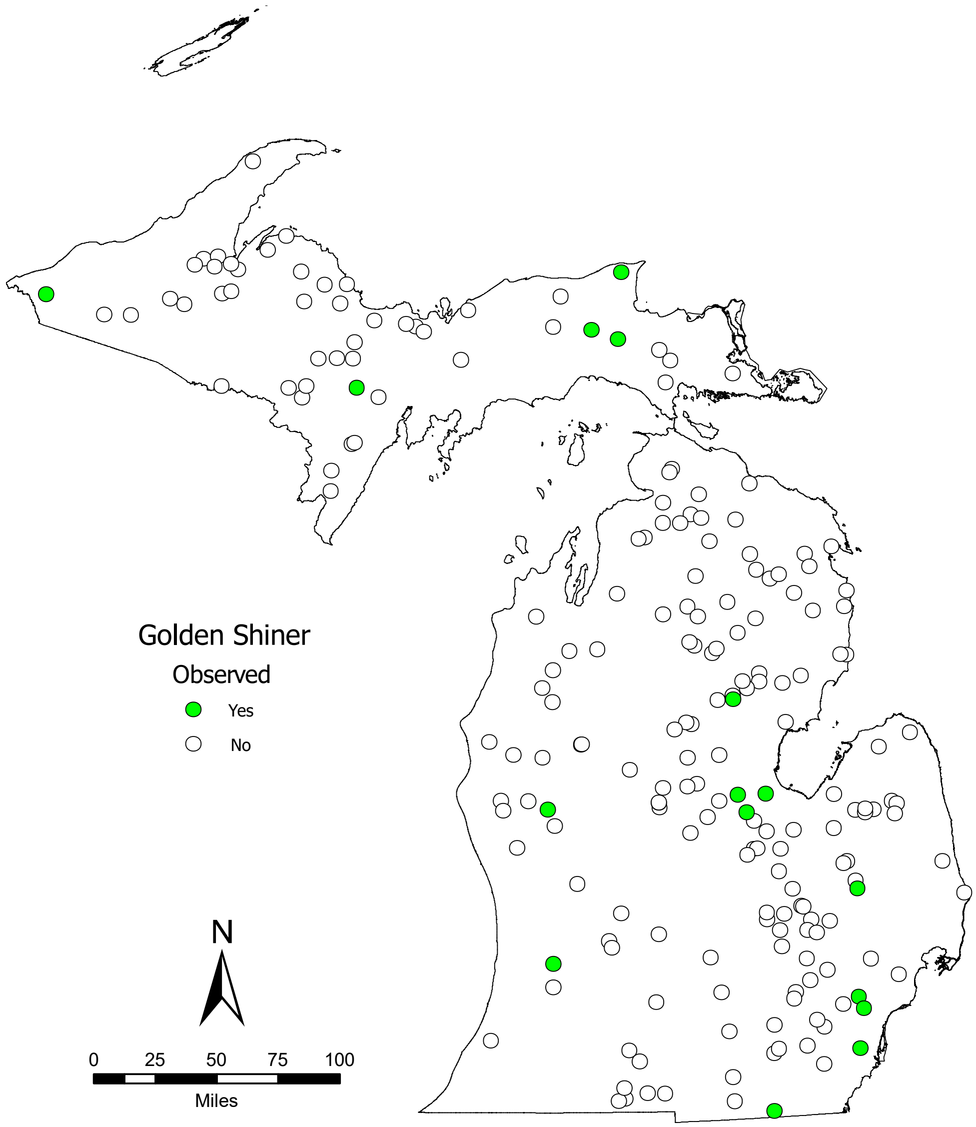

FIGURE A39. Map of distribution of Golden Shiner *Notemigonus crysoleucas* at randomly sampled sites.

TABLE A39. Percentage of Golden Shiner *Notemigonus crysoleucas* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	19	13	5
Medium	13	19	13	7
Large	0	6	0	1
Very Large	0	6	13	3
Total N	2	8	6	16

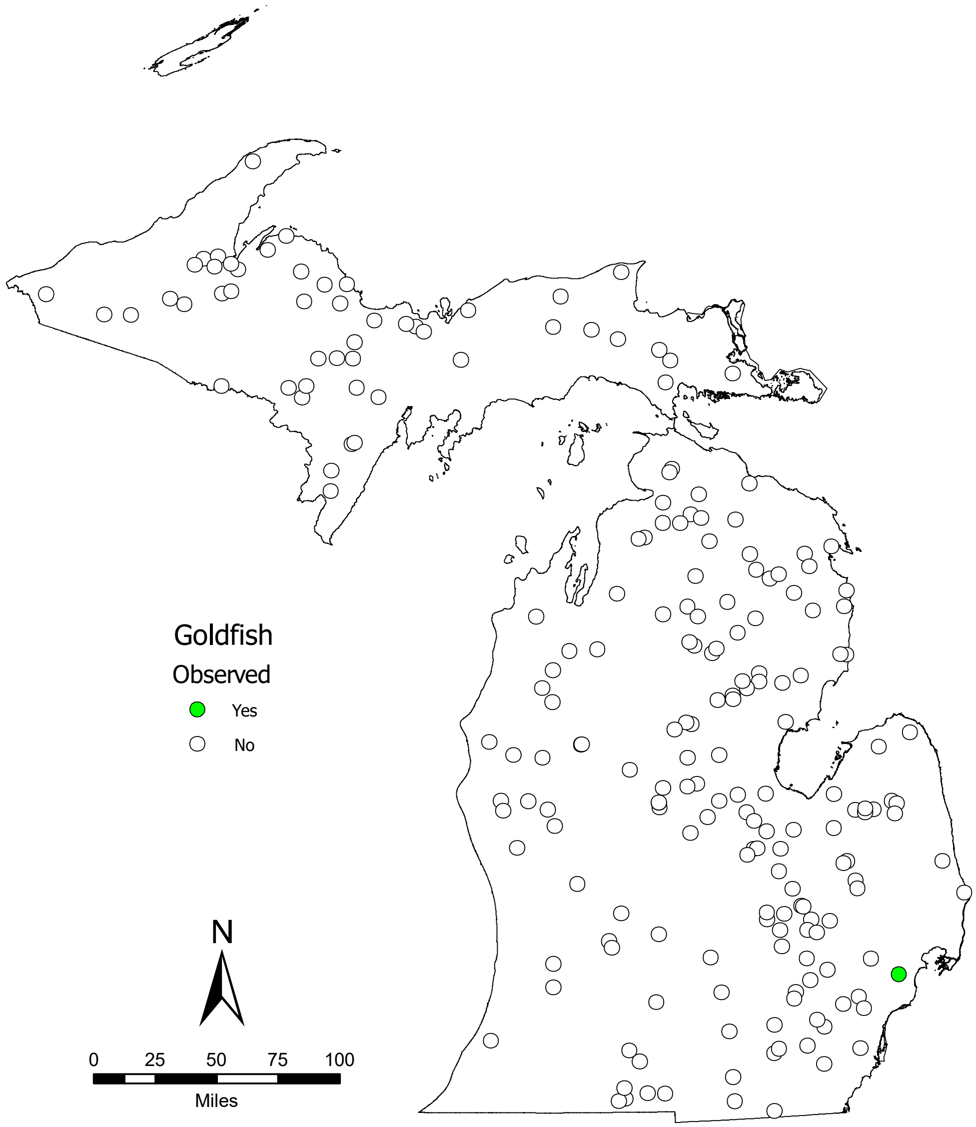

FIGURE A40. Map of distribution of Goldfish *Carassius auratus* at randomly sampled sites.

TABLE A40. Percentage of Goldfish *Carassius auratus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	100	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	0	0	1

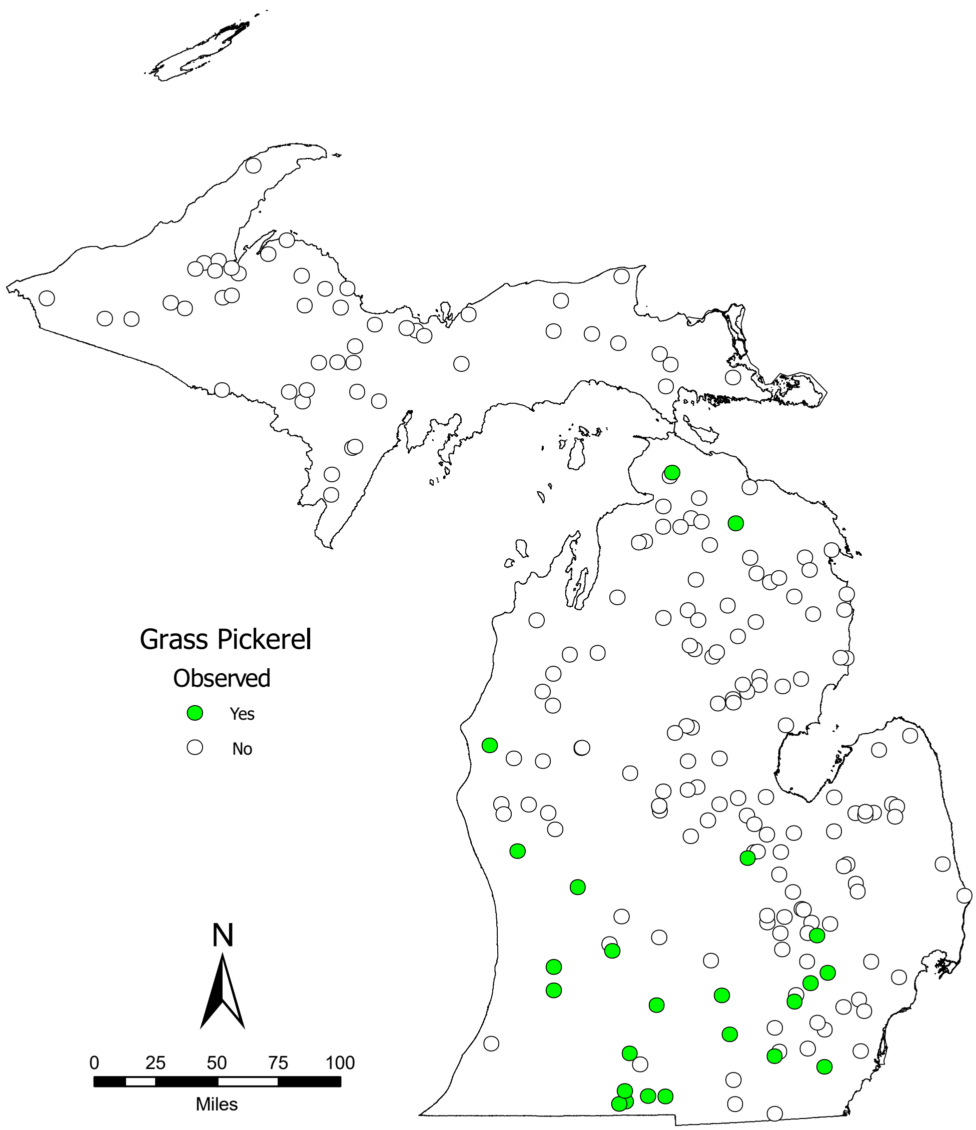

FIGURE A41. Map of distribution of Grass Pickerel *Esox americanus* at randomly sampled sites.

TABLE A41. Percentage of Grass Pickerel *Esox americanus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	12	20	12	11
Medium	8	24	12	11
Large	0	8	0	2
Very Large	0	4	0	1
Total N	5	14	6	25

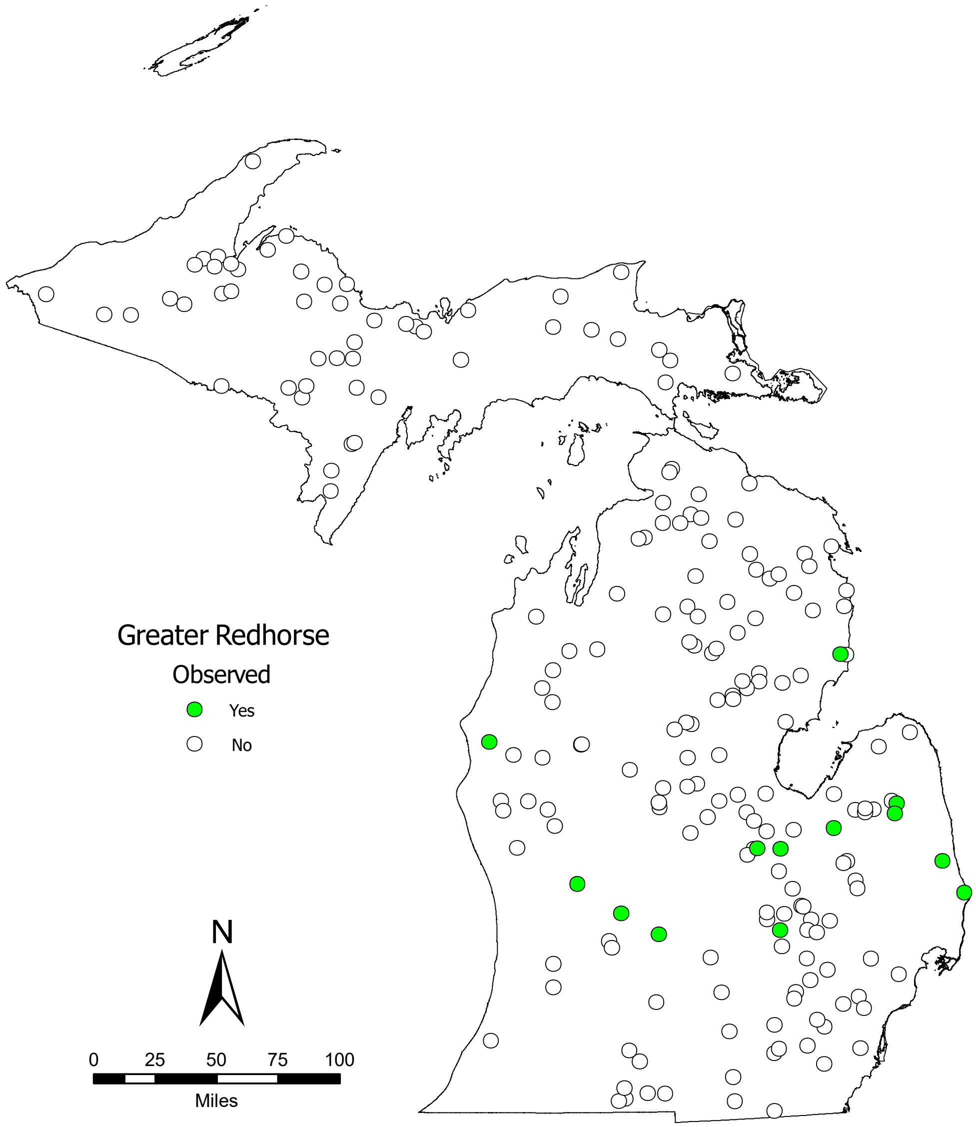

FIGURE A42. Map of distribution of Greater Redhorse *Moxostoma valenciennesi* at randomly sampled sites.

TABLE A42. Percentage of Greater Redhorse *Moxostoma valenciennesi* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	8	15	8	4
Large	0	0	15	2
Very Large	0	15	38	7
Total N	1	4	8	13

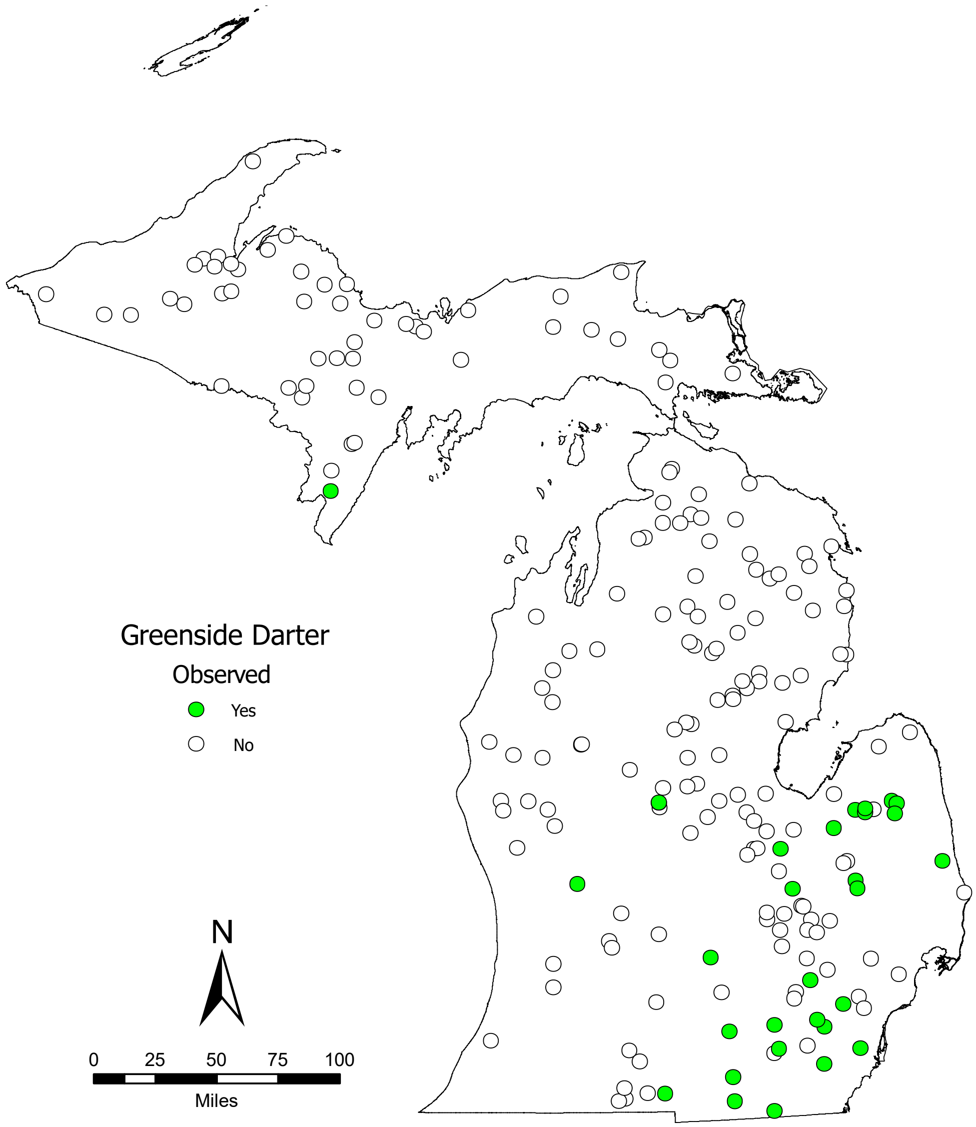

FIGURE A43. Map of distribution of Greenside Darter *Etheostoma blennioides* at randomly sampled sites.

TABLE A43. Percentage of Greenside Darter *Etheostoma blennioides* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	17	10	8
Medium	3	24	14	12
Large	0	10	3	4
Very Large	0	0	17	5
Total N	1	15	13	29

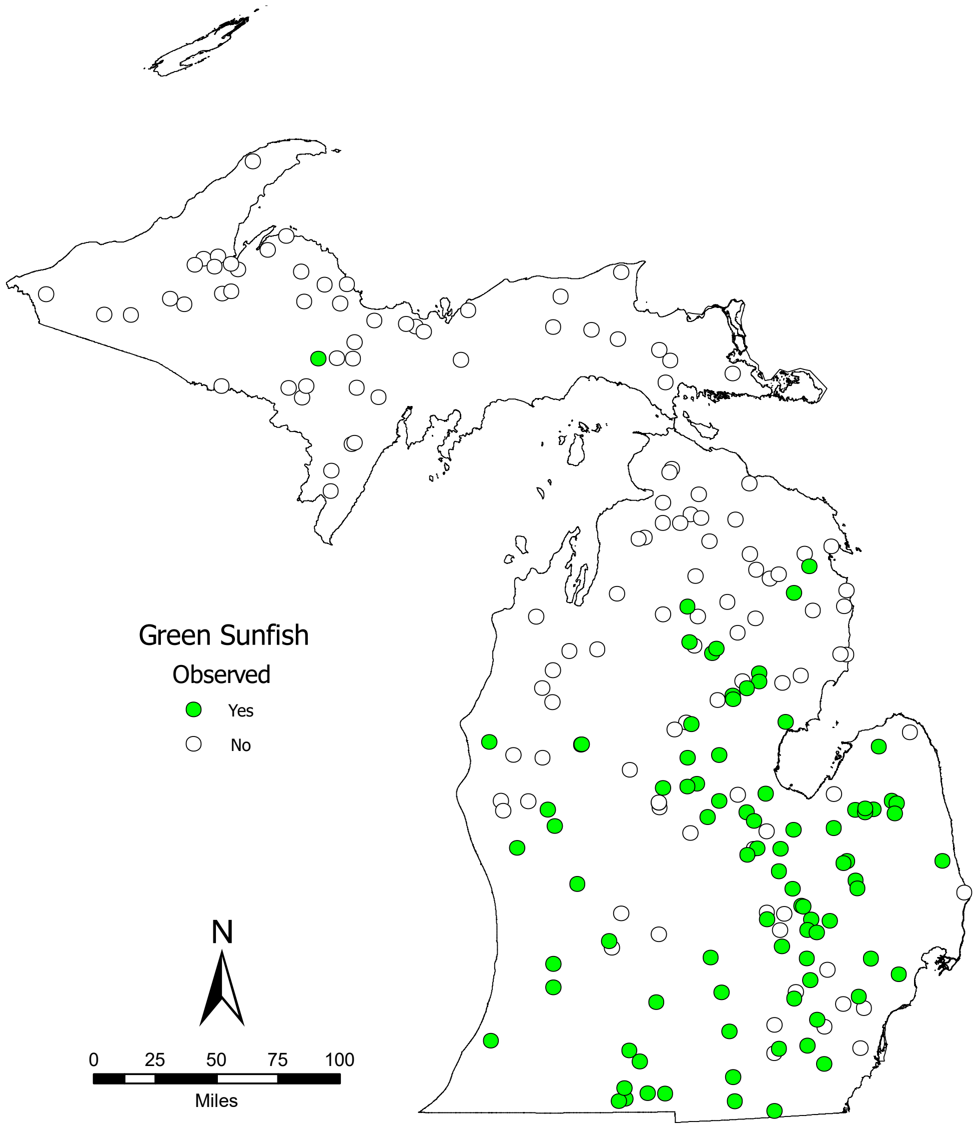

FIGURE A44. Map of distribution of Green Sunfish *Lepomis cyanellus* at randomly sampled sites.

TABLE A44. Percentage of Green Sunfish *Lepomis cyanellus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	10	15	15	35
Medium	9	21	14	38
Large	0	6	6	10
Very Large	0	1	3	4
Total N	17	37	33	87

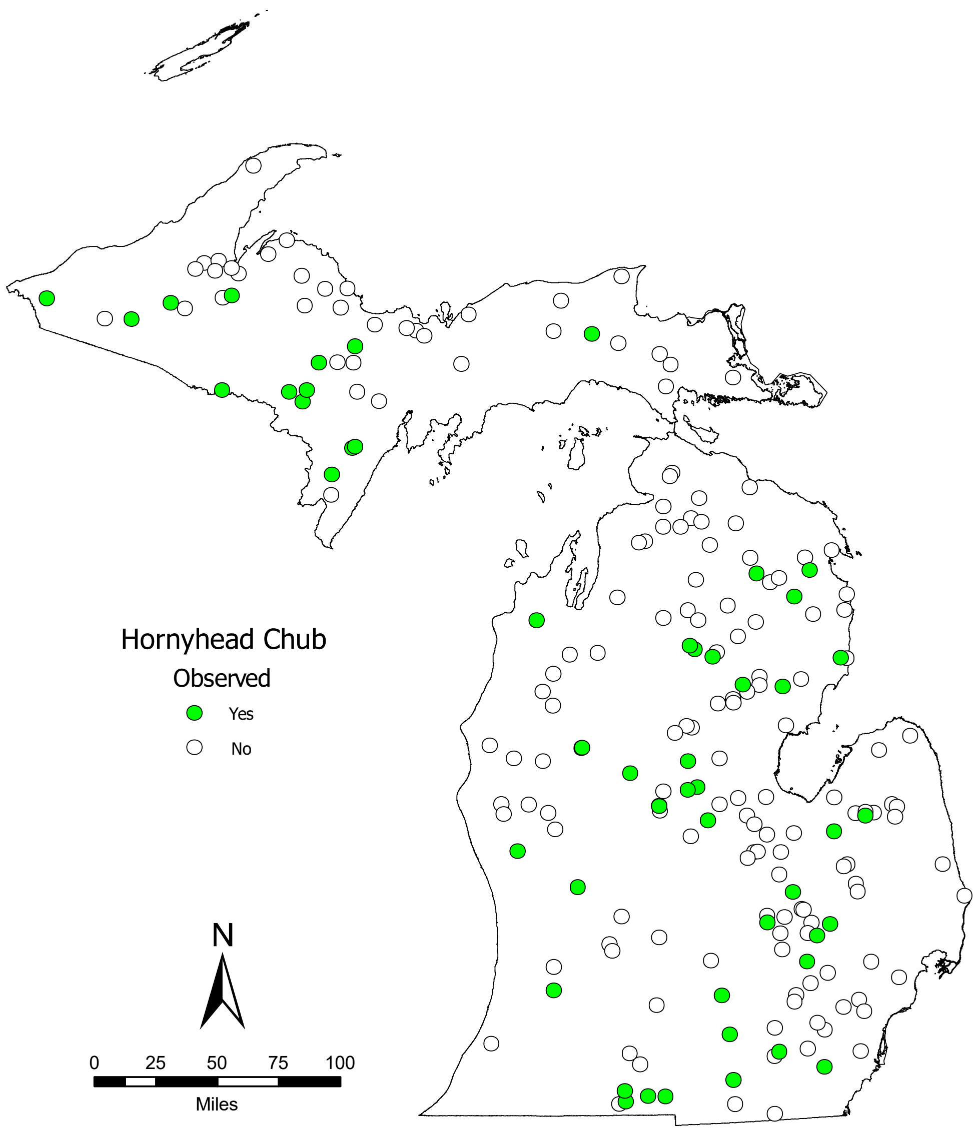

FIGURE A45. Map of distribution of Hornyhead Chub *Nocomis biguttatus* at randomly sampled sites.

TABLE A45. Percentage of Hornyhead Chub *Nocomis biguttatus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	10	4	4	9
Medium	18	25	16	30
Large	2	10	4	8
Very Large	0	4	4	4
Total N	15	22	14	51

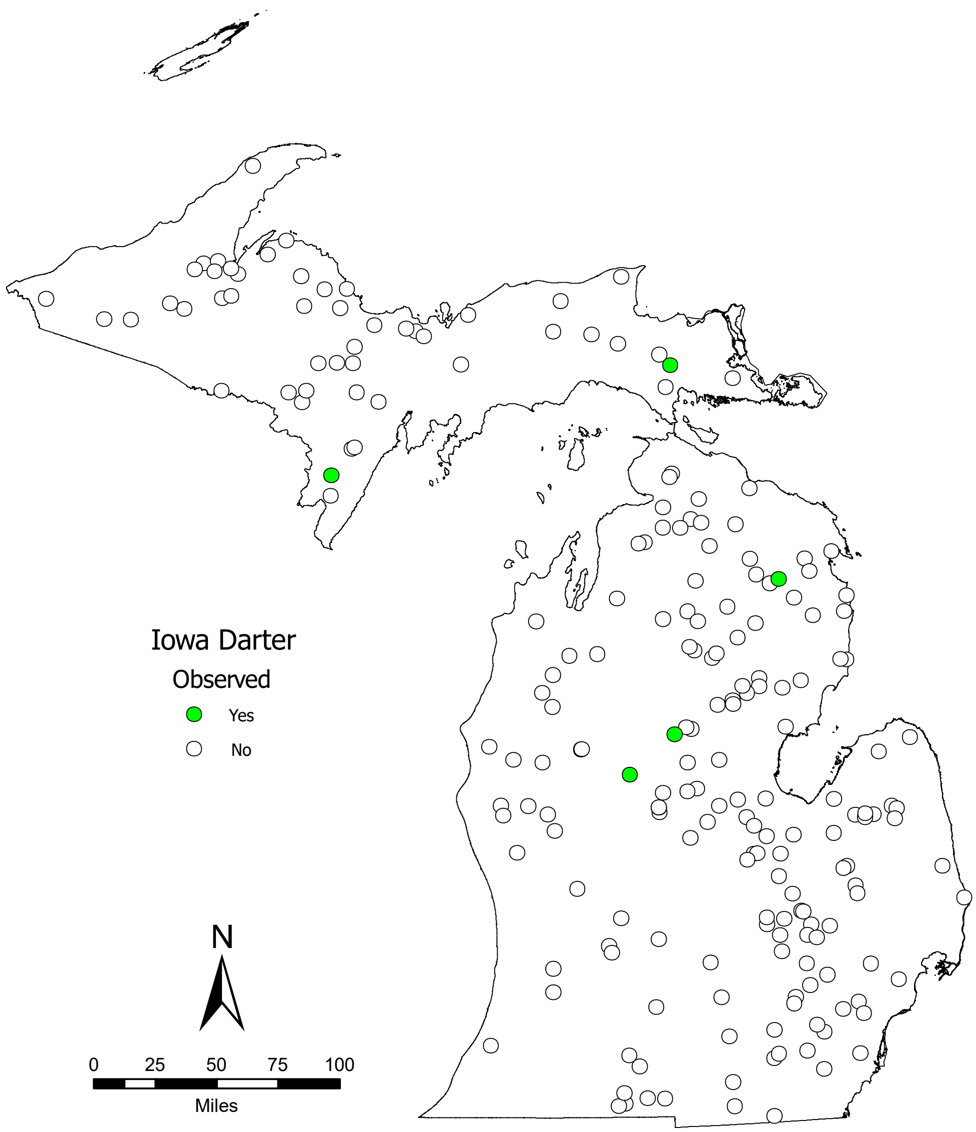

FIGURE A46. Map of distribution of Iowa Darter *Etheostoma exile* at randomly sampled sites.

