

# **Lamprey River Watershed Fish Surveys**



## **Report to the Lamprey River Local Advisory Committee**

New Hampshire Fish and Game  
Inland Fisheries  
Fish Conservation Program  
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## INTRODUCTION

Over 20% of the freshwater fish species in the world are either extinct or in serious decline (Moyle and Leidy 1992). Despite this rapid loss of biodiversity, there is little information available on the status of many fish species. The number of fish species listed as endangered, threatened, or of special concern by state fish and wildlife agencies has increased significantly over the last 30 years. Small fish species are not easily observed, and local extirpations often go unnoticed.

Biologists with the New Hampshire Fish and Game (NHFG) Fish Conservation Program have been working to assess the status and map the distribution of fish species of concern, identified in New Hampshire's Wildlife Action Plan, since 2006. Other than the records from state wide fish surveys conducted by the NHFG Department in the late 1930's and the mid 1980's, there was very little information available on the distribution and status of fish and aquatic habitat in most New Hampshire watersheds. There was a clear need for baseline fish survey data upon which future changes could be compared.

This need for baseline fish survey data has been reinforced by work on the Eastern Brook Trout Joint Venture, a public and private partnership of state fish and wildlife agencies, federal natural resource agencies, academic institutions, and local conservation organizations working to prevent further declines in eastern brook trout populations across their former range in the eastern United States. Large scale models, developed to predict the current distribution and status of brook trout across the region, were used to establish regional conservation priorities (Hudy et al. 2004; Hudy et al. 2007). However, large scale models lack detailed information at the individual stream level. More surveys were needed to provide information on the actual status of brook trout in smaller watersheds throughout the state.

While fish survey data is useful for directing regional conservation efforts, most conservation work is done at the local level. In recognition of the lack of information available about local aquatic resources, the Fish Conservation Program began partnering with land trusts, town conservation commissions, and watershed associations to provide them with fish survey data to help prioritize conservation or restoration opportunities intended to benefit aquatic species and to protect or improve water quality.

The following report summarizes the results of fish survey data collected for the Lamprey River Advisory Committee. This survey work was conducted with the following objectives:



- 1) Collect information on the status of Eastern Brook Trout in the Lamprey River Watershed and as part of an ongoing project using survey protocols developed for the Eastern Brook Trout Joint Venture.
- 2) Collect information on the distribution and status of fish species of concern, listed in New Hampshire's Wildlife Action Plan, and recommend strategies to promote healthy populations and prevent declines of these species.
- 3) Collect baseline fish community data that will help monitor water and habitat quality throughout the Lamprey River watershed. Identify species that may be used as indicators of healthy water quality and good habitat.
- 4) Recommend potential conservation strategies that will protect aquatic habitats and promote water quality throughout the Lamprey River watershed.

## METHODS

### *Study Area*

The Lamprey River watershed drains an area of approximately 554 km<sup>2</sup> (214 mi<sup>2</sup>) in southeastern New Hampshire. The Lamprey River empties into the Great Bay estuary in the town of Newmarket. The terrain consists of foothills in the western headwaters of the river, but the landscape becomes more flat as one moves east, toward the coastal plain. The highest point in the watershed is Saddleback Mountain, in Northwood, at 352 m (1,155 ft). The Lamprey River watershed is dominated by two forest communities described in New Hampshire's Wildlife Action Plan: Appalachian-oak-pine and Hemlock-hardwood-pine. The surficial geology of the area was heavily influenced by receding glaciers. It is a combination of bedrock, estuarine silts and clays, and glacial deposits, including till, stratified drift, kames, and eskers.

Stratified drift consists of sand and gravel deposited in layers by melting glaciers. The porous nature of stratified drift is highly conducive to storing groundwater as aquifers. The distribution and type of stratified drift aquifers has a major influence on the distribution of cold water stream habitat in southeastern New Hampshire (Figure 1). Streams supplied with a year round source of groundwater are the only streams capable of supporting naturally reproducing brook trout populations in the Lamprey River watershed.

The stratified drift aquifers in southeastern New Hampshire can be divided into two categories: glacioestuarine deltas and valley fill (Moore 1990). Glacioestuarine deltas were formed in the eastern part of the watershed, where meltwater deposited sediment as it came into contact with the ocean. Shoreline deltas were formed where glacial meltwater flowed over land before reaching the ocean. Grounding line deltas formed earlier during deglaciation, when melting ice was directly in contact with the ocean. Grounding line deltas are the most productive and extensive aquifers in the watershed.

Valley fill aquifers were formed in the western part of the watershed, where melting glaciers deposited sediment in the low lying areas among the hills. These aquifers were not influenced by the ocean.

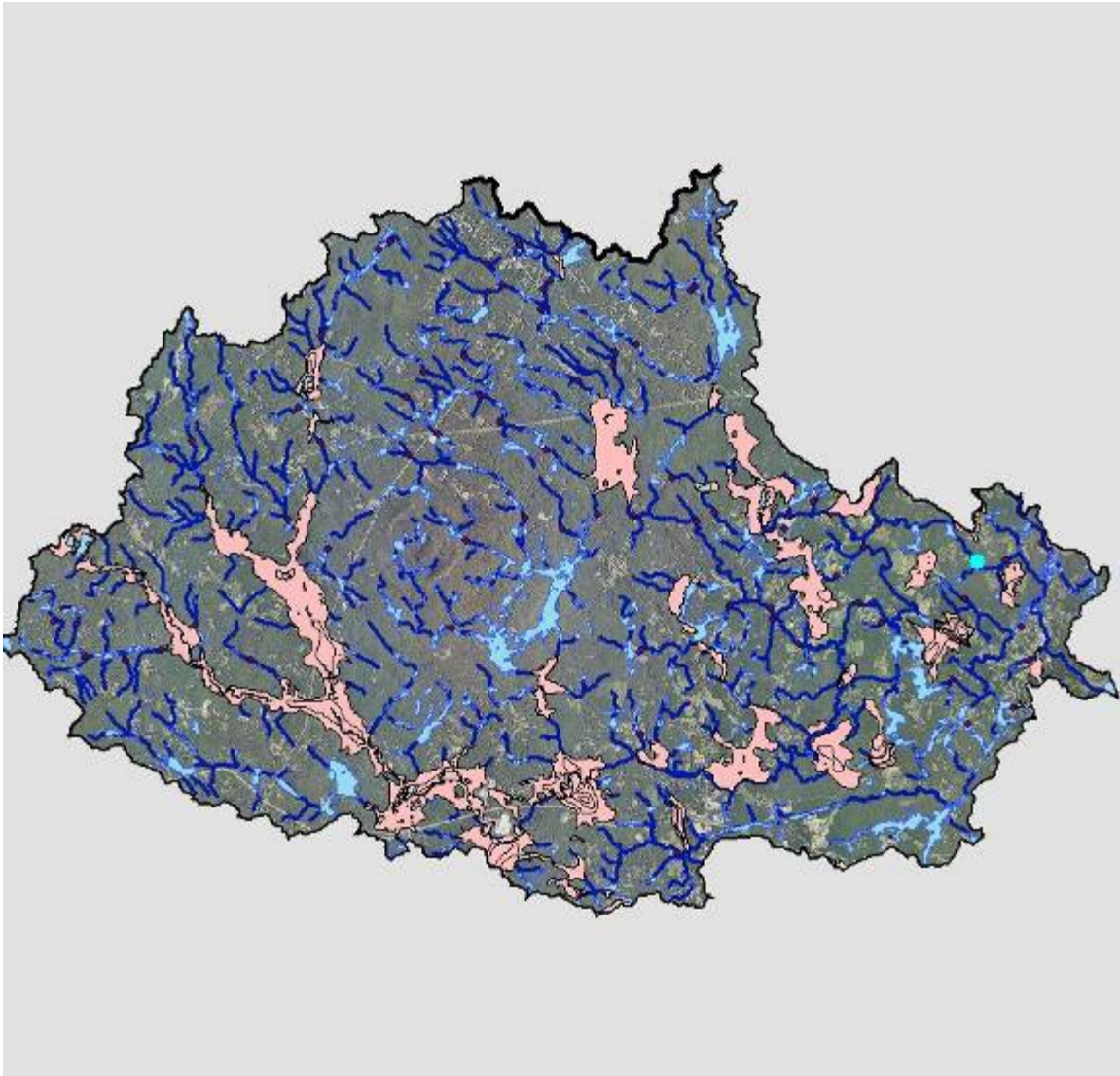


Figure 1. Stratified drift aquifers (pink) in the Lamprey River watershed.

### *Fish surveys*

The Lamprey River Watershed was divided into 9 subwatersheds based on the USGS Hydrologic Unit Code system at the 12 digit scale (HUC12) (Seaber et al. 1987) (Figure 2). The names of the subwatersheds are as follows: North River, Pawtuckaway Lake, Little River, Lower Lamprey River, Piscassic River, Middle Lamprey River, North Branch River, Lamprey River Headwaters, and the Bean River. These subwatersheds can be further divided into smaller drainages, called catchments, originally delineated during

the development of a nutrient loading model known as SPARROW, which was developed by the U. S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS) to monitor nutrient inputs of watersheds throughout the country (USGS 2011) (Figure 3).

Stream sampling techniques were based on those described in Barbour et al (1999). Backpack electrofishing surveys were conducted at the approximate midpoint of each catchment, which ensured that survey sites were distributed throughout each subwatershed and that a variety of habitats were represented. This approach emphasizes small headwater stream habitat, which was under represented in previous survey work. Attempts were made to survey every catchment with an established perennial stream. Streams with depths too great for backpack electrofishing units and intermittent flowages were not surveyed.

In general, a sample length of 100 m of stream was used, although site conditions or time limitations limited the sample length at some sites. In some larger stream habitats, a greater sample length was used to ensure that less abundant species were represented in the survey. Length, weights, and counts were obtained for each fish species. After length and weight was recorded for the first 25 individuals, the remaining individuals were counted and batch weighed. Water temperature, sampling effort (in seconds), stream width, and a qualitative habitat condition survey were recorded at each site. All survey records were entered into a fish survey database maintained by the New Hampshire Fish and Game Department's (NHFGD) Inland Fisheries Division.

In addition to the electrofishing surveys conducted in 2010, data from surveys targeting fish species of concern in the Lamprey River watershed, beginning in 2005, were also included. Methods used included seine surveys, backpack electrofishing, and dip net surveys. In 2011, an additional 18 streams were assessed for potential cold water stream habitat in areas adjacent to known populations of brook trout or where maps of stratified drift aquifers indicated sources of groundwater. Electrofishing surveys were then conducted in streams with suitable summer water temperatures.

Populations of the state threatened bridled shiner have been documented in the Lamprey River, but there was little information on the extent of bridled shiner habitat in the Lamprey River watershed. Bridled shiner surveys were conducted by dip net from a canoe or with a ¼" mesh bag seine. Occupied bridled shiner habitat was delineated with a GPS unit and mapped using GIS software.

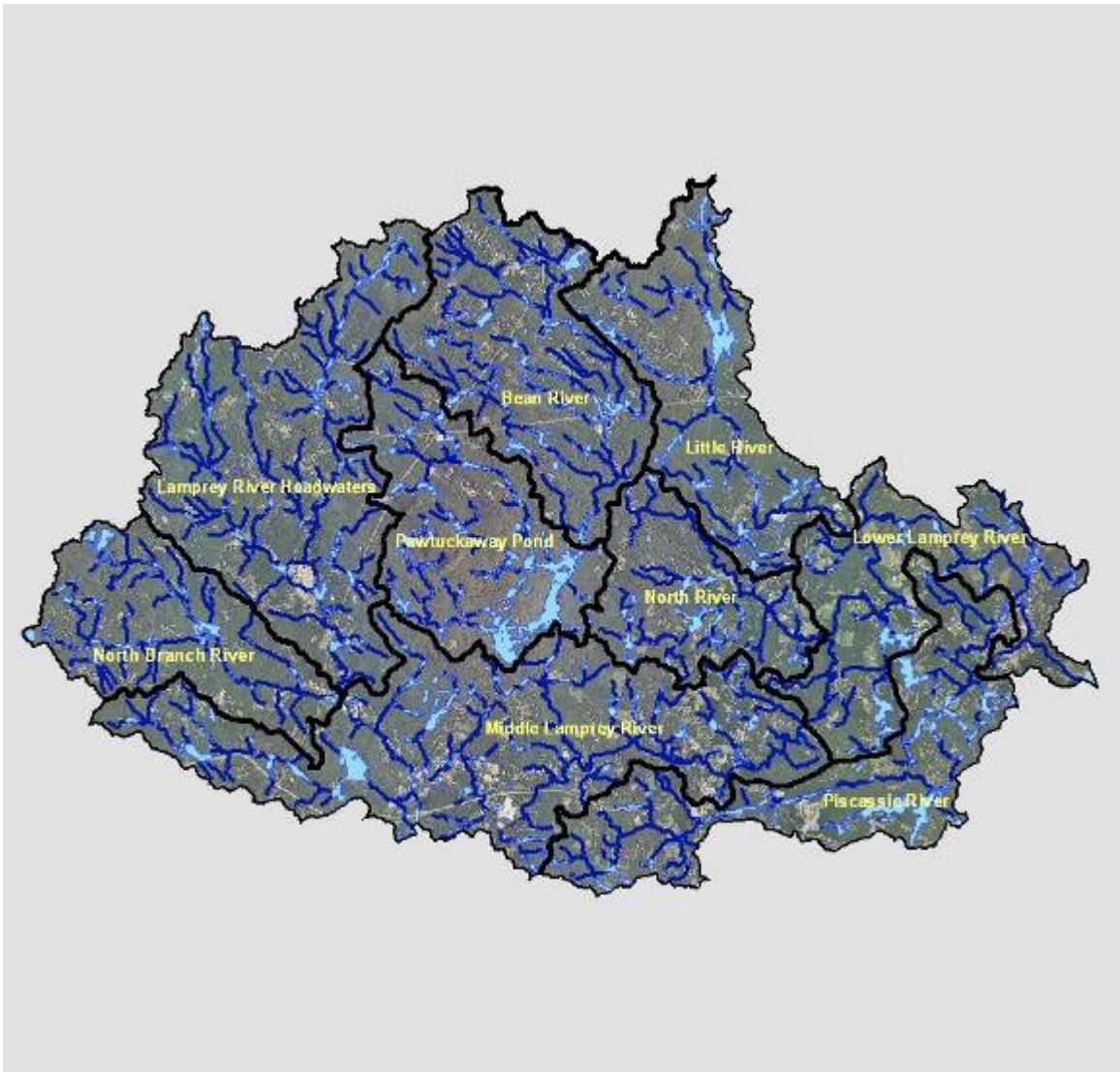


Figure 2. The 9 Subwatersheds (HUC 12) of the Lamprey River watershed.



