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Evaluation of the Fish Community and Related Ecological Features of Cedar Creek, Muskegon County

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Abstract.–Biological and physical evaluations of Cedar Creek were conducted between 1995 and 2006 to assist in developing resource management decisions. Gradient, artificial ditching, discharge, low-flow yield, water temperature, bank stability, bank vegetation, substrate composition, instream wood cover, and fish species composition, abundance, and biomass were evaluated. The middle segment of Cedar Creek supports a self-sustaining coldwater fish community containing brook trout *Salvelinus fontinalis*, rainbow trout (steelhead) *Oncorhynchus mykiss*, and Chinook salmon *Oncorhynchus tshawytscha*. The lower segment flows through the Muskegon River floodplain and contains fish species that prefer warmer water. The headwaters have significant agricultural development that has increased bank erosion. Protection and restoration efforts will be needed to maintain coldwater fisheries as development of the watershed continues; special emphasis needs to be directed at stormwater management.

Cedar Creek, located in Muskegon County in the mid-western portion of Michigan's Lower Peninsula, is one of the principal tributaries of the Muskegon River (Figure 1). Landscape-based groundwater velocity models developed by Wiley and Seelbach (1997) indicate its catchment has the geologic and topographic characteristics that provide the relatively high groundwater velocities typical of Michigan coldwater streams. Accordingly, the entire length of Cedar Creek (24.4 miles) and all of its tributaries (51.2 miles) are trout streams designated by the Michigan Department of Natural Resources (MDNR). Management options provided in the Muskegon River Watershed Assessment (O'Neal 1997) and the Muskegon River Watershed Plan (O'Neal 2003) recommended that Cedar Creek be managed for coldwater fisheries, and that efforts be made to restore water quality in reaches that may be impaired.

The Cedar Creek watershed contains a mixture of high to moderate relief coarse end moraines, an unconfined stream channel lying over glacial–fluvial deposits, and land cover classified as a mixture of forest and light agriculture with some wetlands (Seelbach et al. 1997). The stream is classified as mesotrophic, with moderate nutrients. Stream protection and restoration efforts in Cedar Creek have been ongoing since the 1980s in conjunction with various partner organizations including the U.S. Forest Service, Muskegon–White River Chapter of Trout Unlimited, the Muskegon River Watershed Assembly, the Muskegon County Road Commission, the Michigan Department of Environmental Quality, and the Muskegon River Partnership (which includes multiple university partners). Past activities have included instream habitat improvement, sediment control, and collection of information needed for management initiatives.

Future management activities are expected to focus on land-use and hydrology issues that are of primary importance for long–term protection of this valuable coldwater resource. This report provides a brief evaluation of relevant ecological features and biological potential of Cedar Creek, and is intended to help in developing goals for natural resource protection and restoration. Special emphasis was placed on fisheries and related physical features important to coldwater streams.

Methods

Physical Measures

To assess present physical conditions, channel gradient was determined from 1:24,000 scale United States Geological Survey (USGS) topographic maps. Stream segments that were ditched were determined by identifying straight line channel runs from topographic maps and field inspection of sites.

Stream flow was measured in 1995, 2003, and 2004 at five sampling stations on the mainstem and one tributary (only in 1995). These stations were located at Brickyard Road (only in 2004), Holton (Holton-Duck Lake Road), M–120 downstream of Holton, Crocker Road, Sweeter Road, and at the mouth of Little Henna Creek (Figure 1). Stream discharge was measured at various sites on July 19–21, 1995, October 13, 2003, and October 14, 2004 using a Gurly meter or an electronic Global Flow Probe manufactured by Global Water Instrumentation.

Low–flow yield was calculated by dividing base flow discharge by catchment area. Individual upstream catchment boundaries were delineated for each site based upon subwatershed divides mapped by the MDNR from USGS 1:24,000 scale topographic maps. Watershed boundaries were then locally modified for each site using a 3 arc–second digital elevation model (at a scale of 1:250,000). Catchment areas were measured using ArcView 3.2 (ESRI, Inc.).

Water temperature data were collected at hourly intervals using continuous temperature recorders with an accuracy of ± 0.9°F manufactured by Ryan Instruments. Temperature data were collected at Holton, M–120, Crocker Road, and Sweeter Road from June 1995 through March 1996. Field calibrations were made at least once per deployment using a Traceable TM digital thermometer with a calibrated accuracy of ±0.4°F. Air temperature data obtained from the National Oceanic and Atmospheric Administration National Weather Service in Grand Rapids, Michigan, indicated that June–August air temperatures were somewhat above normal, and January–March air temperatures were somewhat below normal. Air temperature extremes were not evident and should not affect water temperature evaluations.

Bank stability, bank vegetation, substrate composition, instream wood cover, and channel width were evaluated in 2006 using MDNR Fisheries Division sampling protocols (Wills et al. 2006) at sites where fish were collected. Mean channel widths were used to determine surface area (acres) of sample sites.

Biological Measures

Fish samples were collected during August downstream of Brickyard Road (2006), downstream of Holton–Duck Lake Road (2006), upstream of M–120 (2006), downstream of M–120 (1995 & 2006), upstream and downstream of Crocker Road (2006), and downstream of Sweeter Road (1995 & 2006). Upstream (u) and downstream (d) samples were collected at M–120 and Crocker Road to aid in evaluating the potential effects of sand traps that have been maintained there for about 20 years. All data were collected using standard stream electrofishing gear (barge with 2 probes or backpack with one probe). Abundance of trout and salmon was estimated at all sites except Brickyard Road using Chapman–Peterson mark-recapture procedures (Ricker 1975). Biomass was estimated using standard length–weight equations for Michigan fishes (Schneider et al. 2000). All fish collections conducted within the Cedar Creek watershed between 1925 and 1995 were summarized with reference to thermal preferences (Zorn et al. 2002).

Data Analysis

Data from statewide stream inventories were used to compare physical habitat measures and fish abundance in Cedar Creek to other high–quality coldwater streams throughout Michigan (T. Wills, MDNR, unpublished data). Linear correlation analysis was used to determine if there was a significant relationship between physical habitat measures and fish abundance. The statistical significance of linear correlation analyses were based on use of the *t*–test ($P \leq 0.05$).

Results

Gradient

The mainstem of Cedar Creek is 24.4 miles long with an average channel gradient of 6.3 ft/mi (Figure 2). This gradient level typically provides riffle and pool sequences with good hydraulic diversity and good fisheries habitat in streams. Run habitat was prevalent at the six sample sites on Cedar Creek, with four of the sites having 7%–30% riffles and pools.

There are 12 primary tributaries directly connected to the mainstem that account for 29.5 stream miles with an average gradient of 13.9 ft/mi (Table 1). There are also 48 tertiary tributaries that account for 21.6 stream miles. The average gradient of 11.8 miles of the tertiary tributaries was estimated at 29.6 ft/mi. Over 30 miles of stream channel in the Cedar Creek watershed was ditched, which accounts for 40.6% of total stream channel. Ditching occurs to the greatest extent in the tertiary and primary tributaries. Based on the earliest land surveys conducted during the 1830s, some of the ditched channels were originally natural while others were man–made.

Hydrology

Analysis of USGS stream flow data from the Bear Creek gauging station at Giles Road (20 miles from Cedar Creek) indicated that Cedar Creek stream discharge during the sampling periods was near base flow (assuming that there is a correlation in discharge between the two streams). The 39–year record for Bear Creek indicated lowest average monthly flow occurred during July at 6.9 cubic feet per second (ft^3/s); Bear Creek discharge was 4.7 ft^3/s on July 19 and 21 1995, 4.1 ft^3/s on October 13, 2003, and 4.9 ft^3/s on October 14, 2004. Base flow discharge in Cedar Creek increased from Brickyard Road downstream to the last sampling station at Sweeter Road (Figure 3). Discharge appeared to increase in a relatively consistent manner, indicating steady groundwater inflow throughout the middle segment of Cedar Creek.

Low–flow yield values were compared to low–flow yields (95% confidence limits) for Michigan's Lower Peninsula coldwater streams (P. Seelbach, MDNR, unpublished data). Low–flow yields for Cedar Creek downstream of M–120 were within limits typically found for other Michigan coldwater streams, and near the lower limit at Holton (Figure 4). Low–flow yield at Brickyard Road was very low. Yield was greatest for Little Henna Creek, a primary tributary that enters in the middle segment of Cedar Creek.

Water Temperatures

Average summer water temperatures were highest during August 1995 while the lowest winter temperatures occurred during January 1996. Therefore, these months were used to summarize stream temperatures. Average August water temperatures varied by 2.4°F over the 13.7–mi segment sampled (Figure 5). The highest water temperature (72.5°F) was recorded at Holton. Only 56 of the total summer hourly readings were greater than 70ºF, and these occurred at Holton and Sweeter Road. Average January water temperatures varied by 2°F across sampling sites (Figure 5). The lowest water temperature of 31.5°F was recorded at M–120; across all stations only 194 of the total winter hourly readings were 32°F or lower. Summer water temperature values for all locations in Cedar Creek fell within limits typical for Lower Michigan when compared to other trout streams (Figure 6).

Channel Features

Stream bank instability was greatest at Holton and M–120–u. These two sites had the highest percentage of banks with greater than 50% bare soil. Less than 50% of the banks at Holton were stable. Stability of banks was predominantly good at the remaining sites. All sites except Holton had bank stability comparable to the average of other coldwater streams in Michigan (Figure 7).

Riparian vegetation at all sites was primarily composed of large deciduous trees, small deciduous trees and tag alder. Trees were also the predominant vegetation along the banks of other coldwater Michigan streams. Holton and Crocker Road–d had higher levels of grasses and forbs and these were associated with point bars and areas where tree removal had occurred for bank stabilization projects. The M–120 site had some yard along the stream associated with a private residence. Few conifers were present at any site. Sample sites did not have any streamside agriculture although there was substantial agriculture present in the headwaters. Cedar Creek had higher amounts of deciduous trees and lower amounts of conifers than other coldwater streams in Michigan (Figure 8).