TABLE A46. Percentage of Iowa Darter *Etheostoma exile* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	40	20	0	3
Medium	20	20	0	2
Large	0	0	0	0
Very Large	0	0	0	0
Total N	3	2	0	5

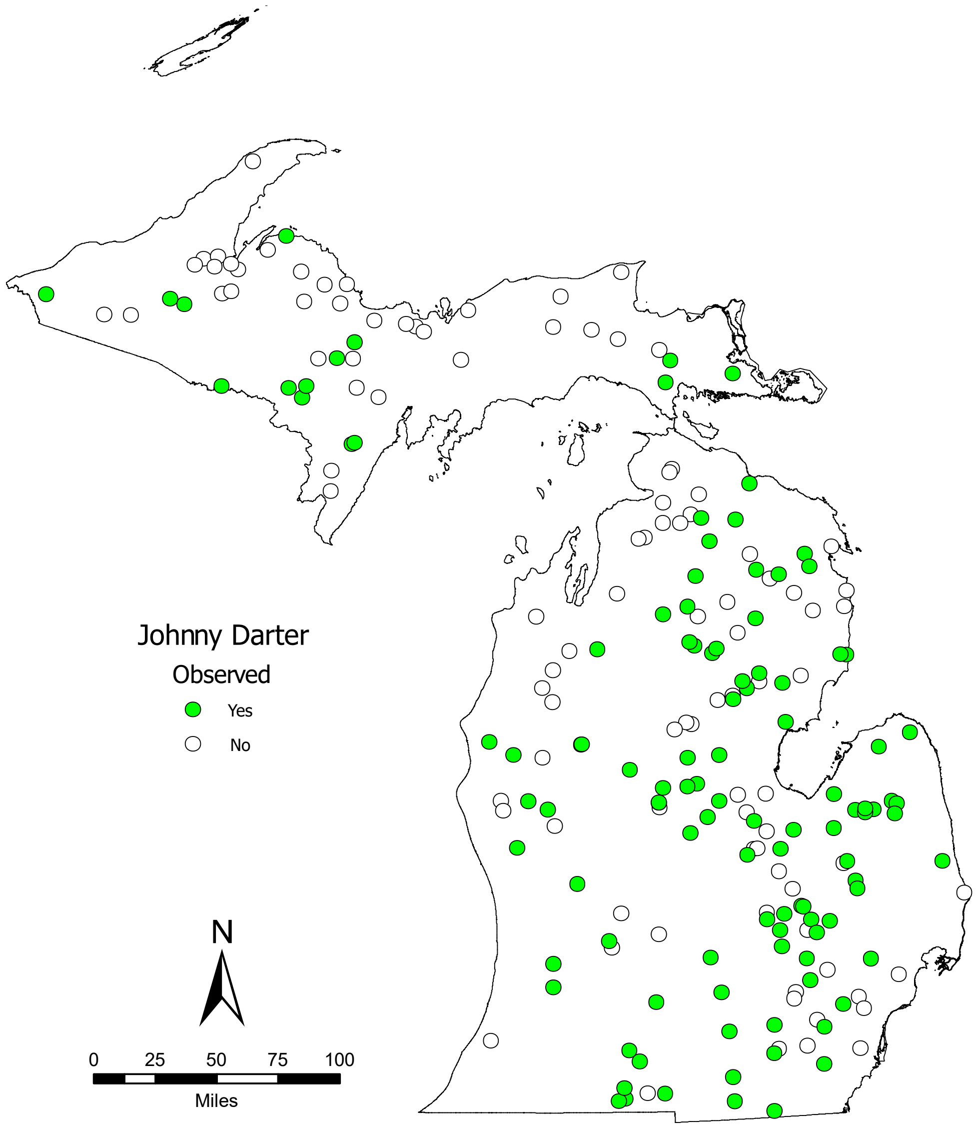

FIGURE A47. Map of distribution of Johnny Darter *Etheostoma nigrum* at randomly sampled sites.

TABLE A47. Percentage of Johnny Darter *Etheostoma nigrum* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	11	12	14	40
Medium	12	21	12	49
Large	2	9	4	16
Very Large	0	2	3	5
Total N	27	48	35	110

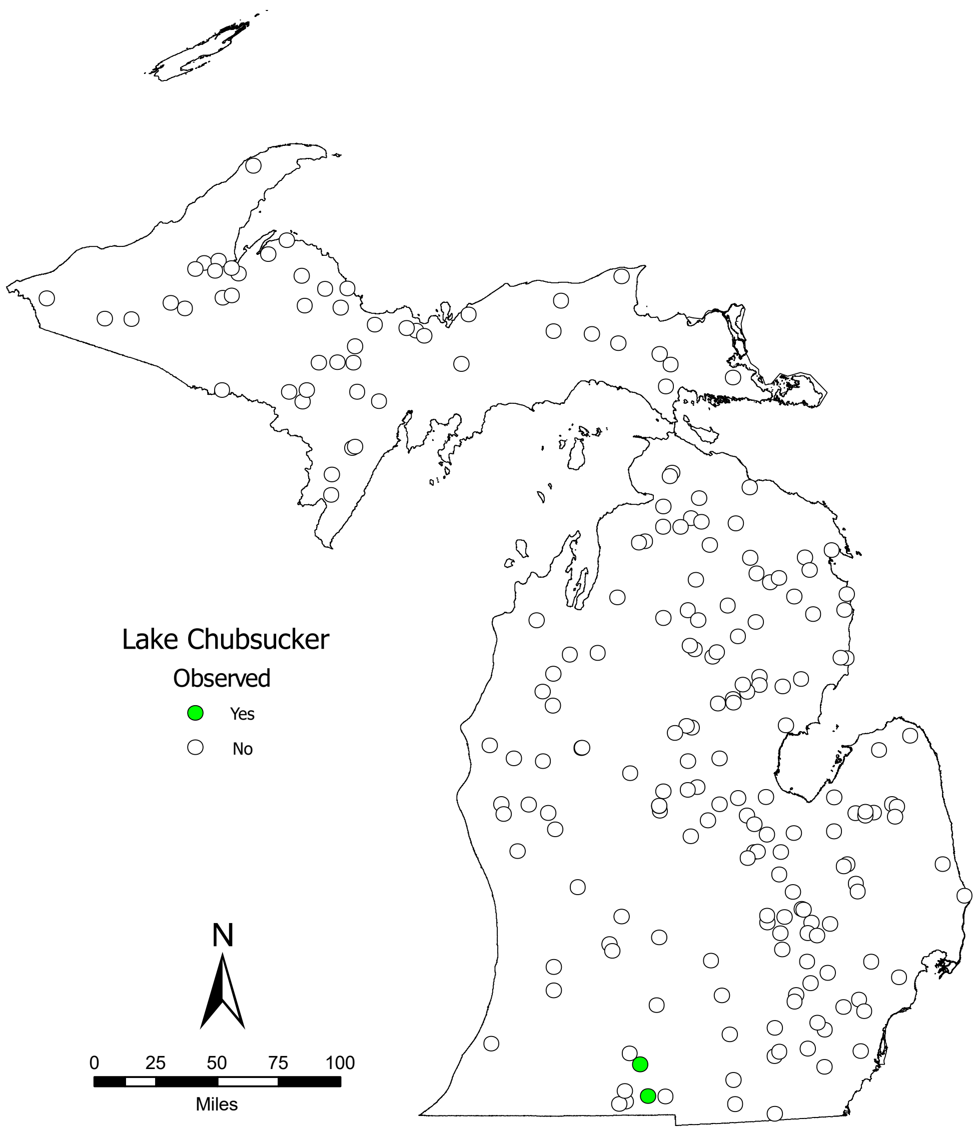

FIGURE A48. Map of distribution of Lake Chubsucker *Erimyzon sucetta* at randomly sampled sites.

TABLE A48. Percentage of Lake Chubsucker *Erimyzon sucetta* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	50	1
Medium	0	50	0	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	1	1	2

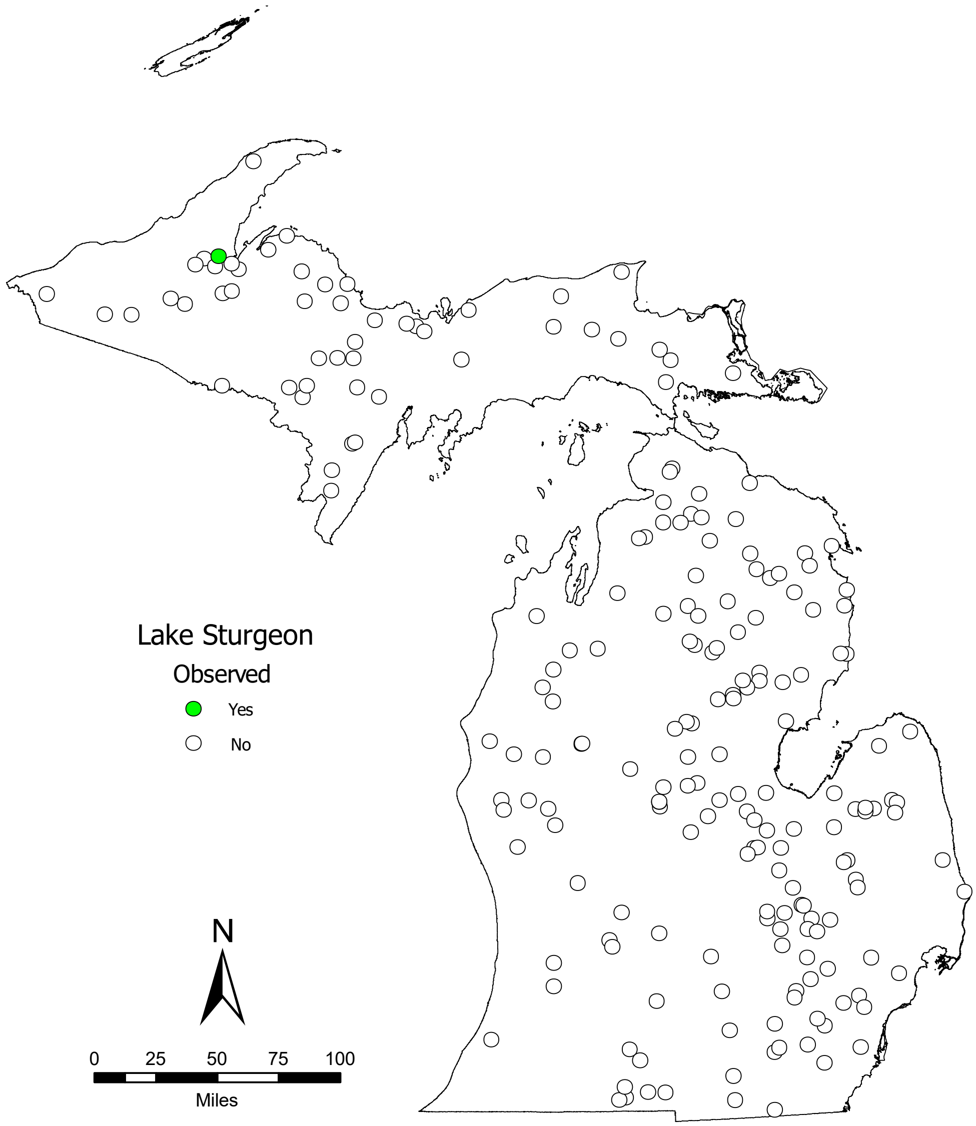

FIGURE A49. Map of distribution of Lake Sturgeon *Acipenser fulvescens* at randomly sampled sites. Lake Sturgeon are a Michigan threatened species.

TABLE A49. Percentage of Lake Sturgeon *Acipenser fulvescens* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	100	0	1
Very Large	0	0	0	0
Total N	0	1	0	1

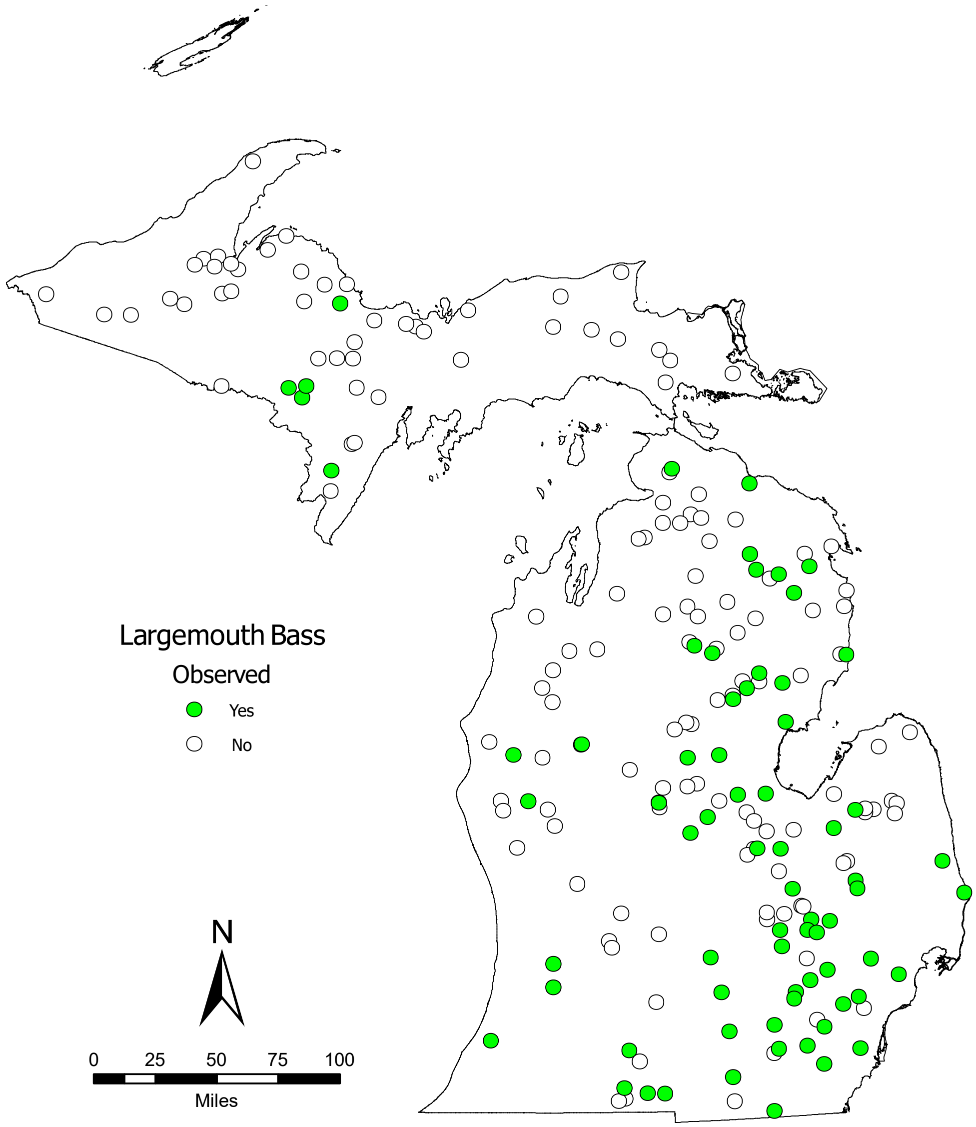

FIGURE A50. Map of distribution of Largemouth Bass *Micropterus salmoides* at randomly sampled sites.

TABLE A50. Percentage of Largemouth Bass *Micropterus salmoides* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	8	11	10	21
Medium	7	25	10	30
Large	0	13	6	13
Very Large	0	0	10	7
Total N	11	35	25	71

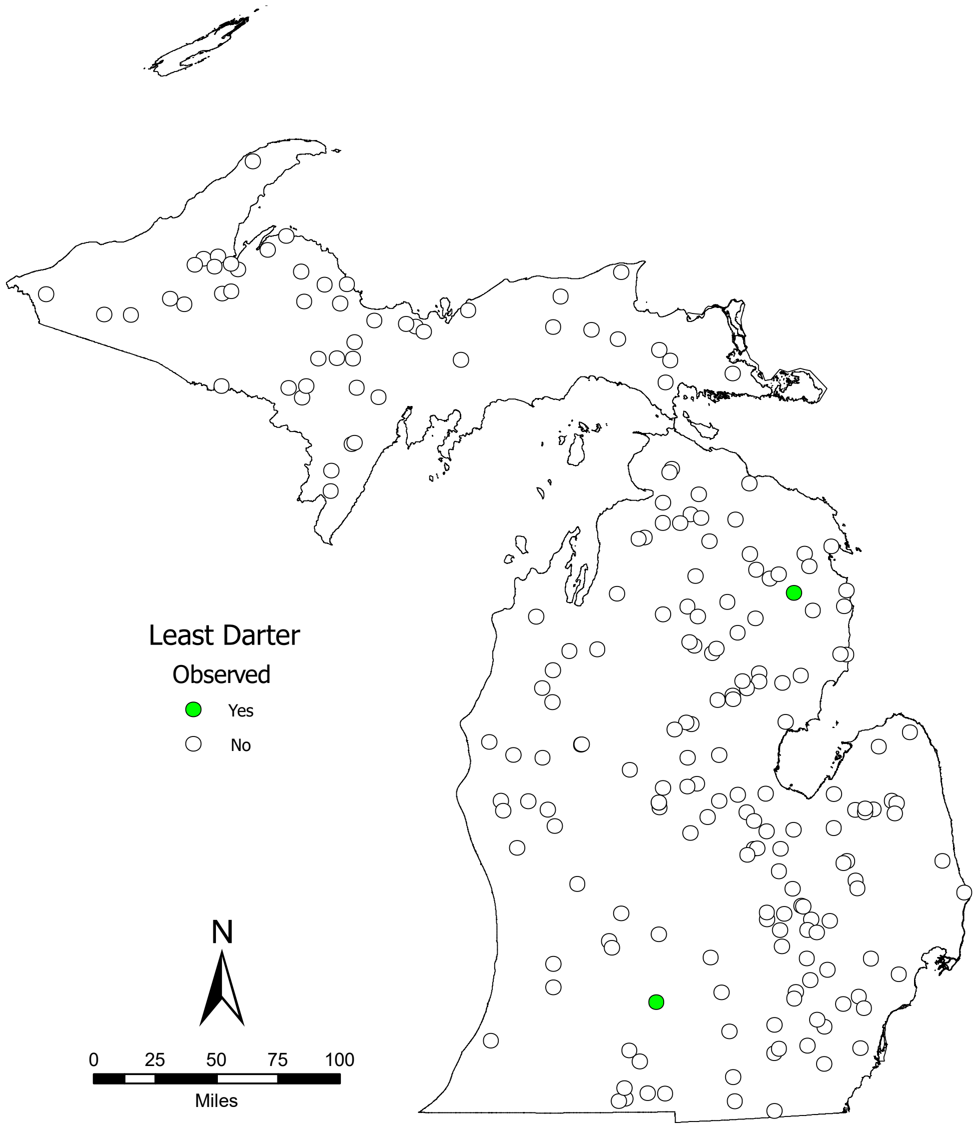

FIGURE A51. Map of distribution of Least Darter *Etheostoma microperca* at randomly sampled sites.

TABLE A51. Percentage of Least Darter *Etheostoma microperca* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	50	1
Medium	50	0	0	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	1	0	1	2

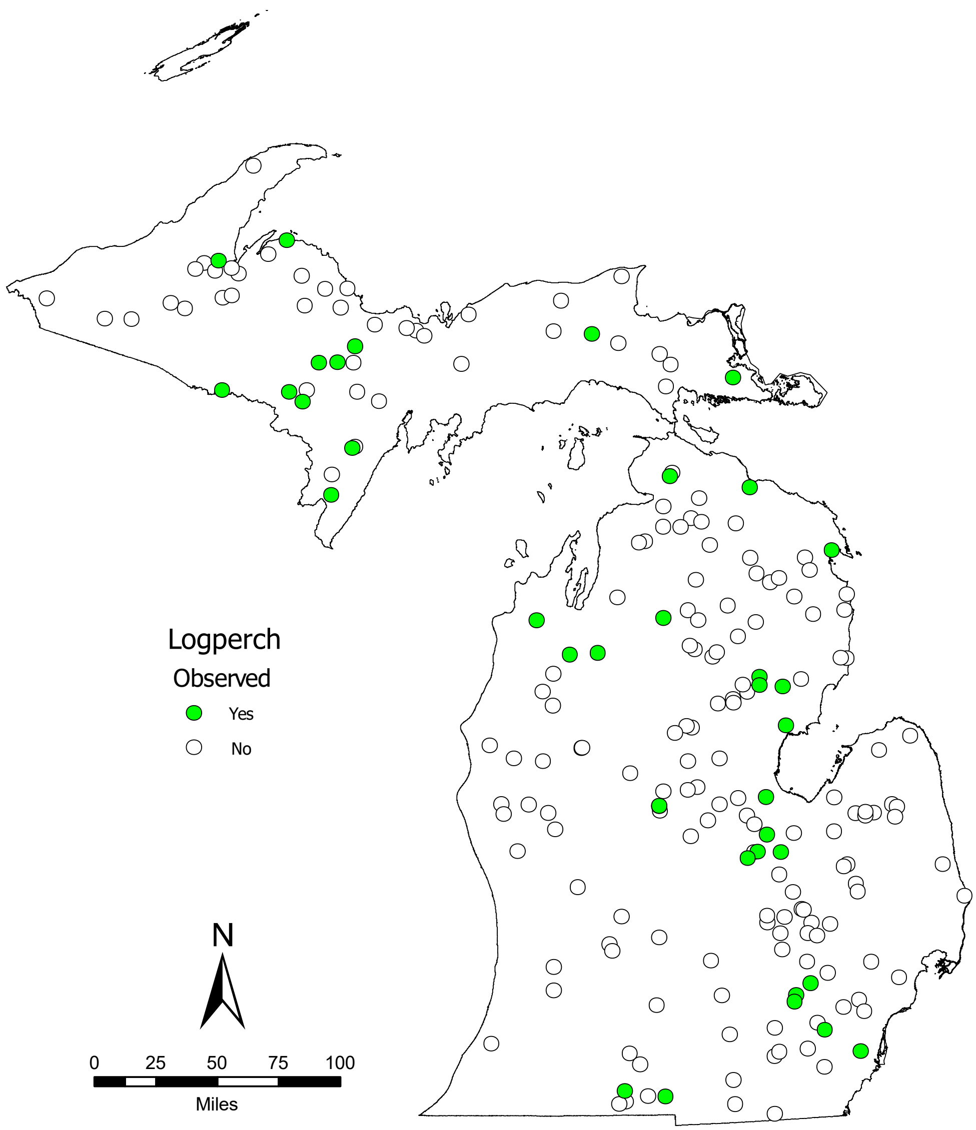

FIGURE A52. Map of distribution of Logperch *Percina caprodes* at randomly sampled sites.

TABLE A52. Percentage of Logperch *Percina caprodes* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	6	6	4
Medium	19	14	17	18
Large	6	11	6	8
Very Large	0	3	14	6
Total N	9	12	15	36

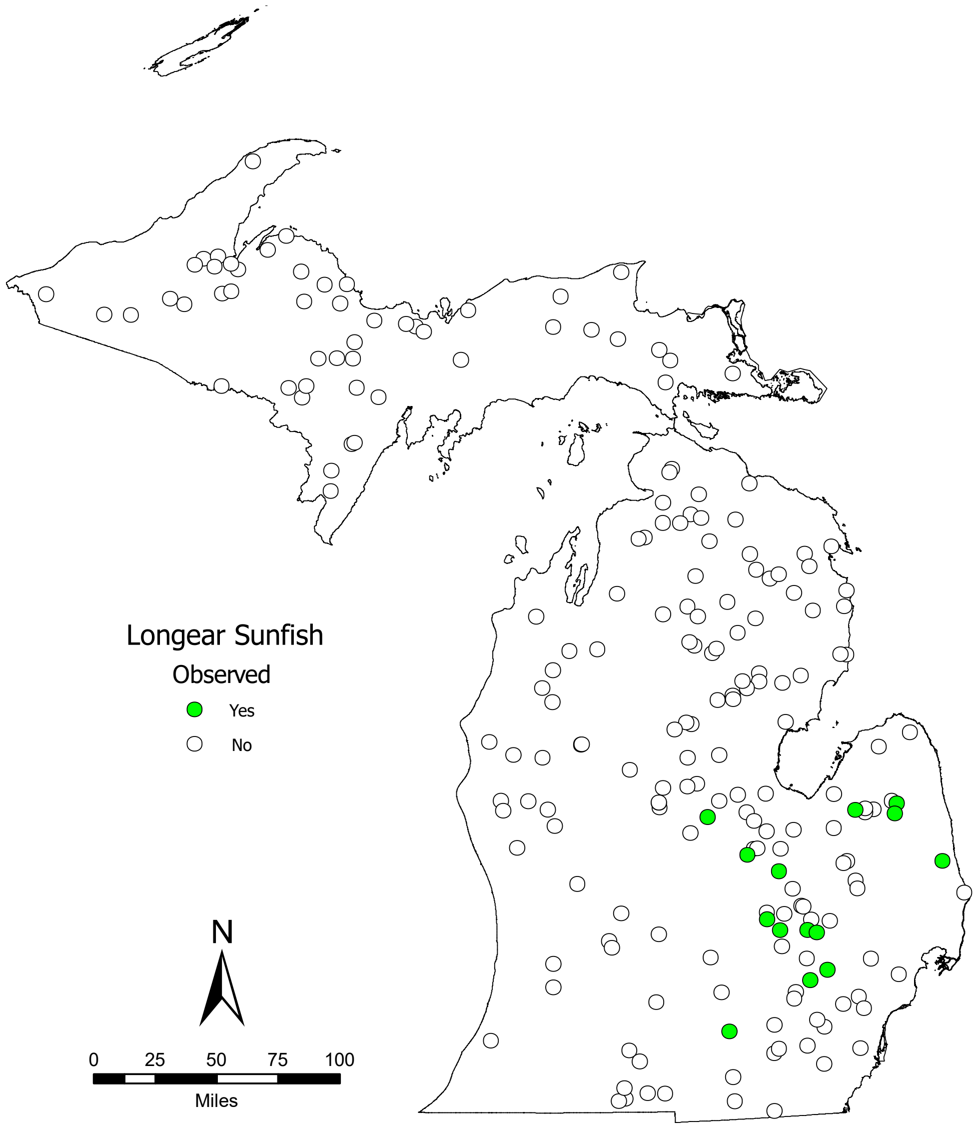

FIGURE A53. Map of distribution of Longear Sunfish *Lepomis megalotis* at randomly sampled sites.

TABLE A53. Percentage of Longear Sunfish *Lepomis megalotis* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	43	21	9
Large	0	14	21	5
Very Large	0	0	0	0
Total N	0	8	6	14

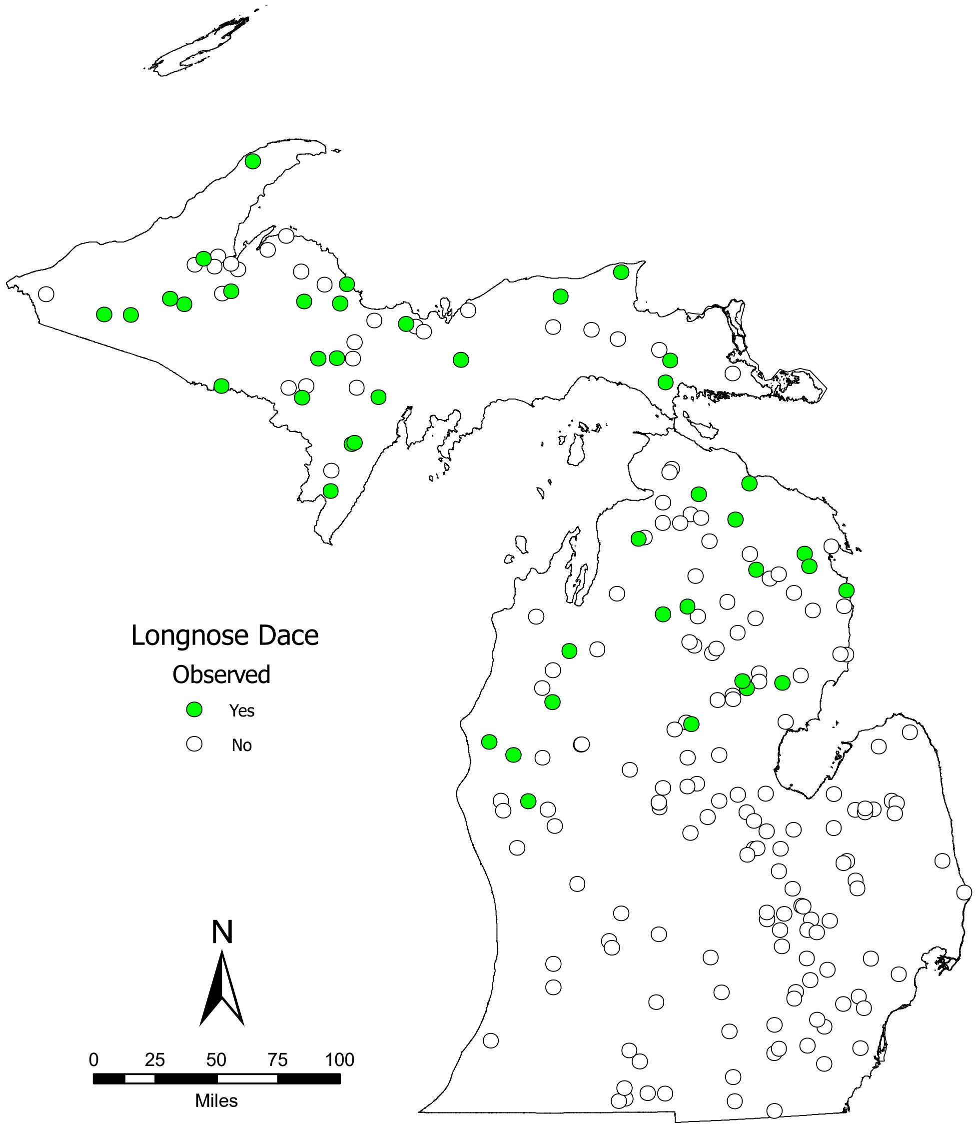

FIGURE A54. Map of distribution of Longnose Dace *Rhinichthys cataractae* at randomly sampled sites.

TABLE A54. Percentage of Longnose Dace *Rhinichthys cataractae* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	14	14	0	12
Medium	21	28	7	24
Large	7	7	0	6
Very Large	0	2	0	1
Total N	18	22	3	43

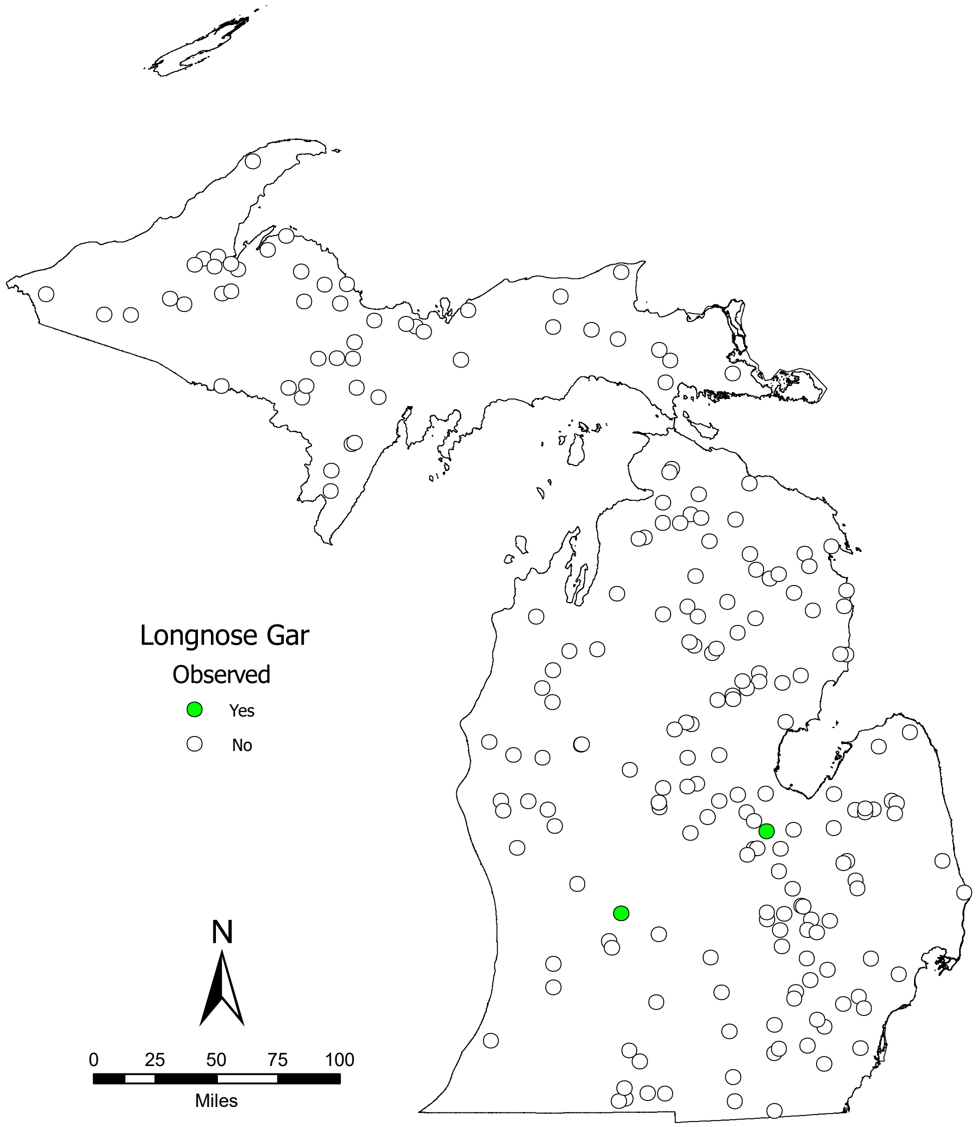

FIGURE A55. Map of distribution of Longnose Gar *Lepisosteus osseus* at randomly sampled sites.