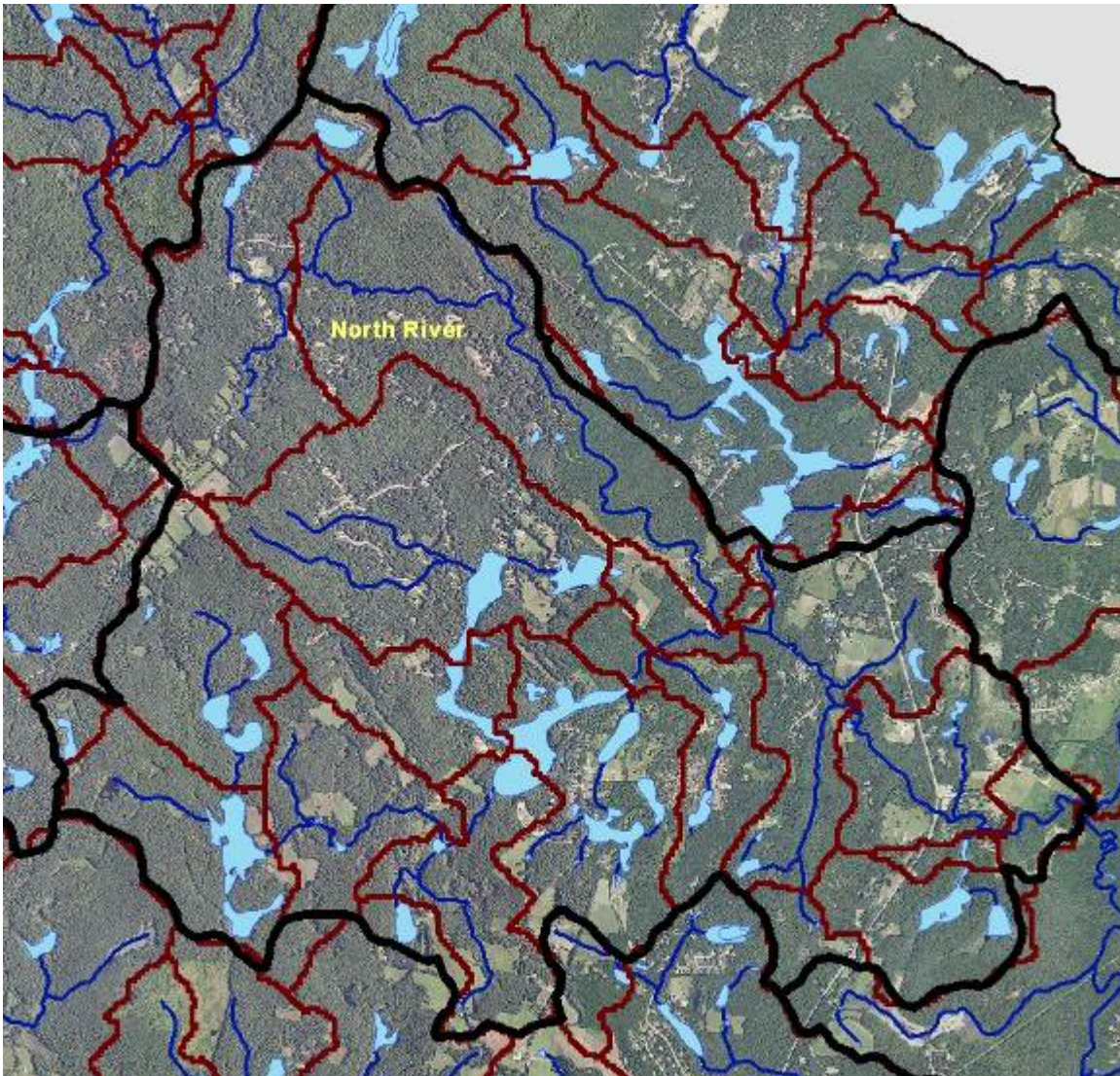


Figure 3. Map of catchments (red) in the North River subwatershed.

## RESULTS / DISCUSSION

A total of 105 survey sites contained adequate data for use in this report (Figure 4). An additional 28 sites were visited, but they were not suitable for electrofishing. Of the 105 sites, 75 sites were sampled in 2010. The North Branch River subwatershed (15 sites) was surveyed in 2007. Eighteen sites were scouted in 2011 for conditions that indicated the potential presence of a spring fed stream. Of these 18 sites, 4 sites were considered worthy of electrofishing. The remaining survey sites were seine or electrofishing surveys conducted for other projects between 2005 and 2009. Counts of each species were recorded at 95 sites, with presence/absence of each species recorded at the remaining 10 sites.

The total number of fish species recorded was 25, not including hatchery stocked fish. A total of 4,226 fish were counted at all sites combined. Table 1 shows the distribution and abundance of all fish species captured in this survey. Fallfish were the most common species (present at 41% of 105 sites), as well as the most abundant, accounting for 30.2% of the 4,226 fish counted. Fallfish, white sucker, and common shiners were both widespread (captured at 41%, 37%, and 29% sites respectively) and abundant, accounting for 60.9% of all fish counted. Brown bullhead, creek chubsucker, American eel, pumpkinseed, largemouth bass, chain pickerel, and golden shiner were relatively common (captured at 21% to 32% of 105 sites), but accounted for a small percent of the total number of fish captured (less than 3.5% of 4,226). Longnose dace and brook trout were not widely distributed (15% and 10% of 105 sites respectively), but made up a large proportion of the total fish captured where they were found.

The most diverse sites were larger river reaches with alternating habitat features including shallow boulder/cobble riffles, deeper pools, slow flowing sections with aquatic vegetation, and sand/gravel sections with fallen trees. These sites supported both warmwater pond species and cool water riverine species. Examples of this could be found in the lower North Branch, Middle Lamprey, and Little River subwatersheds. The greatest number of species captured at one site was 13 in the North Branch River. Twelve species were captured at each of three sites, one in the lower North River, one in the Middle Lamprey River, and one in the Lower Lamprey River. The average number of species captured per site was 4.

The average number of fish caught at each site was 45, but the median was only 17. Over 75% of sites with accurate fish counts had less than 50 fish. The sites with the greatest number of fish were found in wide, shallow sections of the Lamprey River and its larger tributaries. Species including common shiner, fallfish, and longnose dace were extremely abundant in the shallow pools and riffles formed by boulders, cobble, and ledges. Three such sites, one below the Bunker Pond Dam in Epping before its removal, one downstream from Lee Hook Road, and one below the Wiswall Dam, accounted for over 30% of all fish counted in the survey. Most of the mainstem river in the middle and lower Lamprey River subwatersheds is too deep for electrofishing. Shallow, rocky sections of river provide important habitat for fish like longnose dace that prefer turbulent water and depend on spaces between rocks and boulders for shelter.

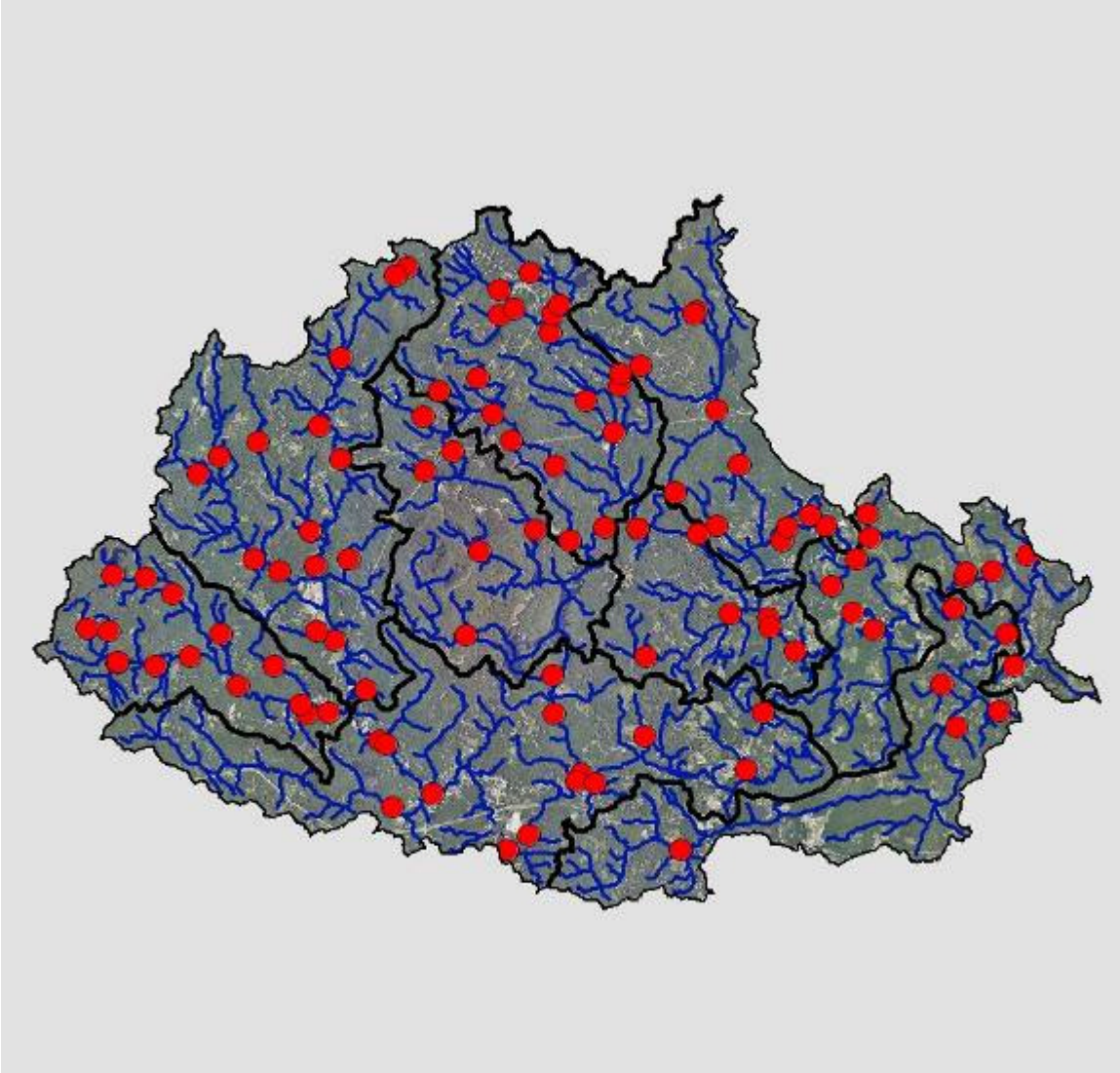


Figure 4. Map showing locations of 105 fish survey sites in the Lamprey River watershed.

Table 1. Summary of Fish data for 105 survey sites in the Lamprey River watershed, with a total fish count of 4,226. Counts were not available for all species.

Species	# of Sites	% of Total Sites	Total Count	% of Total
Alewife	1	1%		N/A
American eel	23	22%	98	2.3%
Banded sunfish	15	14%	53	1.3%
Black crappie	3	3%	N/A	N/A
Blacknose dace	4	4%	37	0.9%
Bluegill	9	9%	34	0.8%
Bridle shiner	5	5%	N/A	N/A
Brook trout	11	10%	174	4.1%
Brown bullhead	5	21%	66	1.6%
Brown trout	2	2%	5	0.1%



Chain pickerel	31	30%	59	1.4%
Common shiner	30	29%	791	18.7%
Creek chubsucker	23	22%	88	2.1%
Fallfish	43	41%	1278	30.2%
Golden shiner	34	32%	126	3.0%
Largemouth bass	29	28%	92	2.2%
Longnose dace	16	15%	287	6.8%
Margined madtom	10	10%	139	3.3%
No fish	13	12%	N/A	N/A
Pumpkinseed	25	24%	149	3.5%
Redbreast sunfish	5	5%	69	1.6%
Redfin pickerel	11	10%	58	1.4%
Smallmouth bass	5	5%	61	1.4%
Stocked brook trout	5	5%	10	0.2%
Swamp darter	2	2%	N/A	N/A
White sucker	39	37%	506	12.0%
Yellow bullhead	5	5%	31	0.7%
Yellow perch	7	7%	14	0.3%

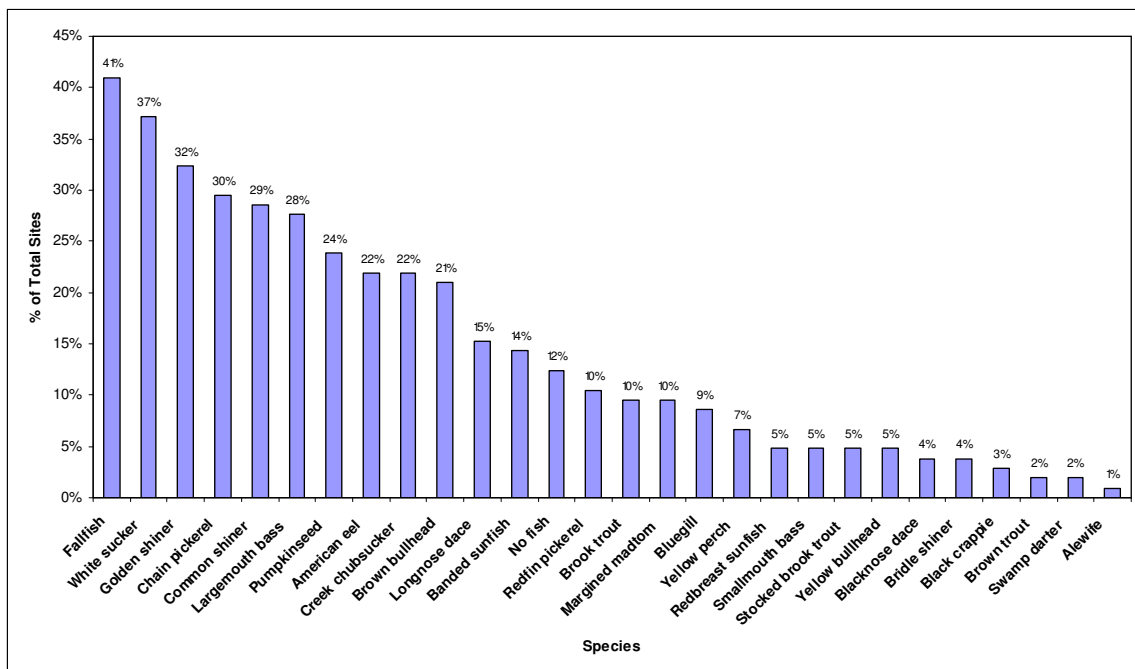


Figure 5. Percentage of sites in which each species was found out of a total of 105 survey sites.



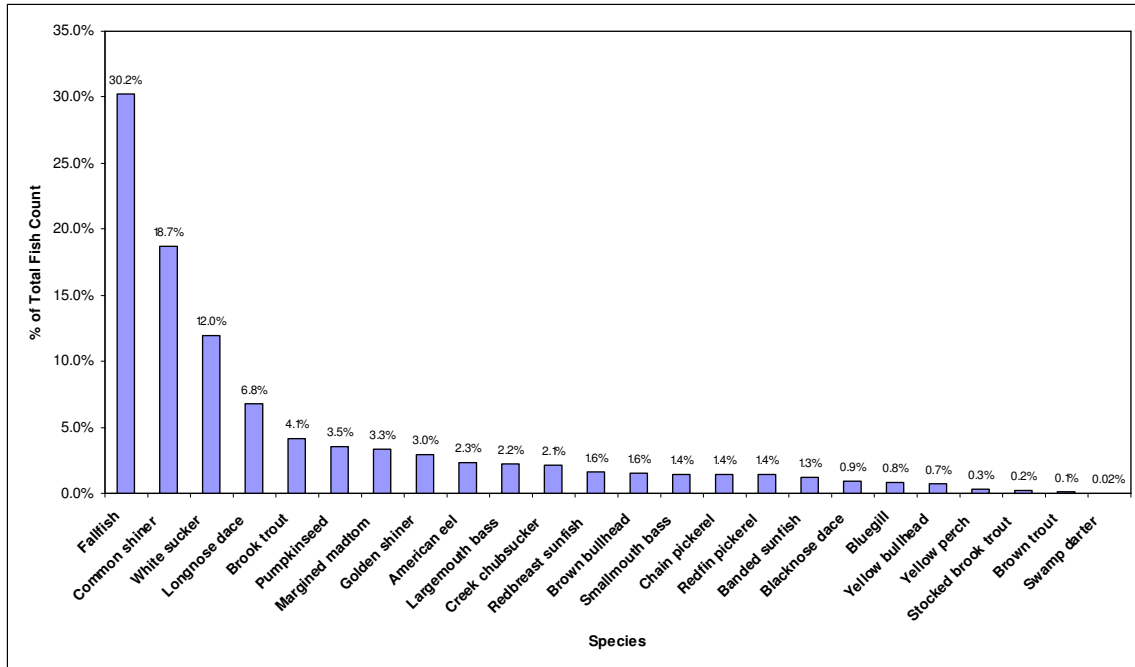


Figure 6. Relative abundance of each species as a percentage of the total fish count (4,226)

## Habitat Summary

Much of the headwater stream habitat in the Lamprey River watershed is characterized by a series of wetland streams, usually in various stages of beaver activity, separated by higher gradient, rocky, warmwater streams. There are often signs of old mill structures or roads at natural constrictions in the stream channel at the outflow of a wetland, just before the stream becomes higher gradient. Ponded sections of stream are difficult to survey, but species that inhabit these areas may be inferred by sampling the higher gradient sections between the ponds. These stream reaches, especially in smaller watersheds, may go dry in some years depending on beaver activity and summer flow. This network of wetlands connected by small streams is largely undisturbed and provides important habitat for aquatic species of concern, including banded sunfish, redfin pickerel, and blanding's turtle. Although good examples of this habitat could be found in all subwatersheds, some of the largest and least impacted examples can be found in the Pawtuckaway Pond, North Branch River, and Bean River subwatersheds.