Cedar Creek had much higher levels of sand substrate than the average of other coldwater streams in Michigan. Substrate was composed of 85% or greater sand at all sites. Detritus accounted for 3% of substrate at Holton and 16% at Sweeter Road. Other Michigan coldwater streams had much higher average levels of gravel and cobble substrate than Cedar Creek, where gravel or cobble accounted for 4–10% of substrate at all sites except Sweeter Road (Figure 9). Nearly all of the gravel or cobble was completely embedded in sand.

Instream wood cover generally decreased from Holton downstream to Sweeter Road (Figure 10). The presence of sand traps at M–120 and Crocker Road did not appear to increase wood cover in the stream. Wood cover was not directly comparable at all sites because M–120–u and Crocker Road–d had a substantial amount of cover composed of artificial structure. Instream wood cover was average or above average at all sites except one when compared to other coldwater streams in Michigan (Figure 11). The Sweeter Road site was below the average but still higher than many other Michigan streams.

Fisheries

Brook trout *Salvelinus fontinalis* and rainbow trout (steelhead) *Oncorhynchus mykiss* were collected at all sites except Brickyard Road, and Chinook salmon *Oncorhynchus tshawytscha* were collected at all sites except Brickyard Road and Sweeter Road. One brown trout *Salmo trutta* was collected at Holton in 1995 and at M–120–u in 2006. Brook trout ranged in size from 1 in – 14 in with good numbers of legal fish present in both years. Rainbow trout ranged in size from 1 in – 10 in with most fish smaller than 8 in, which was expected because most steelhead migrate to Lake Michigan by the time they reach 8 in.

Mean numerical and biomass densities of all trout and salmon in 2006 was greatest between M–120–d and Crocker Road-d (Figure 12). Numerical densities were likely not statistically different between sites as indicated by overlap in the standard error bars. The high abundance of fish at Crocker Road–u was due to the presence of large numbers of young–of–year (3 in) brook trout. Both mean numerical and biomass densities of fish were dominated by brook trout (75.0–96.1%; 91.2–99.1%), followed by rainbow trout (3.2–25.0%; 0.8–8.7%). The abundance of both brook trout and rainbow trout was much greater in 1995 than in 2006 at the two sites evaluated. Brook trout densities in 1995 were more than double 2006 densities, and rainbow trout densities in 1995 were more than 20 times those in 2006. The biomass of trout in Cedar Creek ranged from above to below average when compared to 71 other Michigan coldwater streams containing brook trout (Figure 13). Biomass at most sites on Cedar Creek ranked relatively high among streams dominated by brook and rainbow trout.

Numerical and biomass densities of trout and salmon in 2006 displayed no significant relationship to the density of wood cover in Cedar Creek. The relatively narrow range of wood cover density in Cedar Creek may have precluded establishing a relationship with fish biomass. This is suggested from the one site with the lowest wood cover, which also had the lowest fish biomass. When the relationship between wood cover and biomass of trout and salmon in Cedar Creek was compared to 10 other Michigan brook and rainbow trout streams (Figure 14) a significant ($P = 0.05$, N = 32) correlation was found, but there was substantial variation as indicated by the low value of the correlation coefficient ($r = 0.38$).

No significant correlation was found between stone (gravel, cobble, and boulders) substrate and biomass of trout and salmon when compared to 10 other Michigan brook and rainbow trout streams (Figure 15). Substrate at all Cedar Creek sites was predominantly sand and had similar trout and salmon biomass densities compared to other Michigan coldwater streams high in sand substrate.

Coldwater fish species were present at all sites on the mainstem between Holton and Sweeter Road (Table 2). The presence of some of the more warmwater tolerant species at M–120 and Sweeter Road was likely due to the presence of a beaver impoundment near M–120 and immigration from warmer downstream reaches at Sweeter Road. The fish community at River Road was dominated by warmwater fish. Coho salmon *Oncorhynchus kisutch* were found at this site, but were likely present due to seasonal migratory behavior. The West Branch of Cedar Creek contained predominantly coldwater fish. Little Cedar Creek contained coldwater fish in the upper reaches and warmwater fish in the lower reaches that flow through the Muskegon River floodplain. Sweeter Creek contained primarily warmwater fish, although insufficient sampling has been conducted to determine if coldwater fish may be present in the upper reaches of this stream. Fish samples were not collected on Little Henna Creek. However, angling and other observations have shown this stream contains brook trout, steelhead, and Chinook salmon. Low–flow yield values indicated Little Henna Creek is a coldwater stream.

Discussion and Recommendations

Results of this evaluation indicate that Cedar Creek is a coldwater stream with habitat capable of supporting naturally-sustaining coldwater fish communities between the Holton and Sweeter Road areas. Brook trout were the dominant species of fish in the middle segment of Cedar Creek. Rainbow trout (steelhead) were second in abundance, and some Chinook salmon were also present. Both rainbow trout and Chinook salmon use the stream for spawning and rearing with adults migrating to Lake Michigan. Two brown trout were collected but these could have migrated from the Muskegon

River, which is stocked with brown trout. Annual variability in fish abundance can be high as indicated by comparison of 1995 and 2006 estimates. Variable annual abundance has been noted for these species in other Michigan streams (Alexander and Hansen 1988; Seelbach 1986). Based on mean estimates for 2006, the 15.4 miles of Cedar Creek from 1.3 miles upstream of Holton to 1.3 miles below Sweeter Road, contained 10,761 (± 3,790) brook trout and 780 (± 344) rainbow trout.

Coldwater streams are a limited resource in the Lower Peninsula of Michigan, where approximately 25% of the stream segments were classified coldwater (Seelbach et al. 1997). Coldwater systems in Michigan are at risk due to extensive human development in watersheds. Development generally degrades water quality conditions and destabilizes the hydrology in these streams. Coldwater streams support higher densities of trout than warmwater systems, and serve as spawning grounds and nursery areas for migratory Great Lakes salmonids (O'Neal 1997). They are also an important recreational fishery resource in Michigan. Coldwater streams with characteristics typical of Cedar Creek have average annual angler–day/mi values of 831/year, with an estimated economic value of $22,437/mile/year (MDNR, unpublished data); dollar values were based on an estimated angler–day value of $27 (U.S. Department of the Interior, 2002).

Changes in land–use from pre–settlement time (1800s) to 1998 have occurred to the greatest extent in the headwaters (Figure 16). Fongers (2004) found that the Cedar Creek watershed had retained much (60%–70%) of its natural area. This is partly because the U.S. Forest Service owns a large segment of land bordering Cedar Creek between M–120 and Sweeter Road. Presently, most developed areas are agricultural lands. Land-use trends indicate further development will be a transition from agriculture to urban land uses, with losses of remaining wetlands.

Land–use changes within the watershed have resulted in increased surface water runoff and peak stream flow volumes from the 1800s to 1998 (Fongers 2004). Further increases in storm flow runoff are anticipated with future land-use changes (Tang et al. 2005). Hydrologic models indicate Cedar Creek was within expected storm flow yield values from Brickyard Road to River Road before European settlement. By 1978, 24-hr storm flow yields upstream of M–120 had increased to levels higher than maximum values typical for Michigan trout streams, indicating degraded fisheries habitat. Expanded future development could result in stormwater runoff that impairs fisheries habitat downstream as far as Sweeter Road. Stormwater ordinances presently used in Michigan are not adequate to protect Cedar Creek from stormwater flows above levels typical for Michigan coldwater streams.

Present conditions in Cedar Creek were consistent with the hydrology models. Much of the development that has occurred in the watershed is located in the headwaters upstream of Holton. Approximately 41% of the total mainstem and tributary channels were ditched, and most of this occurred in the headwaters area. Stream channels were present in the 1838–1839 land surveys for upper Cedar Creek (Markle Drain), South Branch Cedar Creek (Folsom Drain), and Martin Drain systems. The original channels appear to have been extensively ditched and new channels added. The extensive ditching in the headwaters is suspected to have reduced groundwater inflows by increasing surface water runoff and decreasing groundwater infiltration, as summer water temperatures appeared to be somewhat elevated. Increased surface runoff may also be indicated by the high bank erosion and relatively low low–flow yields at Holton.

Cedar Creek contains one of the best brook trout fisheries in Michigan and provides high quality spawning and rearing habitat for Great Lakes fish. One of the most important issues that must be addressed is the protection and restoration of system hydrology. A healthy watershed cannot be restored or maintained without appropriate management in this area. The Muskegon River Watershed Assessment and Plan provide many options for management and improvement of the mainstem and tributaries. Protecting and restoring habitat conditions in Cedar Creek is important to the overall ecological integrity of the Muskegon River watershed. Human development and resulting habitat changes have been occurring throughout the watershed for over 150 years; restoration and protection efforts will require a long-term approach and must be pursued in all subwatersheds.

Acknowledgments

T. Wills and K. Wehrly provided data used in the figures that compared Cedar Creek to other Michigan rivers. Helpful editorial suggestions were provided by J. Baker, A. Nuhfer, T. Wills, and T. Zorn. A. Sutton provided help with figures.