TABLE A55. Percentage of Longnose Gar *Lepisosteus osseus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	100	2
Total N	0	0	2	2

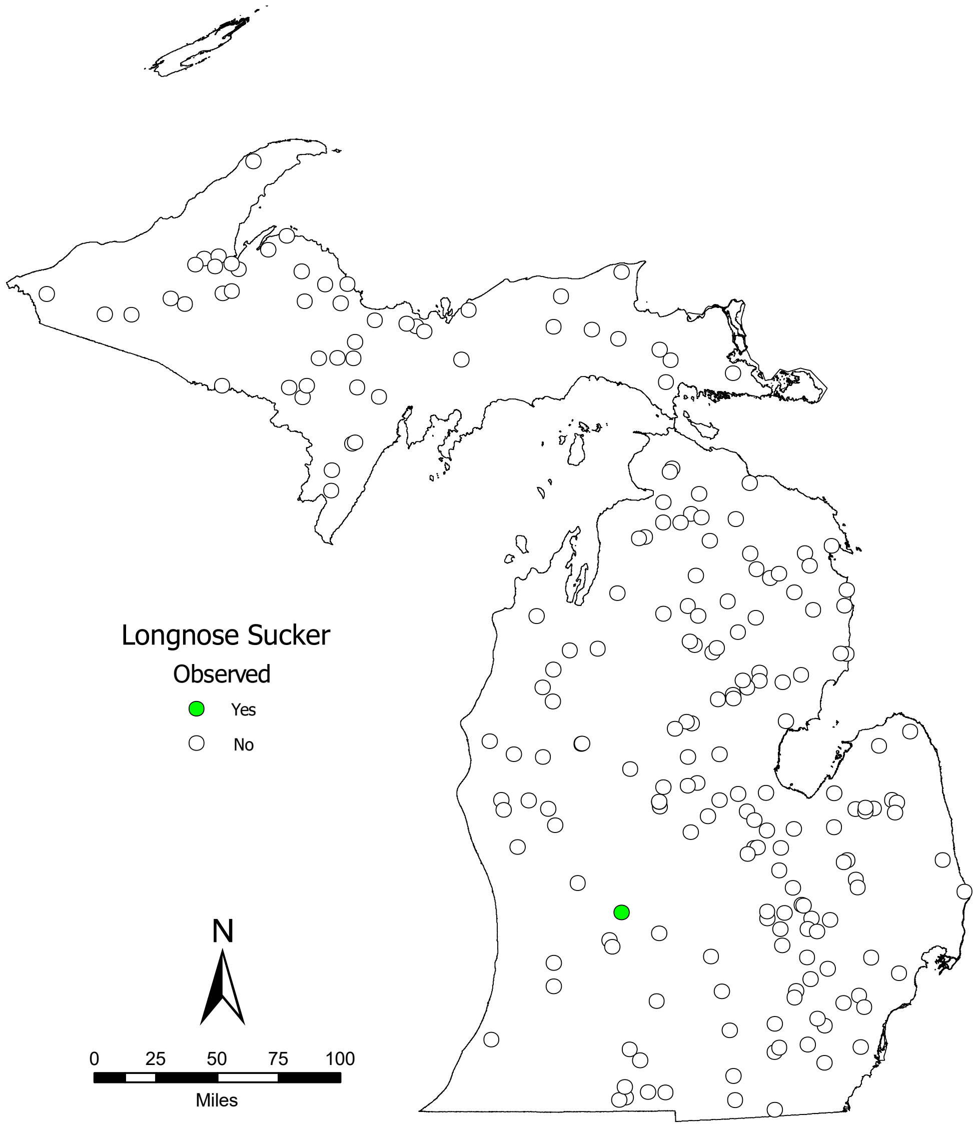

FIGURE A56. Map of distribution of Longnose Sucker *Catostomus catostomus* at randomly sampled sites.

TABLE A56. Percentage of Longnose Sucker *Catostomus catostomus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	100	1
Total N	0	0	1	1

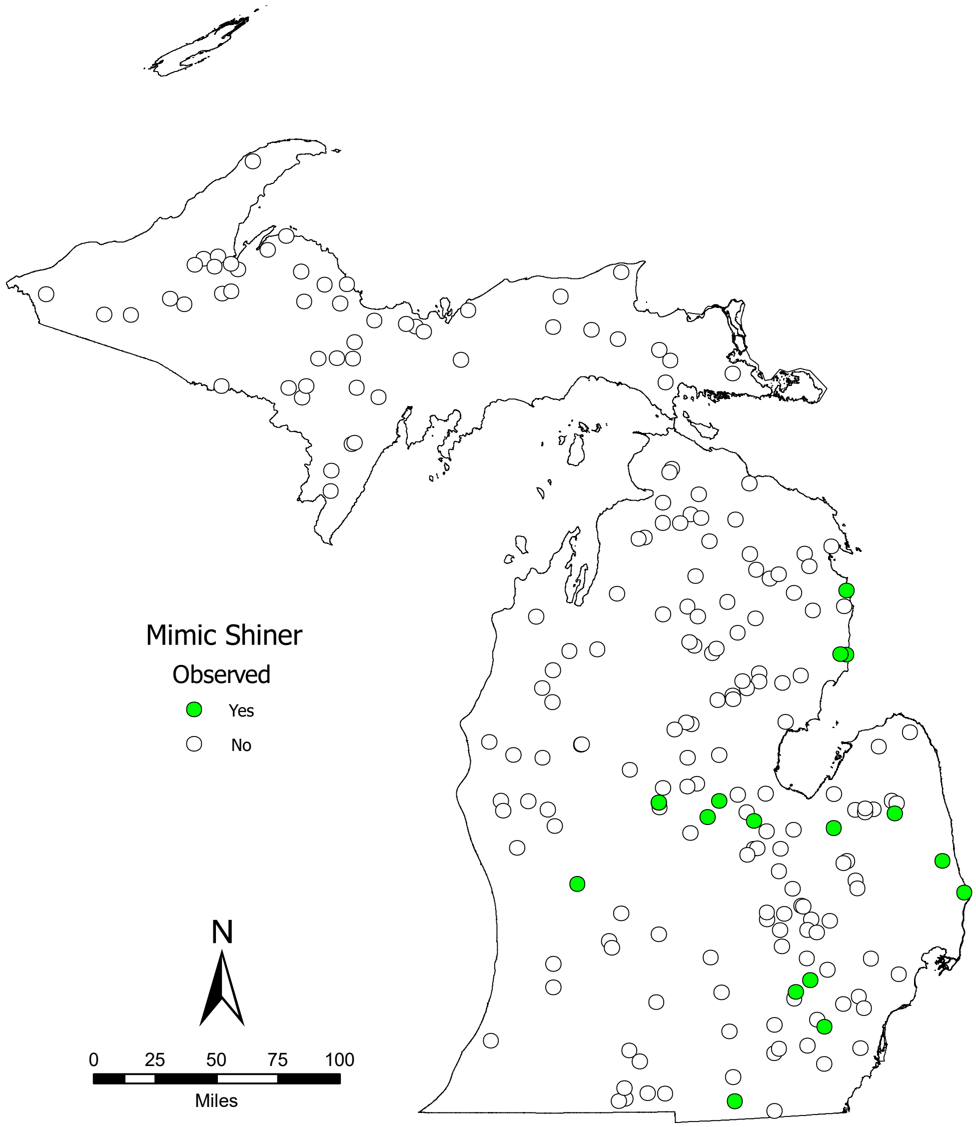

FIGURE A57. Map of distribution of Mimic Shiner *Notropis volucellus* at randomly sampled sites.

TABLE A57. Percentage of Mimic Shiner *Notropis volucellus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	6	0	1
Medium	13	0	13	4
Large	0	19	25	7
Very Large	0	6	19	4
Total N	2	5	9	16

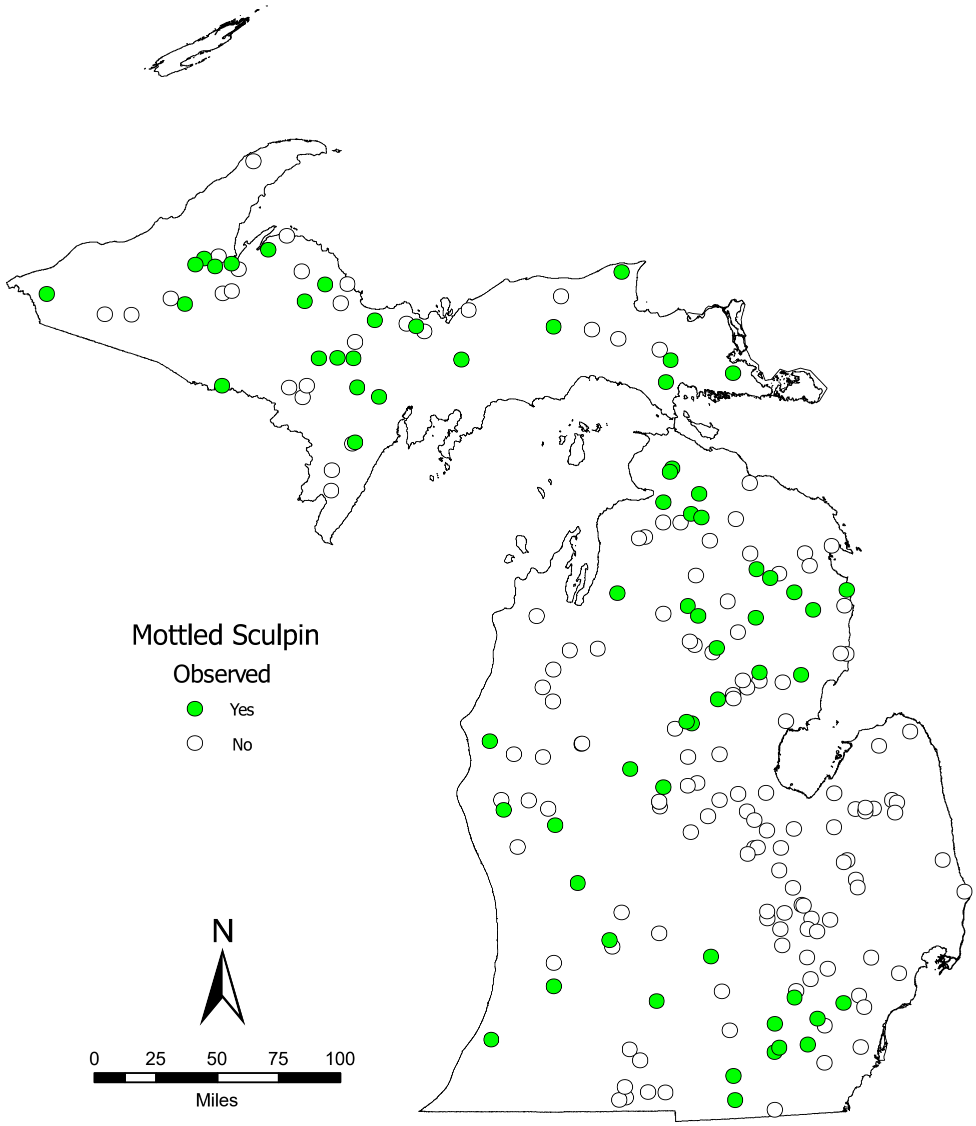

FIGURE A58. Map of distribution of Mottled Sculpin *Cottus bairdii* at randomly sampled sites.

TABLE A58. Percentage of Mottled Sculpin *Cottus bairdii* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	23	25	3	33
Medium	23	12	6	27
Large	2	3	0	3
Very Large	2	2	0	2
Total N	32	27	6	65

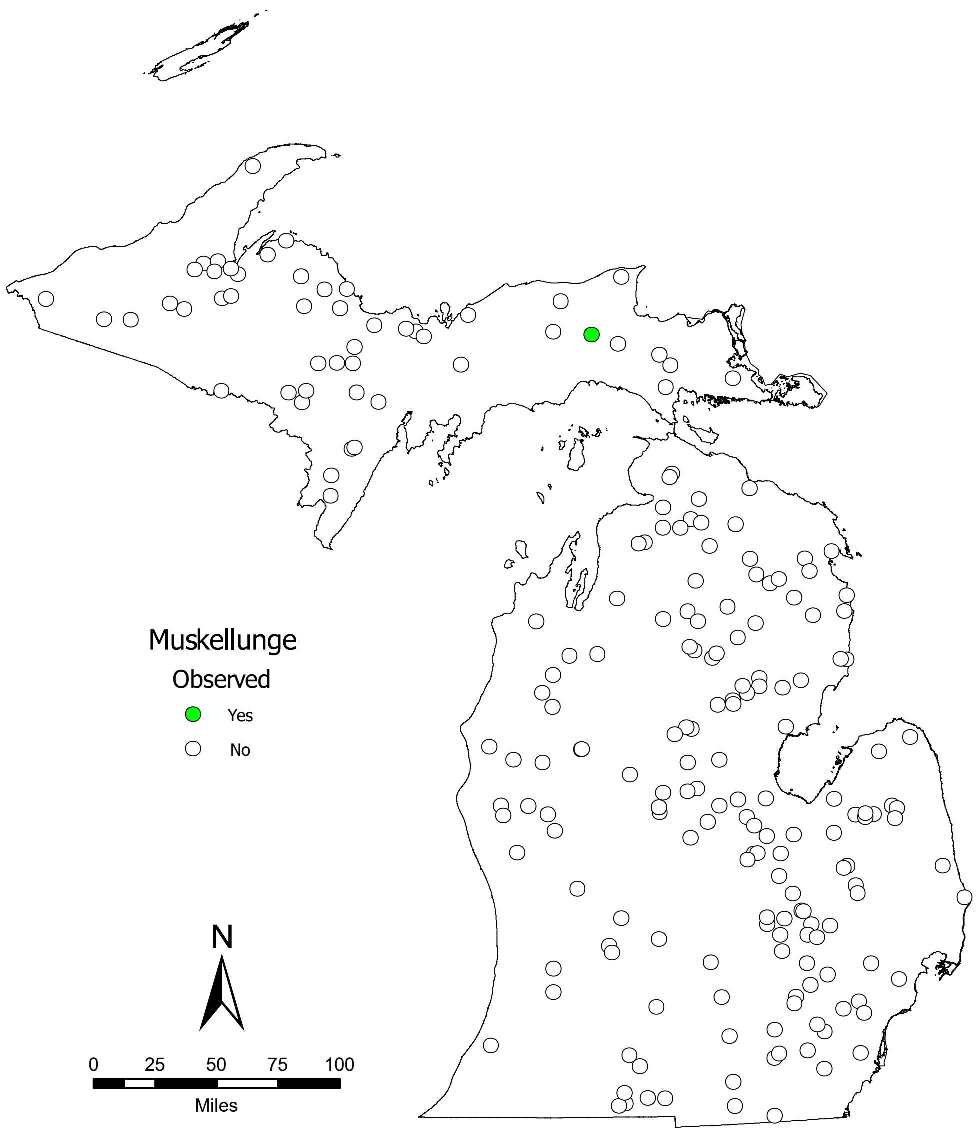

FIGURE A59. Map of distribution of Muskellunge *Esox masquinongy* at randomly sampled sites.

TABLE A59. Percentage of Muskellunge *Esox masquinongy* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	100	0	1
Total N	0	1	0	1

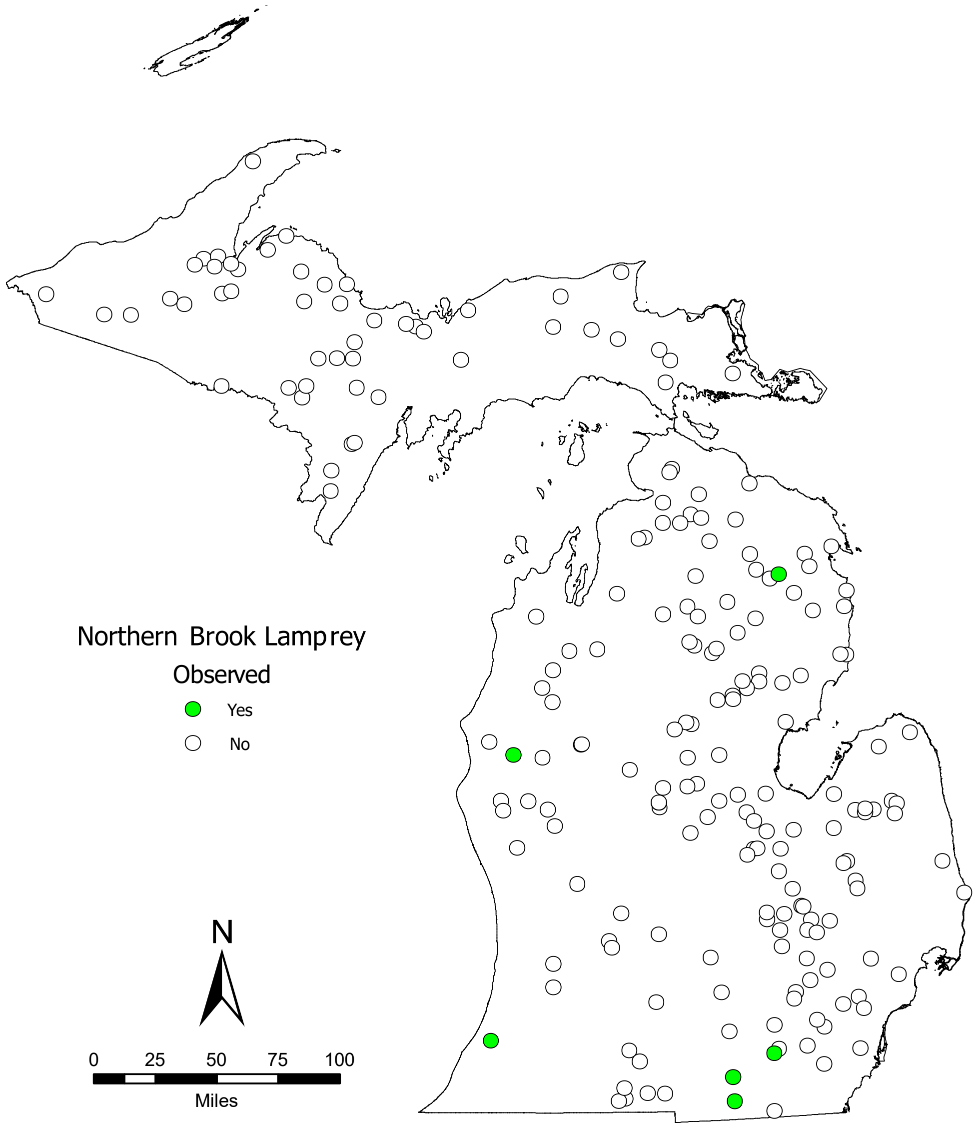

FIGURE A60. Map of distribution of Northern Brook Lamprey *Ichthyomyzon fossor* at randomly sampled sites.

TABLE A60. Percentage of Northern Brook Lamprey *Ichthyomyzon fossor* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	33	50	0	5
Medium	0	0	0	0
Large	0	17	0	1
Very Large	0	0	0	0
Total N	2	4	0	6

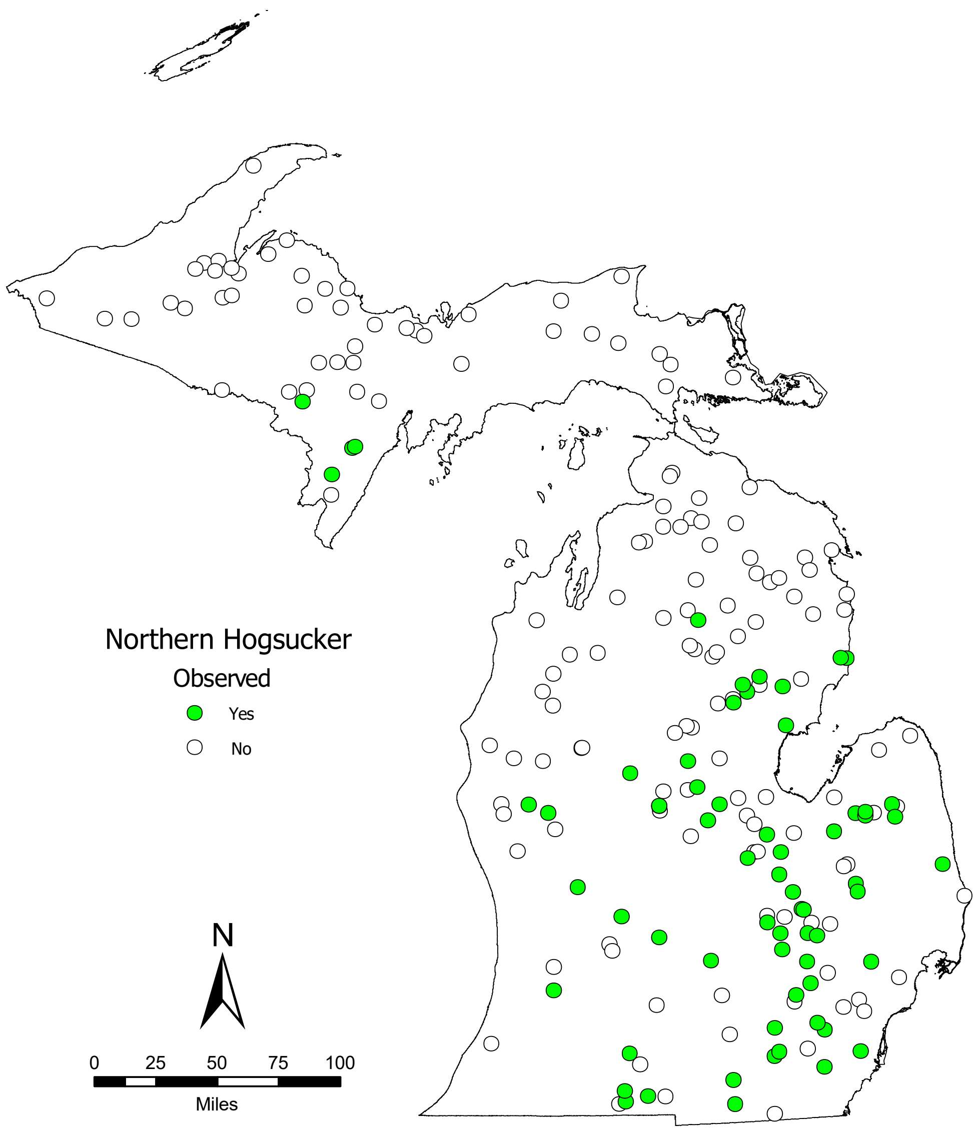

FIGURE A61. Map of distribution of Northern Hogsucker *Hypentelium nigricans* at randomly sampled sites.

TABLE A61. Percentage of Northern Hogsucker *Hypentelium nigricans* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	2	11	5	12
Medium	8	25	17	32
Large	0	9	8	11
Very Large	2	2	12	10
Total N	8	30	27	65

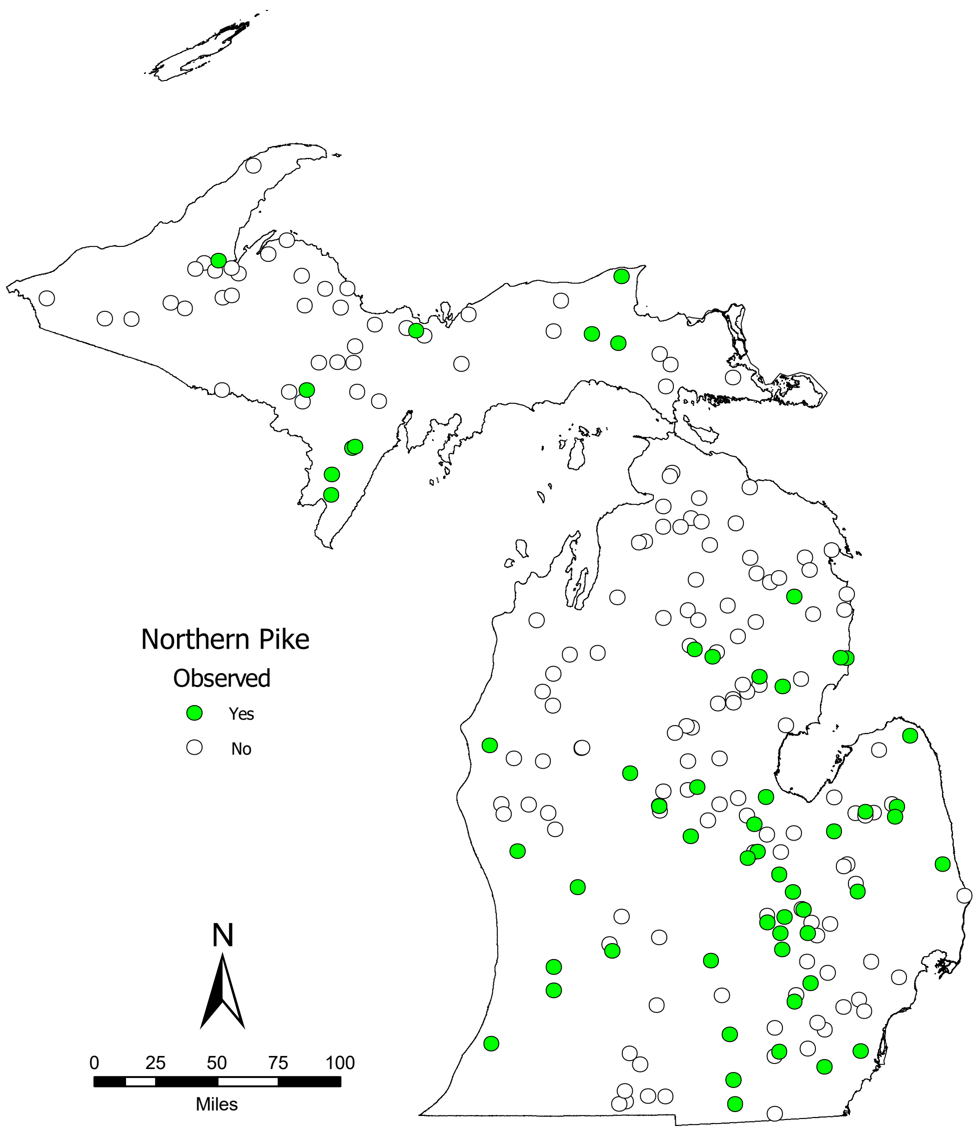

FIGURE A62. Map of distribution of Northern Pike *Esox lucius* at randomly sampled sites.

TABLE A62. Percentage of Northern Pike *Esox lucius* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	7	12	4	13
Medium	9	21	23	30
Large	0	9	5	8
Very Large	0	5	5	6
Total N	9	27	21	57

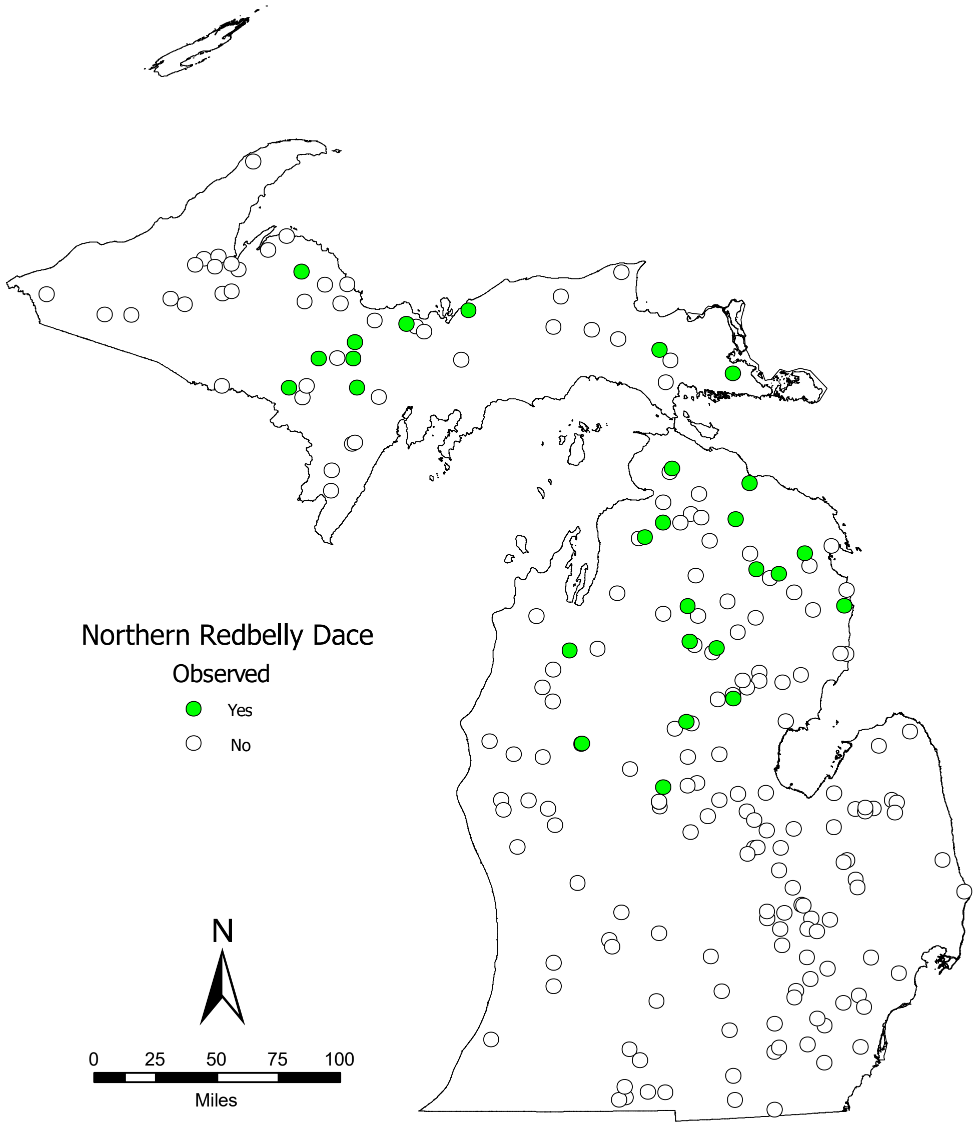

FIGURE A63. Map of distribution of Northern Redbelly Dace *Chrosomus eos* at randomly sampled sites.