As one moves downstream, the stream channel becomes wider and the substrate varies depending on gradient. Low gradient reaches may contain silt or fine sand and shallow areas may support stands of aquatic vegetation such as pond lily, floating heart, or pickerel weed. As flow increases, the channel may meander through broad floodplains with a mostly sand or gravel substrate. In these reaches, undercut banks, fallen trees, and overhanging shrubs provide cover for fish and other aquatic species. Moderate gradient reaches tend to have larger substrates such as gravel, cobble and boulders.

As drainage area increases, the stream channel is less likely to become intermittent during dry years. Reaches with turbulent water and year round flow support fluvial specialists such as longnose dace. The lower mainstem contains long stretches of wide, deep river habitat with sand or gravel substrate interspersed with shorter, shallow reaches dominated by cobble, boulders and ledge. The lower gradient, slower flowing sections tend to support sunfish species, golden shiners, largemouth bass, and other warmwater species that avoid faster flowing water. The higher gradient riffle habitat with cobble and boulder substrate contains species such as longnose dace, fallfish, margined madtom, and juvenile white suckers. The greatest diversity of fish species were recorded at sites where habitats of different gradient, substrate, and flow occurred in close proximity.

One of the rarest and most distinctive stream habitat types in the Lamprey River watershed is the spring fed stream. These small streams are fed by groundwater and maintain relatively stable temperatures despite the extreme fluctuations of air temperature in summer and winter. At an average temperature of 20°C (68°F) or less in the months of July and August, these streams are suitable habitat for cold water species, such as brook trout and various species of cold water stonefly larvae (Lyons et al. 2009). These streams are sometimes so small that they do not even show up on most maps. Unlike the coldwater stream habitat to the north and west, spring fed streams in southeastern New Hampshire tend to be small isolated streams among watersheds dominated by warm water habitat. These streams are usually narrow and shallow, with sand and gravel substrate and occasional boulders. Fallen trees and undercut banks provide important habitat for brook trout and other species. Small seeps or springs can often be seen flowing into the main channel from the banks. Watercress is a common plant species associated with spring fed stream habitat.

## **Comparison to previous surveys**

This survey focused on headwater streams more than previous survey work in the Lamprey River watershed, including Baseline Fish Community surveys by the New Hampshire Department of Environmental Services (NHDES) in the lower river and Fishing For the Future electrofishing surveys conducted by NHFG in the mid 1980's. Out of the 105 sites in this survey, 67 sites had watershed areas less than 8 km<sup>2</sup> (5 mi<sup>2</sup>). Watershed sizes for each site ranged from 471.20 km<sup>2</sup> (181.93 mi<sup>2</sup>) to 0.63 km<sup>2</sup> (0.24 mi<sup>2</sup>). The average watershed size was 43.68 km<sup>2</sup> (16.86 mi<sup>2</sup>). Fish species diversity generally increased with watershed size, yet fish were present even in the smallest watersheds. Of the 11 sites surveyed with watershed areas less than 0.8 km<sup>2</sup> (0.5 mi<sup>2</sup>), 9 sites contained at least one fish species. One of these sites contained 7 species.

The results of this survey are basically similar to those of the backpack electrofishing surveys conducted by NHFG between 1984 and 1986 (Appendix C). In the FFF surveys, fallfish was the most abundant and widely distributed fish species, with white sucker and common shiner in the top 5. The higher prevalence of chain pickerel and common shiner probably reflect a generally larger stream type surveyed in close proximity to slower flowing water. All of the 16 survey sites were conducted at sites with watersheds over

25.9 km<sup>2</sup> (10 mi.<sup>2</sup>). Margined madtom were not recorded by NHFG in the 1980's. Margined madtom were recorded at 10 sites in this survey and were relatively abundant. It is possible that this species was illegally introduced as a baitfish and is now increasing its distribution in the watershed. It prefers rocky, riffle habitat and may compete with longnose dace.

Baseline fish community surveys conducted by NHDES in 2003 were focused more on habitat in the lower lamprey river (Appendix C). They used boat electrofishing and gill netting in addition to backpack electrofishing. The focus on deeper, slower sections of river explains the prevalence of more sunfish species, including redbreast sunfish, pumpkinseed, and bluegill, which are less common in faster flowing sections. Common shiners appear to be more common than fallfish in wider sections of river, while fallfish appear more adept at exploiting smaller stream habitat. White sucker adults tend to inhabit deeper water, while the juveniles are far more common in small streams. Longnose dace and American eels were also relatively common.

The combination of these three surveys, with the larger river habitat focus of the NHDES Baseline Fish Community surveys, the medium sized wadeable stream focus of the FFF surveys and the small headwater stream focus of this survey, provides an excellent baseline on which future trends in fish distribution can be compared.

## **Species of Concern**

### *Eastern Brook Trout*

Brook trout were captured in 11 of 318 catchments in the Lamprey River watershed. Of the total sites surveyed, they were present at 11 of 105 (10%) sites. Brook trout were restricted to small, cold, spring fed streams and were generally the dominant fish species present in this stream type. Of the 11 site where brook trout were found, 3 streams, including Wednesday Hill Brook, Rum Brook, and a small tributary of the Little River, featured relatively unfragmented stream habitat that supported healthy brook trout populations. These streams contained brook trout of multiple age classes, with a number of trout less than 90 mm in length, which indicated that natural reproduction was occurring in the stream. Other streams, including Aunt Mary Brook, and two small unnamed streams in the Lamprey River Headwaters the North River subwatersheds, showed signs of natural brook trout reproduction, but the streams were fragmented by undersized stream crossings and habitat was marginal at low flow. In the remaining 4 sites, brook trout made up a small percent of the fish captured and were not indicative of a resident population. The chance that these were hatchery stocked fish could not be ruled out. Spring fed streams are very rare in the Lamprey River Watershed (Figure 7).

Maps of stratified drift aquifers were used to try to predict the locations of other potential spring fed streams. Interestingly, the presence of a stratified drift aquifer in an area does not necessarily indicate the presence of cold water stream habitat. Of the 18 sites visited in 2011 for potential brook trout surveys, only 6 sites contained suitable water

temperature and habitat conditions to be worth electrofishing. Of these 6 sites, brook trout were found at 2, but only one stream had the potential to support a resident population. The best predictor of spring fed stream habitat turned out to be proximity to other spring fed streams. There are likely to be more cold water streams that were missed by this survey, but their small size makes them difficult to find. Most of the sites where brook trout were found had watershed areas of less than 1mi.<sup>2</sup>. The existence of cold water stream habitat depends not only on the presence of groundwater, but its ability to reach the surface and flow over substrate that is suitable for brook trout spawning. These factors are influenced by subtle differences in local geology.

There appears to be two clusters of spring fed streams that could be considered focus areas within the Lamprey River watershed. One is near the borders of the towns of Candia, Deerfield and Raymond and the streams in this area likely receive groundwater from the valley drift aquifers in this region. The second focus area is along the Rt 125 Corridor, within about 1 mile east and west of the road, where glacioestuarine deltas have created productive aquifers, which supply groundwater to abundant brook trout populations (Figure 8). In general, the streams in focus area one (FY1) contain marginal brook trout habitat that has been degraded by undersized stream crossings and other impacts. These streams may respond well to restoration, but their long term viability should be assessed before resources are invested into restoring a stream that may not have suitable habitat to support brook trout over the long term.

Focus area two (FY2) contains streams that are known to support healthy brook trout populations, including Rum Brook and Wednesday Hill Brook. The watersheds of these streams should be protected. There are also likely to be more undiscovered brook trout streams in FY2 due to the productive nature of aquifers in this area. Much of the Route 125 corridor is zoned for commercial development. It will be important to give careful consideration to all streams within FY2 during the permitting process to ensure that future development does not extirpate undocumented brook trout populations (refer to Recommendations).

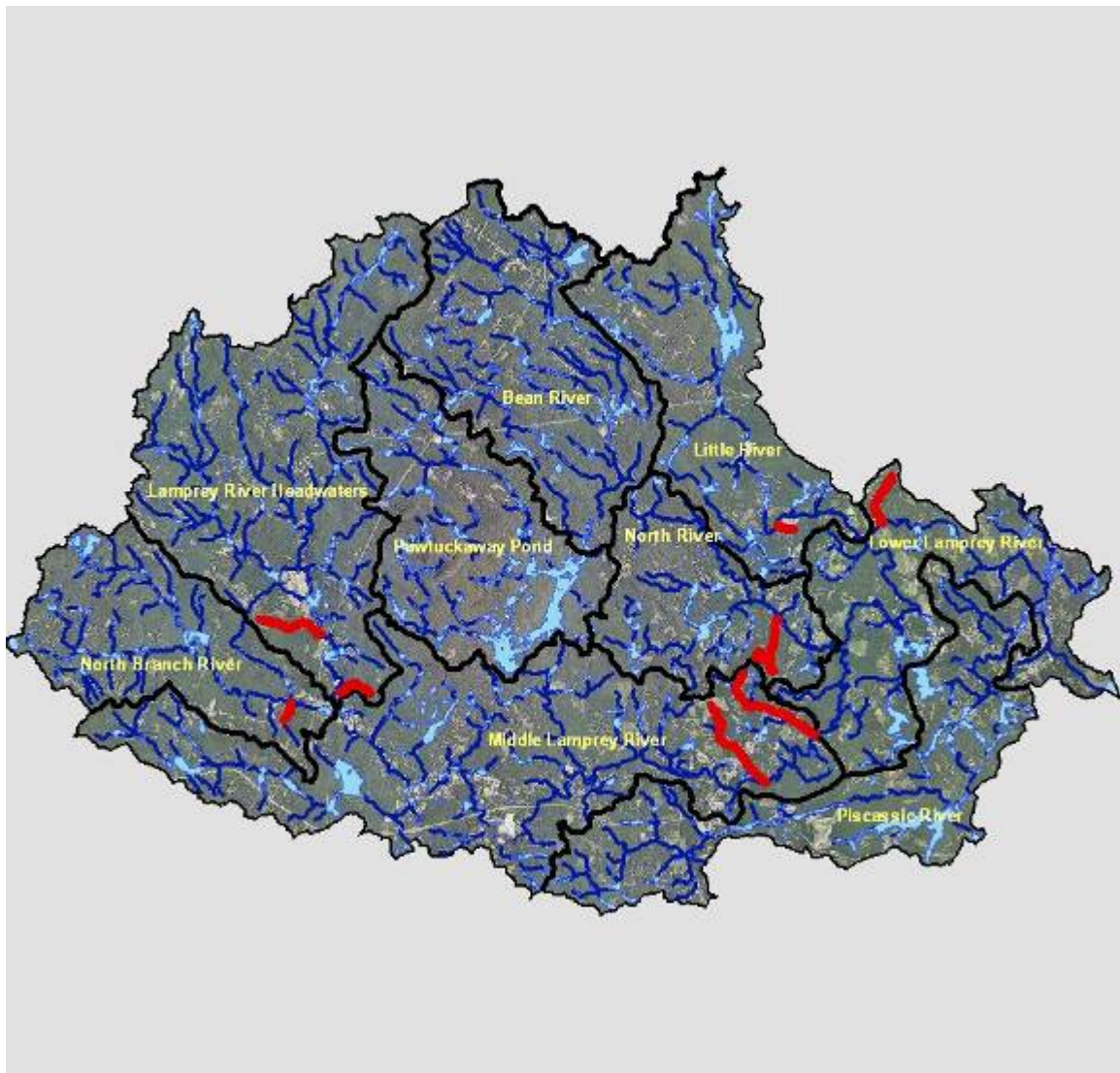


Figure 7. Spring fed stream habitat (red) supporting brook trout populations in the Lamprey River watershed.

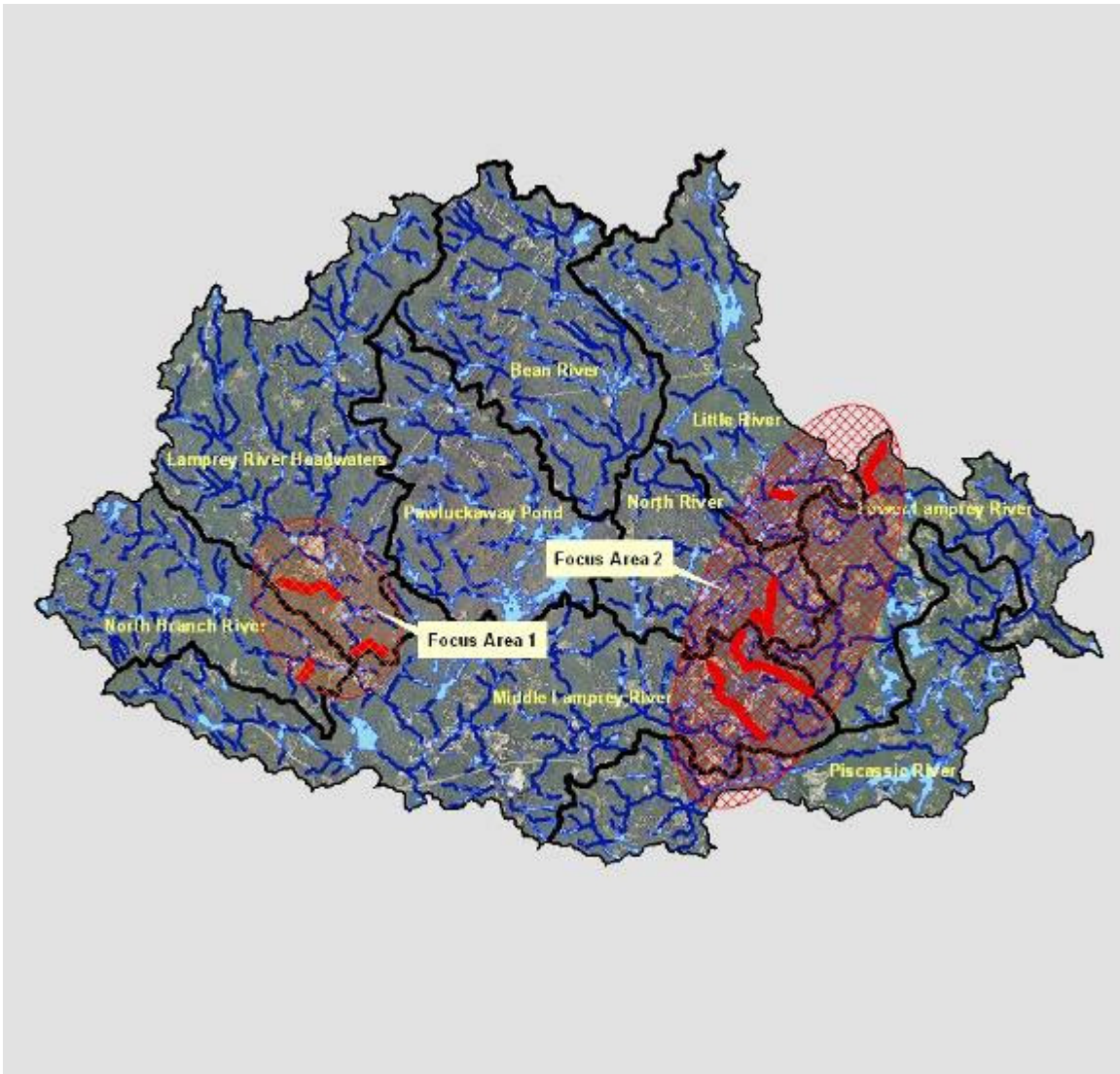


Figure 8. Potential cold water stream focus areas in the Lamprey River watershed

### *Bridle shiner*

Approximately 998 hectares (2,467 acres) of bridle shiner habitat were mapped in 2010 and 2011. Bridle shiner habitat in the Lamprey River consists of slow flowing, low gradient areas with abundant stands of submerged aquatic plants. Bridle shiners observed in this survey were most commonly observed associated with floating heart and pondweed species. Suitable habitat was divided into five distinct areas by higher gradient river reaches with faster flowing waters. Bridle shiners are poor swimmers and dispersal upstream through flowing water is not possible. Downstream dispersal is possible, but decreases in probability with the distance between areas of suitable habitat. Bridle shiners were commonly observed associated with creek chubsuckers, golden shiners,

juvenile largemouth bass, yellow perch, chain pickerel, bluegill, and pumpkinseed sunfish.