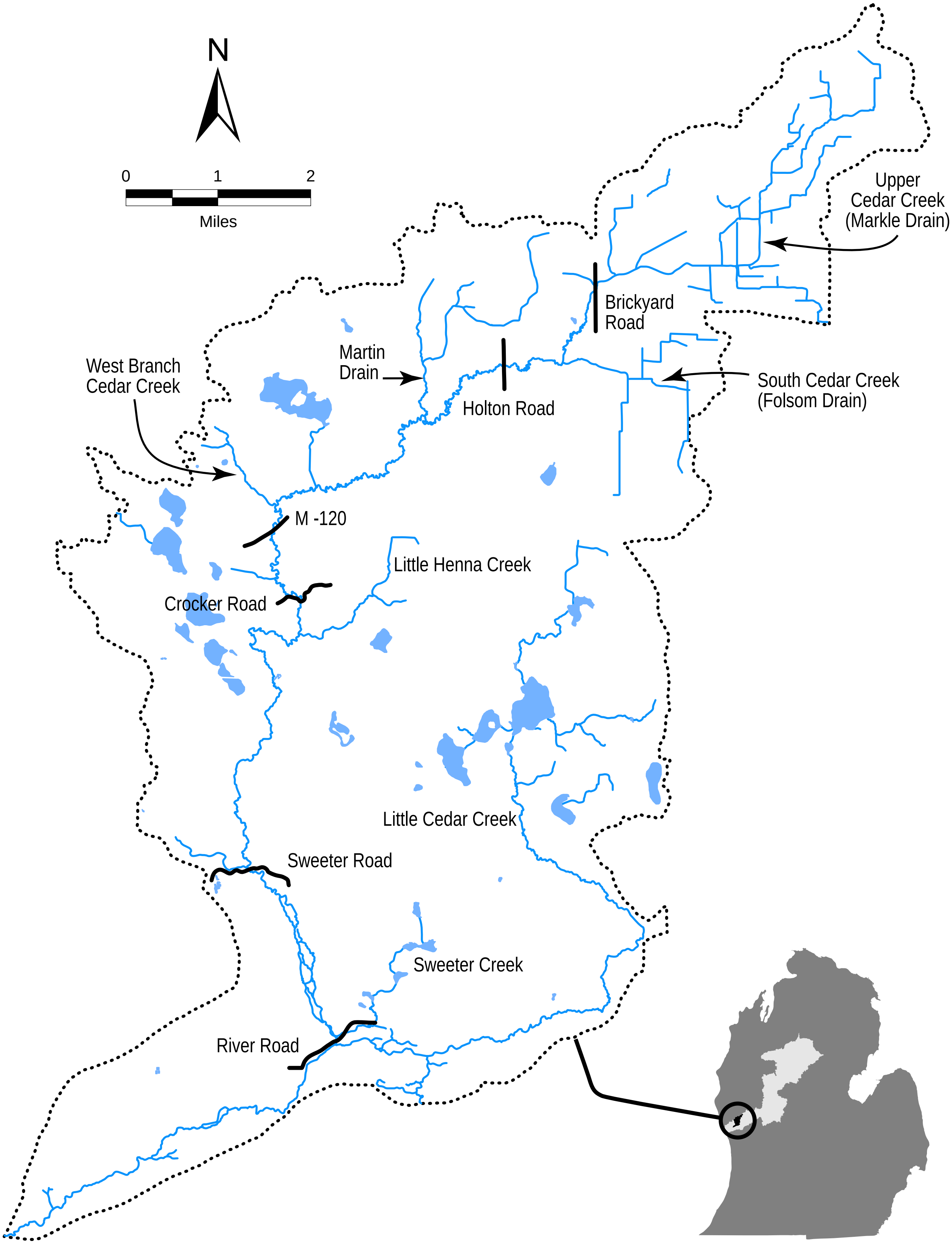

Figure 1.–Cedar Creek watershed and sampling locations.

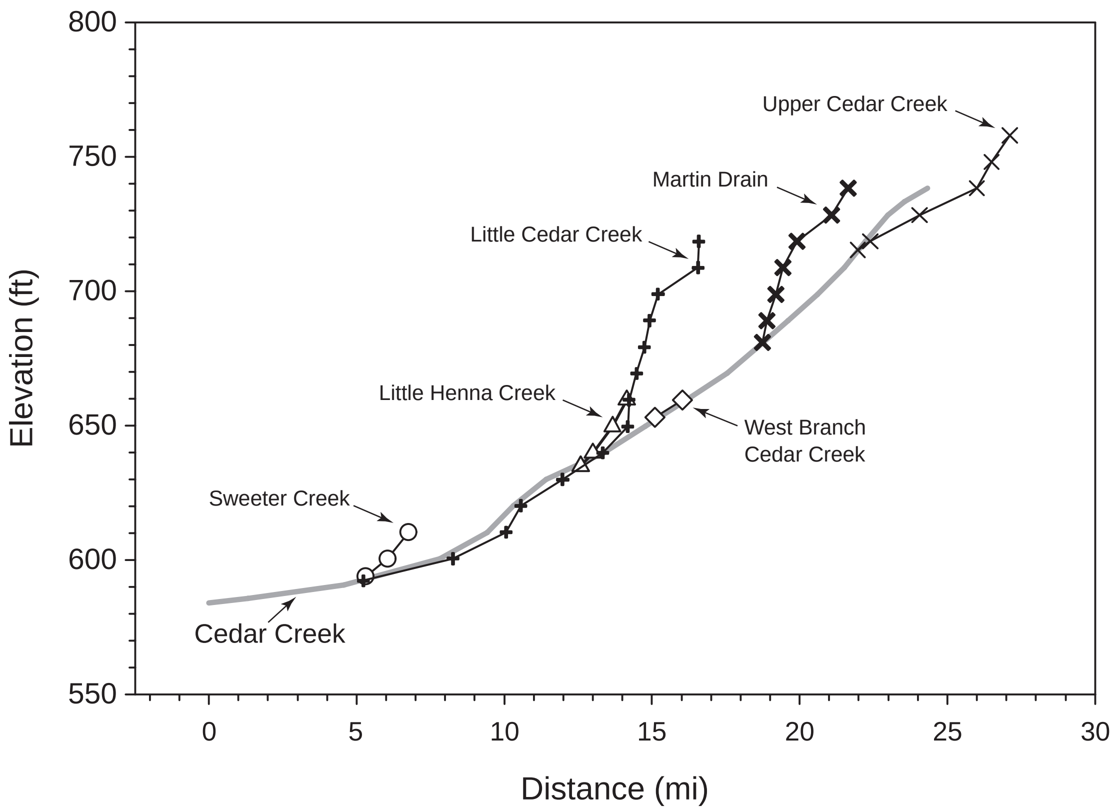

Figure 2.–Gradient profile of Cedar Creek and selected tributaries.

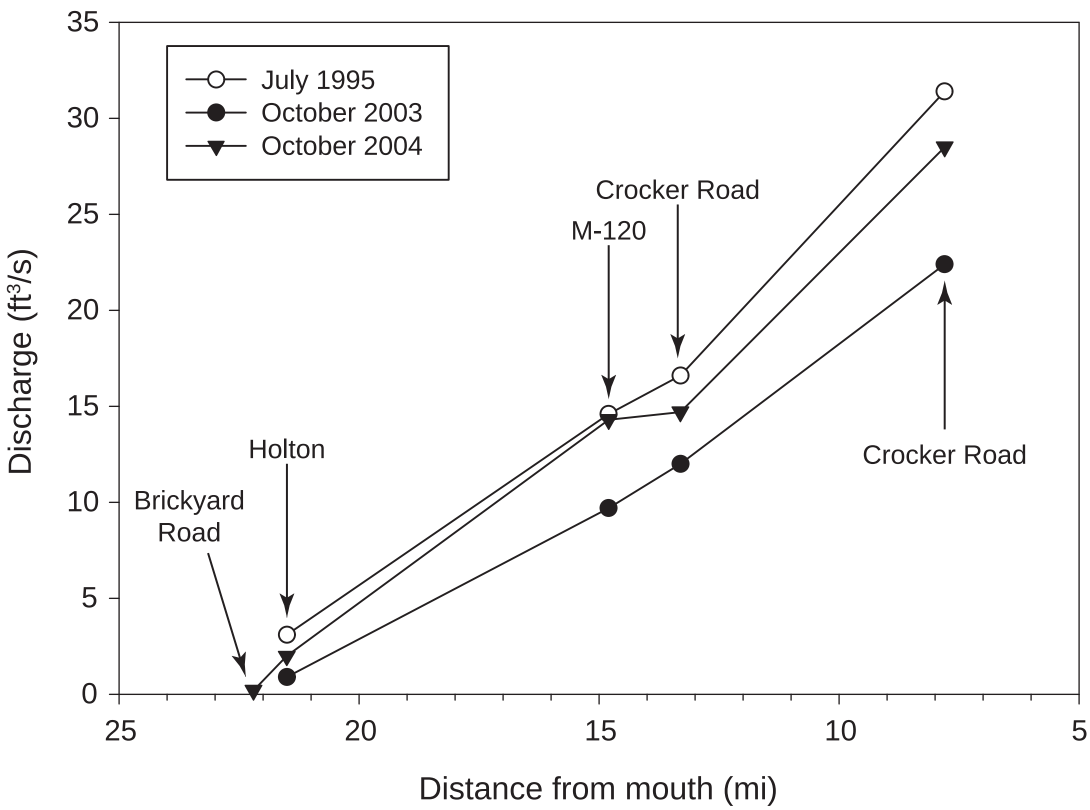

Figure 3.–Cedar Creek discharge measurements.