TABLE A63. Percentage of Northern Redbelly Dace *Chrosomus eos* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	37	15	0	14
Medium	26	15	4	12
Large	0	4	0	1
Very Large	0	0	0	0
Total N	17	9	1	27

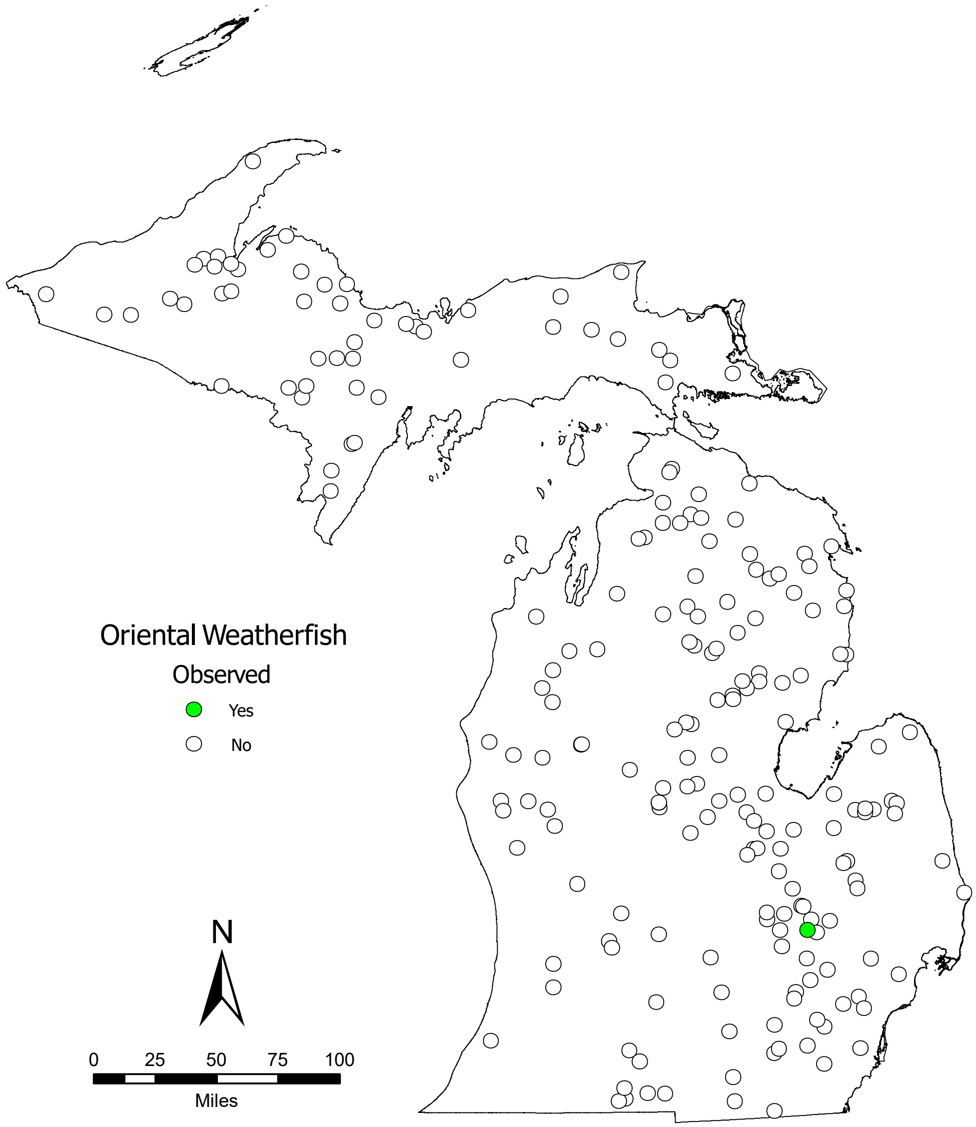

FIGURE A64. Map of distribution of Oriental Weatherfish *Misgurnus anguillicaudatus* at randomly sampled sites.

TABLE A64. Percentage of Oriental Weatherfish *Misgurnus anguillicaudatus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	100	0	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	1	0	1

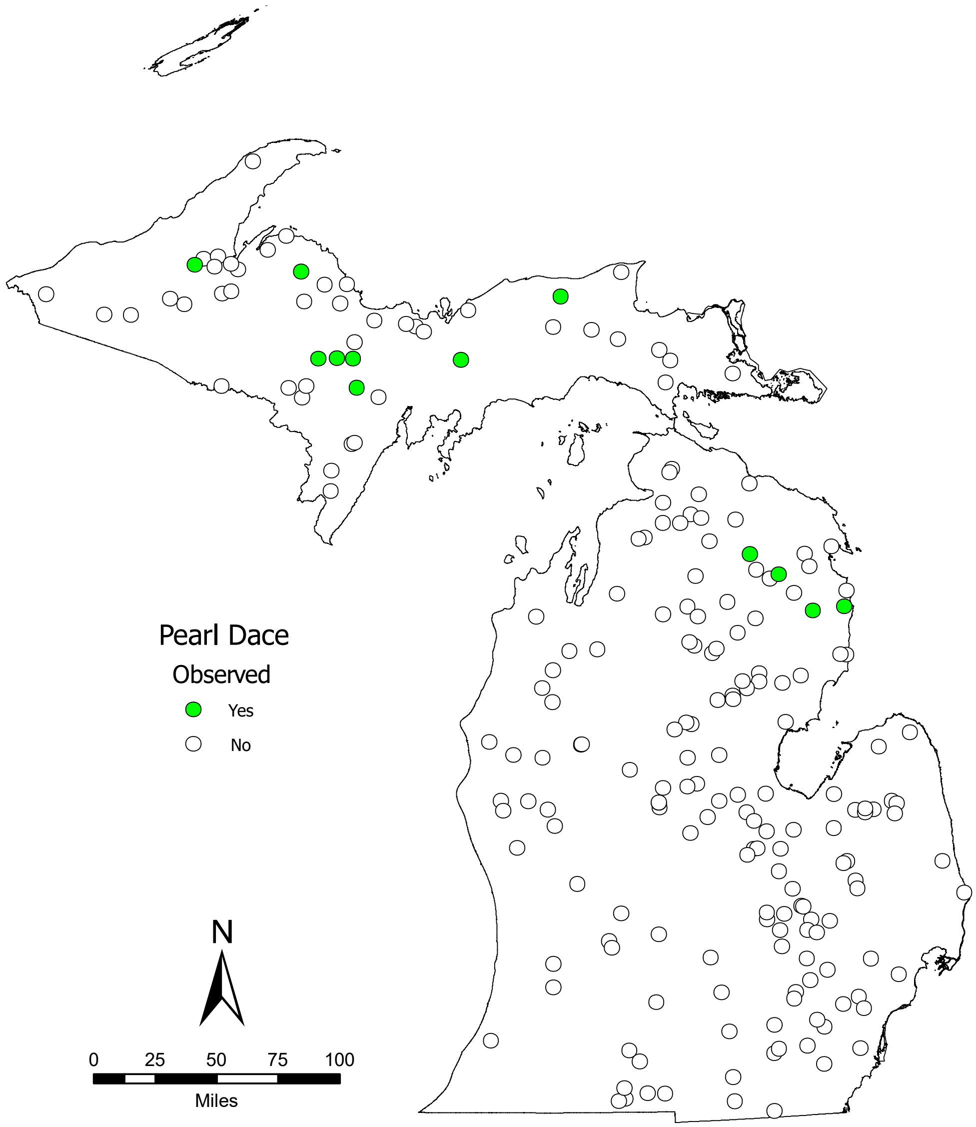

FIGURE A65. Map of distribution of Pearl Dace *Margariscus margarita* at randomly sampled sites.

TABLE A65. Percentage of Pearl Dace *Margariscus margarita* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	58	17	0	9
Medium	8	17	0	3
Large	0	0	0	0
Very Large	0	0	0	0
Total N	8	4	0	12

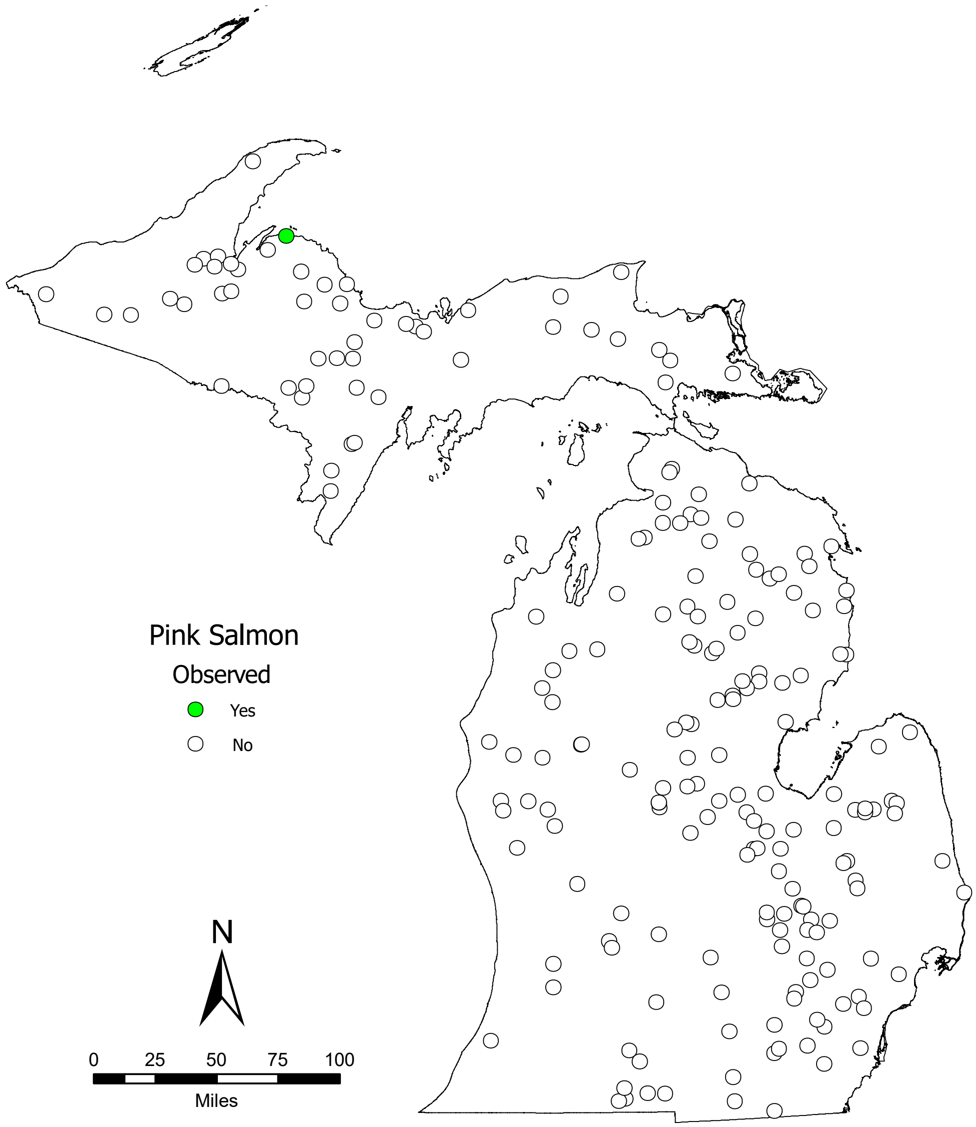

FIGURE A66. Map of distribution of Pink Salmon *Oncorhynchus gorbuscha* at randomly sampled sites.

TABLE A66. Percentage of Pink Salmon *Oncorhynchus gorbuscha* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	100	0	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	1	0	1

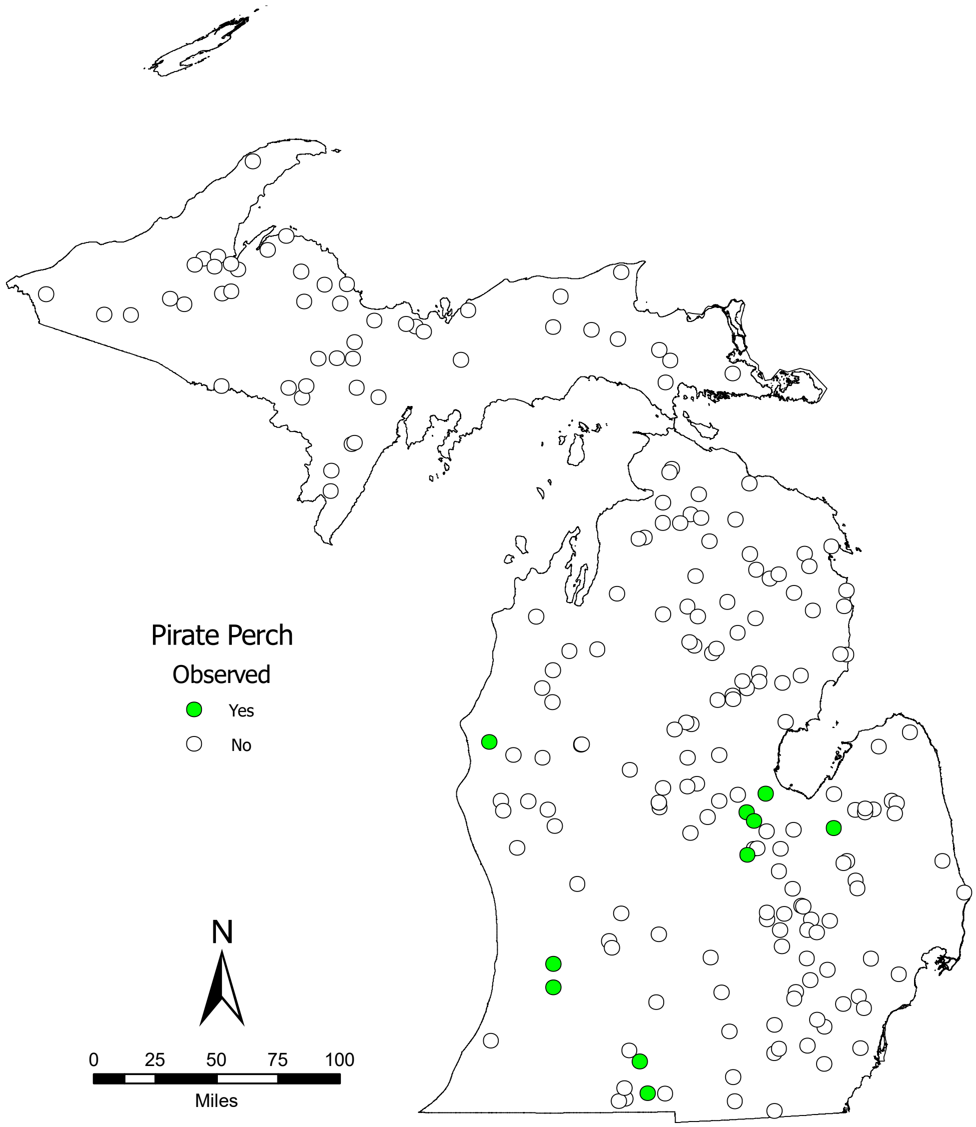

FIGURE A67. Map of distribution of Pirate Perch *Aphredoderus sayanus* at randomly sampled sites.

TABLE A67. Percentage of Pirate Perch *Aphredoderus sayanus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	20	20	4
Medium	0	10	30	4
Large	0	0	0	0
Very Large	0	10	10	2
Total N	0	4	6	10

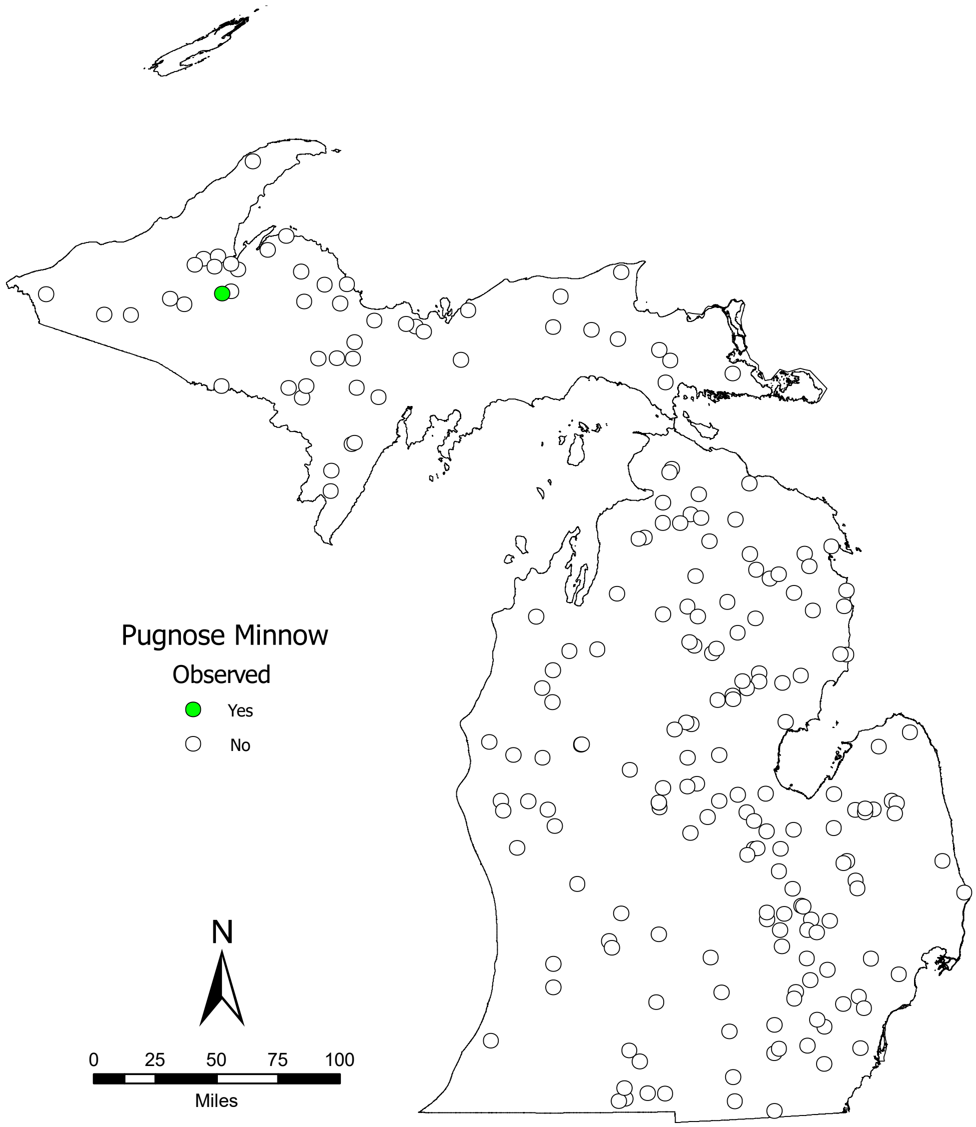

FIGURE A68. Map of distribution of Pugnose Minnow *Opsopoeodus emiliae* at randomly sampled sites. Pugnose Minnow are a Michigan endangered species.

TABLE A68. Percentage of Pugnose Minnow *Opsopoeodus emiliae* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	100	0	1
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	1	0	1

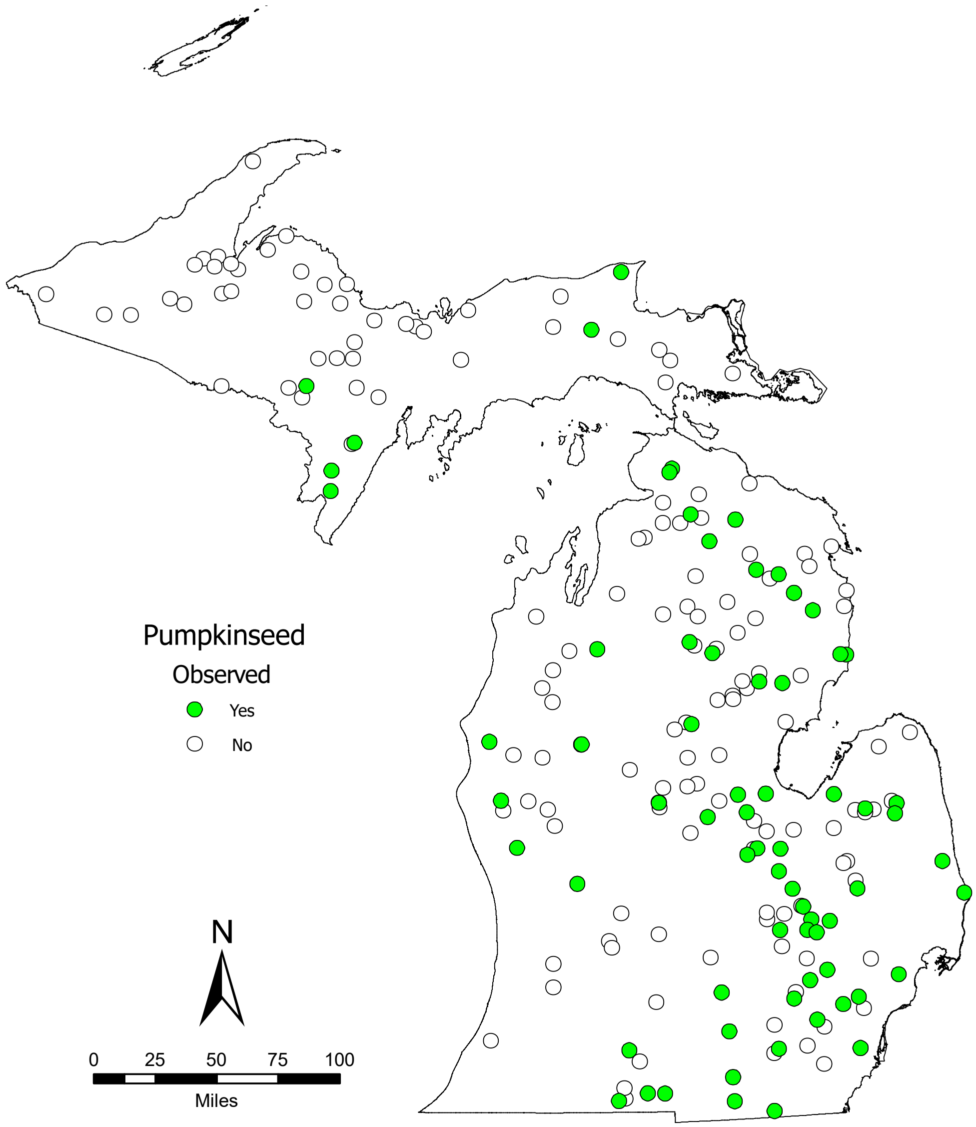

FIGURE A69. Map of distribution of Pumpkinseed *Lepomis gibbosus* at randomly sampled sites.

TABLE A69. Percentage of Pumpkinseed *Lepomis gibbosus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	11	10	10	22
Medium	13	23	11	33
Large	0	7	4	8
Very Large	0	4	7	8
Total N	17	31	23	71

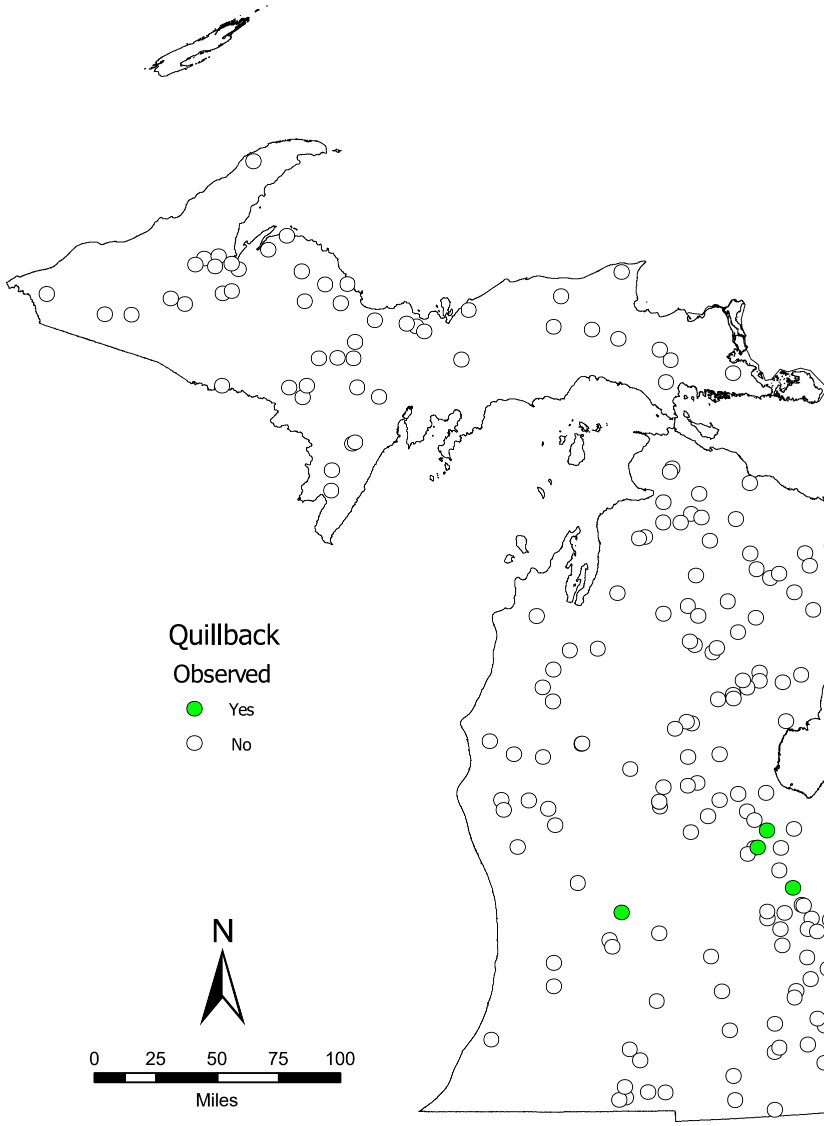

FIGURE A70. Map of distribution of Quillback *Carpiodes cyprinus* at randomly sampled sites.

TABLE A70. Percentage of Quillback *Carpiodes cyprinus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	20	1
Very Large	0	0	80	4
Total N	0	0	5	5

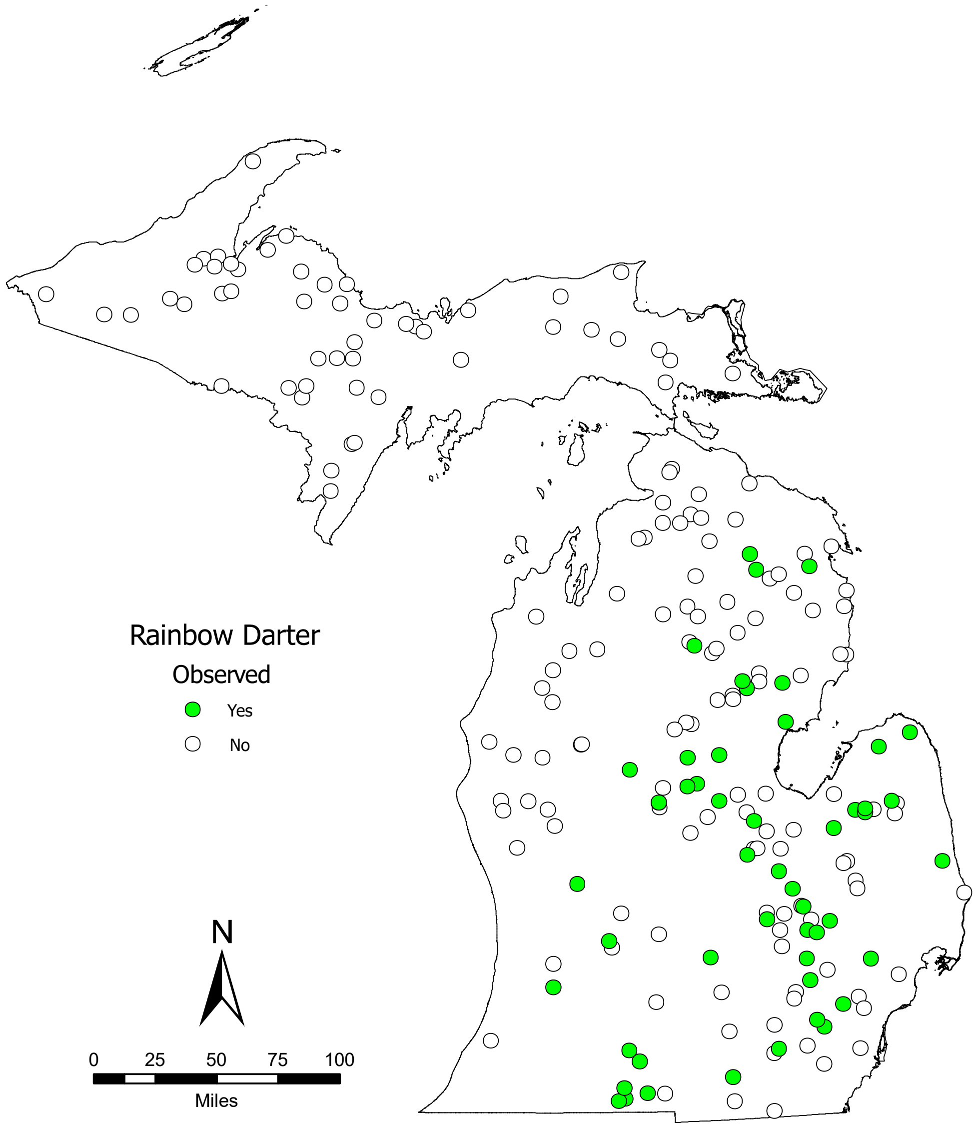

FIGURE A71. Map of distribution of Rainbow Darter *Etheostoma caeruleum* at randomly sampled sites.