The furthest upstream and most abundant population was found in Raymond, near the confluence of the Lamprey River and the North Branch River (Figure 9). This reach was divided from the next population downstream by a short section of higher gradient river habitat with boulder and gravel substrate. It is possible that bridge shiners could disperse downstream from Reach 1 to Reach 2. Bridge shiners were observed in abundance throughout both reaches, which were at least partially influenced by beaver activity. The riparian zone remains largely intact at these upper sites and there were few houses visible from the river.

The next site downstream (Reach 3) is upstream of the Main Street bridge in Raymond (Figure 10). Bridge shiners were observed around the perimeter of this ponded section of river downstream to a point approximately 0.3 miles (0.5km) upstream from the bridge. No bridge shiners were observed from this point down to the next bridge on Epping Street despite the presence of suitable habitat. Housing density increased significantly along this section of river.

Reach 4 was similar to Reach 3, with bridge shiners present around the perimeter of a deep, ponded section of river, as well as in stands of submerged vegetation along the channel upstream and downstream, near the Prescott Road bridge. Bridge shiners were less easily observed, and appeared to be less abundant, in reaches 3 and 4 compared to reaches 1 and 2.

A large number of bridge shiners (120) were captured with a seine net in Epping, upstream of the Route 27 bridge (Figure 11). Bridge shiners were concentrated in a small pool with a remnant stand of aquatic vegetation after the water had been lowered during the Bunker Pond Dam removal in August of 2011. Bridge shiners were present in this pool and in the river channel just upstream of the drained impoundment. The slow draw down most likely allowed bridge shiners to move into the small pool upstream of the bridge. The pool downstream from the old dam was not surveyed, but it appears suitable for bridge shiners. NHFGD will monitor this site to see if the changing habitat conditions after the dam removal will continue to support the bridge shiner population.

NHDES recorded bridge shiners upstream of Wadleigh Falls in 2003, but the species was not observed at this site in 2011. There were no aquatic plants that would provide suitable habitat for bridge shiners above the dam. It is not clear whether the impoundment once contained aquatic vegetation, but filled in with sand, or whether the species was misidentified. Bridge shiners are easily mistaken for creek chubsuckers.

Bridge shiners were collected by Harrington (1946) below Packers Falls during his research on the life history of the species. No bridge shiners were observed or captured anywhere between Packers Falls and the McCallum Dam in Newmarket in four surveys conducted between 2005 and 2011. However, this is a large area with apparently suitable



habitat and the possibility that bridle shiners were missed in these surveys cannot be ruled out.



Figure 9. Bridle shiner habitat (purple) in the Lamprey River near the confluence with the North Branch River in Raymond (Reaches 1 and 2).



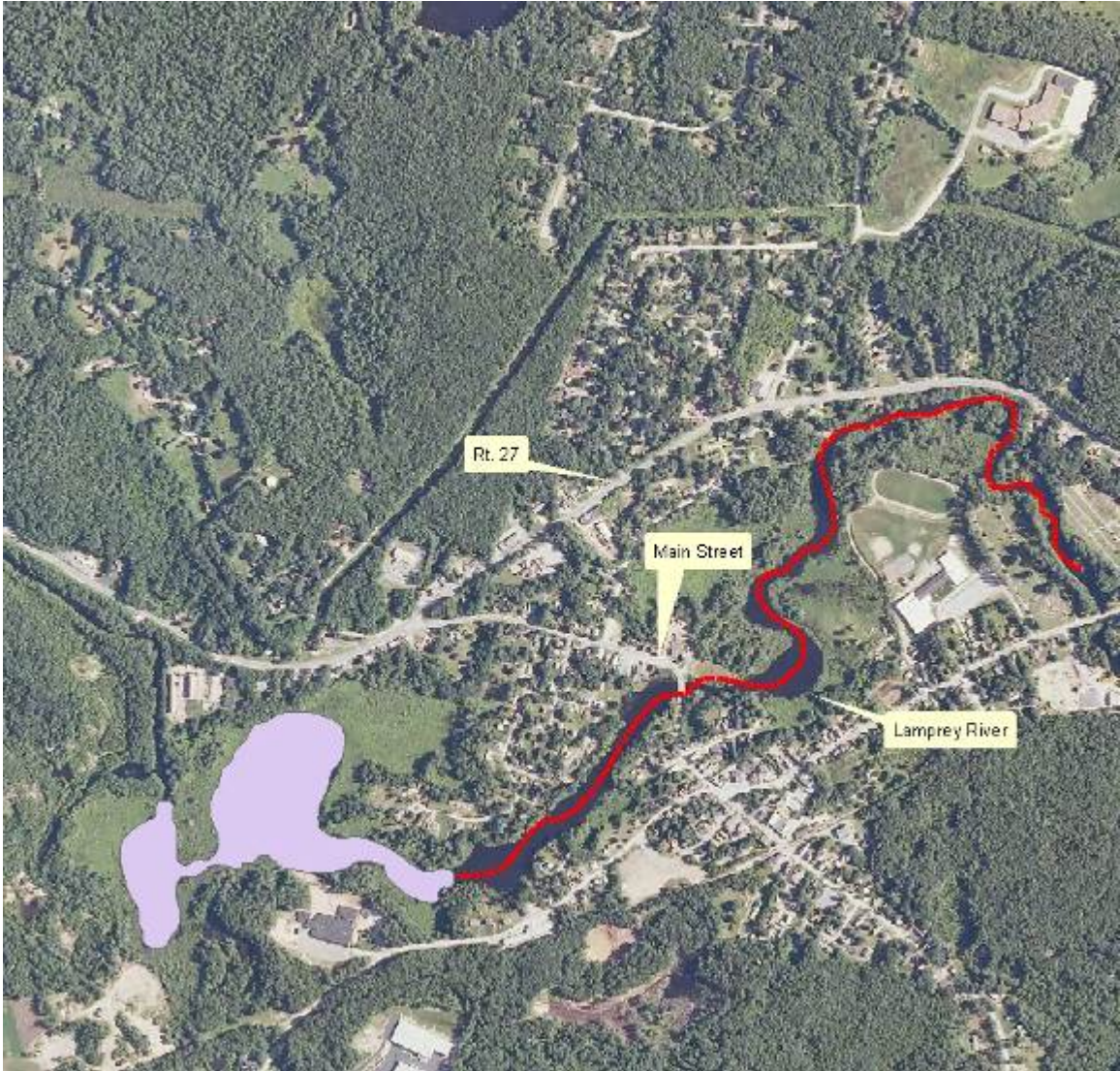


Figure 10. Bridge shiner habitat (purple) in the Lamprey River near the center of Raymond (Reach 3). The red dotted line shows the section of river with suitable, but unoccupied bridge shiner habitat.





Figure 11. Bridle shiner habitat (purple) in the Lamprey River (Reaches 4 and 5). Reach 5 highlights the stream channel after the Bunker Pond Dam was removed. The green dots mark the remaining bridle shiner habitat in this reach.

### *Banded sunfish, Redfin Pickerel, and Swamp Darter*

Banded sunfish were relatively widespread, occurring at 15 of 105 sites (14%) in seven of nine subwatersheds. They were commonly found in small wetland streams and ponds that showed signs of beaver activity. The average watershed size for streams where banded sunfish was found was 6.78 mi.<sup>2</sup> (17.56 km<sup>2</sup>), with the smallest at 0.37 mi.<sup>2</sup> (0.96 km<sup>2</sup>) and the largest at 25.69 (66.54 km<sup>2</sup>). More banded sunfish would likely have been capture using a different survey method, such as seine nets or minnow traps. The headwaters of the Lamprey River and its tributaries may represent some of the least impacted banded sunfish habitat in southeastern New Hampshire.

Redfin pickerel were found in even smaller streams than banded sunfish. The average watershed size at the 11 sites where redfin pickerel were found was 3.8 mi.<sup>2</sup> (9.8 km<sup>2</sup>). The largest watershed size was 24.32 mi.<sup>2</sup> (63.99 km<sup>2</sup>). Six of the 11 locations had watershed sizes of less than 1 mi.<sup>2</sup> (2.59 km<sup>2</sup>). Redfin pickerel were found in 4 of 9 subwatersheds and appear to be restricted to lower elevation sites along the coastal plain. They are approaching the northern extent of their range in the Lamprey River watershed. Redfin Pickerel seem tolerant of habitat disturbance and may be found at very low flows in fragmented habitat. Water may be turbid or clear, but they seem less dependant on aquatic vegetation than chain pickerel or banded sunfish. While only one redfin pickerel was recorded in the Piscassic River, the low gradient, wetland stream habitat appears to be excellent redfin pickerel habitat. A survey effort that focused on the mainstem of the Piscassic River would likely yield more redfin pickerel records.

Swamp darter were uncommon in this survey. They were found at two sites, one in the Lower Lamprey subwatershed and one in the Little River subwatershed. Although they are usually associated with aquatic vegetation, they are also found over sandy/gravel bottom in a variety of stream sizes. Swamp darters are small and difficult to capture. A kick seine would probably be the best method for a focused survey to describe the distribution of swamp darters in southeastern New Hampshire. The status of swamp darters in New Hampshire is not well understood, but they are probably more abundant than records indicate.

### *Diadromous Fish*

There were two diadromous species recorded in this survey: alewife and American eel. The one alewife record came from a seine survey, targeting bridle shiners, below Packers Falls in Durham. American eels were widely distributed throughout the watershed, with 23 records in 8 of 9 subwatersheds. The abundance of eels at each site dropped significantly upstream of the Wiswall Dam. Fifty-three eels were counted at the site just below the Wiswall Dam, in Lee, compared to just 5 eels counted at the site below the Lee Hook Road bridge, which is less than 3 miles upstream of the dam..

Since surveys were completed in 2011, two major changes have occurred on the Lamprey River with respect to the diadromous fish. A fish ladder was installed at the Wiswall Dam, and the Bunker Pond Dam, in Epping, was removed. If fish passage is effective at the Wiswall Dam, one would expect an increase in the distribution of river herring and sea lamprey in the lower river subwatersheds, and an increase in the distribution and abundance of American eels throughout the Lamprey River Watershed. This survey and previous surveys may be used as a baseline on which to monitor changes in diadromous fish distribution over time. Record river herring returns (over 90,000 counted at the fishway in Newmarket) to the Lamprey River in the spring of 2012 provided an opportunity to assess the effectiveness of the new Wiswall Dam fish ladder. Many river herring were observed passing through the ladder and large schools of herring were seen below the ruins of the Wadleigh Falls dam. The Wadleigh Falls dam may be the next upstream barrier to river herring in the Lamprey River. A small rock ramp, or nature like

fishway, at this site may be necessary to provide access for river herring to the many miles of spawning habitat upstream (Kevin Sullivan, Fisheries Biologist, NHFGD, Marine Division, personal comm.).

## **Habitat Condition**

Overall the Lamprey River watershed is in good condition, but it is beginning to show signs of impacts from the expanding population in southeastern New Hampshire. Headwater stream habitat is largely intact in the upper subwatersheds, including the North Branch River, Lamprey River Headwaters, Bean River, Pawtuckaway Pond, North River, and Little River subwatersheds. Although there are examples of habitat degradation within these upper subwatersheds, it is in the Middle Lamprey River subwatershed that impacts to aquatic habitat become more widespread. Smaller streams become noticeably degraded as the density of development increases around the main population center in the town of Raymond. The mainstem of the Lamprey River shows increasing signs of erosion and sediment deposition from recent floods as one moves downstream. The frequency of development within the riparian zone also increases in the Middle Lamprey subwatershed. Bridle shiners appear to have been extirpated from a section of suitable habitat in the Lamprey River in the town of Raymond.

In the Lower Lamprey River and Piscassic River subwatersheds, habitat along the banks of the mainstem rivers remains mostly undeveloped until one reaches the town of Newmarket. However, the smaller streams within these subwatersheds have become increasingly fragmented. There have been great strides made, in recent years, toward opening up habitat to diadromous fish in the lower Lamprey River. Juvenile river herring, juvenile sea lamprey, and American eel should begin to make up a larger proportion of the fish community in the Lower Lamprey River subwatershed.

## *Importance of Headwater Streams*

Headwater streams with unfragmented, forested watersheds are critical habitat for many species and provide important benefits to the lower river by storing and slowly releasing water during periods of low flow and by maintaining cooler water temperatures (Meyer et al. 2007). Future water quality in the lower Lamprey River will depend largely on the protection of headwater stream habitat in the upper subwatersheds. Despite their ecological value, headwater streams are often overlooked when it comes to conservation. New Hampshire's Comprehensive Shoreland Protection Act does not apply to 1<sup>st</sup>, 2<sup>nd</sup>, or 3<sup>rd</sup> order streams. The small size of most headwater streams makes them vulnerable to human impacts. There are numerous examples, throughout the country, of species endemic to headwater streams that have been extirpated or greatly reduced in number. Groundwater extraction can cause streams to dry up. Road crossings fragment streams, causing sedimentation and isolating populations. Runoff from impervious surfaces can

introduce pollutants, increase flooding, and cause spikes in stream temperature. These and other threats are compounded by the tendency to dismiss small streams, especially low gradient wetland streams, because they do not command the same recreational and aesthetic appeal of the larger lakes and rivers. However, protecting a headwater stream may provide more value, in terms of species diversity and water quality, than protecting an equal area of shoreline on a large river or lake.

The level of protection for headwater streams varies by town and is usually accomplished by zoning ordinances. The best way to avoid impacts to this habitat is to leave naturally vegetated buffers along the stream bank with a minimum width of 15 meters, but ideally 100 meters or more. The wider the buffer, the more species that will use it as a travel corridor and the better protection it will serve against sedimentation and pollutants. Road stream crossings should be designed not to alter the natural flow or sediment transport characteristics of the stream channel. Storm water designs that discharge directly into the stream should be avoided in favor of systems that filter stormwater into the ground. Taking these steps to protect headwater streams has the potential to prevent irreversible losses to New Hampshire's biodiversity as well as save countless dollars by protecting water quality and preventing flood damage.