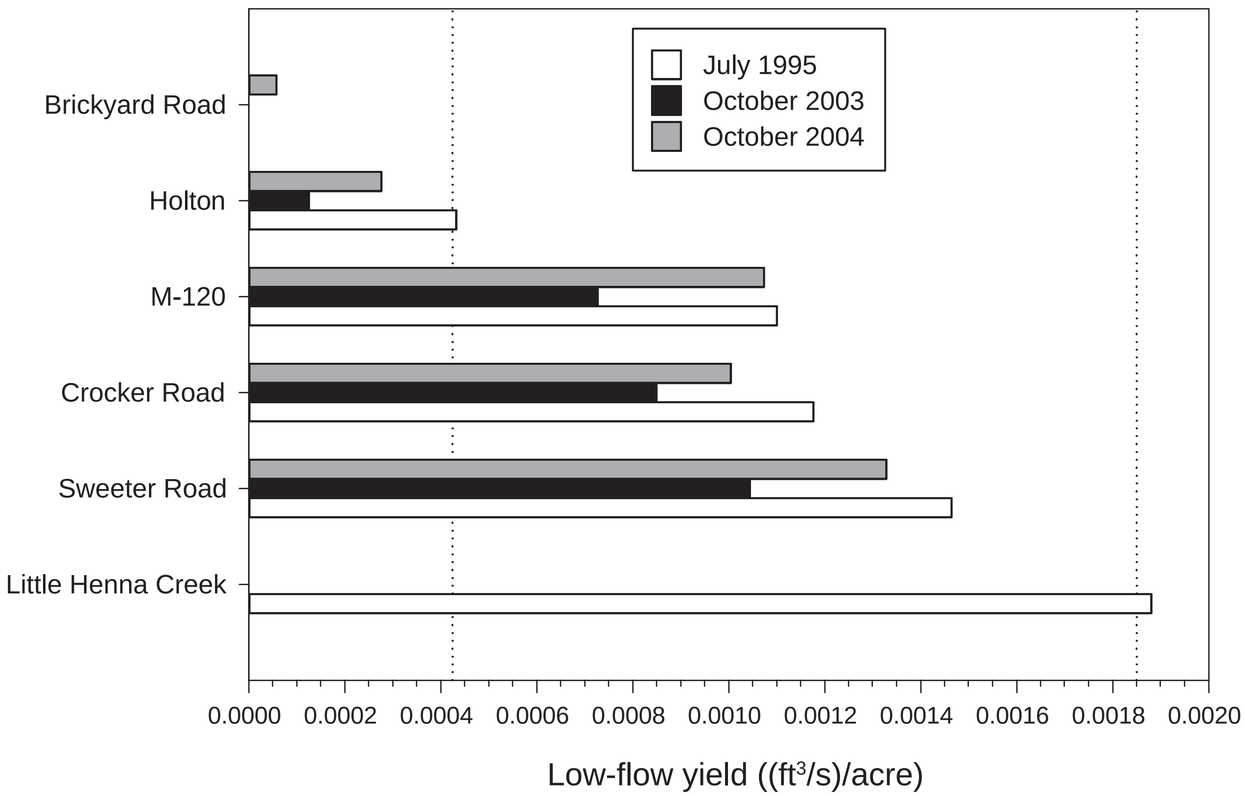

Figure 4.–Low-flow yields for Cedar Creek and Lower Michigan coldwater streams (bounded by dotted vertical lines). Mainstem sites (Brickyard Road–Sweeter Road) are sorted from upstream to downstream. Coldwater stream limits represent 95% confidence intervals for low–flow yields of coldwater streams in the Lower Peninsula of Michigan (P. W. Seelbach, MDNR, personal communication).

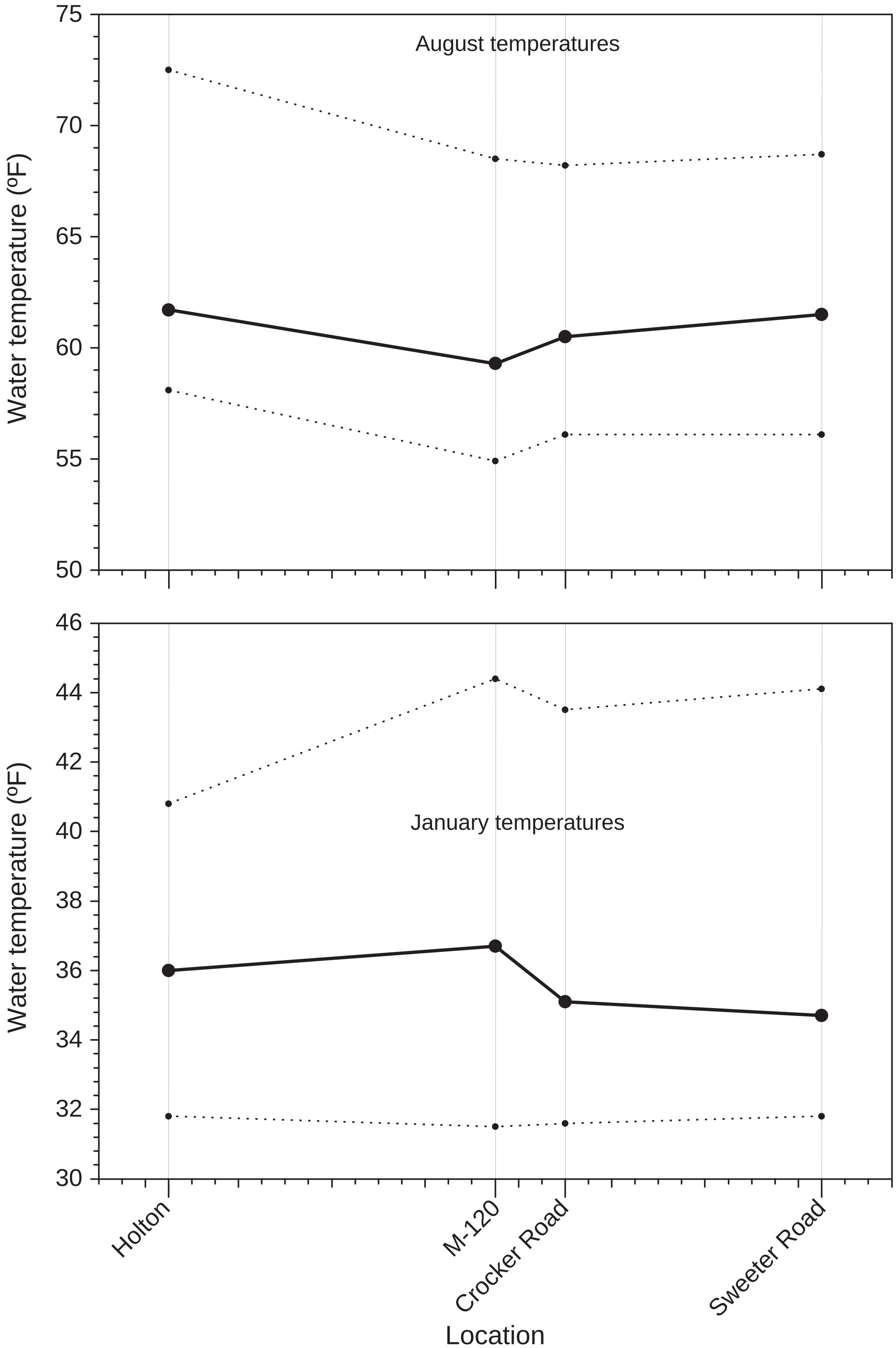

Figure 5.–Average, minimum, and maximum water temperatures in Cedar Creek during August 1995 (upper figure) and January 1996 (lower figure).

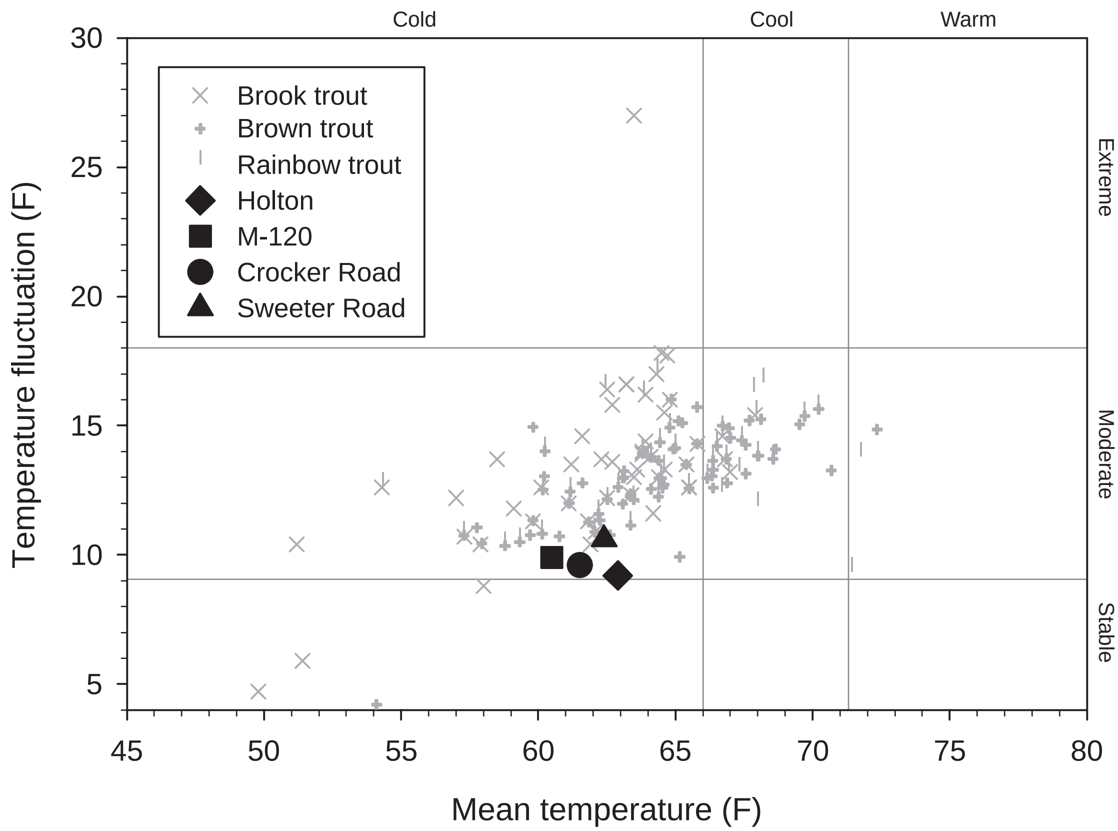

Figure 6.–August 1995 water temperatures at four sites on Cedar Creek compared to coldwater stream values for other Lower Michigan streams determined by Wehrly et al. (1998). Data from Michigan brook, brown, and rainbow trout streams illustrate their temperature distribution within Wehrly's classification system. Most trout streams had cold or cool temperatures with moderate or stable fluctuations, as did all four sites on Cedar Creek.