TABLE A71. Percentage of Rainbow Darter *Etheostoma caeruleum* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	6	8	8	11
Medium	4	29	20	27
Large	0	14	6	10
Very Large	0	0	6	3
Total N	5	26	20	51

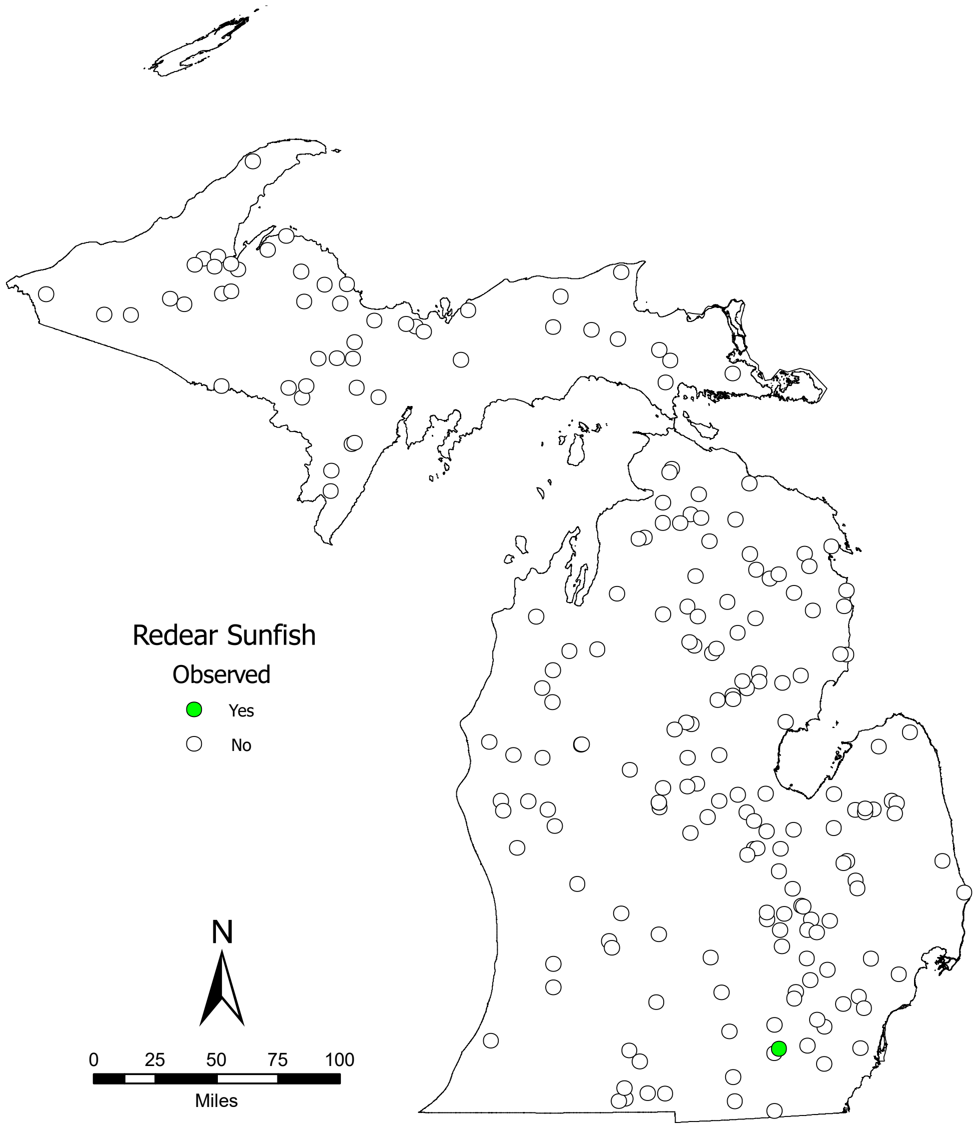

FIGURE A72. Map of distribution of Redear Sunfish *Lepomis microlophus* at randomly sampled sites.

TABLE A72. Percentage of Redear Sunfish *Lepomis microlophus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	100	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	0	1	1

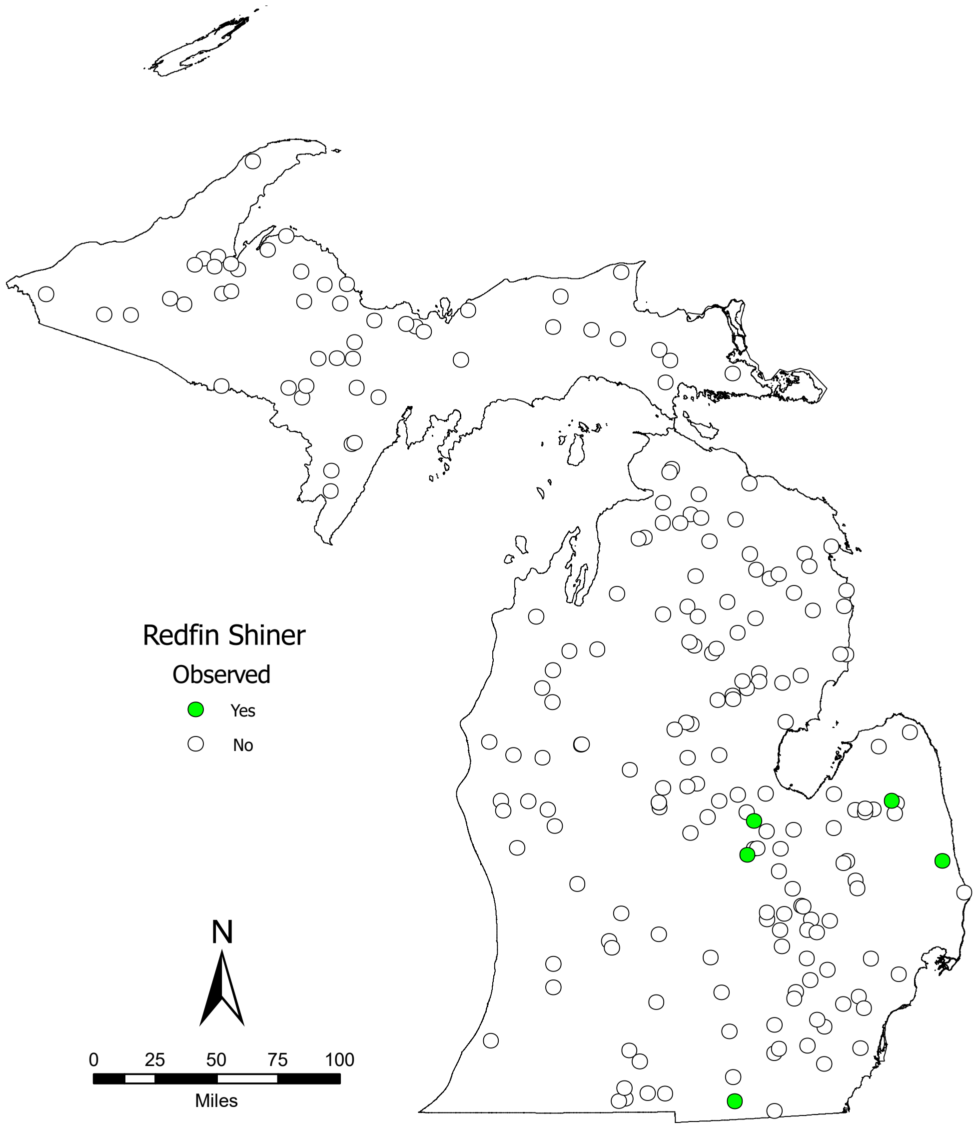

FIGURE A73. Map of distribution of Redfin Shiner *Lythrurus umbratilis* at randomly sampled sites.

TABLE A73. Percentage of Redfin Shiner *Lythrurus umbratilis* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	20	20	2
Medium	0	0	40	2
Large	0	0	20	1
Very Large	0	0	0	0
Total N	0	1	4	5

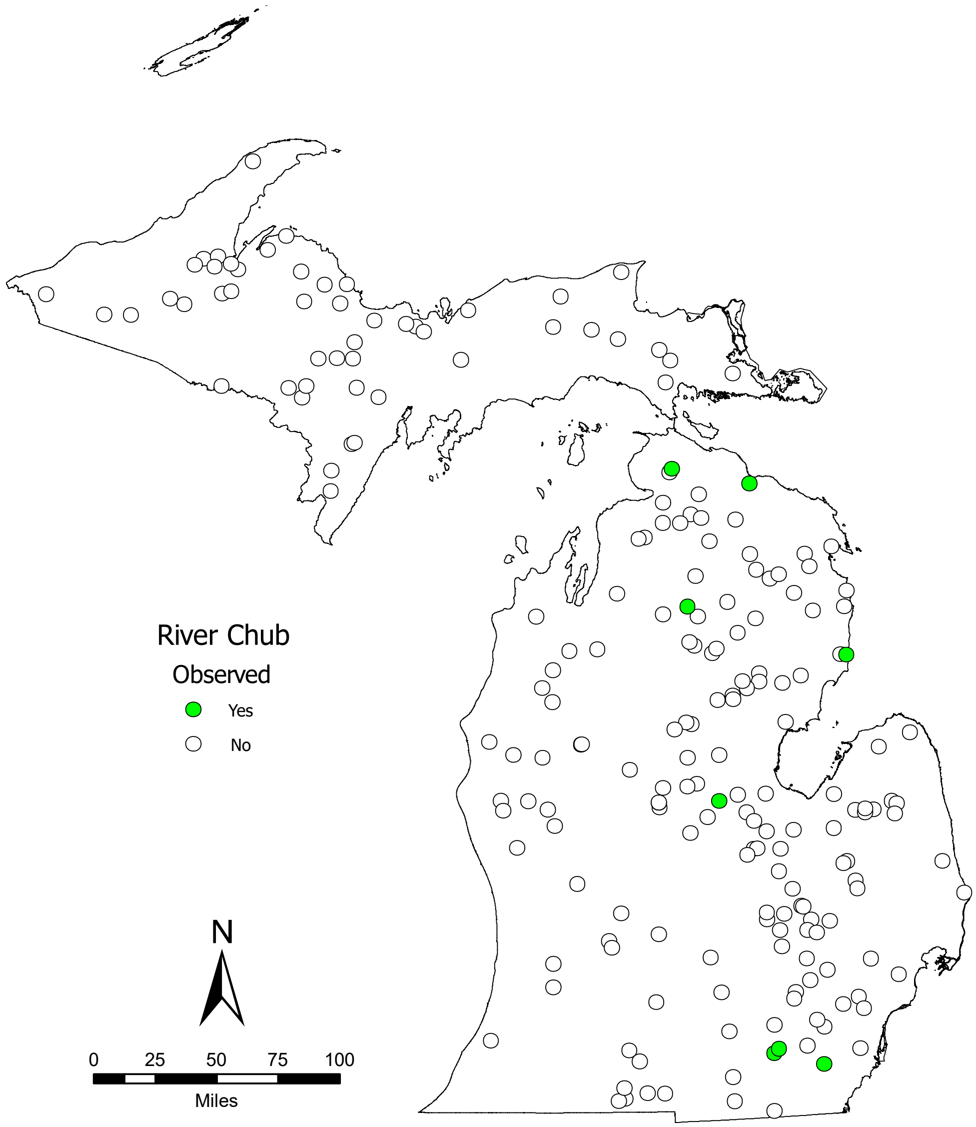

FIGURE A74. Map of distribution of River Chub *Nocomis micropogon* at randomly sampled sites.

TABLE A74. Percentage of River Chub *Nocomis micropogon* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	13	0	1
Medium	13	25	25	5
Large	0	13	13	2
Very Large	0	0	0	0
Total N	1	4	3	8

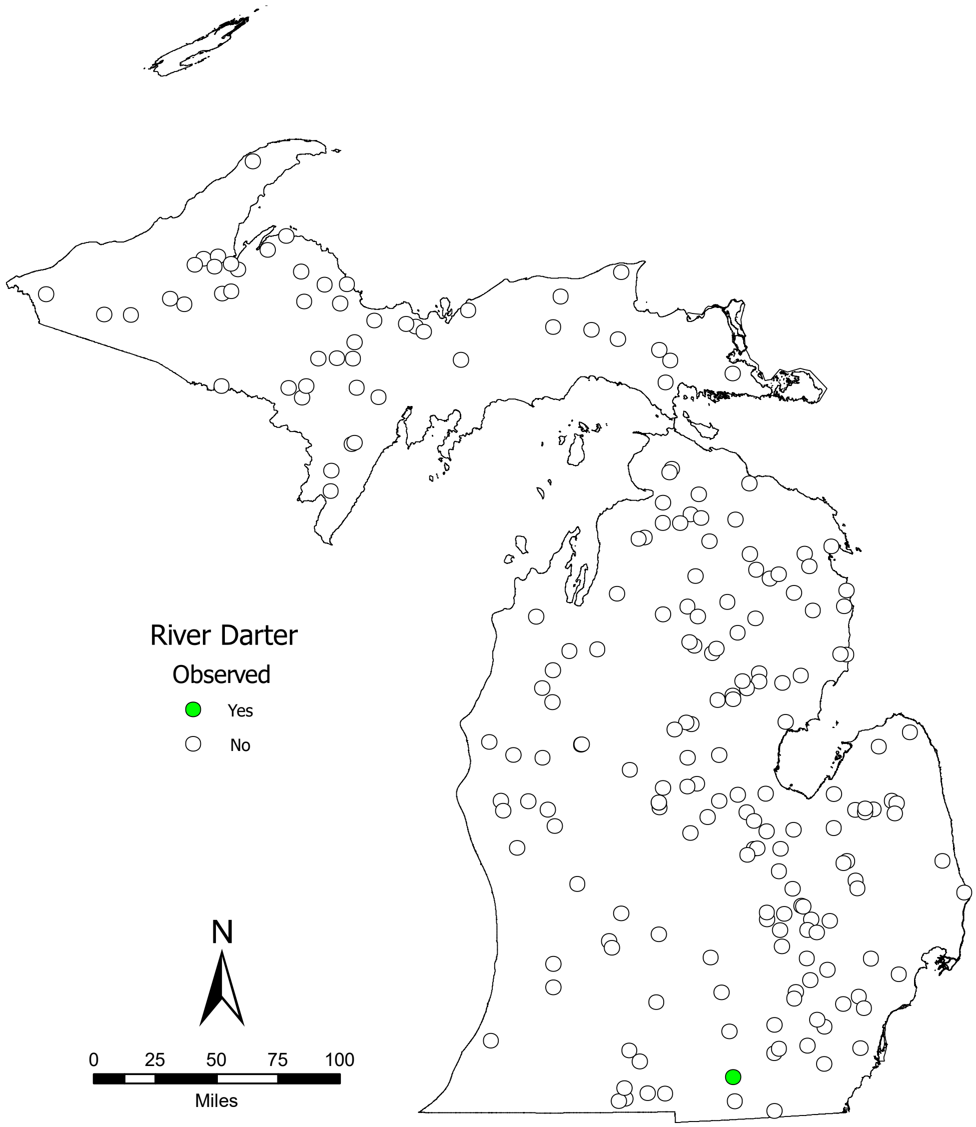

FIGURE A75. Map of distribution of River Darter *Percina shumardi* at randomly sampled sites. River Darter are a Michigan endangered species.

TABLE A75. Percentage of River Darter *Percina shumardi* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	100	0	1
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	1	0	1

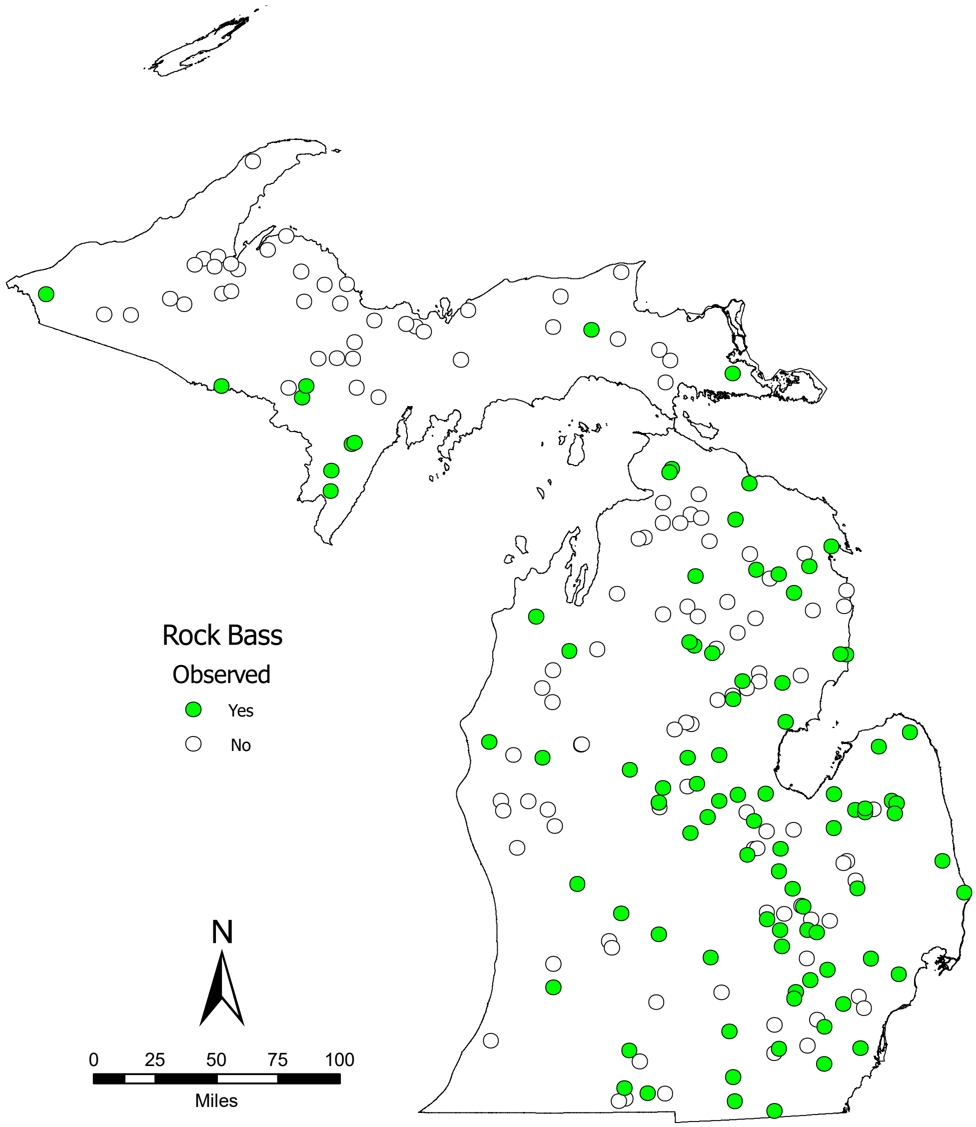

FIGURE A76. Map of distribution of Rock Bass *Ambloplites rupestris* at randomly sampled sites.

TABLE A76. Percentage of Rock Bass *Ambloplites rupestris* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	3	4	8	14
Medium	12	24	17	49
Large	1	11	5	16
Very Large	0	3	11	13
Total N	15	39	38	92

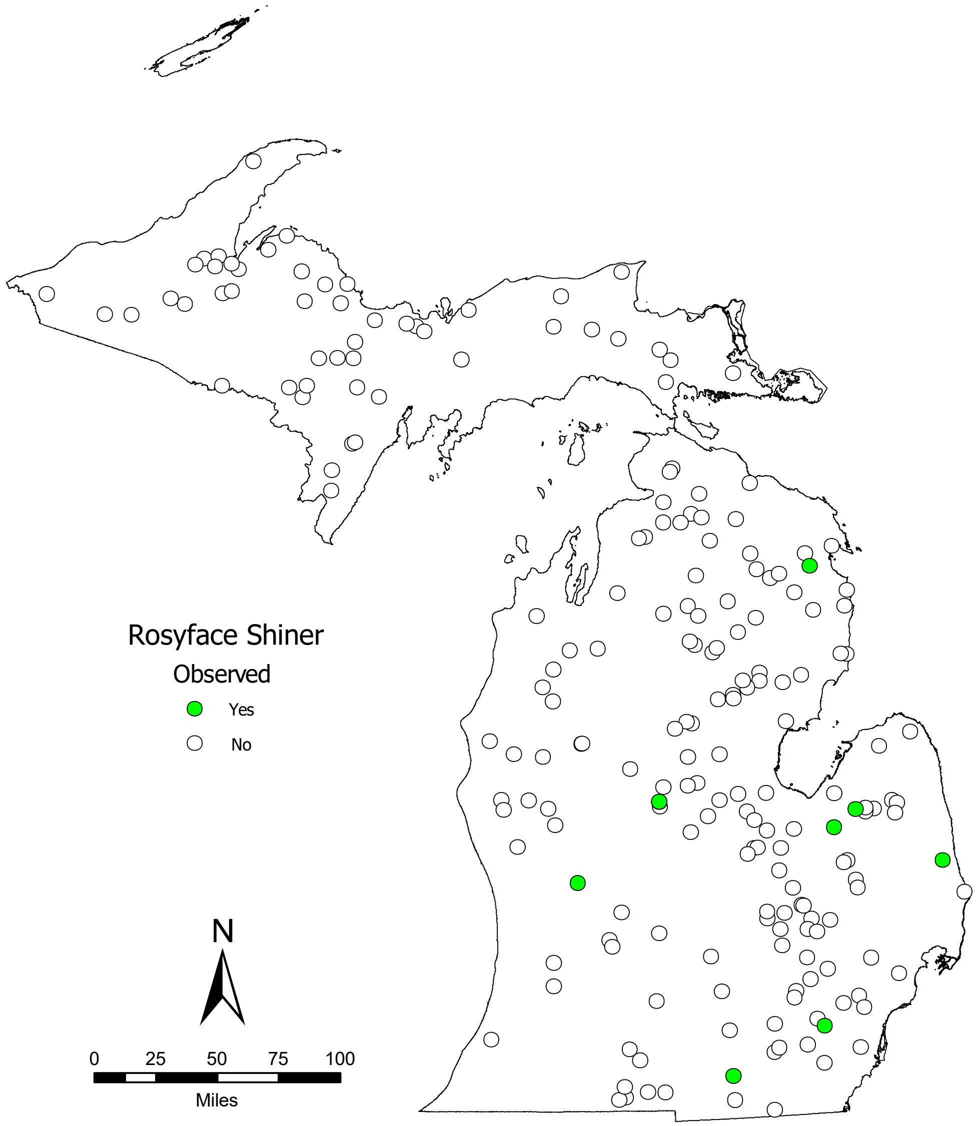

FIGURE A77. Map of distribution of Rosyface Shiner *Notropis rubellus* at randomly sampled sites.

TABLE A77. Percentage of Rosyface Shiner *Notropis rubellus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	11	0	1
Medium	11	11	0	2
Large	0	33	11	4
Very Large	0	0	22	2
Total N	1	5	3	9

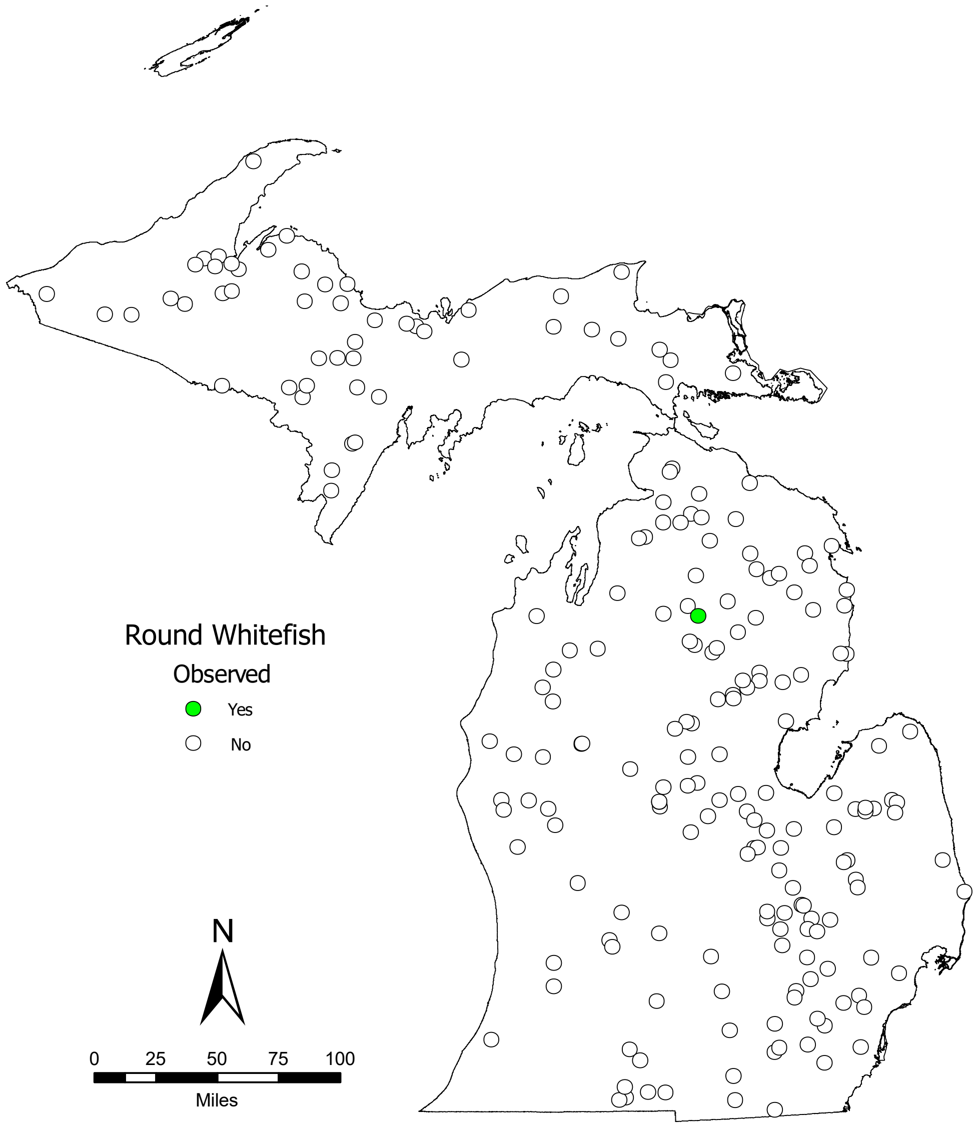

FIGURE A78. Map of distribution of Round Whitefish *Prosopium cylindraceum* at randomly sampled sites.

TABLE A78. Percentage of Round Whitefish *Prosopium cylindraceum* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0
Very Large	100	0	0	1
Total N	1	0	0	1

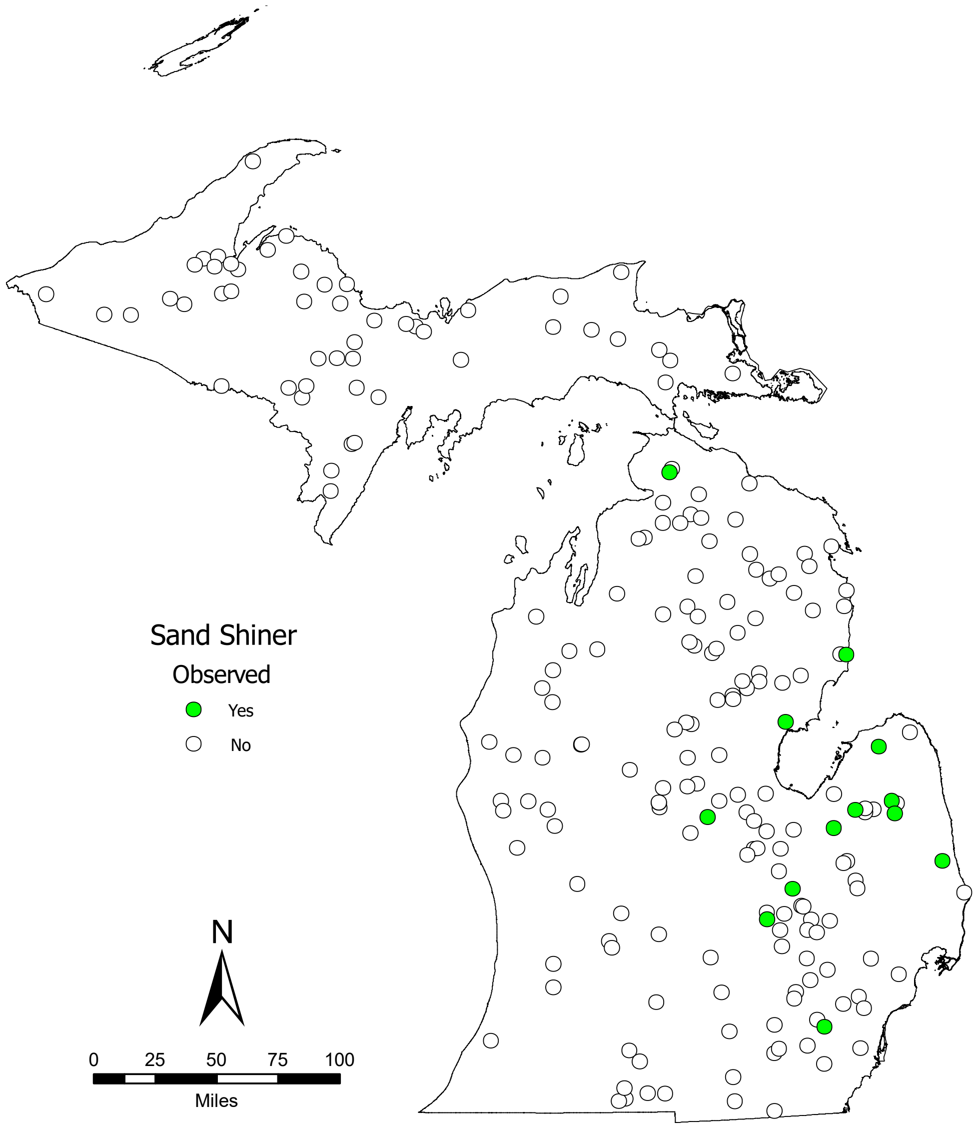

FIGURE A79. Map of distribution of Sand Shiner *Notropis stramineus* at randomly sampled sites.

TABLE A79. Percentage of Sand Shiner *Notropis stramineus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	15	2
Medium	8	8	8	3
Large	0	15	23	5
Very Large	0	0	23	3
Total N	1	3	9	13

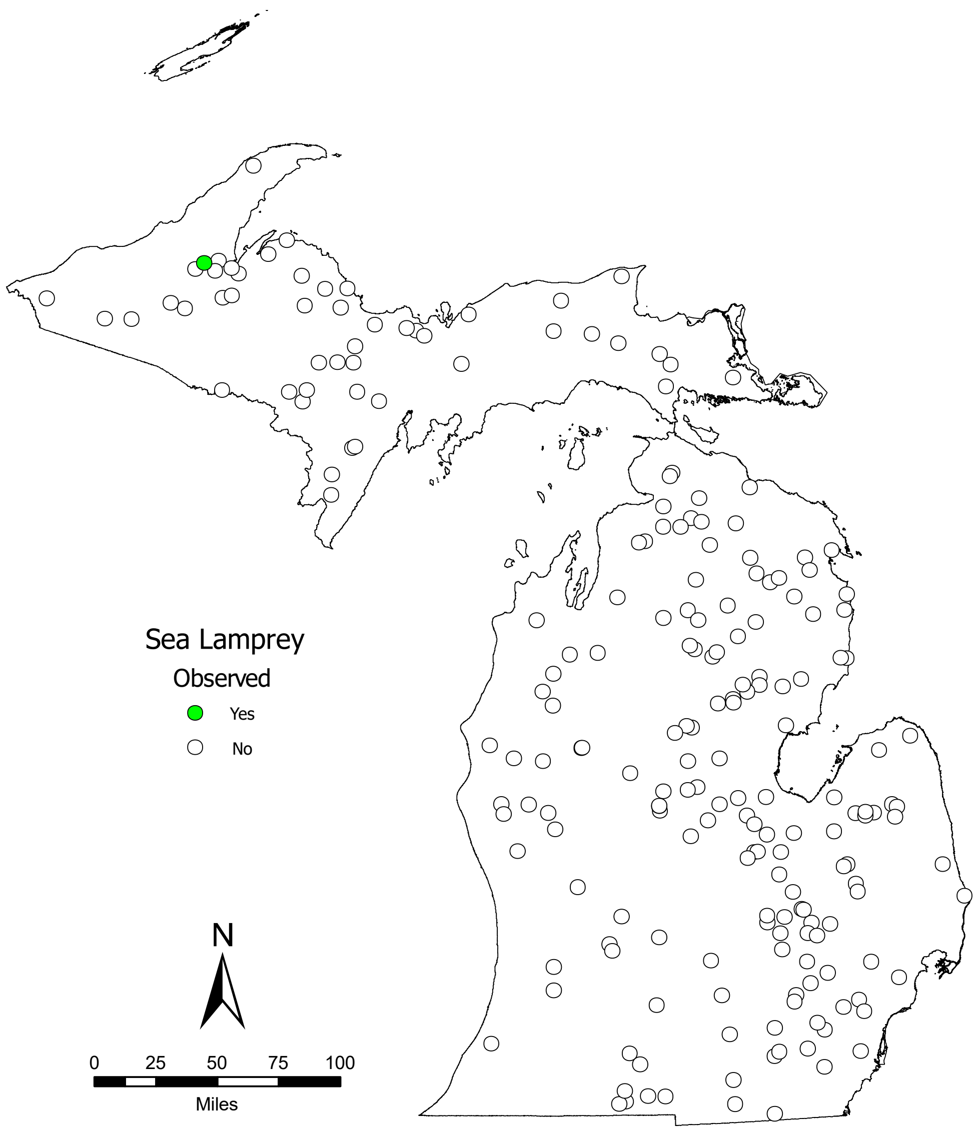

FIGURE A80. Map of distribution of Sea Lamprey *Petromyzon marinus* at randomly sampled sites.