### *Stream Crossings*

The most commonly observed impact to headwater stream habitat was undersized stream crossings. Stream crossings acting as barriers to fish passage were noted at 25% of sites surveyed in 2010. This number would have been higher if sites were selected at stream crossings and not randomly selected at the center of each catchment. The majority of stream crossings observed on small, headwater streams in the Lamprey River watershed restrict the movement of aquatic organisms at high and low flows. Freedom of movement is critical for species to access feeding or spawning habitat at the appropriate time of year. Brook trout seek out small cool streams in the summer for thermal refuge when temperatures in larger river increase. White suckers migrate into small streams during the spring to spawn. Undersized culverts cause stream bed scouring, which lowers the stream elevation at the downstream end of the culvert and eventually leads to what is referred to as a "perched" crossing (Figure 12). Once a stream crossing becomes perched, it will remain a barrier to aquatic organism passage until it is replaced with an appropriately sized crossing.

In addition to fragmentation, stream crossings degrade stream habitat by increasing erosion and sediment deposition rates. Record storms in recent years have revealed the inadequacy of the current infrastructure to handle large flows. Many sites near road crossings showed signs of road fill washing into the stream and creating deposits of excess sediment. These deposits of road fill often become barriers at low flow as water begins to flow "subsurface" under the newly deposited material. In some cases, a new stream channel had formed as flow is directed around or through the freshly deposited sediment (Figure 13). Constricted flow through undersized culverts and bridges also causes bank or stream bed erosion and leads to fine sediment deposition downstream.

Though some erosion is natural during floods, the cumulative effect of undersized crossings is moving a tremendous amount of excess sediment in the river during periods of high flow. Excess sediment is one of the main suspected factors causing the decline in mussel species throughout the watershed (Nedean 2011).





Figure 12. Impassable culvert (perched) on Woodman Brook in the Lower Lamprey River subwatershed.





Figure 13. Deposition from a road washout at a stream crossing during the construction of a new development.

### *Impervious surfaces and stormwater management*

The second most commonly observed impact to aquatic habitats during this survey was stormwater runoff from impervious surfaces such as roads or parking lots. Stormwater management is a major cause of habitat degradation in the Lamprey River watershed. In most cases stormwater is piped or ditched directly into rivers and streams wherever the river or stream approaches or crosses under a road or parking area (Figure 14). Nutrients and chemicals from pesticides, fertilizers, and petroleum products flow along the surface, especially during intense thunderstorms in the summer, and make their way into the water. Rainfall that would normally filter into the ground and be released into streams and rivers over a long period of time is instead flowing over land and into water bodies in a matter of minutes. This increases the flashiness of local streams, which leads to more stream bed and bank erosion. The effects of stormwater runoff are felt all the way into Great Bay where excess nitrogen and turbidity, attributed largely to nonpointsource pollution, has caused the decline of eel grass beds (PREP 2009).

Impervious surfaces are increasing rapidly in the Lamprey River watershed. The effects are most evident near population centers in the Middle and Lower Lamprey River



subwatersheds in the towns of Raymond, Epping, and Newmarket. The Middle Lamprey River and Piscassic River subwatersheds, in particular, have increased in impervious surface coverage by 10% since 1990. Aquatic invertebrate communities and brook trout populations begin to show signs of degradation in watersheds with less than 5% impervious surface coverage. Impervious surfaces in the Middle Lamprey River subwatershed were estimated at 21.7% in 2010. With the greatest extent of impervious surface coverage, and the largest number of stream crossings (143), the Middle Lamprey River subwatershed is a high priority as a focus area for restoration.



Figure 14. The tail end of a pipe that directs stormwater runoff into Dudley Brook.

### *Riparian Zone*

Overall, the riparian zone within 15 m of the river or stream banks at most sites was well vegetated, consisting of mature forest or wetland plants and shrubs. Although the riparian zone is generally intact along the Lamprey River and its tributaries, there are some areas where trees and other vegetation have been cut right up to the river or stream bank. This practice increases bank erosion and provides poor buffering against pollutants. Streamside vegetation provides shading, which reduces daily extremes in temperature fluctuations. Intact riparian zones also offer food and cover for resident fish populations in the form of wood, leaves, and terrestrial invertebrates, which drop into the

water. Agriculture makes up a small percent of the land use in the Lamprey River, but there are some areas where it is impacting aquatic habitat. Eroded banks from cattle walking in streams and potential runoff from fields treated with fertilizer and pesticides were noted at some sites.

### *Dams*

There are many dams throughout the watershed. Some are very old mill dams in ruins and their remains are having little if any impact on the movement of fish and other aquatic species. Others are larger and of more recent construction, and their presence prevents upstream fish passage. Impoundments upstream of dams may increase water temperatures below the dam and cause water quality issues such as low dissolved oxygen.

Access to habitat for diadromous fish has increased significantly since 2011 with fish passage built at the Wiswall Dam and the removal of the Bunker Pond Dam. However, dams (or dam ruins) still limit fish access to large amounts of habitat in the Piscassic River, Little River, and the upper Lamprey River.

## **RECOMMENDATIONS**

The Lamprey River watershed continues to support healthy fish communities, but it may be approaching a tipping point. Impervious surfaces in eight of the nine subwatersheds that make up the Lamprey River watershed have nearly doubled since 1990. Freshwater mussel communities in the Lamprey River have declined significantly in the last 10 years. Excess phosphorous and nitrogen have contributed to low dissolved oxygen levels at the mouth of the river as well as to declines in eel grass beds in Great Bay (PREP 2009). The Lamprey River watershed currently supports a number of fish species of concern, but their populations are vulnerable to the effects of expanding development and water withdrawals.

The challenge facing town and regional planners in the Lamprey River watershed is how to support development that will accommodate an expanding population without degrading aquatic habitat and reducing water quality. Land protection is an important strategy for protecting habitat for species of concern and preserving existing conditions, but land protection alone will not bring about improvements in aquatic habitat and water quality. Despite making great progress toward its land protection goals, PREP reported declines in its indicators of ecosystem health and water quality in Great Bay (PREP 2009). Working toward improvement, rather than just stemming the decline, will require a revolution in approach toward development and stormwater management. This approach must be based on the principal that all aquatic habitats, including the smallest headwater streams, are valuable resources worth protecting. Headwater streams are the interface between land and water and their health will determine future trends in water quality and ecosystem integrity in the Lamprey River watershed.

### *Low impact development and innovative stormwater design*

It has been standard practice to divert stormwater from roads, parking lots, and driveways directly into rivers and streams. This leads to bank erosion, excess sediment loads, and elevated levels of pollutants, such as petroleum products, that wash in from pavement and other impervious surfaces. Stormwater retention ponds heat up in the summer and result in an influx of heated water when they overflow into streams.

New construction should use Low Impact Development (LID) techniques, which are based on the principal that stormwater should be filtered through the ground before it enters any surface waters. The amount of base flow during the summer is determined by groundwater recharge from rain and snowfall during fall, winter and spring. Using LID practices, such as porous asphalt and gravel wetlands, rain gardens, bioretention systems, and tree filters, increases onsite infiltration of stormwater and improves groundwater recharge rates. The University of New Hampshire (UNH) Stormwater Center is a valuable local resource for technical assistance on LID practices.

The UNH stormwater center has been involved in a number of restoration projects using LID technology, such as the Berry Brook Urban Watershed Renewal in Dover. Stream restoration projects in densely populated areas create opportunities to demonstrate alternatives to traditional stormwater management practices. Once constructed, these demonstration projects may serve as outdoor classrooms for town and regional planners, especially when compared to examples of stormwater management practices that have caused obvious impacts to aquatic habitats. The town of Raymond, in the Middle Lamprey River subwatershed and the town of Newmarket, in the Lower Lamprey River subwatershed, would be good locations for LID demonstration projects. Promoting LID practices in the Middle Lamprey River subwatershed in particular would benefit both local stream habitat and improve water quality in the mainstem of the Lamprey River.

### *Stormwater outfall surveys*

Retrofitting previously constructed stormwater management systems is expensive. Mapping stormwater outfalls is one way to prioritize stormwater retrofit projects to ensure that the worst offending systems are dealt with first. A good place to begin mapping outfalls would be in the town of Raymond, which has seen a significant increase in impervious surfaces. The absence of bridle shiners from a stretch of the Lamprey River in the town of Raymond may be linked to increases in shoreline development and potential nutrient loading from stormwater runoff. A project to map stormwater outfalls in the Middle Lamprey River subwatershed should be accompanied by water quality monitoring to establish baseline conditions prior to any restoration work.

### *Stream crossing design*

Stream crossing design has had a major influence on headwater stream habitat in the Lamprey River. Each subwatershed had numerous examples of stream crossings that limited aquatic organism passage. Designing stream crossings to appropriately match the size, dimension, and water velocity of the stream channel on site would improve aquatic organism passage and greatly reduce damage during high flows. Natural substrate within the crossing is preferred. Sediment transport characteristics of the stream channel upstream of the crossing should match that of the stream channel downstream of the crossing. In other words, the stream crossing should not influence the velocity of the stream through the crossing. Increases in stream velocity through undersized stream crossings lead to stream bed scouring and bank erosion, and, eventually, to perched crossings. Conversely, over widening of the stream channel through the crossing may lead to excess sediment deposition within the stream channel. For detailed recommendations on stream crossing design for new and replacement stream crossings, refer to the New Hampshire Stream Crossing Guidelines available at: [http://www.unh.edu/erg/stream\\_restoration/](http://www.unh.edu/erg/stream_restoration/)

### *Stream crossing surveys*

Stream crossing surveys are an excellent way to prioritize stream crossing replacement projects. A large scale survey was recently conducted of over 100 stream crossings in the Oyster River watershed (Stack et al. 2010). These surveys were used to identify the crossings most likely to fail under increasing precipitation scenarios predicted by climate change models. NHFGD fish survey data was incorporated into the final analysis to identify crossings that would both prevent flood damage and benefit fish species. A similar approach could be taken in the Lamprey River watershed. The two subwatersheds with the greatest estimated number of stream crossings are the Middle Lamprey River (143) and the Lamprey River Headwaters (81). Either of these two subwatersheds would be a good place to begin a large scale stream crossing survey effort. A smaller scale stream crossing survey should be focused on cold water streams known to support brook trout populations. A standard stream crossing survey protocol is available at: [http://www.unh.edu/erg/stream\\_restoration/](http://www.unh.edu/erg/stream_restoration/)

### *Riparian Zone Protection*

Although the riparian zone was largely intact at most survey sites, there were many areas observed throughout the Lamprey River watershed where vegetation had been removed right up to the bank. Zoning ordinances that protect riparian zones are critical for protecting aquatic habitat. A minimum buffer width of 15 m from the stream bank on both sides of the stream or river should be protected. A 15 meter buffer provides a basic level of protection for water quality and instream habitat. In general, the greater the width of the buffer, the more benefits it will provide for aquatic habitats. Protected riparian buffers of between 15m and 100m have more capacity to filter pollutants, reduce

runoff, and encourage groundwater recharge. Riparian buffers of 100m or greater are more likely to be used by wildlife, including large mammals and certain species of turtles, as travel corridors.

In 2007, the Southern New Hampshire Planning Commission (SNHPC) worked with PREP to develop zoning ordinances that would increase the level of riparian buffer protection in the headwater streams in the towns of Deerfield and Candia (SNHPC 2006). Unfortunately the recommendations were not fully adopted by the towns, but the report may serve as a model for future buffer protection efforts in all of the towns within the Lamprey River watershed. PREP offers extensive technical assistance to communities on riparian buffer protection and other strategies for protecting water quality in the watersheds that drain into Great Bay.

Small streams are sometimes considered a nuisance or a hindrance to development and they are frequently straightened, ditched, or filled by developers or landowners. Riparian buffer protection ordinances are sometimes perceived as a threat to land owner rights. Outreach on the value of headwater streams, including intermittent streams, and the importance of riparian zones to water quality may facilitate the passage of riparian buffer protective legislation. Education and outreach materials should provide examples of the economic benefits of protecting water quality compared to the high cost of water treatment facilities (Mack 2009).

### *Land Protection and managing future development*

Land protection can take many forms, including conservation easements on private property, land purchases by conservation organizations, land trusts, or government agencies, deed restrictions, and zoning ordinances. The most effective way to manage development is through town zoning ordinances that reduce the amount of new development in watersheds that have not yet been impacted by impervious surfaces and fragmented by stream crossings. Figure 15 shows the catchments with less than 6% impervious surface coverage that are not currently protected. Development should also be limited in areas known to contain aquifers, especially those that support cold water streams (Figure 1; Figure 7). Accomplishing a watershed approach to conservation will require that towns coordinate through regional planning commissions, like the SNHPC, to avoid the patchwork of zoning ordinances that result in sprawling development.

Priority for land protection should be given to watersheds and shoreline habitat where brook shiners and brook trout have been documented. Secondary consideration should be given to habitat that supports banded sunfish, redbfin pickerel, and swamp darter. Larger watersheds that contain relatively unfragmented forests, especially in areas adjacent too or connecting existing parcels of conserved land, should also be given priority. These areas are discussed in more detail in Appendix B. Bear Paws Regional Greenways is a land trust with a focus area that overlaps much of the upper Lamprey River watershed.



Supporting their conservation plan will help protect headwater stream habitat, which will in turn benefit water quality in the main stem of the Lamprey River.

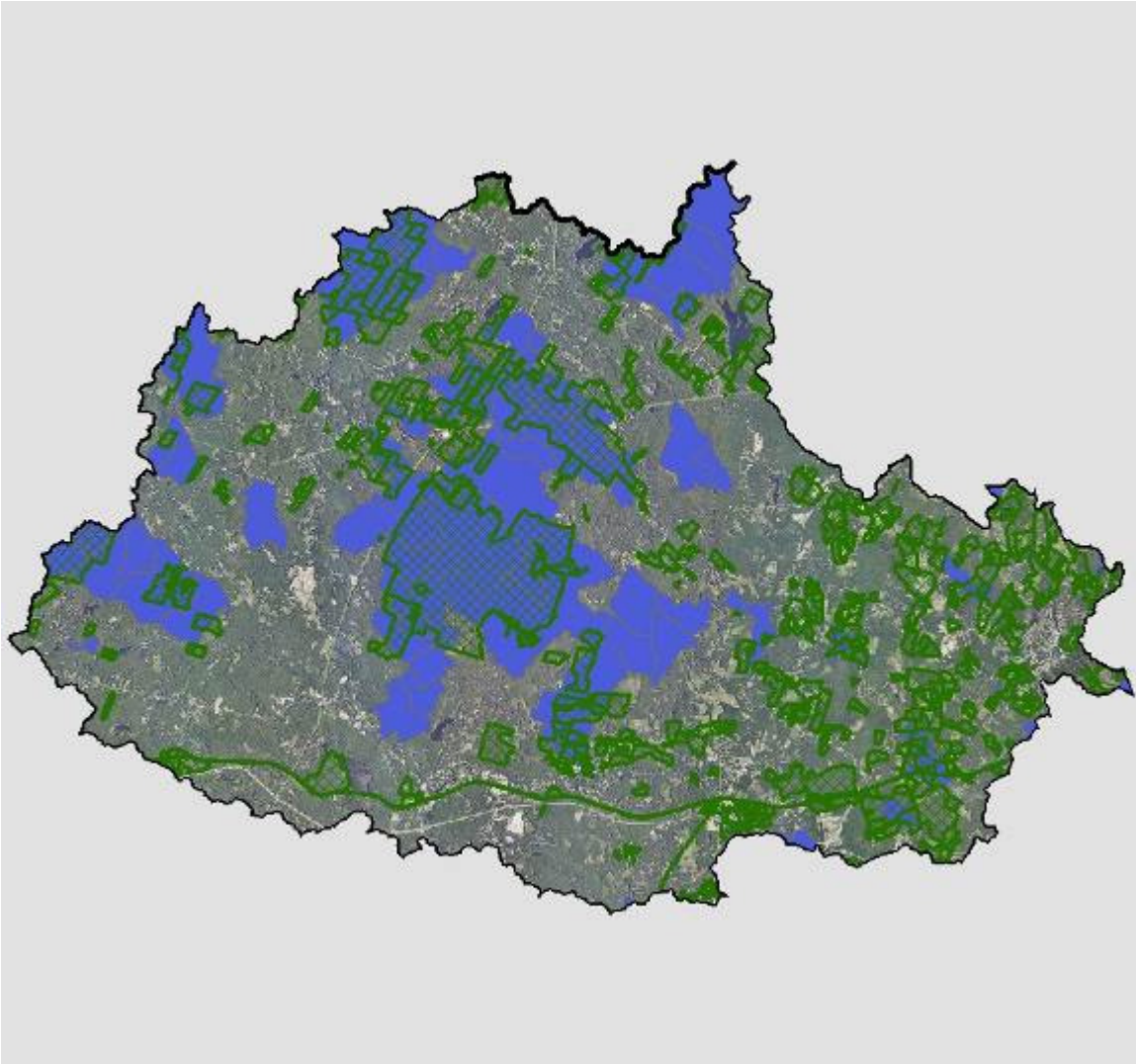


Figure 15. Remaining catchments with less than 6% impervious surface coverage (blue) in the Lamprey River watershed. Existing conservation land is outlined in green.