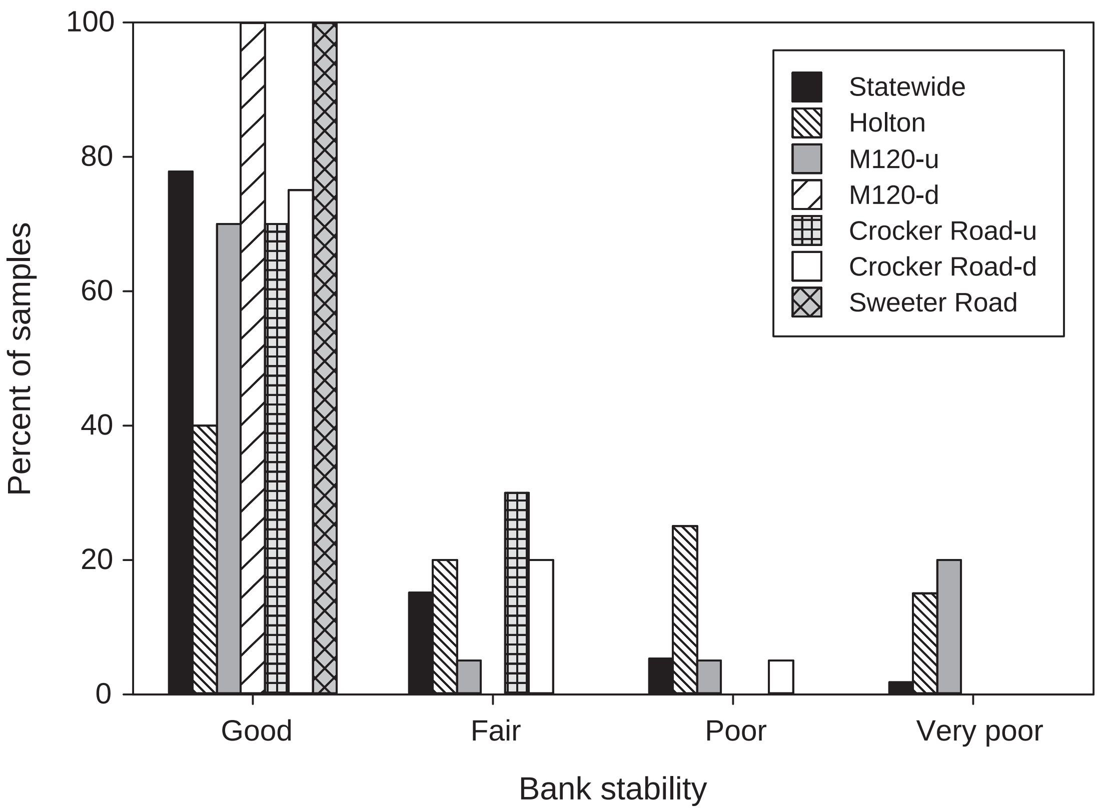

Figure 7.–Bank stability at six sampling stations on Cedar Creek in 2006 compared to averages for other coldwater streams (N=73) located throughout Michigan. Stability classes indicated by percent of stream bank with bare soil were good (<25%), fair (25–50%), poor (50–75%), and very poor (>75%).

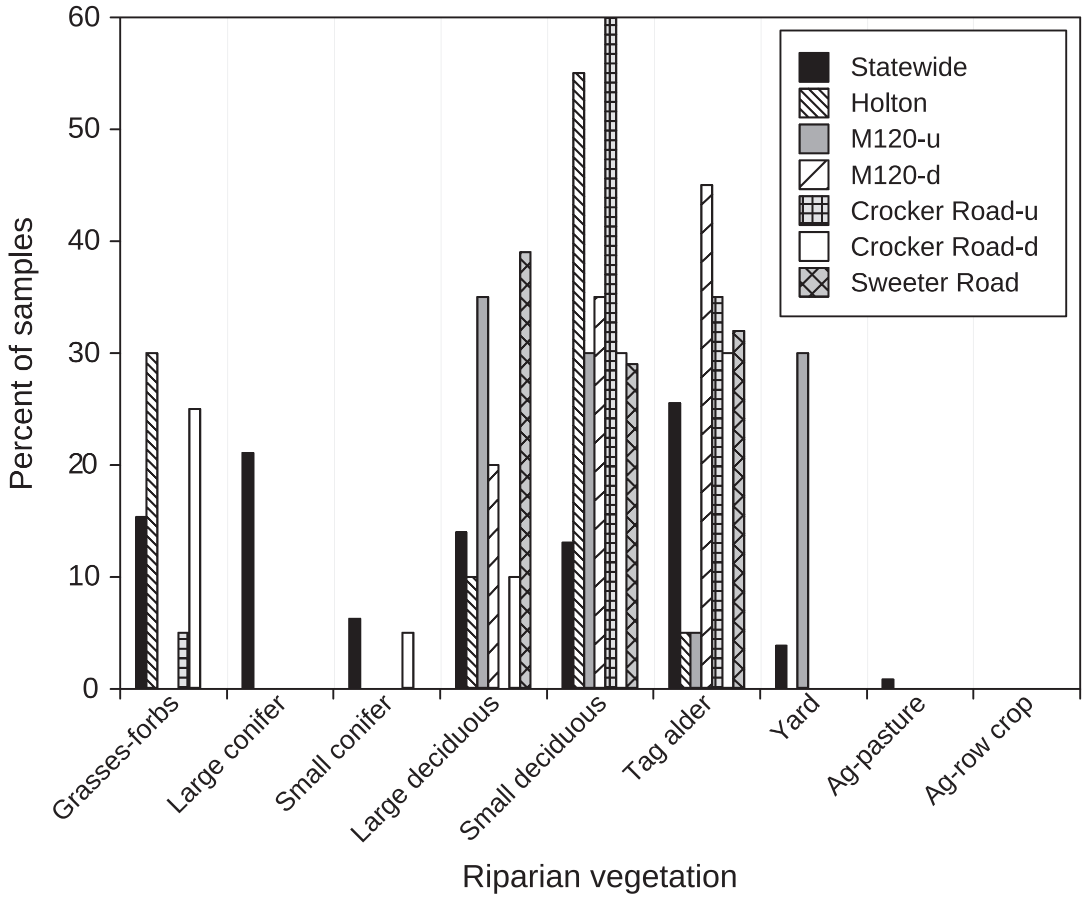

Figure 8.–Bank vegetation at six sampling stations on Cedar Creek in 2006 compared to averages for other coldwater streams (N=73) located throughout Michigan.

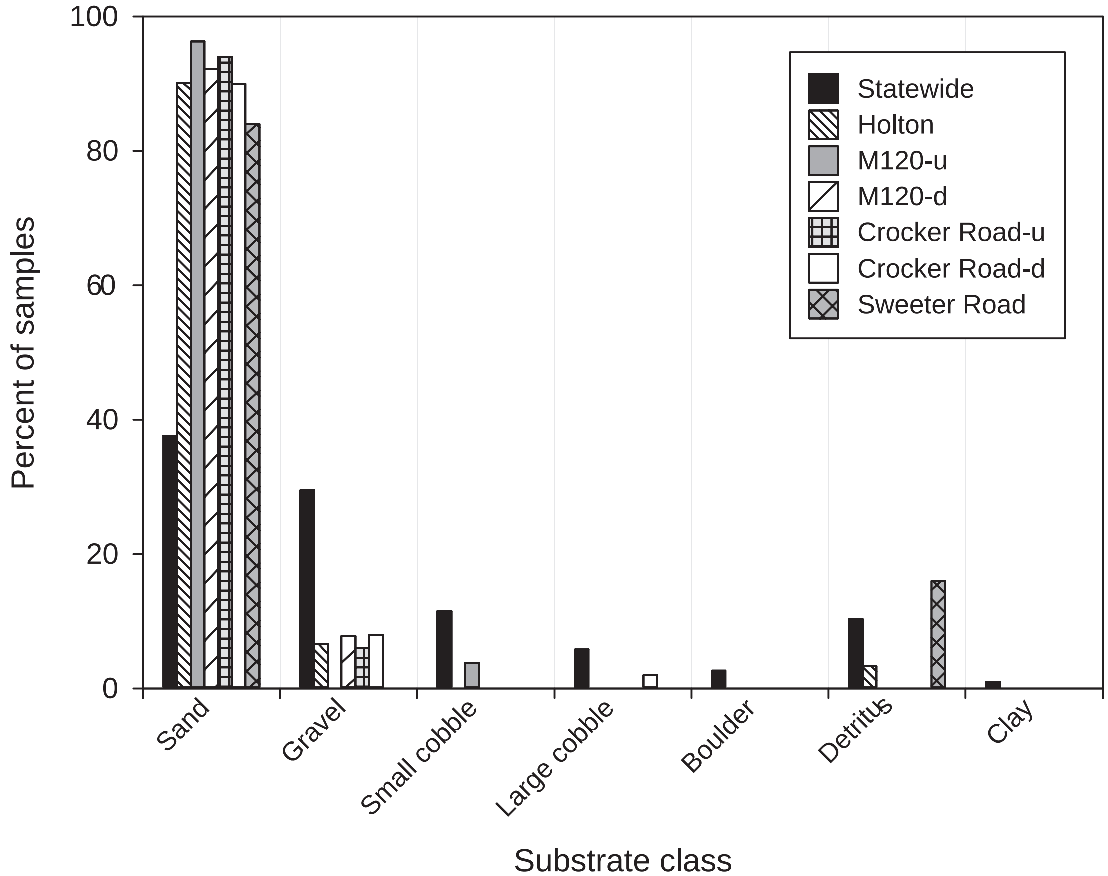

Figure 9.–Substrate composition at six sampling stations on Cedar Creek during 2006 compared to averages for other coldwater streams (N=73) located throughout Michigan.