TABLE A80. Percentage of Sea Lamprey *Petromyzon marinus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	100	0	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	1	0	1

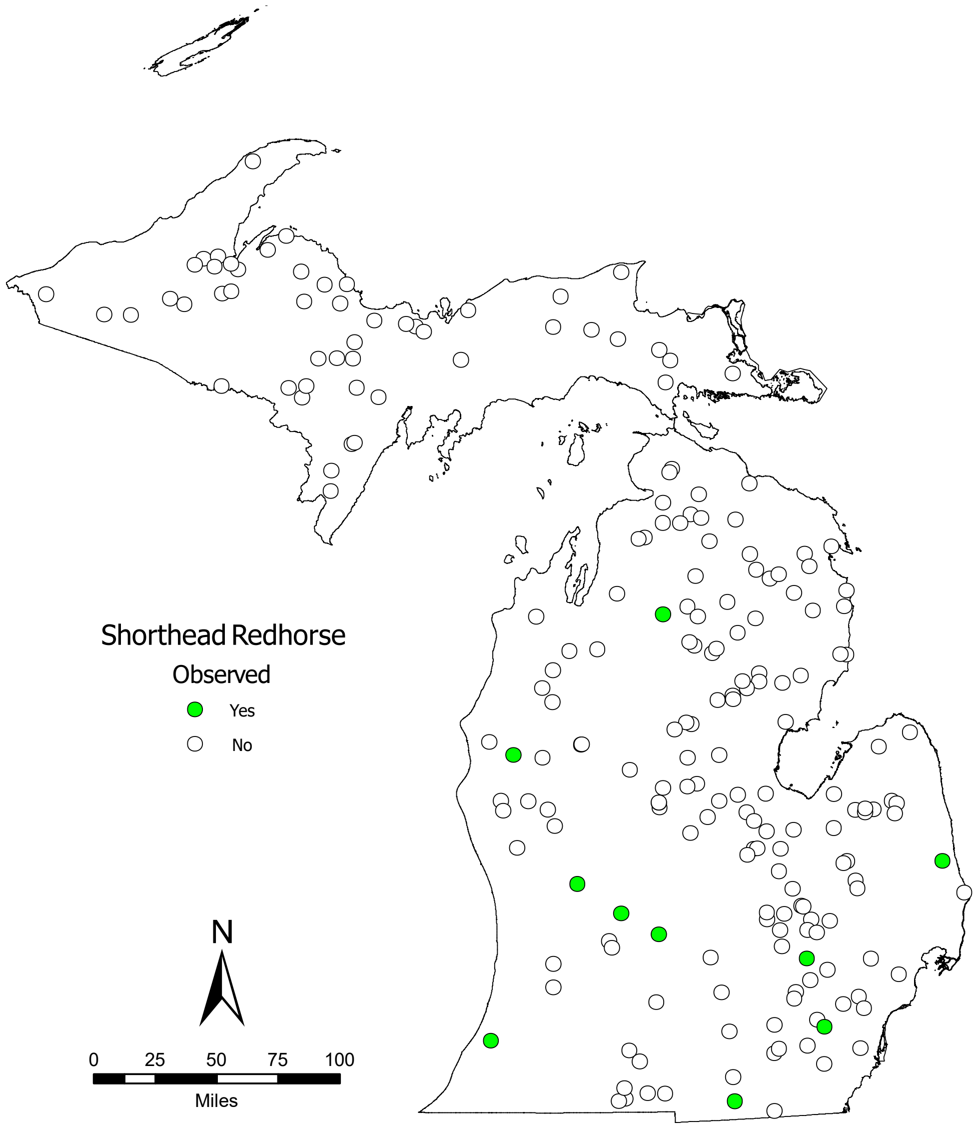

FIGURE A81. Map of distribution of Shorthead Redhorse *Moxostoma macrolepidotum* at randomly sampled sites.

TABLE A81. Percentage of Shorthead Redhorse *Moxostoma macrolepidotum* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	10	10	0	2
Medium	10	10	0	2
Large	10	10	10	3
Very Large	0	0	30	3
Total N	3	3	4	10

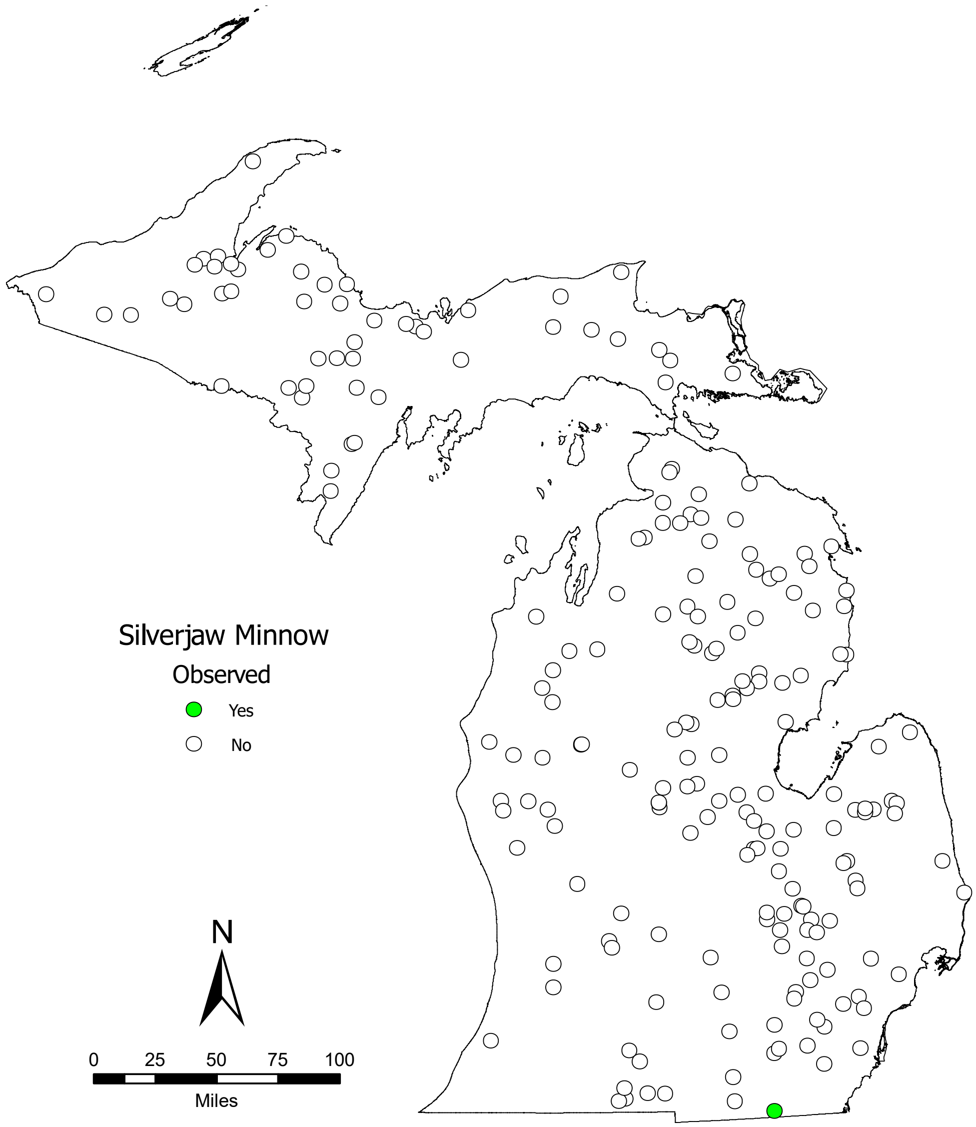

FIGURE A82. Map of distribution of Silverjaw Minnow *Notropis buccatus* at randomly sampled sites.

TABLE A82. Percentage of Silverjaw Minnow *Notropis buccatus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	100	1
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	0	1	1

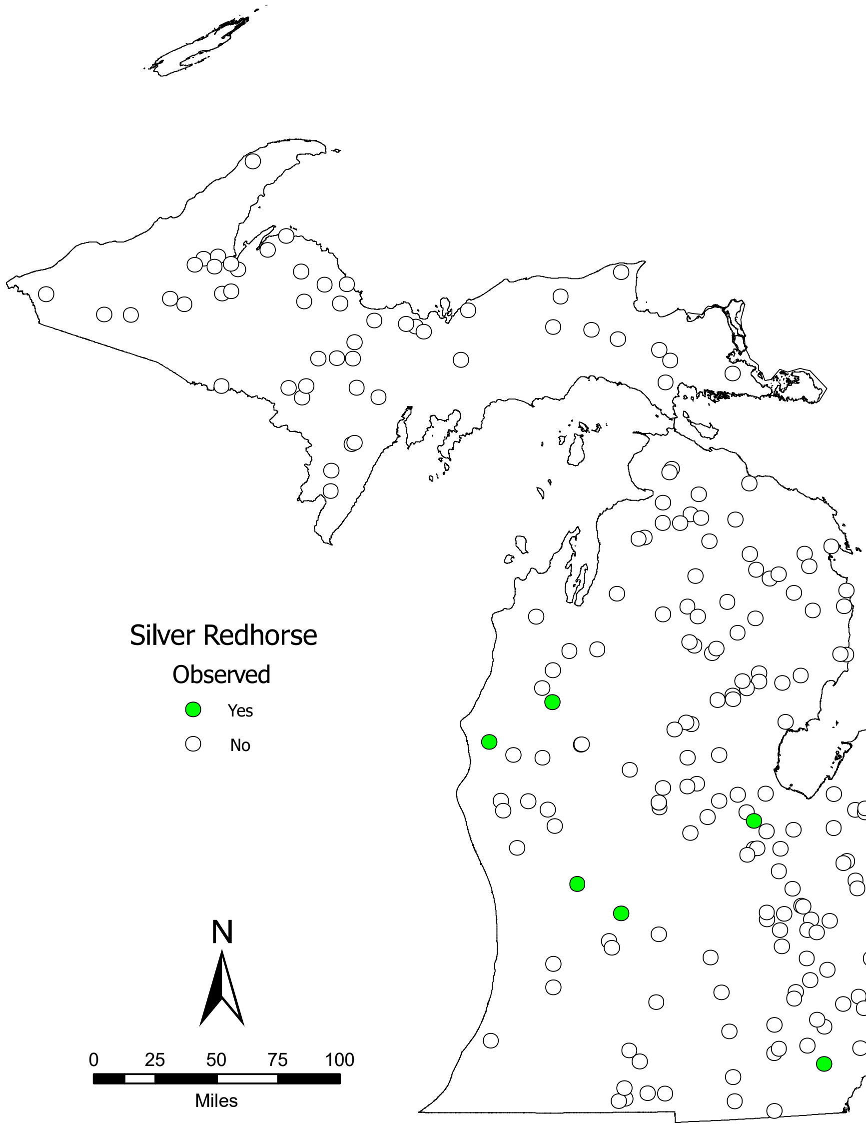

FIGURE A83. Map of distribution of Silver Redhorse *Moxostoma anisurum* at randomly sampled sites.

TABLE A83. Percentage of Silver Redhorse *Moxostoma anisurum* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	13	0	25	3
Large	13	0	13	2
Very Large	0	13	25	3
Total N	2	1	5	8

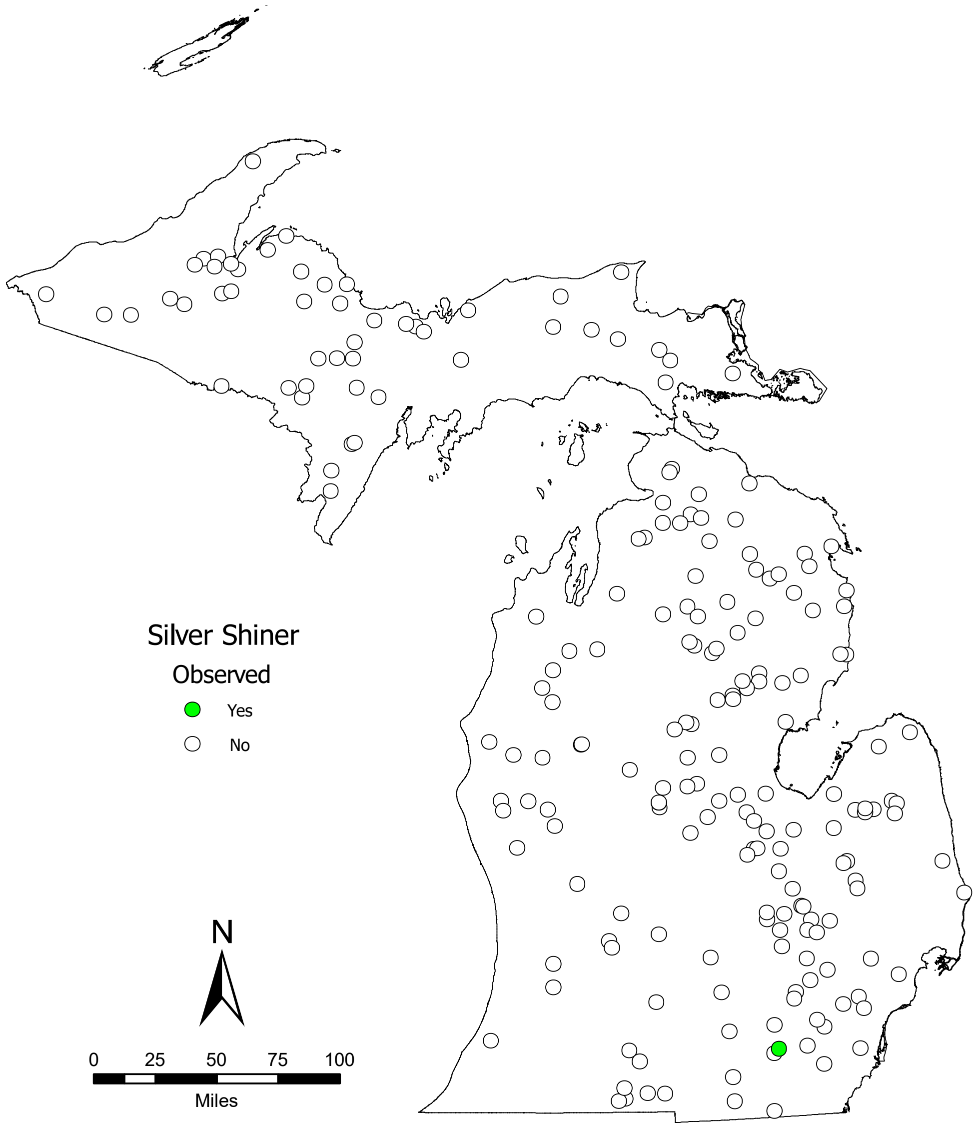

FIGURE A84. Map of distribution of Silver Shiner *Notropis photogenis* at randomly sampled sites. Silver Shiner are a Michigan endangered species.

TABLE A84. Percentage of Silver Shiner *Notropis photogenis* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	100	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	0	1	1

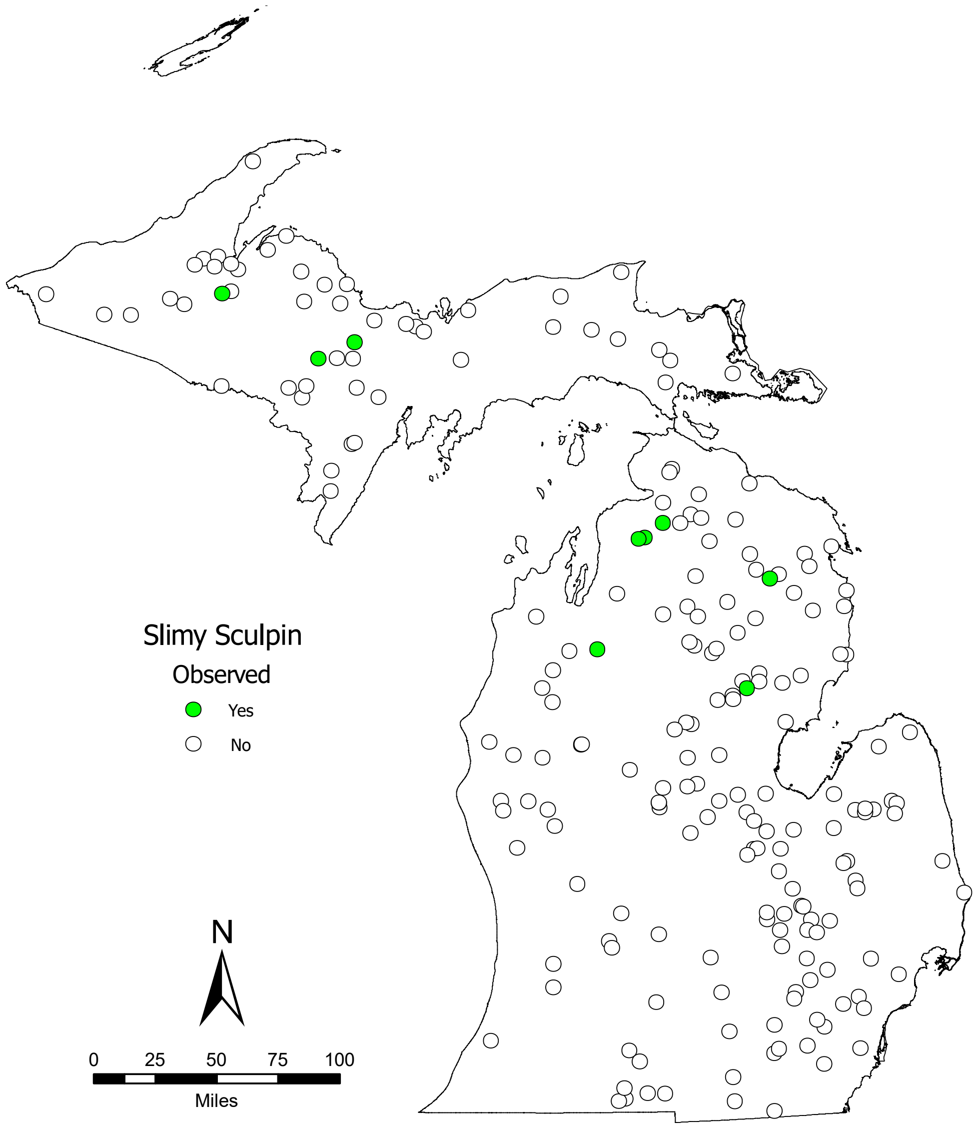

FIGURE A85. Map of distribution of Slimy Sculpin *Cottus cognatus* at randomly sampled sites.

TABLE A85. Percentage of Slimy Sculpin *Cottus cognatus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	44	11	11	6
Medium	11	22	0	3
Large	0	0	0	0
Very Large	0	0	0	0
Total N	5	3	1	9

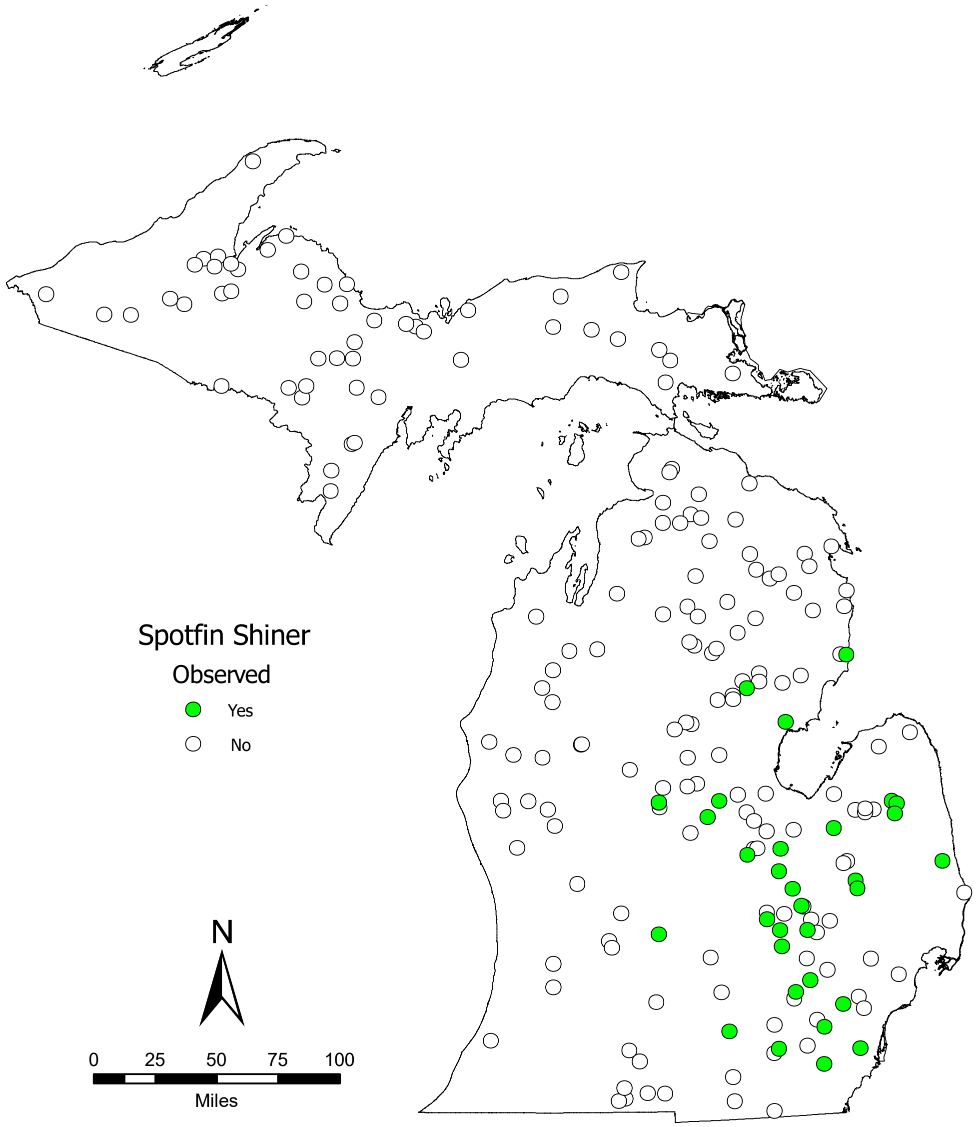

FIGURE A86. Map of distribution of Spotfin Shiner *Cyprinella spiloptera* at randomly sampled sites.

TABLE A86. Percentage of Spotfin Shiner *Cyprinella spiloptera* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	3	10	4
Medium	0	55	45	11
Large	0	16	16	10
Very Large	0	0	19	6
Total N	0	12	19	31

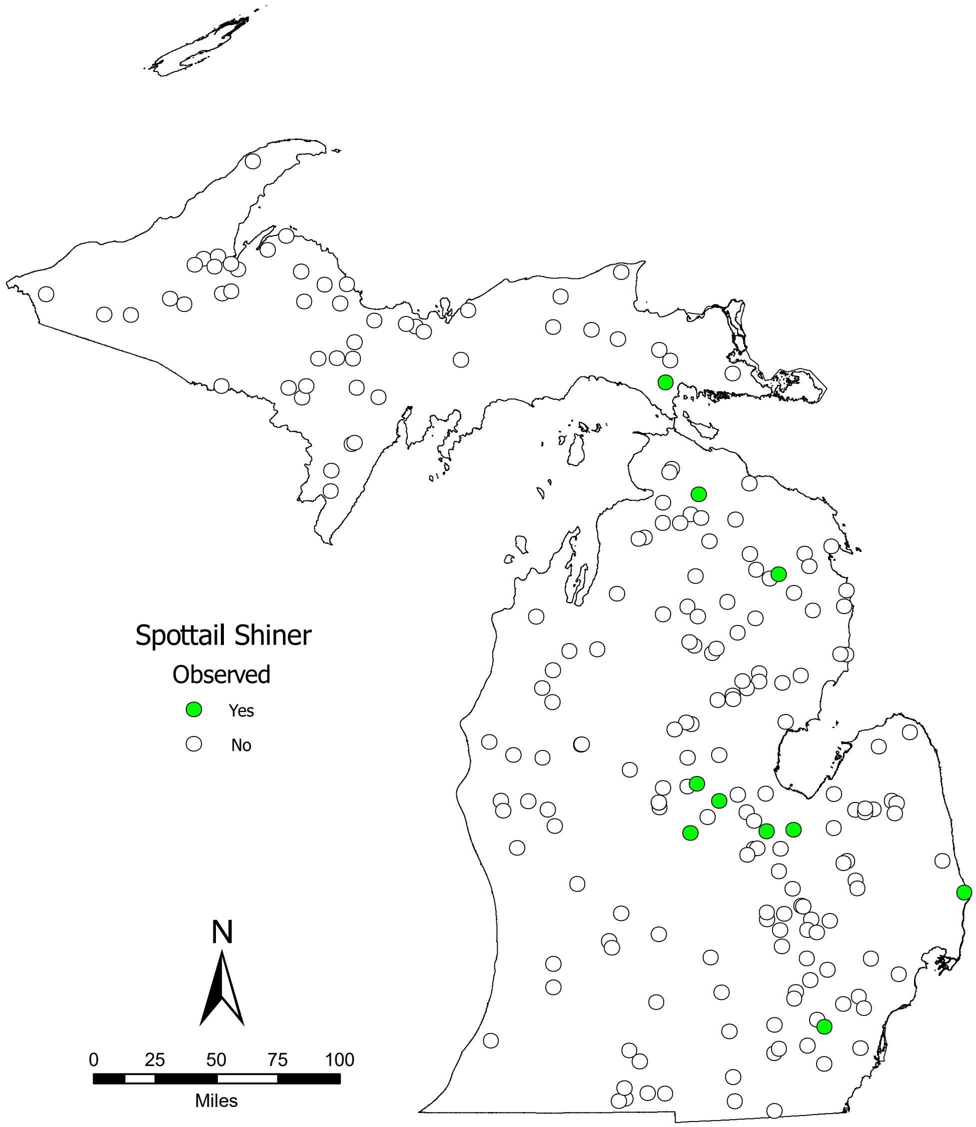

FIGURE A87. Map of distribution of Spottail Shiner *Notropis hudsonius* at randomly sampled sites.

TABLE A87. Percentage of Spottail Shiner *Notropis hudsonius* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	10	0	20	3
Medium	10	10	10	3
Large	0	0	10	1
Very Large	0	0	30	3
Total N	2	1	7	10

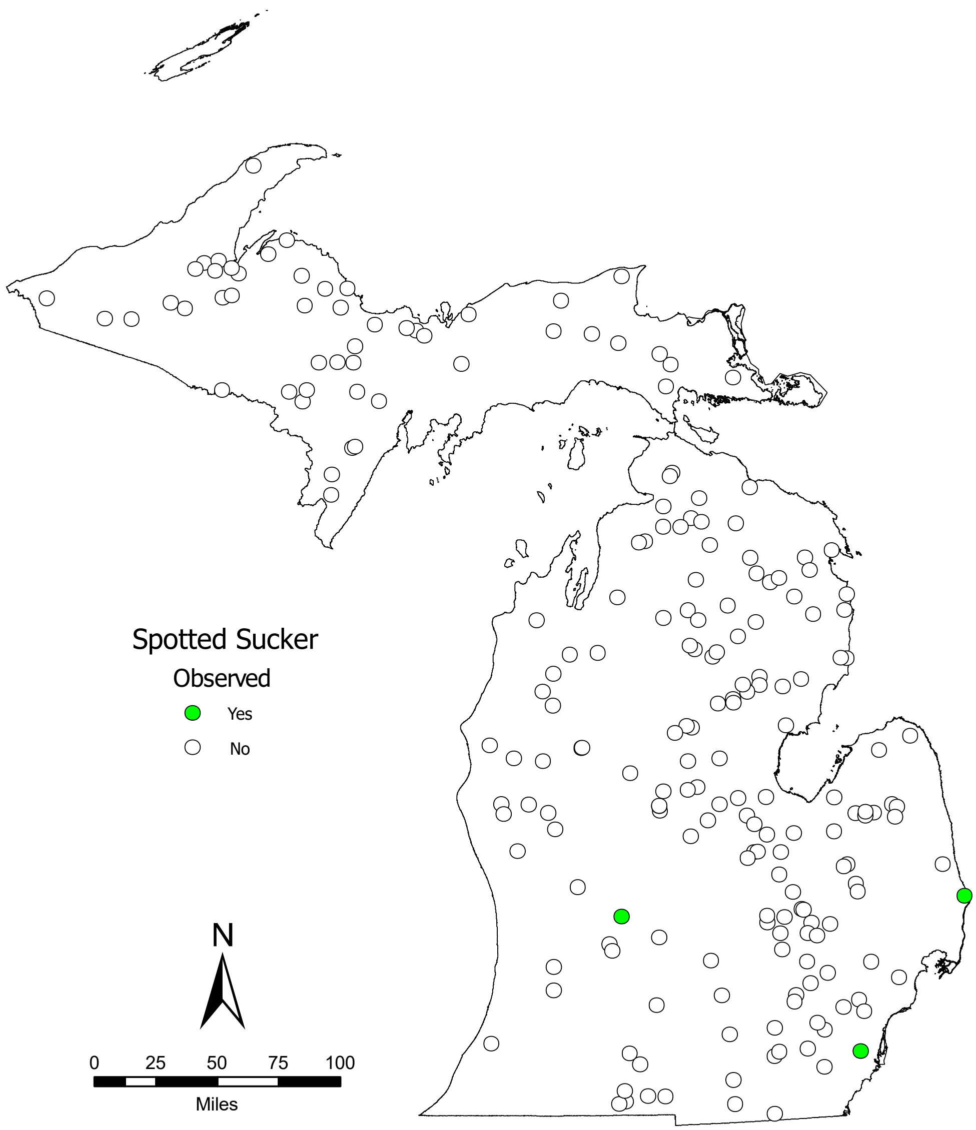

FIGURE A88. Map of distribution of Spotted Sucker *Minytrema melanops* at randomly sampled sites.