### *Funding sources and potential partnerships*

National Oceanic and Atmospheric Administration Habitat Conservation Restoration Center: Funds stream crossing restorations and fish passage projects in coastal rivers.  
<http://www.habitat.noaa.gov/restoration/regional/northeast.html>

Eastern Brook Trout Joint Venture:

Funds stream crossing replacements and other restoration projects that benefit wild brook trout.

<http://www.easternbrooktrout.org/>

Piscataqua Region Estuaries Project:

Technical assistance for riparian buffer protection, fish passage improvement, stream crossing surveys, education, and outreach.

<http://prep.unh.edu/about/index.htm>

Natural Resources Conservation Service:

Funding and technical assistance for habitat restoration work on private land.

<http://www.nh.nrcs.usda.gov/>

University of New Hampshire Stormwater Center:

Technical assistance and outreach related to LID technology:

<http://www.unh.edu/unhsc/>

Bear Paw Regional Greenways:

Land trust working to protect land in the upper Lamprey River watershed.

<http://www.bear-paw.org/>

New Hampshire Department of Transportation and town Departments of Public Works:

Agencies in charge of road maintenance should be consulted in relation to any potential stream crossing restoration or survey work.

<http://www.nh.gov/dot/>

Local businesses:

Local businesses are an underutilized funding source in conservation work. Businesses often sponsor youth sports, community gardens, and neighborhood trash clean ups. They may also be interested in sponsoring a local stream restoration.

## CONCLUSION

There are few watersheds in New Hampshire that match the diversity and abundance of fish species in the Lamprey River. Of all coastal rivers in New Hampshire, the Lamprey River has arguably the greatest potential for diadromous fish restoration. The Lamprey River watershed provides important habitat for fish species of concern, including the state threatened bridled shiner, banded sunfish, redbfin pickerel, and swamp darter. Wild brook trout populations are restricted to isolated coldwater streams, which owe their existence to groundwater stored in deposits of sand and gravel left by melting glaciers. Protecting

these brook trout streams, along with the many other aquatic habitats that continue to support healthy fish communities, will require a coordinated effort to manage the impacts of sprawling suburban development. A focus on headwater streams, using a combined strategy of land protection, stream restoration, riparian buffer protection, and education, will have lasting benefits, not only for local species, but for the water quality and ecological integrity of the Lamprey River, its tributaries, and the Great Bay estuary.

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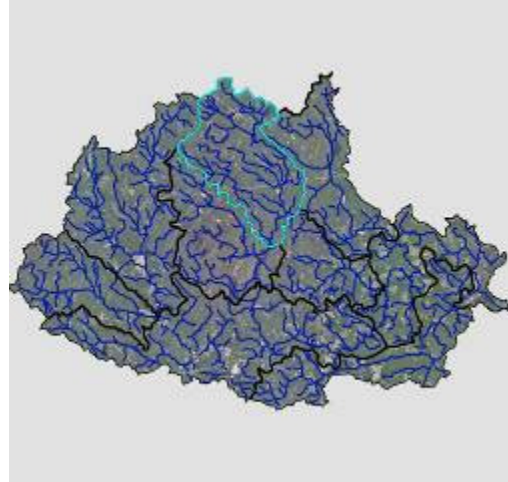
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## **APPENDIX A. Fish Survey Summary by Subwatershed.**

### **Bean River**

Sixteen fish surveys were conducted in the Bean River subwatershed. Aquatic habitat was largely intact, with well forested riparian zones. Stream habitat ranged from flashy boulder and cobble substrates dominated by fallfish to warm wetland streams and beaver impoundments containing golden shiners, largemouth bass, and chain pickerel.



The Bean River subwatershed has the second lowest impervious surface coverage, estimated at 9.29% of land surface area, in the Lamprey River watershed. Only the Pawtuckaway Pond subwatershed, a large part of which is protected by Pawtuckaway State Park, has lower impervious surface levels. Although the subwatershed remains relatively unfragmented compared to faster growing parts of the region, impervious surface coverage has nearly doubled since 1990, when it was estimated at 5.15%.

Efforts to protect land in the Bean River subwatershed will benefit both healthy fish communities and downstream water quality. Much of the central part of the subwatershed has been protected by the Mulligan Forest conservation easement. Connecting this property with Pawtuckaway State Park, to the south, would help prevent future impacts to aquatic habitat in local streams while expanding one of the largest unfragmented forest areas in southeastern New Hampshire.

There are an estimated 48 stream crossings in the Bean River subwatershed. While many of these crossings are undersized, perched, or contributing to erosion or sediment deposition, the cumulative impact of these crossings is less noticeable than in subwatersheds with higher road densities. Stream crossings should be replaced opportunistically in this subwatershed, but large inventories and restoration efforts focused on reducing the impacts of stream crossings in the Lamprey River watershed should be focused elsewhere.

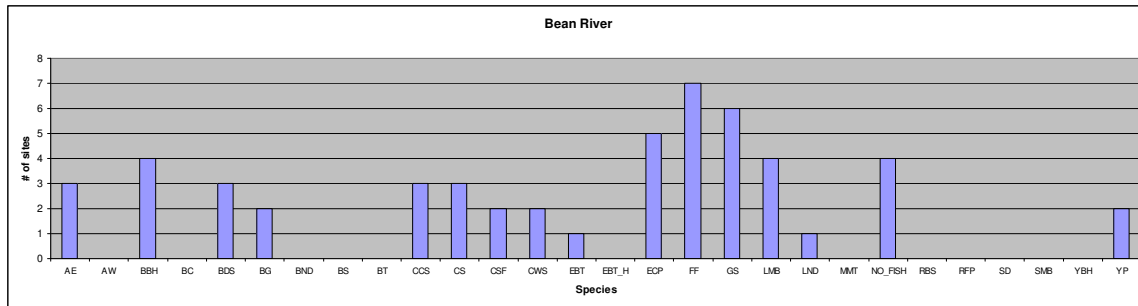


Figure A.1 - Number of species recorded at 16 sites surveyed in the Bean River subwatershed.

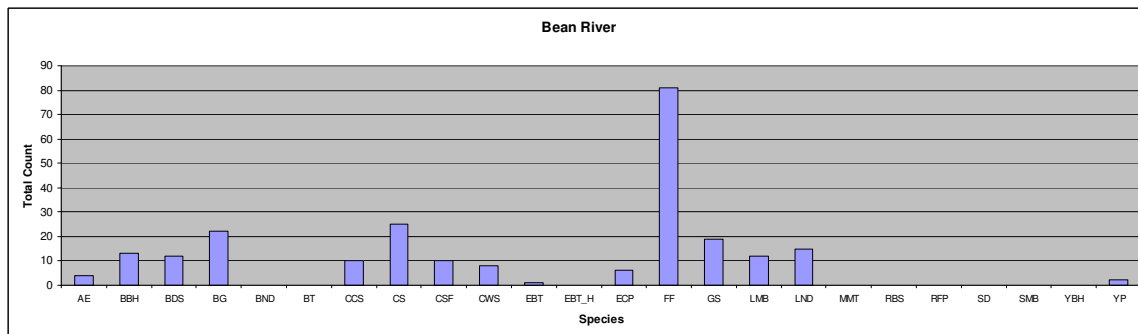


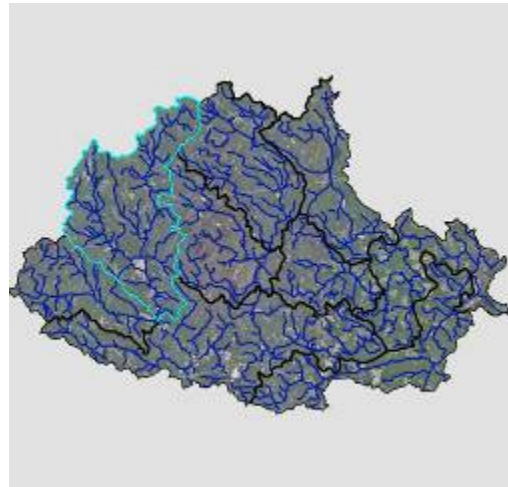
Figure A.2 - Total counts of each species captured at 16 sites in the Bean River subwatershed.



Figure A.3 - Rocky section of the Bean River with intact riparian zone.

## Lamprey River Headwaters

Sixteen surveys were conducted in the Lamprey River Headwaters subwatershed. The small headwater tributaries in the subwatershed were dominated by fallfish and common white sucker. Fish diversity increases with stream size as you move south along the upper mainstem of the Lamprey River, where common shiners and longnose dace become more prevalent. Three of the four sites containing blacknose dace, a species common throughout most of New Hampshire, but relatively rare in the Lamprey River watershed, were recorded in the Lamprey River Headwaters. The longnose dace population reaches its upstream limit in this subwatershed. Reductions in the distribution of longnose dace, which depend on rocky riffle habitat with year round flow, in the upper mainstem of the Lamprey River may be an early indicator of impacts to instream flow. American eel were recorded at 2 sites in the Lamprey River Headwaters subwatershed. Their numbers and distributions are expected to increase with the construction of fish passage at the Wiswall Dam and the removal of the Bunker Pond Dam.



The Lamprey River Headwaters remains relatively forested. The estimated impervious surface coverage in 2010 was 9.5% compared to 4.8% in 1990. Riparian zones remain largely intact, despite the significant increase in impervious surfaces over the last 20 years. Very little land in the Lamprey River Headwaters subwatershed has been protected outside of a patchwork of conservation easements that surround Northwood Meadows State Park. Land protection efforts in the headwaters of Hartford Brook and Nicholls Brook would benefit local fish populations and downstream water quality.

There are an estimated 81 stream crossings in the Lamprey River Headwaters subwatershed. The cumulative effects of these stream crossings, many of which were washed out multiple times during floods over the past 6 years, may have contributed to the excessive sediment deposition that has contributed to declines in freshwater mussels downstream (Nedeau 2011). A stream crossing inventory that documents and prioritizes stream crossings in need of restoration would be beneficial in this subwatershed.

Freeze's Pond Dam is the next upstream barrier to river herring migration. Depending on fish passage at Wadleigh Falls, Freeze's Pond Dam may become a candidate for river herring passage (or removal) in the future. The dam would also be a suitable site for an elver trap to monitor eel passage. This would make an excellent project for middle school or high school students.

Wild brook trout were found at two sites in the Lamprey River Headwaters subwatershed. The source of groundwater appears to be a valley fill aquifer formed from glacial



outwash deposited in low lying areas of southern Deerfield, Raymond, and eastern Candia. There may be other cold water streams in the area that were missed by this survey effort. Brook trout habitat was marginal at both sites and the streams should be resurveyed before any restoration work is considered. Driveway and road crossings were causing impacts, especially in the small unnamed stream that borders Grout Farm Road in northwestern Raymond. Reducing fragmentation in this stream by replacing undersized crossings would benefit the resident brook trout population if it were determined to be sustainable. Flow was extremely low in the stream on July 15, when it was surveyed in 2010. A total of seven trout were captured in pools of just a few inches in depth.

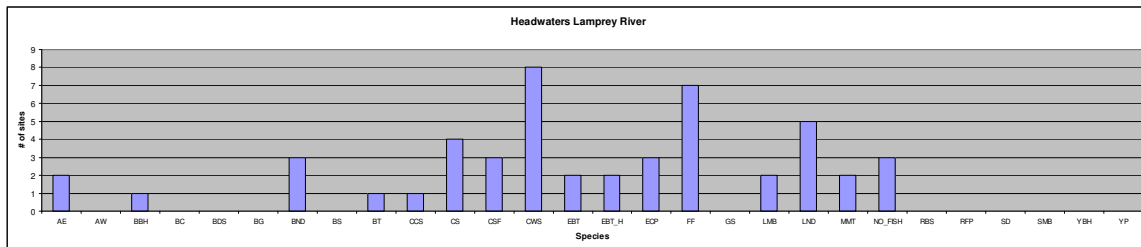


Figure A.4 - Number of species recorded at 16 sites surveyed in the Lamprey River Headwaters subwatershed.

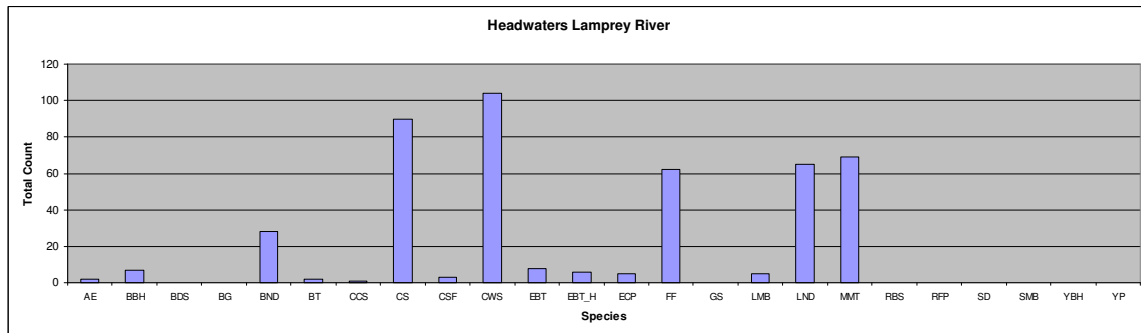


Figure A.5 - Total counts of each species captured at 16 sites in the Lamprey River Headwaters subwatershed.



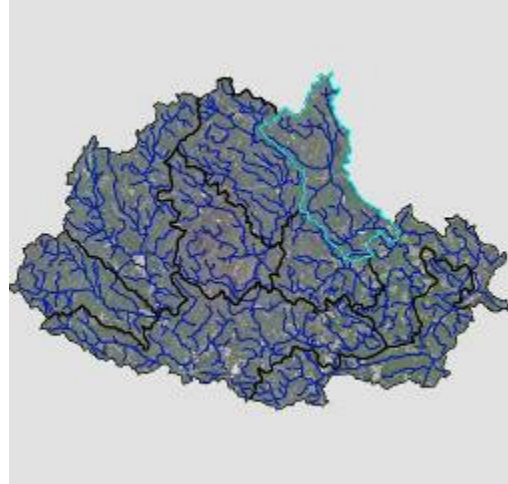
Figure A.6 - One of three Driveway culverts impacting fish passage on a coldwater stream in the Lamprey River Headwaters subwatershed.