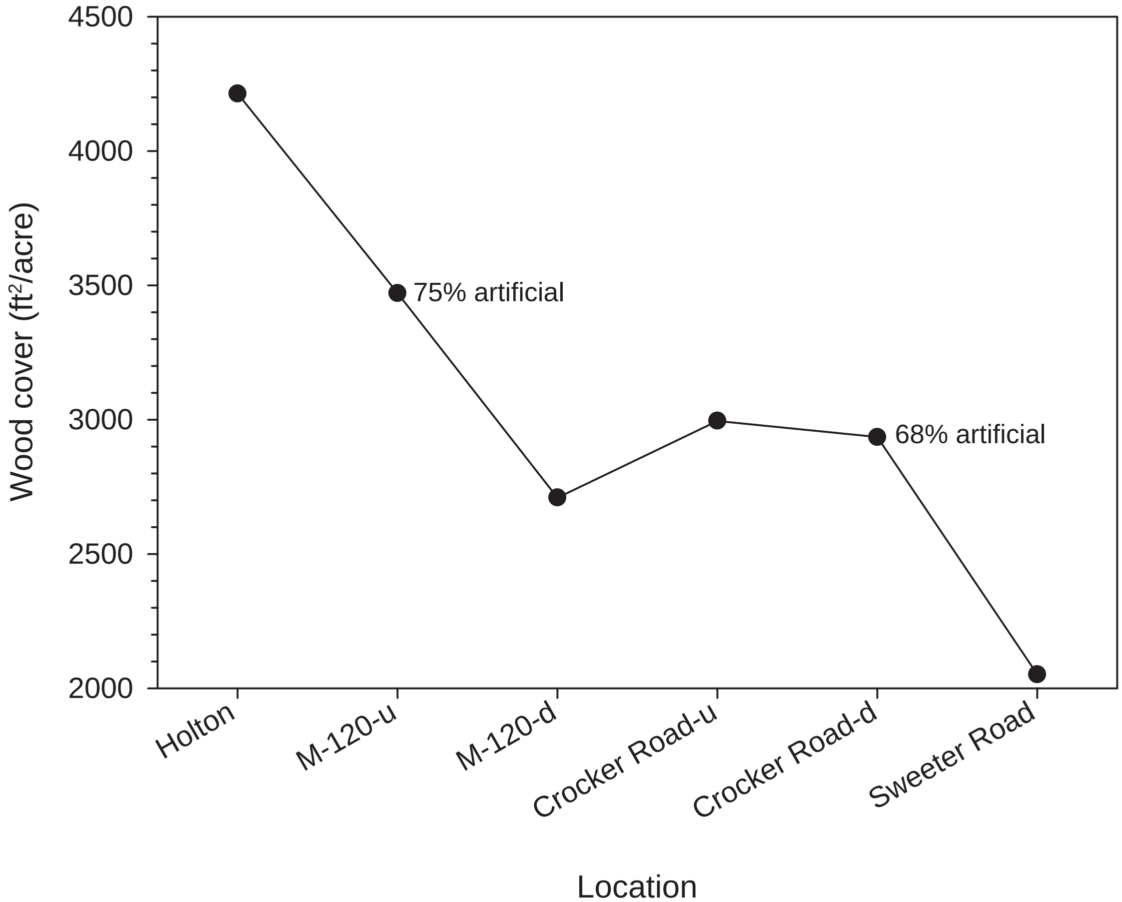

Figure 10.–Estimated amount of wood cover at six sampling stations in Cedar Creek in 2006. Locations are arranged in order from upstream (left) to downstream (right).

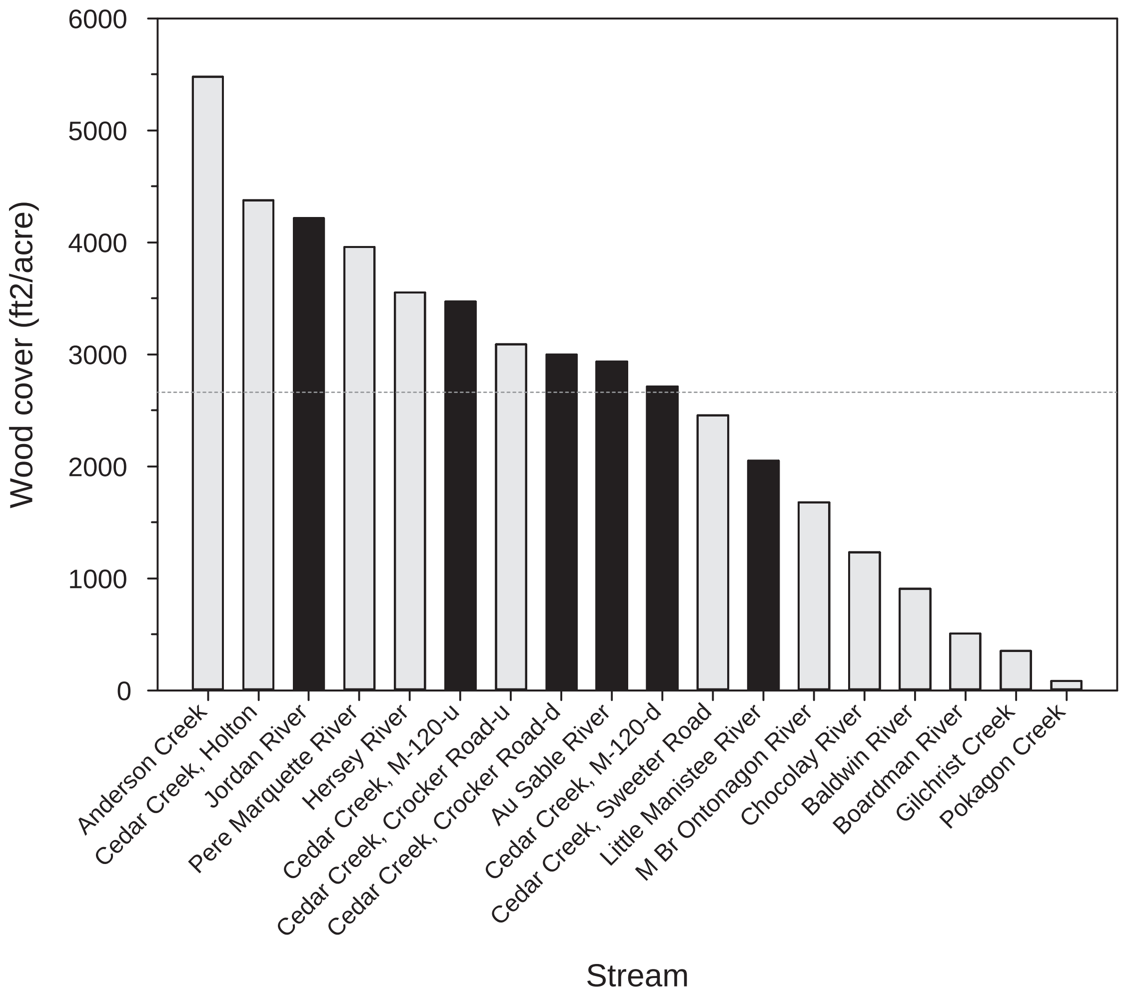

Figure 11.–Wood cover at six sampling stations on Cedar Creek during 2006 compared to select coldwater streams located throughout Michigan. The dotted line represents average wood cover (2,659 ft^2/acre, range of 84–24,339 ft2/acre) in all coldwater streams with data available (N=57).