TABLE A88. Percentage of Spotted Sucker *Minytrema melanops* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	100	3
Total N	0	0	3	3

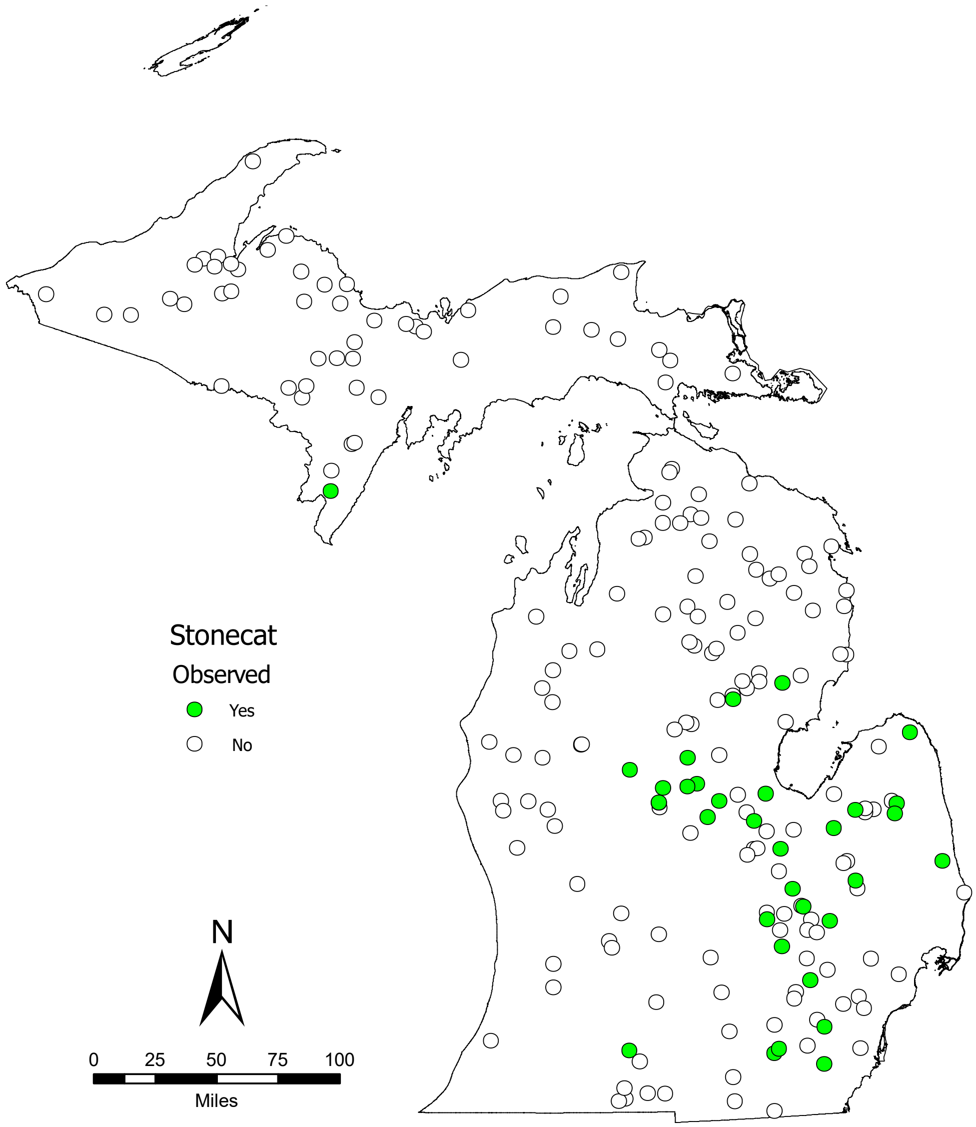

FIGURE A89. Map of distribution of Stonecat *Noturus flavus* at randomly sampled sites.

TABLE A89. Percentage of Stonecat *Noturus flavus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	9	3	4
Medium	0	28	28	18
Large	0	6	13	6
Very Large	0	0	13	4
Total N	0	14	18	32

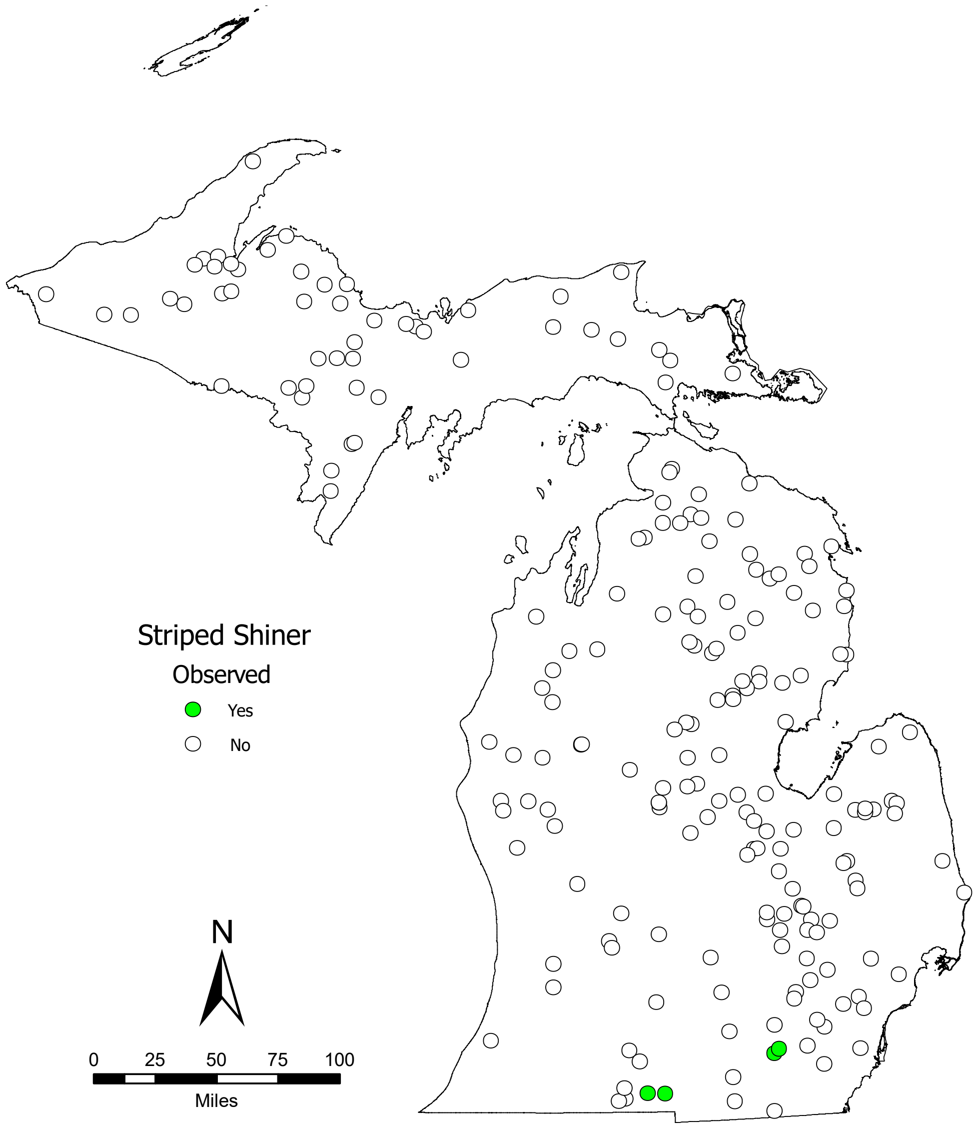

FIGURE A90. Map of distribution of Striped Shiner *Luxilus chrysocephalus* at randomly sampled sites.

TABLE A90. Percentage of Striped Shiner *Luxilus chrysocephalus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	25	25	2
Medium	0	25	25	2
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	2	2	4

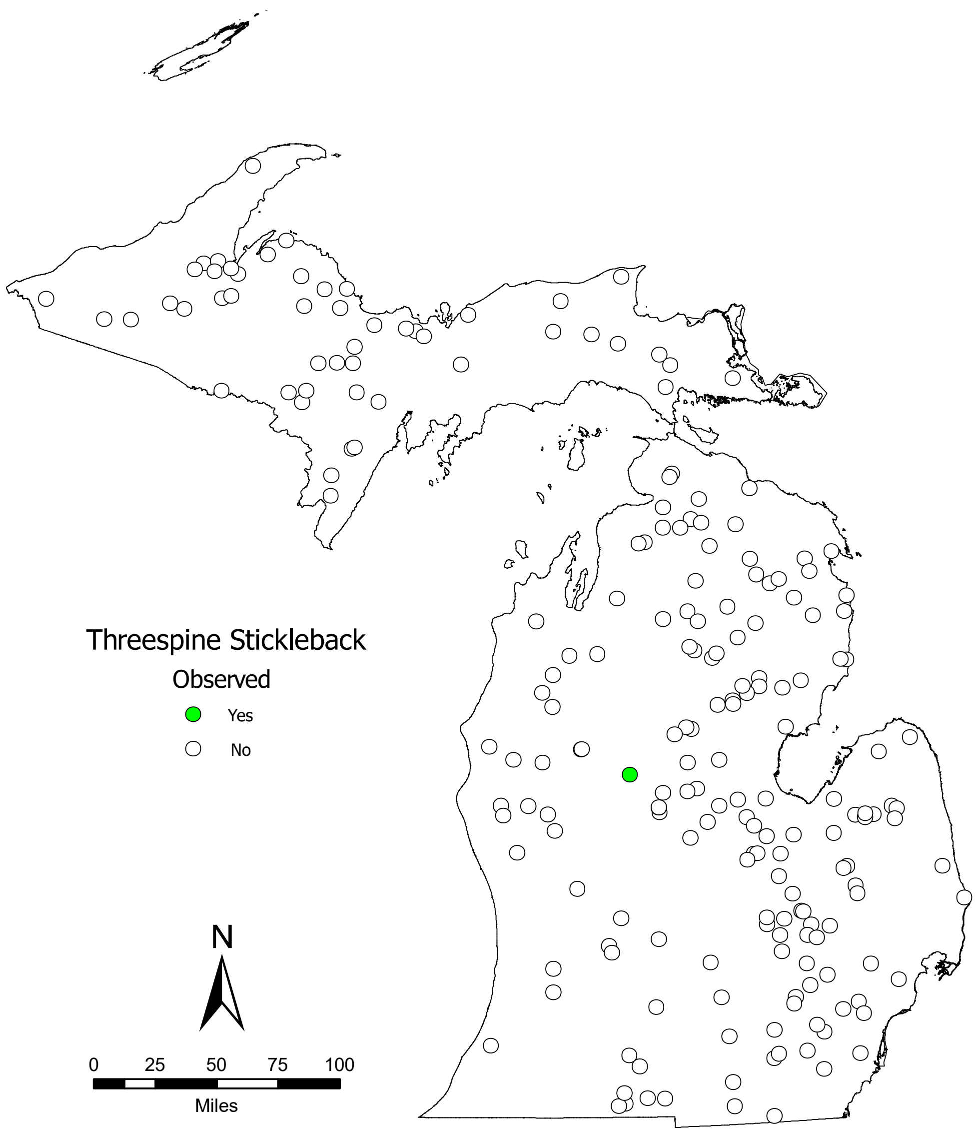

FIGURE A91. Map of distribution of Threespine Stickleback *Gasterosteus aculeatus* at randomly sampled sites.

TABLE A91. Percentage of Threespine Stickleback *Gasterosteus aculeatus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	100	0	0	1
Large	0	0	0	0
Very Large	0	0	0	0
Total N	1	0	0	1

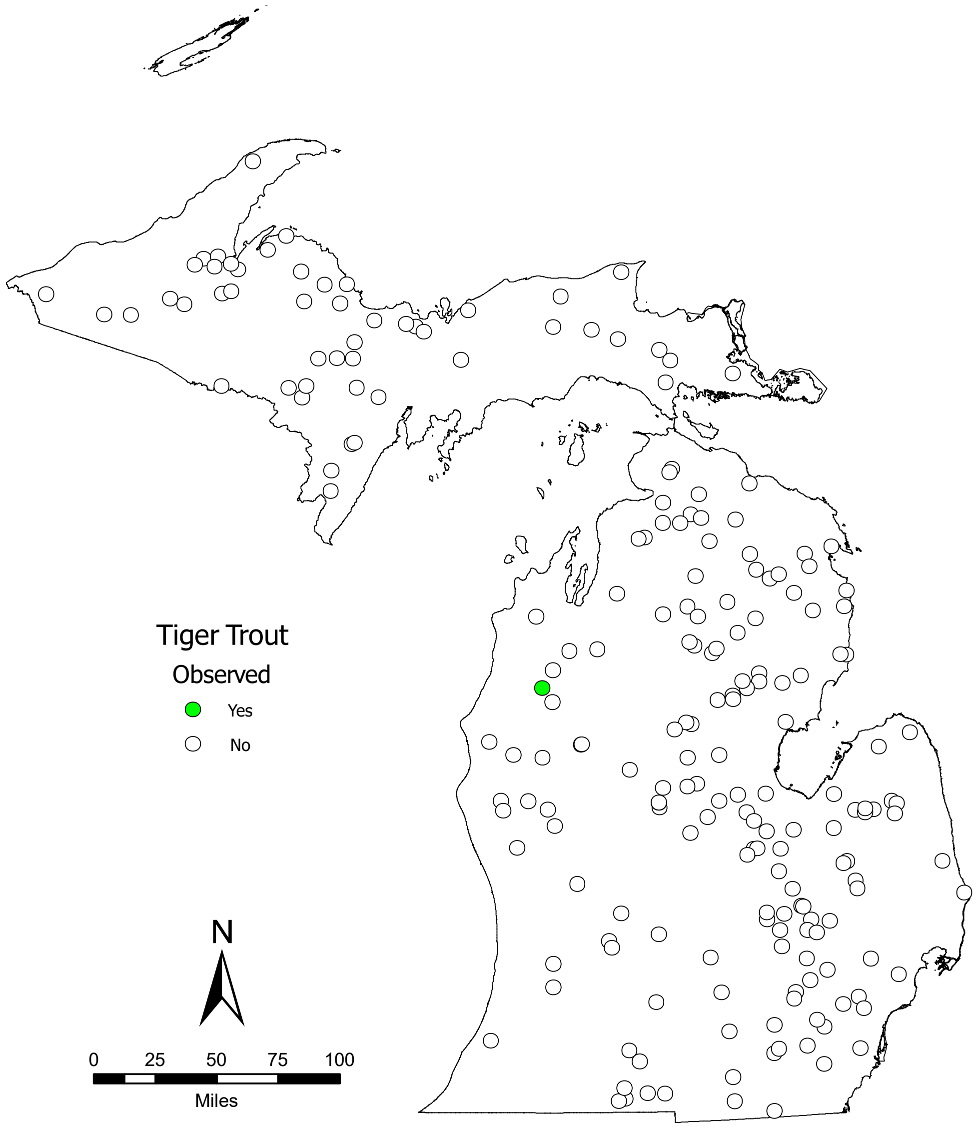

FIGURE A92. Map of distribution of Tiger Trout *Salmo trutta* X *Salvelinus fontinalis* at randomly sampled sites.

TABLE A92. Percentage of Tiger Trout *Salmo trutta* X *Salvelinus fontinalis* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	100	0	0	1
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	0	0
Total N	1	0	0	1

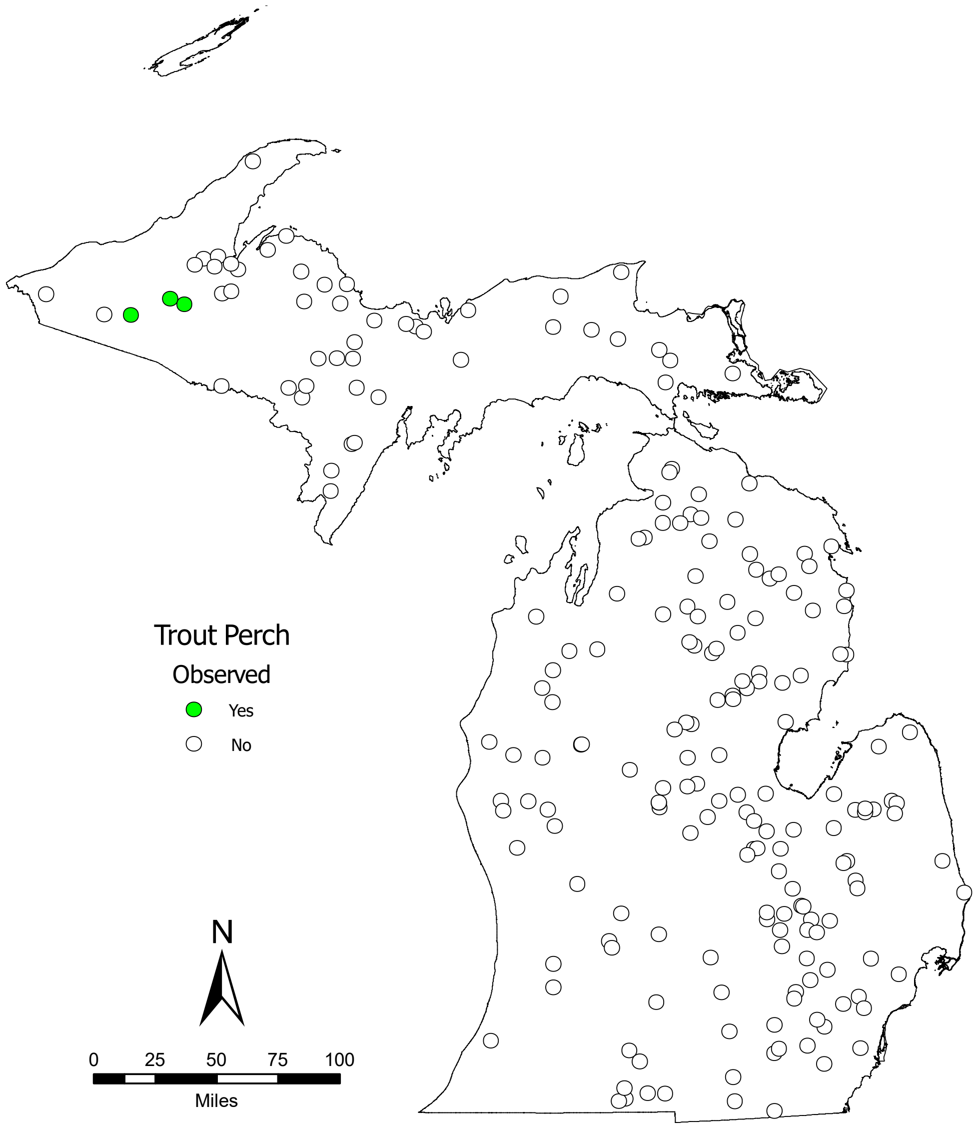

FIGURE A93. Map of distribution of Trout Perch *Percopsis omiscomaycus* at randomly sampled sites.

TABLE A93. Percentage of Trout Perch *Percopsis omiscomaycus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	100	0	0	3
Large	0	0	0	0
Very Large	0	0	0	0
Total N	3	0	0	3

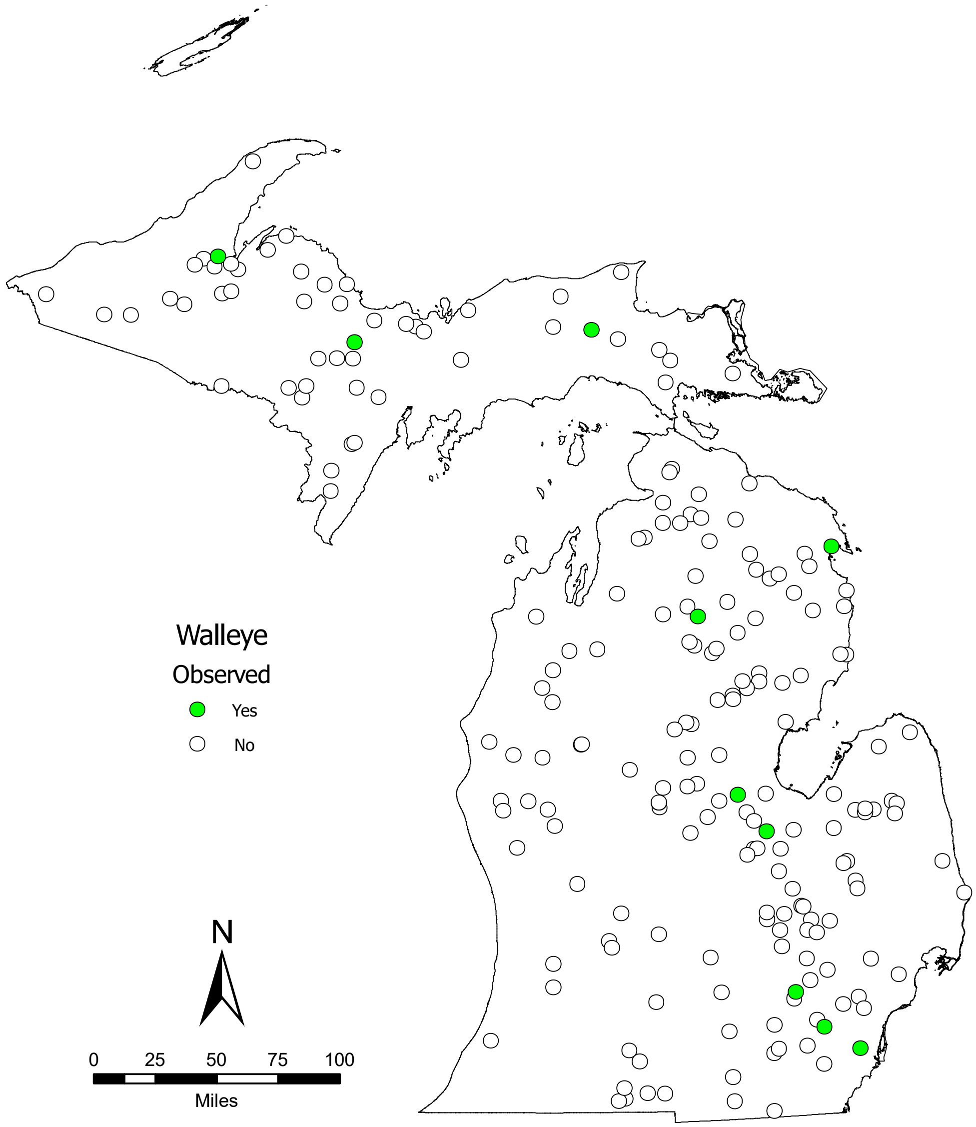

FIGURE A94. Map of distribution of Walleye *Sander vitreus* at randomly sampled sites.

TABLE A94. Percentage of Walleye *Sander vitreus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	10	0	0	1
Large	0	10	10	2
Very Large	10	10	50	7
Total N	2	2	6	10

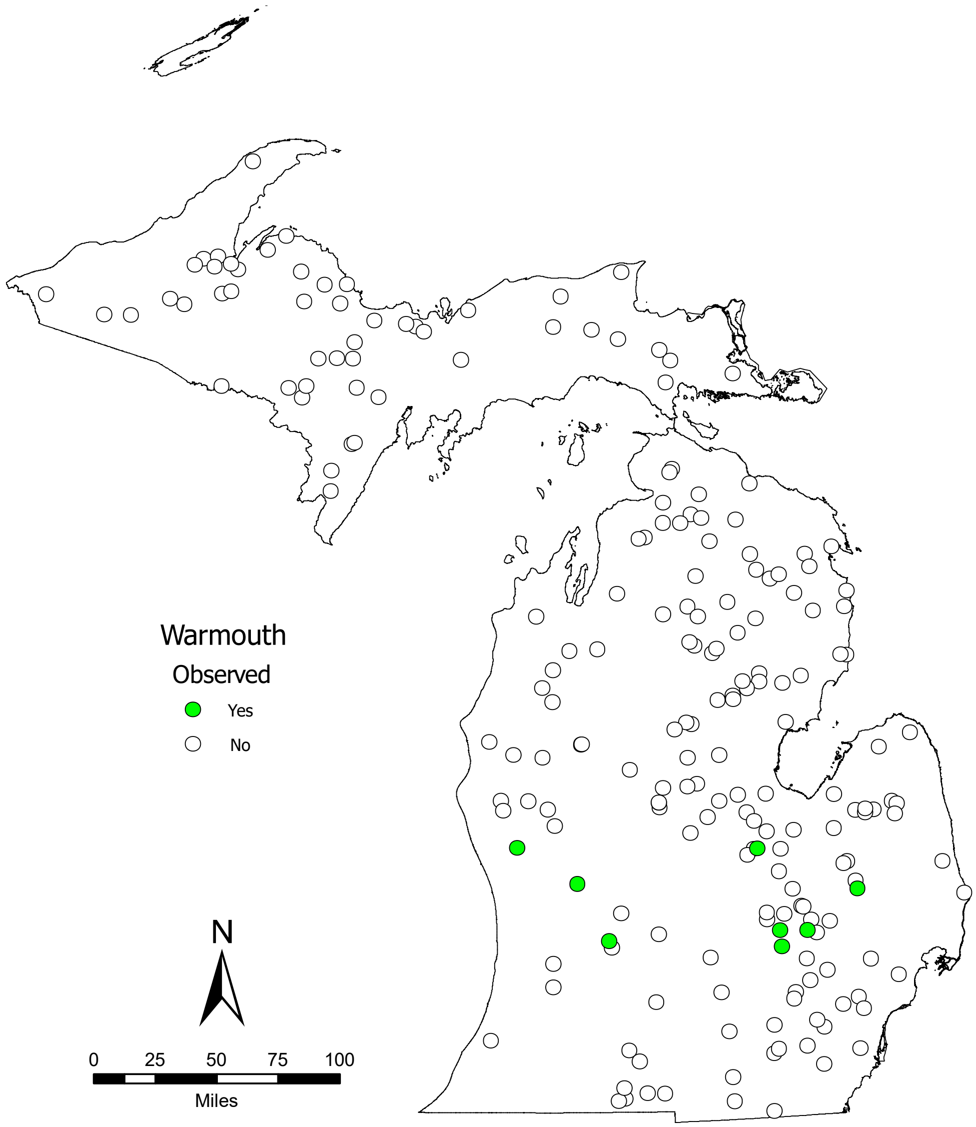

FIGURE A95. Map of distribution of Warmouth *Lepomis gulosus* at randomly sampled sites.

TABLE A95. Percentage of Warmouth *Lepomis gulosus* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	22	0	11	3
Medium	11	44	0	5
Large	0	0	11	1
Very Large	0	0	0	0
Total N	3	4	2	9

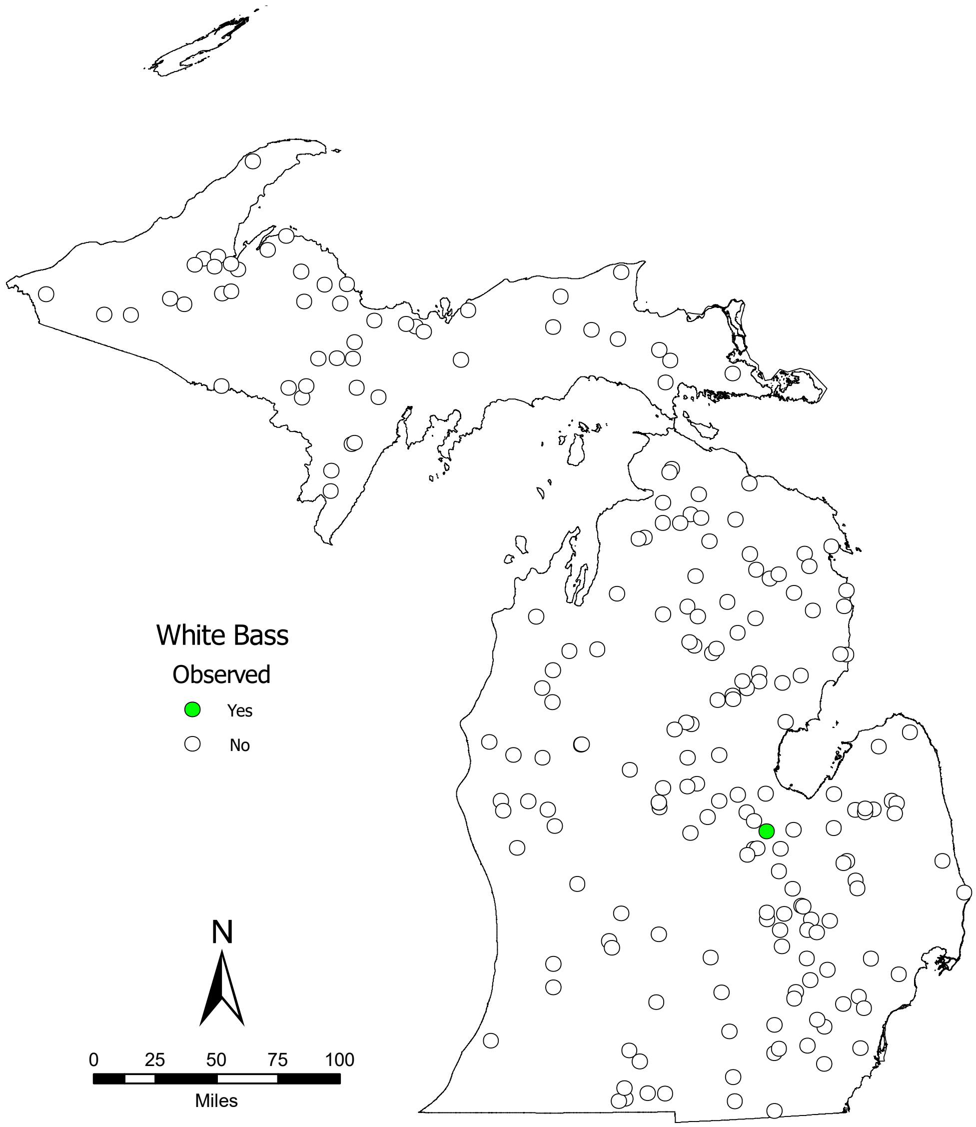

FIGURE A96. Map of distribution of White Bass *Morone chrysops* at randomly sampled sites.

TABLE A96. Percentage White Bass *Morone chrysops* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	100	1
Total N	0	0	1	1

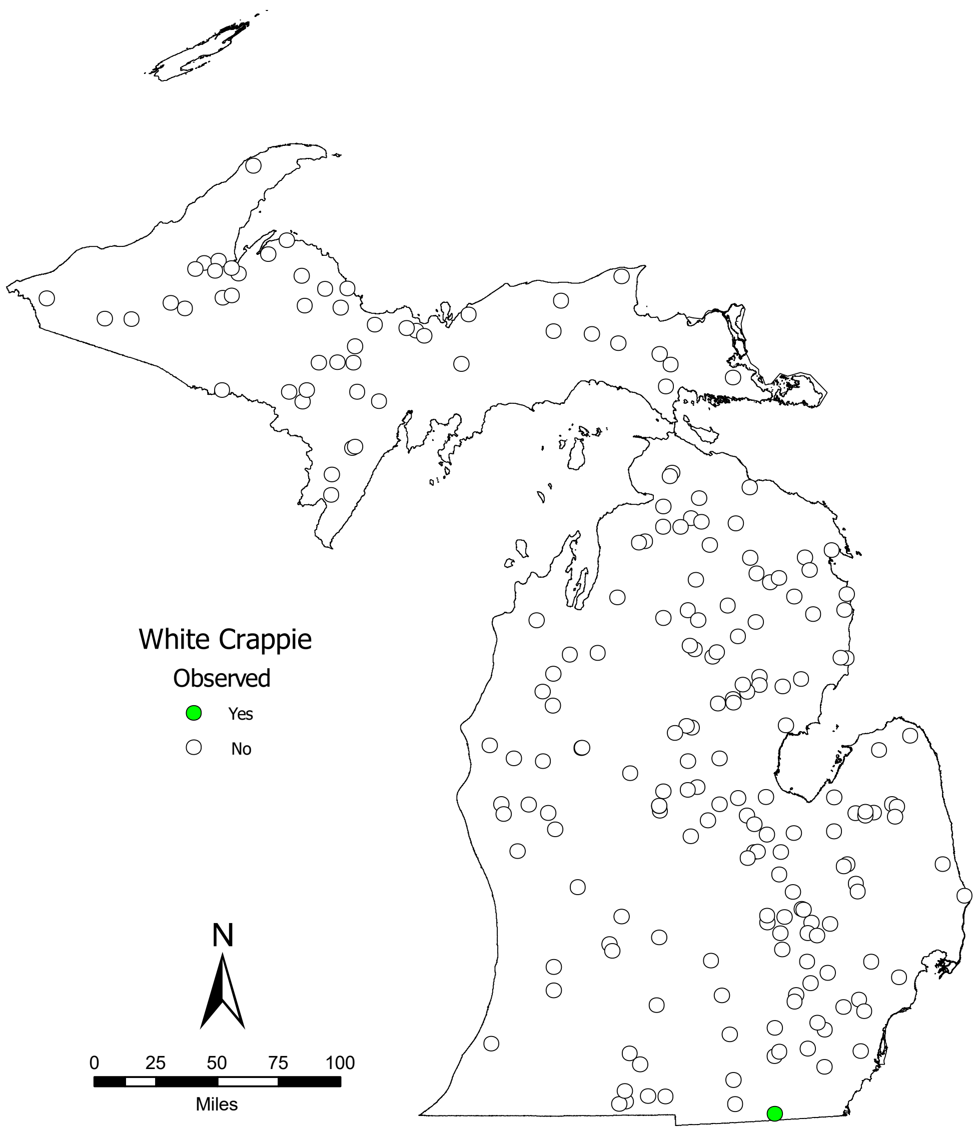

FIGURE A97. Map of distribution of White Crappie *Pomoxis annularis* at randomly sampled sites.