Figure A.7 - Wild brook trout captured in unnamed stream that borders Grout Farm Road in northwest Raymond.

## Little River

Eleven surveys were conducted in the Little River watershed. Fallfish, common white sucker, and golden shiners were the most commonly encountered species. The high occurrence of golden shiners was due to the presence of wetland or beaver impounded streams upstream or downstream of the sample site. Habitat in the Little River is generally a meandering stream channel surrounded by broad floodplains with sand, gravel, and cobble substrate. There are two significant dams in the watershed, one at Nottingham Lake and another at Mendums Pond. These dams are barriers to upstream fish migration. Both dams may be good candidates for eel passage. While eels have been documented in Mendums Pond, it is likely that these dams reduce the eel population in the headwaters of the Little River. These dams may also be contributing to warmer water temperatures in the Little River.



A small cold water stream was discovered behind the Lee Motor Speedway. Twenty one wild brook trout were captured in a stream that was on the USGS topographic map for the area. This illustrates the importance of protecting even the smallest streams in areas known to have productive aquifers. Streams within a mile buffer of Route 125 should be given special attention during the permitting process for commercial or residential development. Fifteen meter protected riparian buffers and LID stormwater management techniques should be required within the watersheds of all coldwater streams. Groundwater extraction should be limited to avoid effecting summer base flows in cold water stream habitat.

Although most of the riparian zone along the mainstem of the Little River remains intact, impervious surfaces have nearly doubled between 1990 (6.6%) and 2010 (12.2%). The subwatershed has the second lowest estimated number of stream crossings, at 33. Despite the increase in impervious surfaces, much of the headwaters of the Little River remain undeveloped. Protection of the large unfragmented forest area which drains into Mendums Pond should be a high conservation priority.

One of only two swamp darter records occurred in the Little River at a site downstream of Mendums Pond near the Route 4 Bridge. More information is needed on the distribution and status of swamp darters in southern New Hampshire. The Little River may be the focus of future survey work.

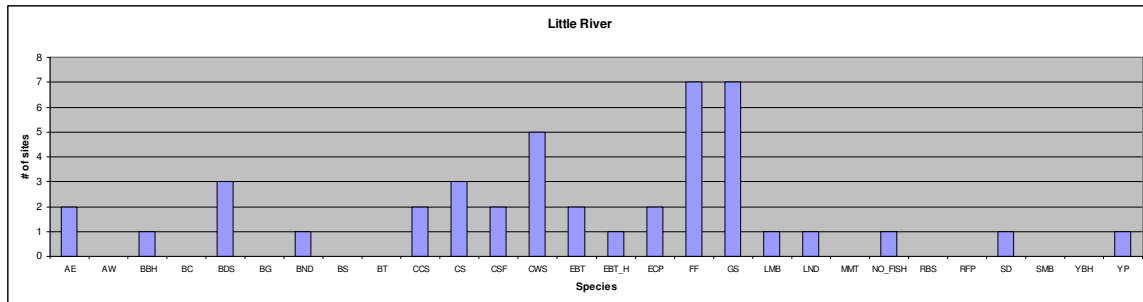


Figure A.8 - Number of species recorded at 11 sites surveyed in the Little River subwatershed.

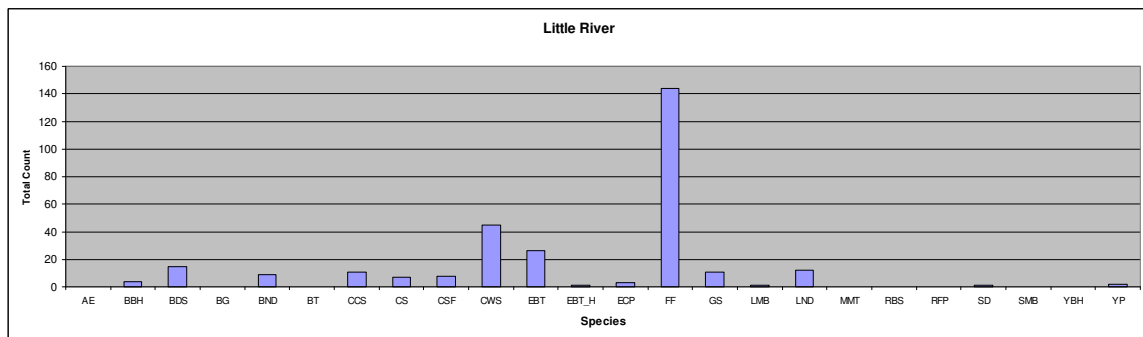


Figure A.9 - Total counts of each species captured at 11 sites in the Little River subwatershed.

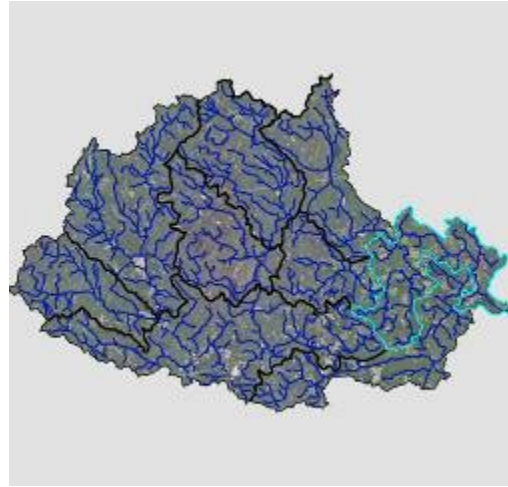


Figure A.10 - A typical reach of the Little River, with its wide channel, broad floodplains, and sandy substrate mixed with gravel and cobble.



## Lower Lamprey River

Eleven surveys were conducted in the Lower Lamprey River subwatershed. The smaller tributaries were dominated by fallfish and common white sucker, while the mainstem river saw the emergence of redbreast sunfish and smallmouth bass as common species. Much of the river is deep and sandy with broad floodplains, but shallow riffle sections contain abundant populations of longnose dace, common shiner, fallfish, and margined madtom. American eel are present throughout the mainstem, but the greatest number (53) occurred below the Wiswall Dam. American eel numbers



dropped significantly (5) at the next site upstream, below the Lee Hook Road bridge. This site has the potential to be an index site for detecting changes in eel numbers after the construction of a fishway at the Wiswall dam in 2011.

Redfin pickerel and banded sunfish were documented in the tributaries of the Lower Lamprey River subwatershed, but attempts to confirm a previous record of bridle shiners above Wadleigh Falls were unsuccessful. The river lacks suitable aquatic vegetation habitat to support bridle shiners in this reach. It is not known whether this section once supported stands of aquatic vegetation, which no longer exist due to changes in river conditions, or whether the bridle shiners were incorrectly identified. Records of bridle shiners below Packers Falls have so far been unconfirmed (Harrington 1946).

Impervious surfaces increased from 11.1% in 1990 to 17.8% in 2010, mostly due to population growth in the town of Newmarket. There are 39 stream crossings in the Lower Lamprey River subwatershed, many of which are undersized and impacting local stream habitat. Water quality in the mainstem river is influenced as much by subwatersheds upstream as by development along the river banks.

Wednesday Hill Brook is a productive, cold water stream that flows into the Lamprey River in the town of Lee. Seventy brook trout were counted at the site, many of which were young-of-year fish, which is a sign of a sustainable population. Students and Faculty from UNH have been monitoring temperature and flow in Wednesday Hill Brook to better understand the dynamics of cold water streams. Another stream in the town of Newmarket had temperatures and habitat suitable for brook trout, yet redbfin pickerel were the only fish species captured. Future surveys may be warranted.

The Lower Lamprey subwatershed is a high priority for diadromous fish restoration. River herring, sea lamprey, and a small number of American shad are counted by NHFG staff at the fish ladder on the McCallum Dam, at the head of tide in Newmarket each spring. Until 2012, diadromous fish migration was blocked by the Wiswall Dam. Construction of a fish ladder at the dam allowed for the successful passage of river

herring in the spring of 2012. Construction was timely, for many fish were observed passing through the new fishway in a record return year of over 90,000 river herring counted at the McCallum Dam. Large numbers of river herring were observed schooling below the ruins of Wadleigh Falls Dam, which may be the next upstream barrier to migration. A rock ramp or nature-like fishway constructed at this site would open up many miles of river habitat in the Middle Lamprey River, North Branch River, Lamprey River Headwaters, North River, and Little River subwatersheds.

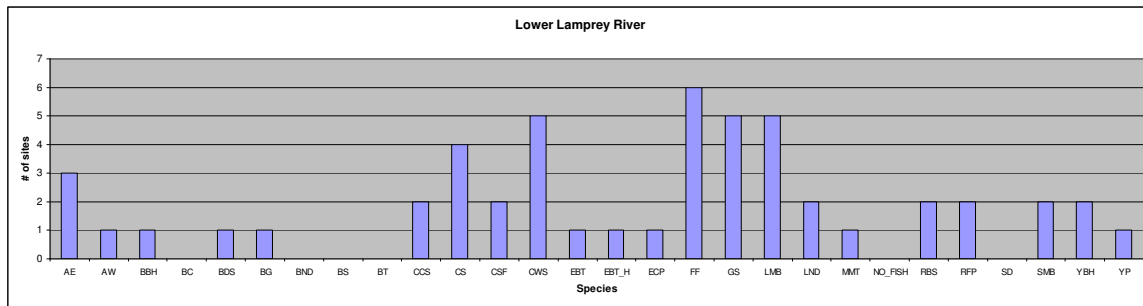


Figure A.11 - Number of species recorded at 11 sites surveyed in the Lower Lamprey River subwatershed.

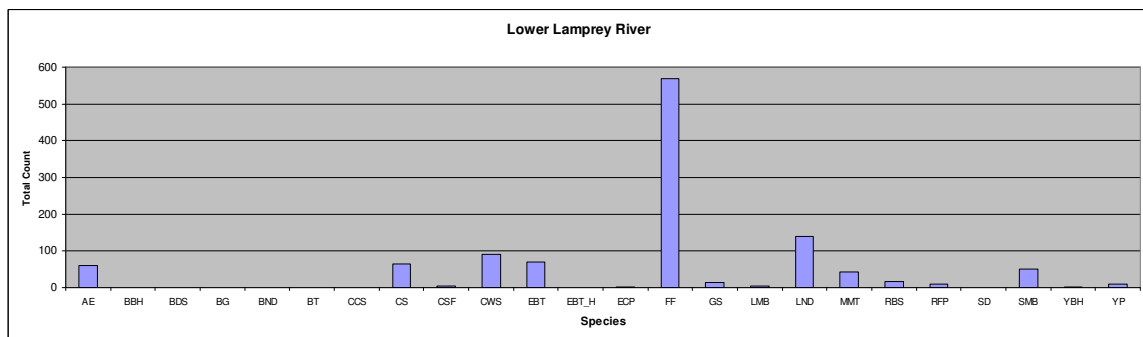


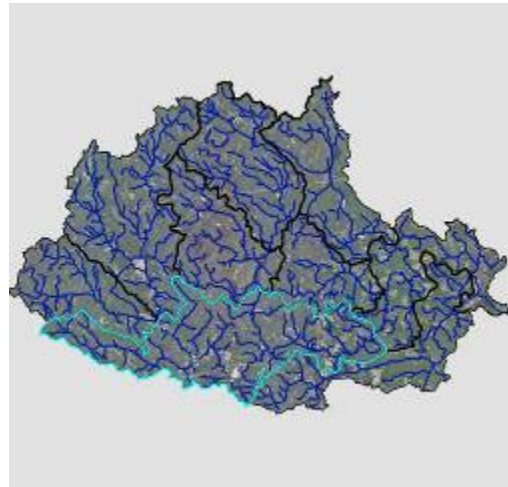
Figure A.12 - Total counts of each species captured at 11 sites in the Lower Lamprey River subwatershed.



Figure A.13 - Two alewives (top) and two blueback herring (bottom). River herring numbers are expected to increase with improvements to fish passage in the Lower Lamprey River.

## Middle Lamprey River

Fourteen surveys were conducted in the Middle Lamprey River subwatershed. This was the most diverse watershed in terms of fish species, with 24 species recorded. The river becomes wide and deep as it passes through the town of Raymond, with limited sites for electrofishing. Habitat consists of riffles and pools with gravel, boulder, and sand substrate, alternating with deep, slow flowing reaches with silt bottom and stands of aquatic vegetation in shallow areas.



The small tributaries flowing into the mainstem of the Lamprey River are noticeably more impacted in this subwatershed. There are an estimated 143 stream crossings in the Middle Lamprey subwatershed, which is the largest number of crossings out of the nine subwatersheds in the Lamprey River drainage. This would be an excellent subwatershed to begin a stream crossing assessment that documents the existing conditions of all crossings and identifies stream crossing replacements that would have the most benefit to aquatic organism passage and habitat quality. The Middle Lamprey River subwatershed also has the greatest coverage of impervious surfaces, at 21.7% in 2010 compared to 12.2% in 1990. Some studies show that impacts to aquatic habitat and water quality can occur at impervious surface covers of less than 4% (Cuffney et al. 2010; Stranko et al. 2008). Expanding development in the Middle Lamprey subwatershed has left its mark on smaller streams in the form of washed out roads, bank and stream bed erosion, and sediment deposition in slower moving reaches. Mussel abundance and diversity has been severely depleted in this subwatershed (Nedeau 2011).

The Middle Lamprey River subwatershed contains the only remaining populations of the state threatened bridle shiner in the Lamprey River watershed. The populations occur at five distinct reaches of the mainstem where slow moving water allows for the growth of aquatic vegetation, such as floating heart, on which bridle shiners depend for spawning and cover. The rate of dispersal, if any, between populations is unknown. It is interesting to note that bridle shiners were not found downstream of the Main Street Bridge in Raymond, despite the presence of suitable habitat. There is a significant increase in housing density at this point along the river and it is possible that stormwater runoff may be impacting the water quality. This would be a good location for a water quality monitoring station. A map of stormwater outfalls should be developed for the town of Raymond with recommendations for improvements to stormwater management that would benefit water quality in the Lamprey River.

Two potential spring fed streams were identified in the Middle Lamprey River subwatershed. Rum Brook, where over 28 wild brook trout were counted, appears to be a relatively healthy cold water stream and should be protected. Three juvenile brook trout were also found at an unnamed stream just south of Rum Brook. Although habitat was



marginal at this site, it appears better upstream and future surveys are warranted. Streams within a one mile buffer on either side of Route 125 have the potential to contain brook trout populations due to the productive aquifer that runs roughly north/south along this corridor. Careful attention should be given to even the smallest streams during the permitting process for new developments within this corridor. A minimum of 15 m buffers should be protected along all streams and LID technology should be used to ensure adequate groundwater recharge to maintain stream flow during dry periods.

Banded sunfish, redbfin pickerel, American eel, were species of concern recorded in the Middle Lamprey subwatershed. Even juvenile river herring, offspring of adults stocked by the NHFG Marine division in Pawtuckaway Lake each spring, are known to migrate through part of this subwatershed as they migrate out to sea. Fifteen American eels were counted below the Bunker Pond Dam, which was subsequently removed, making the Lamprey River free flowing throughout this subwatershed. A population of bridge shiners previously inhabited the impoundment upstream of the dam. This population will be monitored to assess the ability of bridge shiners to survive under new habitat conditions as the river channel changes in response to the dam removal.

The Middle Lamprey subwatershed should be the primary focus of restoration efforts in the Lamprey River watershed. It shows the most recent signs of impacts from development, yet its fish communities remain largely intact.