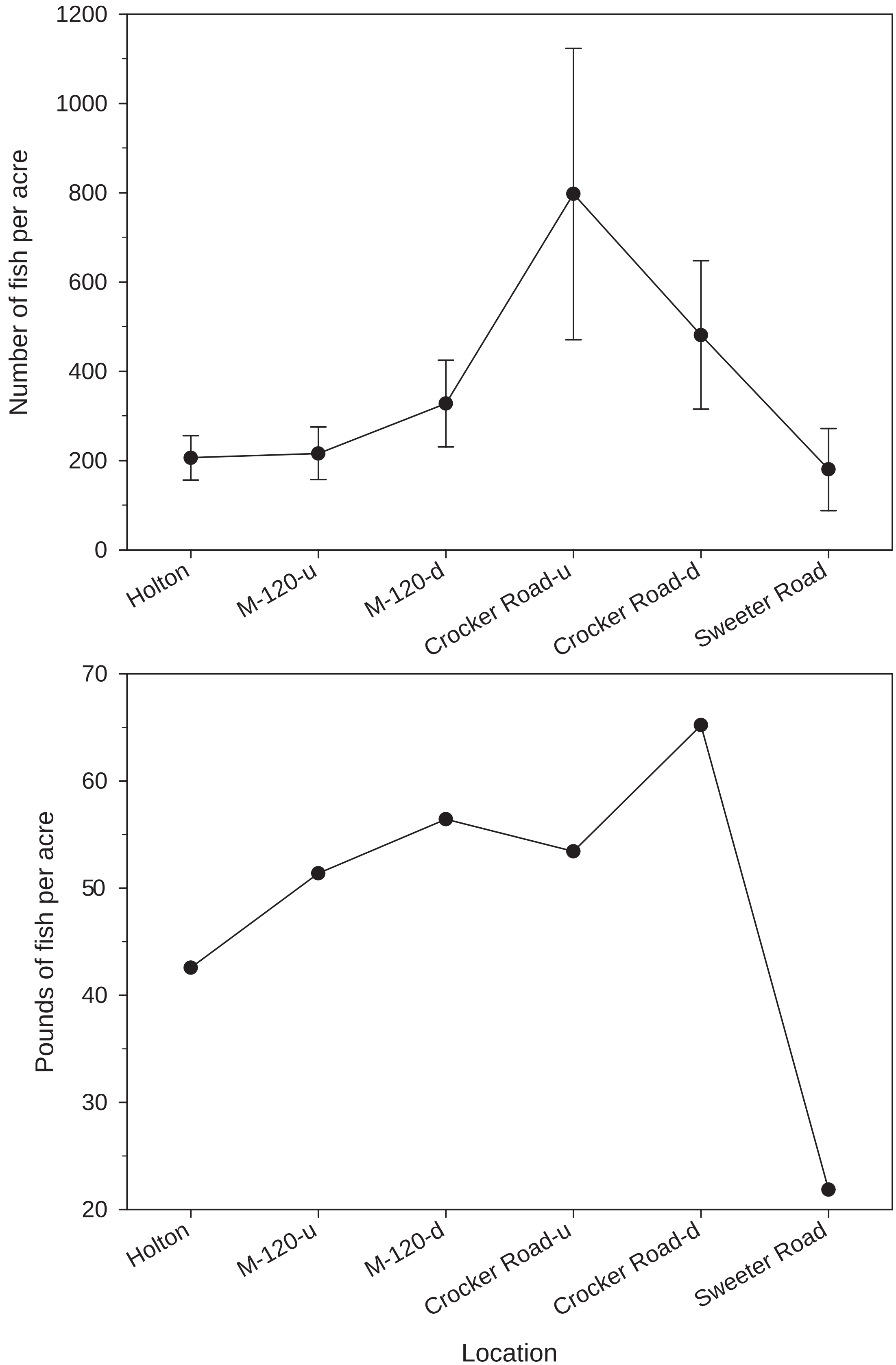

Figure 12.–Mean numerical (±2 standard errors, upper figure) and biomass densities (lower figure) of all trout and salmon at six sampling sites on Cedar Creek in August 2006.

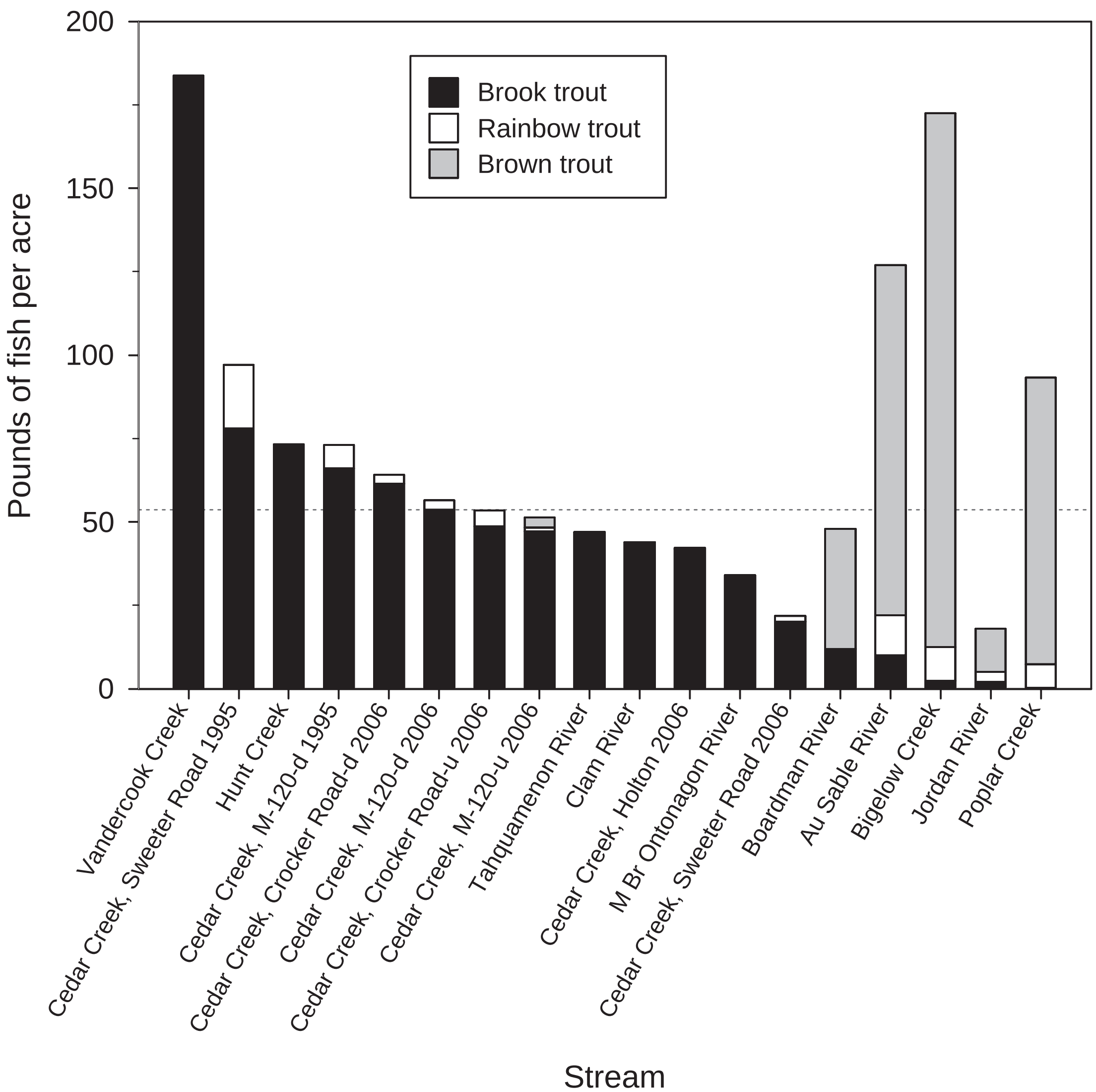

Figure 13.–Biomass of trout in Cedar Creek (1995 and 2006) compared to select coldwater streams that contain brook trout located throughout Michigan. The dotted line represents average trout biomass (54.6 pounds/acre, range of 0.9–183.8 pounds/acre) for Michigan coldwater streams containing brook trout (N=71).

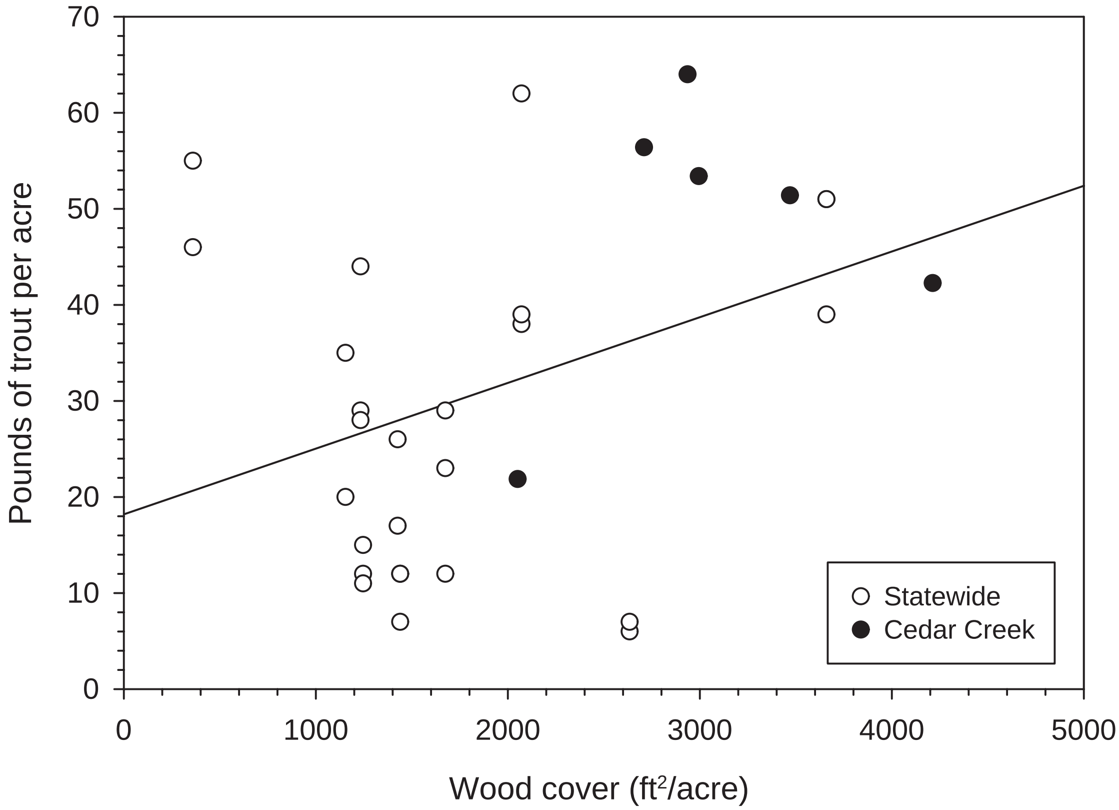

Figure 14.–Total trout biomass as a function of instream wood cover in Cedar Creek (August 2006) and ten (N=26) other Michigan coldwater streams with fish communities dominated by brook trout and rainbow trout. Two or three consecutive year biomass estimates were available for each stream. The regression line describes all statewide sites and Cedar Creek sites.