TABLE A97. Percentage White Crappie *Pomoxis annularis* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	100	1
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	0	0
Total N	0	0	1	1

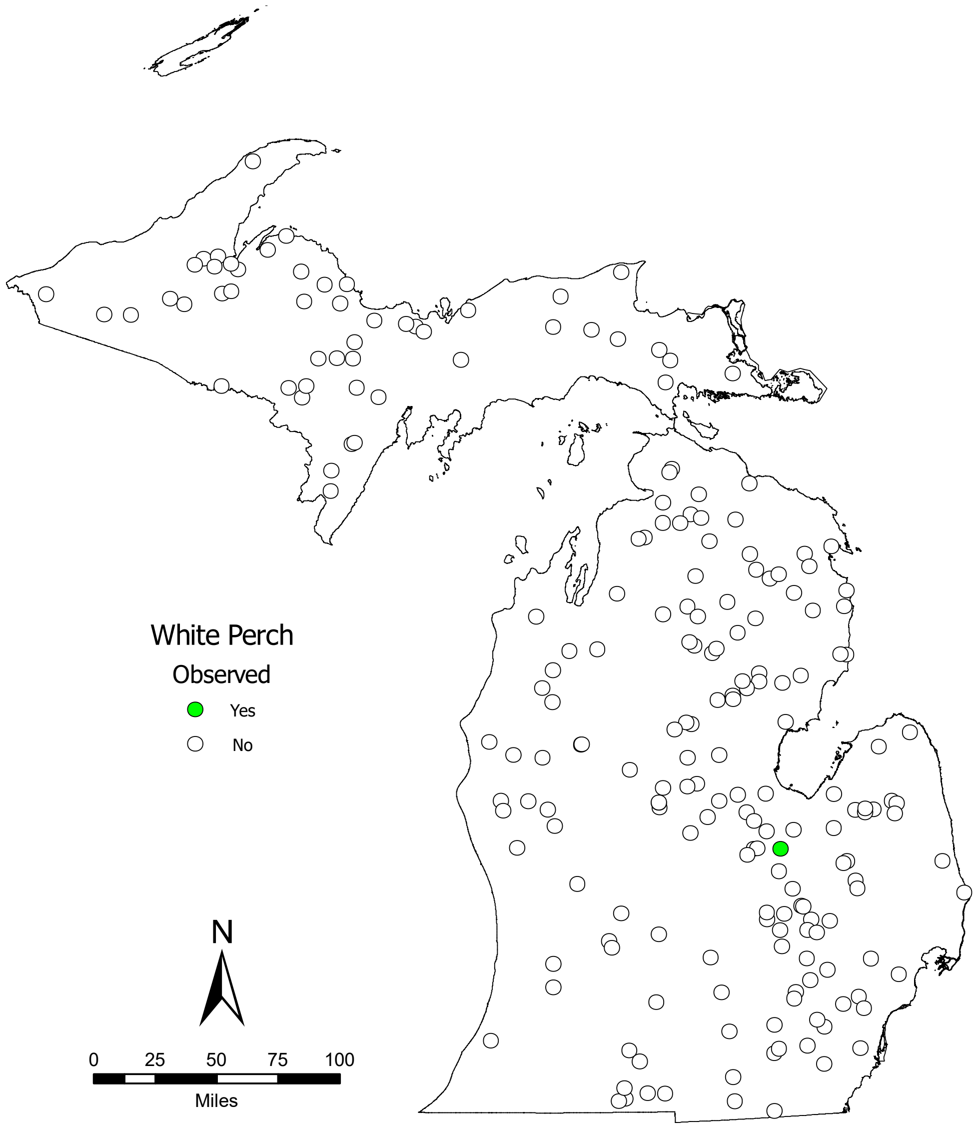

FIGURE A98. Map of distribution of White Perch *Morone americana* at randomly sampled sites.

TABLE A98. Percentage White Perch *Morone americana* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0
Very Large	0	0	100	1
Total N	0	0	1	1

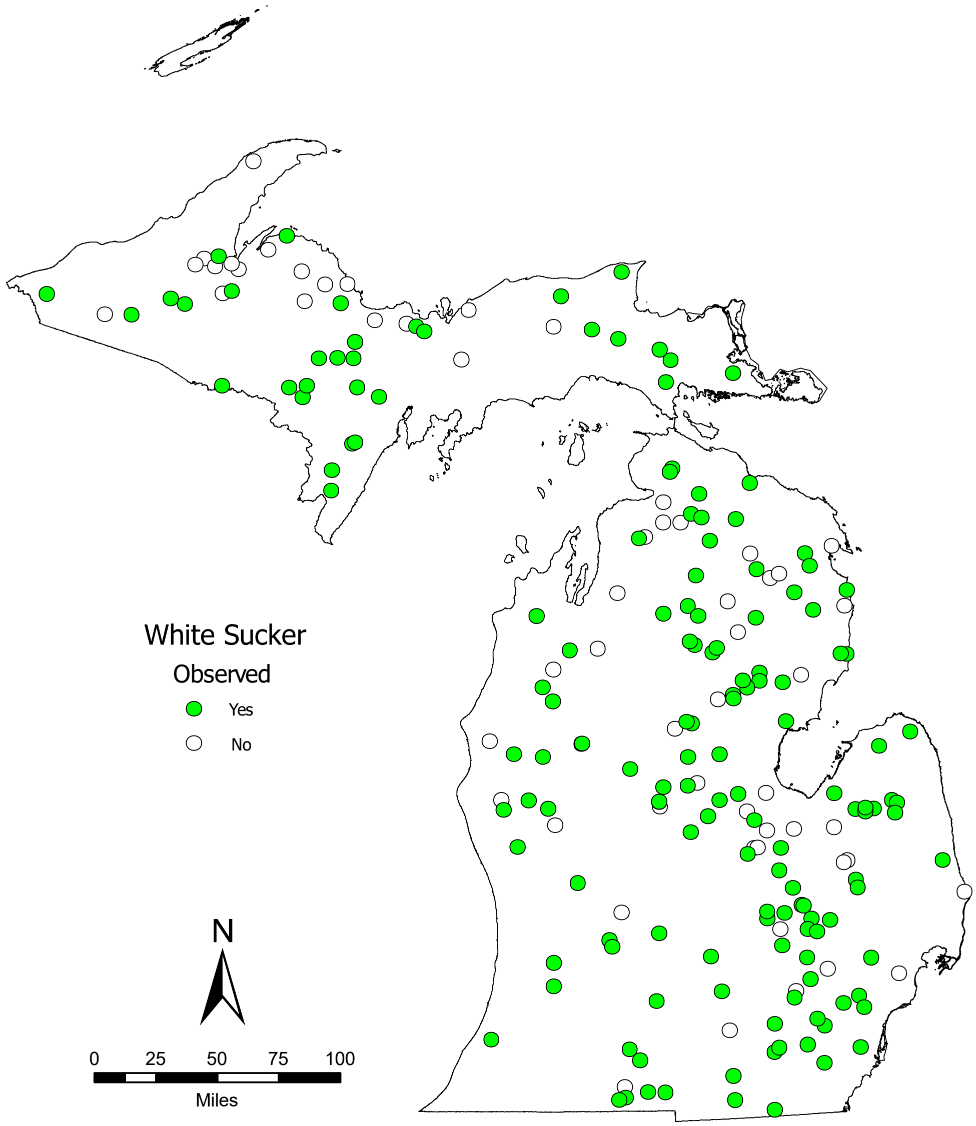

FIGURE A99. Map of distribution of White Sucker *Catostomus commersonii* at randomly sampled sites.

TABLE A99. Percentage White Sucker *Catostomus commersonii* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	12	15	8	54
Medium	16	22	9	73
Large	2	7	3	18
Very Large	1	1	4	9
Total N	47	70	37	154

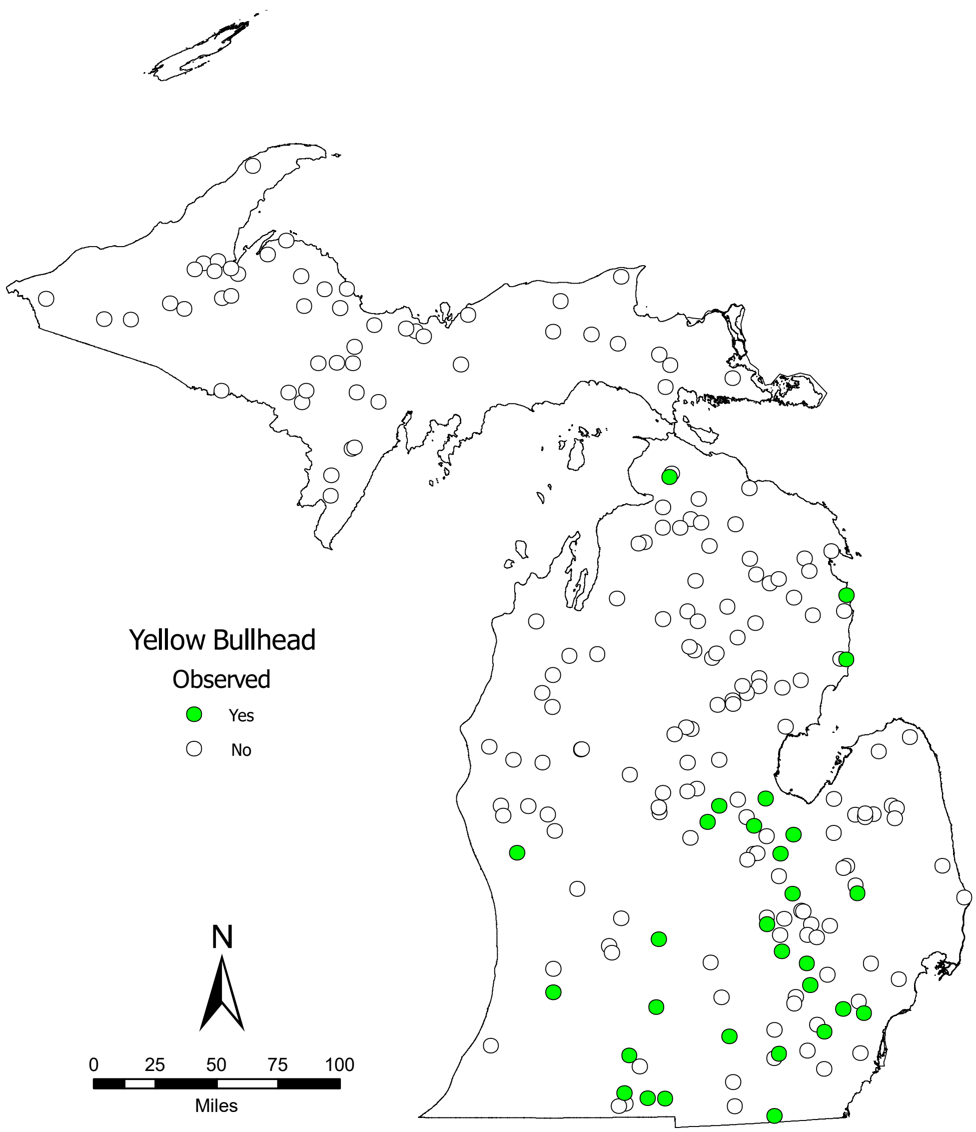

FIGURE A100. Map of distribution of Yellow Bullhead *Ameiurus natalis* at randomly sampled sites.

TABLE A100. Percentage Yellow Bullhead *Ameiurus natalis* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	7	3	17	8
Medium	7	17	17	12
Large	0	10	10	6
Very Large	0	0	13	4
Total N	4	9	17	30

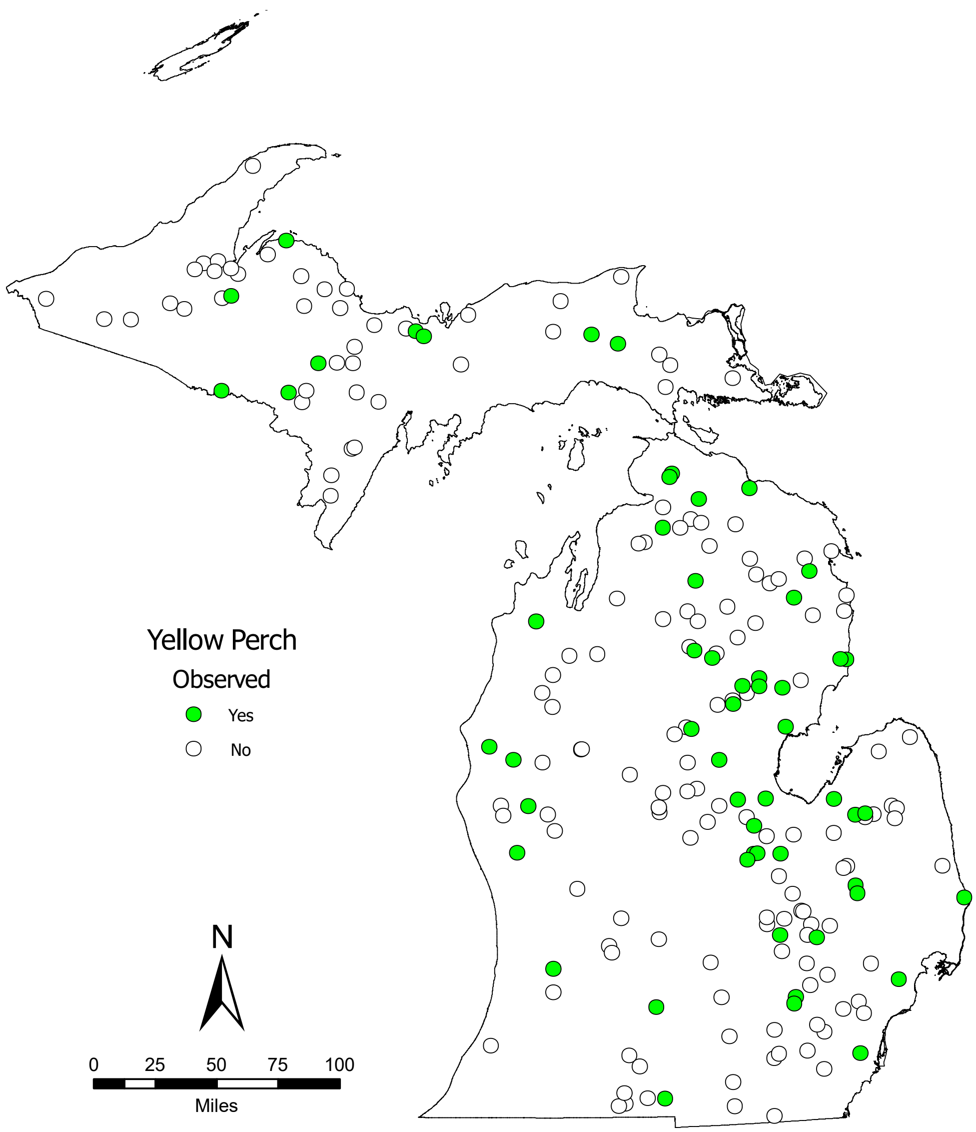

FIGURE A101. Map of distribution of Yellow Perch *Perca flavescens* at randomly sampled sites.

TABLE A101. Percentage Yellow Perch *Perca flavescens* occurrences in stream temperature (cold, cool, warm) and size (small, medium, large, and very large) strata. The total number (Total N) of occurrences for each stratum is given at the bottom of each row and column, respectively, with grand total given in the lower diagonal.

	Percentage			
	Cold	Cool	Warm	Total N
Small	11	9	7	15
Medium	14	25	11	28
Large	2	7	4	7
Very Large	0	5	7	7
Total N	15	26	16	57

TABLE A102. The proportion of occurrences of fish species detected in randomly sampled streams with (Yes) and without (No) Great Lakes access, and the total number of occurrences (N). Corrected data represent proportion of occurrence corrected for survey effort.

Species	Great Lakes Access				
	Raw Data		Corrected Data		
	Yes	No	Yes	No	N
American Brook Lamprey	0.14	0.86	0.29	0.71	7
Banded Killifish	0.67	0.33	0.83	0.17	3
Bigmouth Buffalo	0.00	1.00	0.00	1.00	1
Black Bullhead	0.14	0.86	0.29	0.71	21
Blackchin Shiner	0.67	0.33	0.83	0.17	3
Black Crappie	0.29	0.71	0.50	0.50	17
Blacknose Dace	0.30	0.70	0.51	0.49	104
Blacknose Shiner	0.30	0.70	0.51	0.49	10
Black Redhorse	0.00	1.00	0.00	1.00	5
Blackside Darter	0.18	0.82	0.34	0.66	68
Blackstripe Top Minnow	0.00	1.00	0.00	1.00	2
Bluegill	0.22	0.78	0.41	0.59	85
Bluntnose Minnow	0.24	0.76	0.43	0.57	84
Bowfin	0.18	0.82	0.35	0.65	11
Brassy Minnow	0.50	0.50	0.71	0.29	6
Brindled Madtom	0.00	1.00	0.00	1.00	1
Brook Silverside	0.00	1.00	0.00	1.00	1
Brook Stickleback	0.28	0.72	0.48	0.52	29
Brook Trout	0.32	0.68	0.54	0.46	71
Brown Bullhead	0.14	0.86	0.29	0.71	14
Brown Trout	0.32	0.68	0.53	0.47	60
Burbot	0.35	0.65	0.57	0.43	17
Central Mudminnow	0.19	0.81	0.36	0.64	101
Central Stoneroller	0.14	0.86	0.28	0.72	43
Channel Cat	0.55	0.45	0.75	0.25	11
Chestnut Lamprey	0.25	0.75	0.45	0.55	4
Chinook Salmon	1.00	0.00	1.00	0.00	5
Coho Salmon	0.89	0.11	0.95	0.05	9
Common Carp	0.30	0.70	0.51	0.49	30
Common Shiner	0.23	0.77	0.42	0.58	109
Creek Chub	0.24	0.76	0.44	0.56	147
Emerald Shiner	0.37	0.63	0.59	0.41	19
Fantail Darter	0.23	0.77	0.42	0.58	13
Fathead Minnow	0.18	0.82	0.35	0.65	11

TABLE A102 continued.

Species	Great Lakes Access				
	Raw Data		Corrected Data		
	Yes	No	Yes	No	N
Finescale Dace	0.40	0.60	0.62	0.38	5
Flathead Catfish	1.00	0.00	1.00	0.00	1
Freshwater Drum	0.67	0.33	0.83	0.17	6
Gizzard Shad	0.70	0.30	0.85	0.15	10
Gobies	1.00	0.00	1.00	0.00	3
Golden Redhorse	0.32	0.68	0.54	0.46	34
Golden Shiner	0.13	0.88	0.26	0.74	16
Goldfish	1.00	0.00	1.00	0.00	1
Grass Pickerel	0.16	0.84	0.32	0.68	25
Greater Redhorse	0.46	0.54	0.68	0.32	13
Green Side Darter	0.14	0.86	0.28	0.72	29
Green Sunfish	0.21	0.79	0.39	0.61	87
Hornyhead Chub	0.18	0.82	0.34	0.66	51
Iowa Darter	0.20	0.80	0.38	0.62	5
Johnny Darter	0.23	0.77	0.42	0.58	110
Lake Chub Sucker	0.00	1.00	0.00	1.00	2
Lake Sturgeon	1.00	0.00	1.00	0.00	1
Largemouth Bass	0.21	0.79	0.40	0.60	71
Least Darter	0.00	1.00	0.00	1.00	2
Log Perch	0.44	0.56	0.66	0.34	36
Longear Sunfish	0.00	1.00	0.00	1.00	14
Longnose Dace	0.40	0.60	0.62	0.38	43
Longnose Gar	1.00	0.00	1.00	0.00	2
Longnose Sucker	1.00	0.00	1.00	0.00	1
Mimic Shiner	0.31	0.69	0.53	0.47	16
Mottled Sculpin	0.31	0.69	0.52	0.48	65
Muskellunge	0.00	1.00	0.00	1.00	1
Northern Brook Lamprey	0.33	0.67	0.55	0.45	6
Northern Hog Sucker	0.22	0.78	0.40	0.60	65
Northern Pike	0.33	0.67	0.55	0.45	57
Northern Redbelly Dace	0.26	0.74	0.46	0.54	27
Oriental Weather Fish	0.00	1.00	0.00	1.00	1
Pearl Dace	0.25	0.75	0.45	0.55	12
Pink Salmon	1.00	0.00	1.00	0.00	1
Pirate Perch	0.30	0.70	0.51	0.49	10

TABLE A102 continued.

Species	Great Lakes Access Raw Data Yes	No	Corrected Data Yes	No	N
Pugnose Minnow	0.00	1.00	0.00	1.00	1
Pumpkinseed	0.24	0.76	0.44	0.56	71
Quillback	1.00	0.00	1.00	0.00	5
Rainbow Darter	0.18	0.82	0.34	0.66	51
Rainbow Trout	0.63	0.37	0.81	0.19	41
Redear Sunfish	0.00	1.00	0.00	1.00	1
Redfin Shiner	0.20	0.80	0.38	0.62	5
River Chub	0.25	0.75	0.45	0.55	8
River Darter	0.00	1.00	0.00	1.00	1
Rock Bass	0.26	0.74	0.46	0.54	92
Rosyface Shiner	0.11	0.89	0.23	0.77	9
Round Whitefish	0.00	1.00	0.00	1.00	1
Sand Shiner	0.31	0.69	0.52	0.48	13
Sea Lamprey	1.00	0.00	1.00	0.00	1
Shorthead Redhorse	0.40	0.60	0.62	0.38	10
Silverjaw Minnow	0.00	1.00	0.00	1.00	1
Silver Redhorse	0.63	0.38	0.80	0.20	8
Silver Shiner	0.00	1.00	0.00	1.00	1
Slimy Sculpin	0.22	0.78	0.41	0.59	9
Smallmouth Bass	0.37	0.63	0.59	0.41	54
Spotfin Shiner	0.19	0.81	0.37	0.63	31
Spottail Shiner	0.30	0.70	0.51	0.49	10
Spotted Sucker	1.00	0.00	1.00	0.00	3
Stonecat	0.22	0.78	0.41	0.59	32
Striped Shiner	0.00	1.00	0.00	1.00	4
Threespine Stickleback	0.00	1.00	0.00	1.00	1
Tiger Trout	0.00	1.00	0.00	1.00	1
Trout Perch	0.67	0.33	0.83	0.17	3
Walleye	0.40	0.60	0.62	0.38	10
Warmouth	0.44	0.56	0.66	0.34	9
White Bass	1.00	0.00	1.00	0.00	1
White Crappie	0.00	1.00	0.00	1.00	1
White Perch	1.00	0.00	1.00	0.00	1
White Sucker	0.24	0.76	0.44	0.56	154
Yellow Bullhead	0.27	0.73	0.47	0.53	30
Yellow Perch	0.40	0.60	0.62	0.38	57

TABLE A103. Mean and standard error of catch per effort (number of fish per mile sampled) of fish species detected in randomly sampled streams in the Southern Lower Peninsula (SLP), Northern Lower Peninsula (NLP) and Upper Peninsula (UP). Blanks indicate that the species was not detected in that region and NA indicates that standard error could not be calculated because there was only one sample.

Species	SLP		NLP		UP	
	Mean CPE	SE of CPE	Mean CPE	SE of CPE	Mean CPE	SE of CPE
American Brook Lamprey	47.5	21.3	35.0	NA		
Banded Killifish	465.5	342.5	9.0	NA		
Bigmouth Buffalo	18.0	NA				
Bigmouth Shiner					9.0	NA
Black Bullhead	9.9	2.3	8.3	1.9	22.5	18.5
Blackchin Shiner Black	8.0	1.0	137.0	NA		
Crappie	10.7	2.9	10.0	6.0	4.0	NA
Black Redhorse	60.3	20.9				
Blacknose Dace	407.9	103.9	524.9	133.7	294.9	47.1
Blacknose Shiner	11.0	3.2			90.3	67.5
Blackside Darter	78.9	13.8	68.3	34.0	45.0	22.9
Blackstripe Topminnow	77.0	20.0				
Bluegill	145.1	28.7	37.4	11.1	22.0	NA
Bluntnose Minnow	300.8	100.9	68.5	43.7	28.6	12.9
Bowfin	18.6	5.2	92.0	NA		
Brassy Minnow	35.5	20.3	42.0	NA	4.0	NA
Brindled Madtom	26.0	NA				
Brook Silverside					114.0	NA
Brook Stickleback	23.1	6.1	120.4	71.7	29.5	6.9
Brook Trout	41.4	18.5	363.8	72.6	307.7	78.8
Brown Bullhead	23.0	5.8	13.0	NA	112.3	102.4
Brown Trout	371.2	98.6	421.8	106.4	71.4	15.9
Burbot	211.0	NA	21.3	5.4	47.0	13.8
Central Mudminnow	478.0	248.1	390.2	172.5	124.2	51.9
Central Stoneroller	300.6	109.0	241.0	208.0		
Channel Catfish	16.2	5.2				
Chestnut Lamprey	18.3	6.3				
Chinook Salmon			16.4	5.1		
Coho Salmon			113.3	52.3	313.7	222.1
Common Carp	31.0	5.4	7.0	NA		
Common Shiner	544.8	207.9	368.3	171.9	304.9	109.0
Creek Chub	591.0	94.8	342.6	73.6	263.5	92.3
Emerald Shiner	118.8	46.9	33.0	29.0		
Fantail Darter	112.2	36.6			154.0	145.0
Fathead Minnow	84.7	70.4			35.3	23.8
Finescale Dace	4.0	NA	340.5	314.5	105.5	84.5

TABLE A103 continued.

Species	SLP		NLP		UP	
	Mean CPE	SE of CPE	Mean CPE	SE of CPE	Mean CPE	SE of CPE
Flathead Catfish	3.0	NA				
Freshwater Drum	10.8	2.2	5.5	4.5		
Gizzard Shad	101.5	28.5				
Golden Redhorse	92.5	32.2	3.0	1.0		
Golden Shiner	13.7	3.6	9.0	NA	21.8	13.1
Goldfish	3.0	NA				
Grass Pickerel	20.3	4.0	34.8	15.5		
Greater Redhorse	38.6	20.8	5.5	0.5		
Green Sunfish	102.5	16.5	17.4	6.1	5.0	NA
Greenside Darter	398.8	235.1			4.0	NA
Hornyhead Chub	249.0	67.4	468.1	227.0	280.1	94.9
Hybrid Sunfish	28.2	8.6				
Iowa Darter	48.5	35.5	53.0	NA	42.0	31.0
Johnny Darter	382.0	133.0	166.9	58.3	49.2	15.6
Lake Chubsucker	192.5	166.5				
Lake Sturgeon					6.0	NA
Largemouth Bass	54.1	10.4	60.3	18.6	15.0	7.0
Least Darter	7.0	NA	13.0	NA		
Logperch	261.2	162.0	92.6	36.9	34.1	14.9
Longear Shiner	110.4	41.7				
Longnose Dace	90.3	73.9	242.1	111.8	262.4	91.1
Longnose Gar	1.0	0.0				
Longnose Sucker	1.0	NA				
Mimic Shiner	112.9	51.8	84.0	79.0		
Mottled Sculpin	703.9	144.2	165.1	45.7	182.6	37.0
Muskellunge					4.0	NA
Northern Brook Lamprey	11.3	3.1	12.5	8.5		
Northern Hog Sucker	148.9	47.7	21.8	13.7	11.5	7.8
Northern Pike	26.2	5.1	20.0	7.7	14.5	5.7
Northern Redbelly Dace	81.3	69.0	71.2	32.5	249.9	140.3
Oriental Weather Fish	4.0	NA				
Pearl Dace			121.5	53.1	99.6	32.5
Pink Salmon					1.0	NA
Pirate Perch	138.4	71.5	12.0	NA		
Pugnose Minnow					53.0	NA
Pumpkinseed	41.6	15.1	34.0	14.2	20.2	9.7

TABLE A103 continued.

Species	SLP		NLP		UP	
	Mean CPE	SE of CPE	Mean CPE	SE of CPE	Mean CPE	SE of CPE
Quillback	6.4	1.6				
Rainbow Darter	448.1	190.1	132.8	95.9		
Rainbow Trout	257.4	115.8	243.2	83.7	240.4	103.3
Redear Sunfish	4.0	NA				
Redfin Shiner	45.6	14.8				
River Chub	280.5	130.2	55.7	25.3		
River Darter	66.0	NA				
Rock Bass	220.8	46.6	49.3	12.4	78.6	20.2
Rosyface Shiner	36.1	12.2	62.0	NA		
Round Whitefish			72.0	NA		
Sand Shiner	234.6	100.9	9.0	4.0		
Sea Lamprey					172.0	NA
Shorthead Redhorse	23.8	10.7	32.5	27.5		
Silver Redhorse	22.2	7.7	21.0	17.0		
Silver Shiner	4.0	NA				
Silverjaw Minnow	760.0	NA				
Slimy Sculpin	32.0	NA	288.6	77.5	37.7	10.3
Smallmouth Bass	131.8	48.3	91.4	52.2	27.3	8.4
Spotfin Shiner	226.4	116.7	18.0	NA		
Spottail Shiner	225.7	125.8	12.0	1.0	6.0	NA
Spotted Sucker	35.0	14.0				
Stonecat	35.1	6.7			42.0	NA
Striped Shiner	144.5	48.5				
Threespine Stickleback	4.0	NA				
Tiger Trout			7.0	NA		
Troutperch					38.0	17.7
Walleye	4.6	0.4	1.5	0.5	8.3	4.8
Warmouth	11.4	4.7	20.5	9.5		
White Bass	5.0	NA				
White Crappie	11.0	NA				
White Perch	11.0	NA				
White Sucker	270.7	47.6	147.2	42.1	108.2	25.6
Yellow Bullhead	54.0	23.8	6.0	1.7		
Yellow Perch	49.2	25.3	22.0	5.5	15.7	8.9