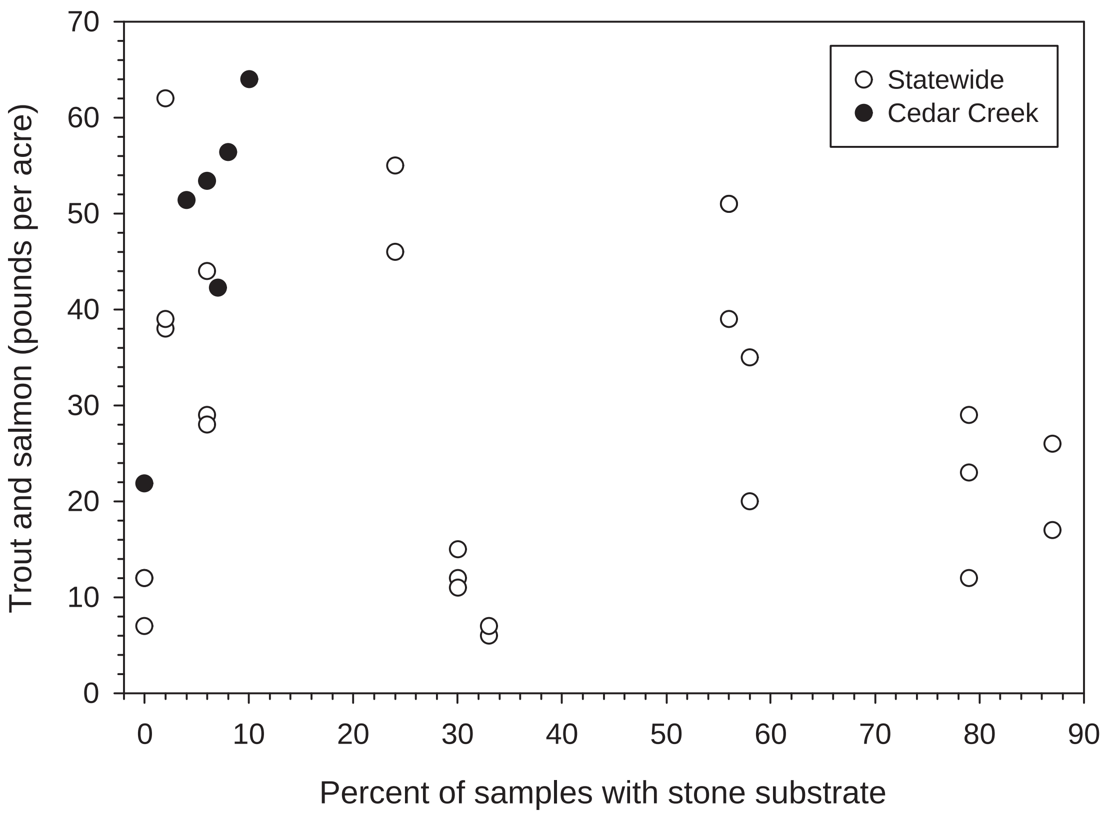

Figure 15.–Total trout biomass as a function of percent stone (gravel, cobble, boulder) substrate in Cedar Creek (August 2006) and ten (N=26) other Michigan coldwater streams with fish communities dominated by brook trout and rainbow trout. Two or three consecutive year biomass estimates were available for each stream.

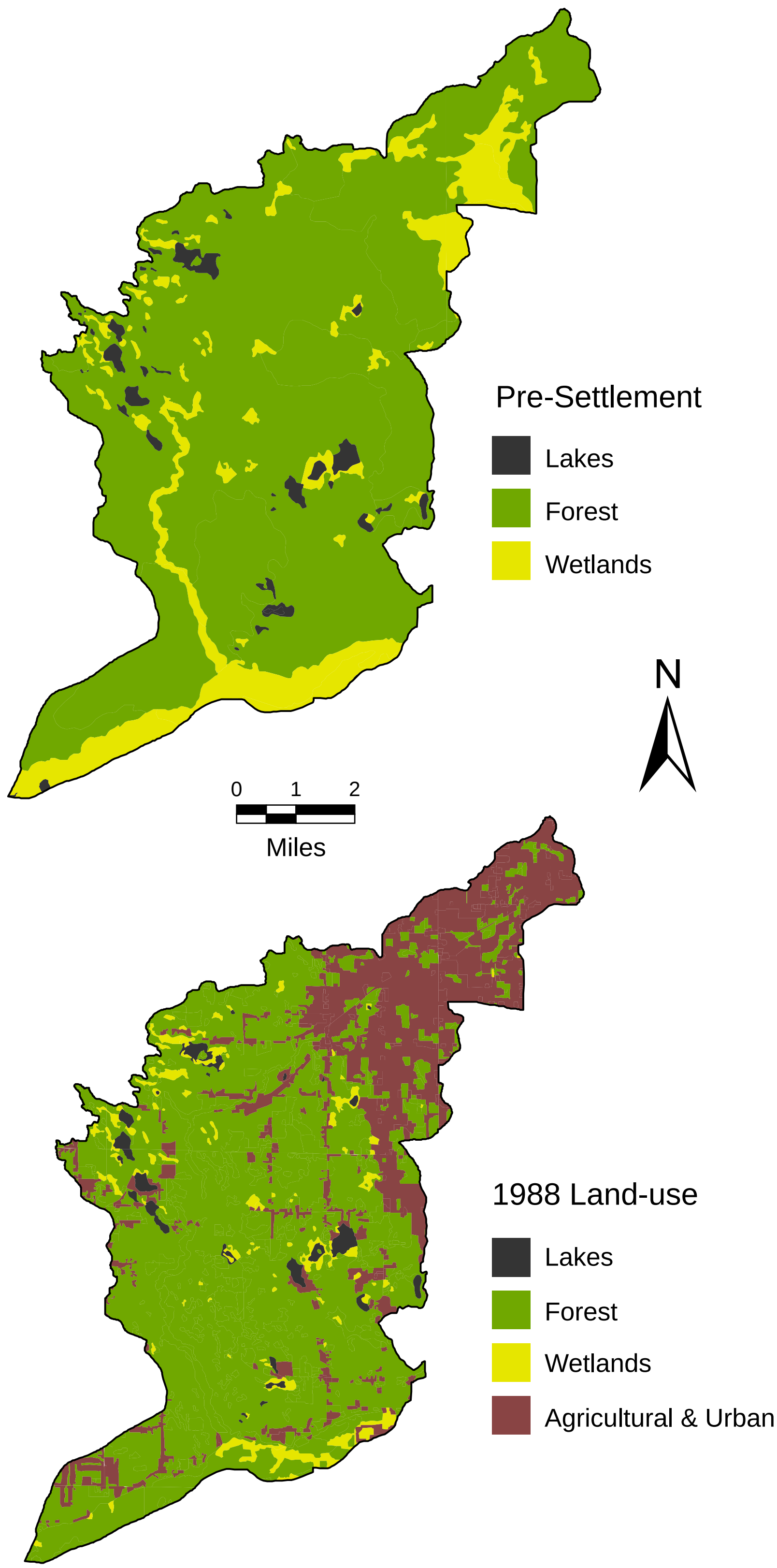

Figure 16.–Pre-settlement (upper figure) and 1998 (lower figure) land–use in the Cedar Creek watershed (Grand Valley State University, Annis Water Institute, unpublished data).

Table 1.–Channel distance and average gradient (ft/mi) of various stream segment types in Cedar Creek. Primary tributaries discharge directly into Cedar Creek. Tertiary tributaries include all tributaries of the primary tributaries. Values for ditched segments are in parentheses.

Stream segment type	Miles		Percent of total		Average gradient	
Mainstem	24.4	(2.9)	32.3	(3.8)	6.3	(10.5)
Primary tributaries	29.5	(12.7)	39.1	(16.8)	13.9	(13.2)
Tertiary tributaries	21.6	(15.1)	28.6	(20.0)		
Tertiary tributaries with known gradient	11.8	(9.9)			29.6	(20.0)
Total	75.6	(30.7)	100	(40.6)		

Table 2.–Species of fish collected in Cedar Creek watershed, 1925-2006, listed in order from coldwater to warmwater thermal preference (Zorn et al. 2002). Collections were not systematic or throughout the watershed.

	Mainstem locations (headwater to mouth)											
Species *Scientific name*	Brickyard Road	Holton Road	Crystal Lake Road	M-120	Crocker Road	Ryerson Road	AustinRoad	Sweeter Road	River Road	West Br. Cedar Creek	Little Cedar Creek	Sweeter Creek
Mean July temperature < 66 °F												
Brook trout- *Salvelinus fontinalis*		X	X	X	X	X	X	X		X	X	
Slimy sculpin- *Cottus cognatus*											X	
Coho salmon- *Oncorhynchus kisutch*									X			
Chinook salmon- *Oncorhynchus tshawytscha*		X		X	X							
Rainbow trout- *Oncorhynchus mykiss*		X	X	X	X	X		X				
Brown trout- *Salmo trutta*			X	X							X	
Mottled sculpin- *Cottus bairdii*	X	X		X	X	X	X	X	X	X		
Western blacknose dace- *Rhinichthys obtusus*		X			X			X				
Mean July temperature > 66 °F												
Burbot- *Lota lota*					X	X		X			X	
Northern redbelly dace- *Phoxinus eos*								X			X	X
Creek chub- *Semotilus atromaculatus*							X	X			X	X
Central stoneroller- *Campostoma anomalum pullum*											X	X
Common shiner- *Luxilus cornutus*											X	
Bluntnose minnow- *Pimephales notatus*											X	
Johnny darter- *Etheostoma nigrum*								X	X		X	
White sucker- *Catostomus commersonii*	X	X	X	X	X	X	X	X	X		X	X
Fathead minnow- *Pimephales promelas*			X									
Northern pike- *Esox lucius*											X	
Central mudminnow- *Umbra limi*	X			X				X	X	X		X
Blackside darter- *Percina maculata*								X	X			
Rock bass- *Ambloplites rupestris*	X								X			
Black bullhead- *Ameiurus melas*				X								
Yellow perch- *Perca flavescens*				X				X				
Tadpole madtom- *Noturus gyrinus*									X			X
Unclassified by temperature												
Silver lamprey- *Ichthyomyzon unicuspis*											X	
Lake chub sucker- *Erimyzon sucetta*												X

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