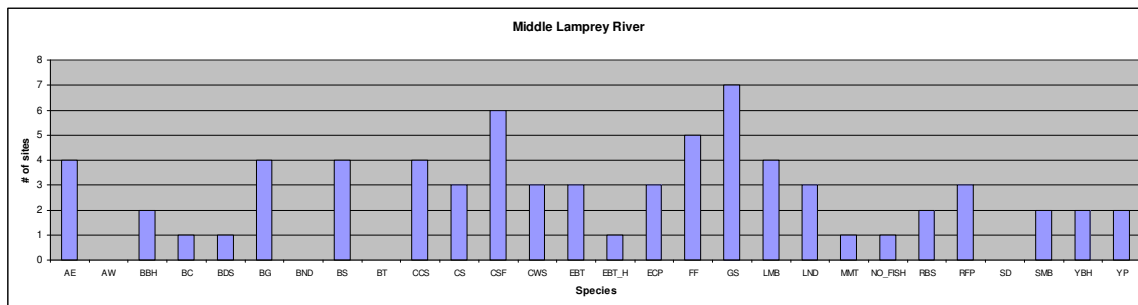


Figure A.14 - Number of species recorded at 14 sites surveyed in the Middle Lamprey River subwatershed.

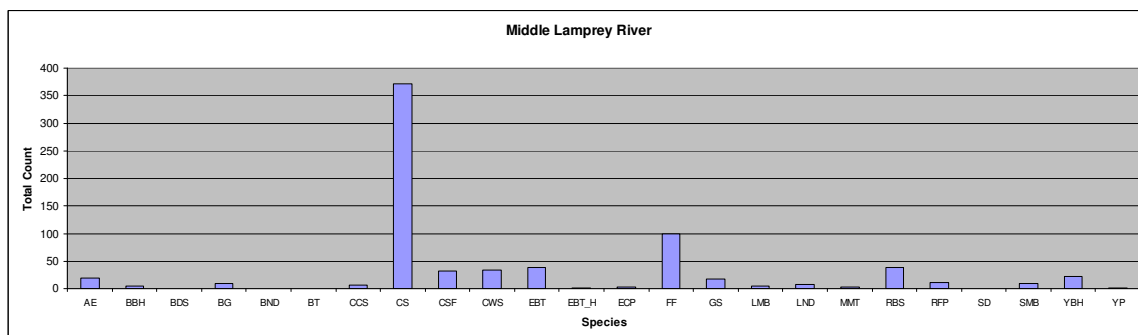


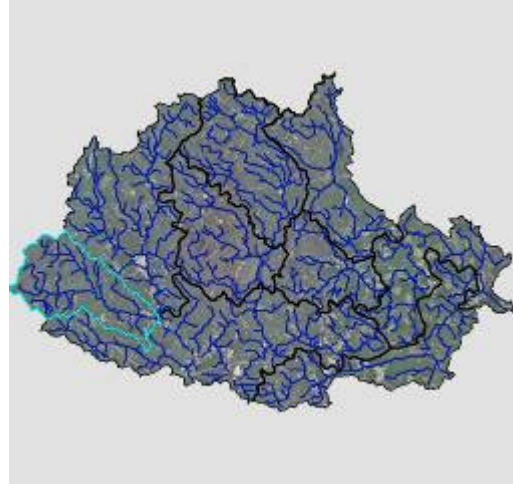
Figure A.15 - Total counts of each species captured at 14 sites in the Middle Lamprey River subwatershed.



Figure A.16 - West Epping Dam before its removal in August of 2011. A population of state threatened bridge shiners was identified upstream.

## North Branch River

Fifteen surveys were conducted in the North Branch River subwatershed. These surveys were conducted in 2007 during an earlier pilot study to develop survey protocols for the Eastern Brook Trout Joint Venture. The headwaters of the North Branch River provide some of the best examples of old mill structures at the transition between low gradient wetland streams or beaver ponds and steeper rocky streams below the ruins of an old dam or road (Fig. A.19). This pattern is reflected in the fish



survey data, with a number of species, such as brown bullhead, common sunfish, and chain pickerel, which are usually associated with wetland streams or pond habitat, that were captured in higher gradient, rocky stream sections below old mill dams. Fish diversity and abundance increase significantly as one moves downstream into the mainstem of the North Branch River, where over 13 species were captured at one site. Here the channel becomes wider, with gravel and cobble riffles interspersed with beaver impounded, slower flowing reaches. Species like longnose dace, common shiner, and margined madtom inhabit faster flowing reaches, while largemouth bass and common sunfish prefer the slower moving water. The furthest upstream record of smallmouth bass in this survey was found in the North Branch River.

Seventeen temperature sensors were deployed throughout the North Branch River subwatershed in 2007. The average water temperature in July and August was above the threshold for supporting wild brook trout ( $19^{\circ}\text{C}$ ) at all sites except one cold water stream known locally as Aunt Mary Brook. The stream, which flows north into the North Branch River near its confluence with the Lamprey River in east Candia, likely receives groundwater from the valley fill aquifers deposited in this region (Moore 1990). The lower section of Aunt Mary Brook was filled with sediment and had run dry due to the impacts of a driveway culvert and the excavation of the streambed near a residence (Fig. A.20). Thirty wild brook trout were captured above the culvert. Replacing the culvert with a properly sized crossing and restoring the stream channel downstream would greatly increase the amount of habitat available to brook trout as well as restore the connection between Aunt Mary Brook and the North Branch River.

The large wetlands and connecting streams of the North Branch River subwatershed are relatively unfragmented and offer important habitat for many species of concern, including Blanding's and spotted turtles. Banded sunfish were found at one survey site and are likely more common in the thickly vegetated beaver impoundments, which are difficult to sample with electrofishing gear. The North Branch River has relatively few dams and American eel were found at three sites. Their distribution is expected to increase with improvements to fish passage in the lower Lamprey River.

Very little of the North Branch River subwatershed has been protected, despite the quality of its habitat. Impervious surface coverage has increased considerably from 6.3% in 1990 to 11.6% in 2010. Although there are a number of examples of undersized stream crossings that are impacting stream habitat, the overall number of crossings, estimated at 35, is relatively low compared to other subwatersheds in the Lamprey River drainage. In addition to slowing the spread of impervious surfaces, land conservation in the North Branch River would build on the large area protected by Bear Brook State Park, to the west. Efforts to protect riparian buffers along headwater streams were initiated in the towns of Candia and Deerfield through a partnership between the Southern New Hampshire Planning Commission and the Piscataqua Region Estuaries Project (SNHPC 2006). These efforts should continue and be used as a model for other town planners in the Lamprey River watershed.

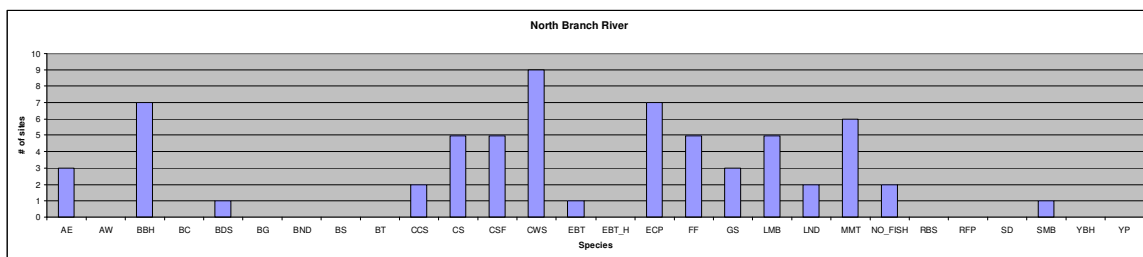


Figure A.17 - Number of species recorded at 15 sites surveyed in the North Branch River subwatershed.

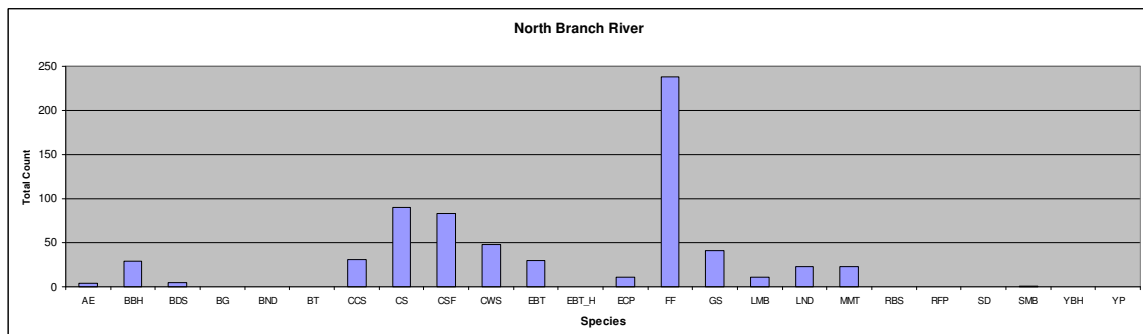


Figure A.18 - Total counts of each species captured at 15 sites in the North Branch River subwatershed.





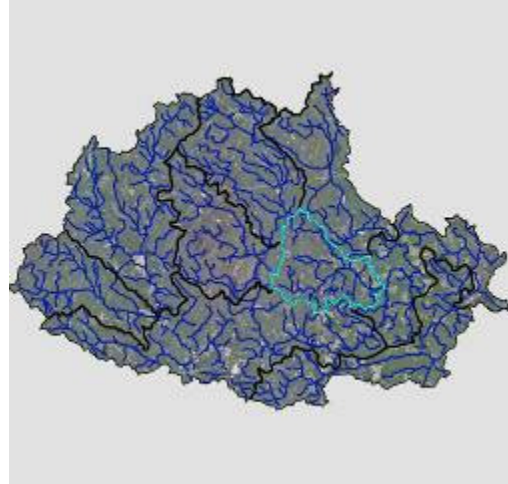
Figure A.19 - Rocky stream channel downstream from the ruins of an old mill.



Figure A.20 - This driveway culvert marks the downstream limit of brook trout in Aunt Mary Brook.

## North River

Nine surveys were conducted in the North River subwatershed. At 19 different fish species recorded, it was among the most diverse subwatersheds in the Lamprey River drainage. The mainstem of the North River contains a wide variety of habitats, from low gradient reaches dominated by submerged and emergent vegetation to rocky riffle reaches occasionally used by whitewater paddlers. Aquatic habitat in the North River subwatershed remains largely intact, although very little of it is protected.



Wild brook trout were found in one small tributary of the North River downstream of Birch Hill Road in Lee. Most of the trout were found in a small pool below a perched culvert, but two juvenile brook trout were found upstream of Birch Hill Road (Fig. A.24). Further surveys should be conducted to determine the viability of this brook trout population. If suitable habitat exists for a significant length of the stream, then the perched stream crossing may be a candidate for replacement.

Four of the 9 survey sites contained banded sunfish and three sites contained redbfin pickerel. The diversity of fish habitat in the North River subwatershed provides excellent refuge for native cool to warmwater fish communities. Efforts to increase the protection of riparian zones and reduce the spread of impervious surfaces should be a priority in this subwatershed. Unfortunately, estimates of impervious surfaces have nearly doubled from 5.4% in 1990 to 11.3% in 2010.

The North River is relatively unfragmented, with only 37 road stream crossings and no mainstem dams. Eel numbers are likely to increase with fish passage construction at the Wiswall Dam. The North River also contains suitable spawning habitat for river herring, although upstream passage may currently be limited by the ruins of the Wadleigh Falls Dam in Lee (Kevin Sullivan, NHFG Fisheries Biologist, personal communication).

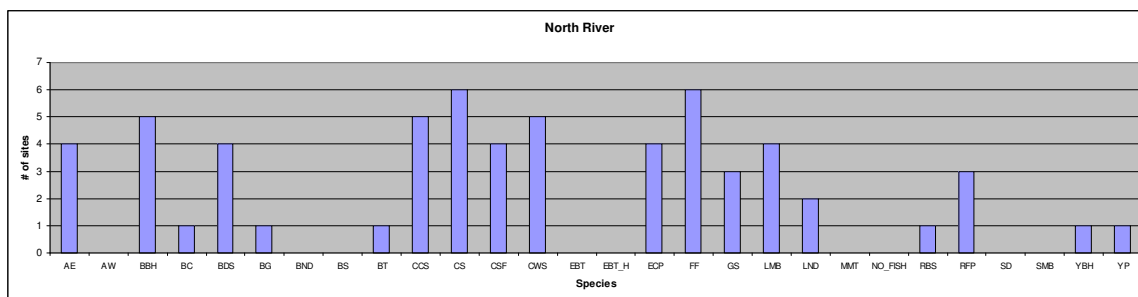


Figure A.21 - Number of species recorded at 9 sites surveyed in the North River subwatershed.

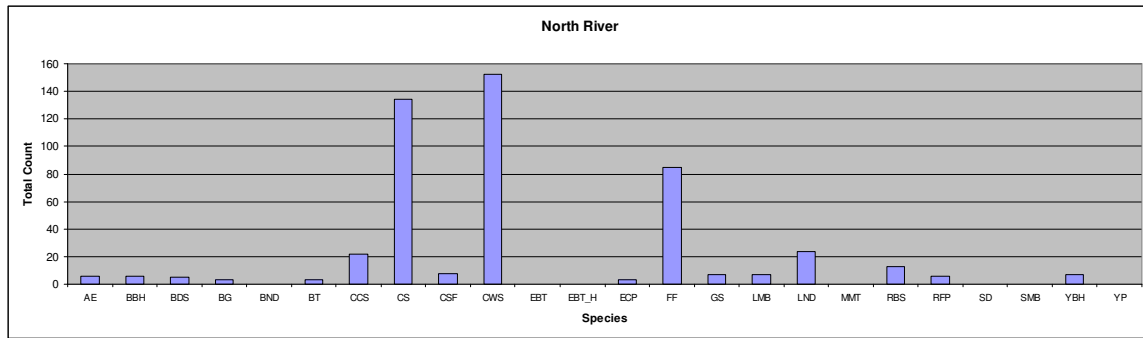


Figure A.22 Total counts of each species captured at 9 sites in the North River subwatershed.



Figure A.23 Twelve fish species were recorded in this rocky section of the North River downstream of Mcrillis Road in Nottingham.





Figure A.24 - Perched culvert above scour pool where brook trout were captured in an unnamed tributary of the lower North River.

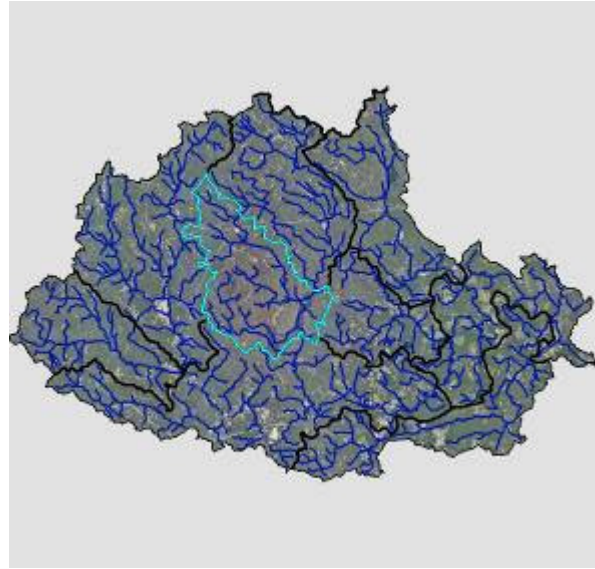


Figure A.25 - Brook trout captured below a perched culvert in the North River subwatershed.



## Pawtuckaway Pond

There were six fish surveys conducted in the Pawtuckaway Pond subwatershed. Habitat consisted of ponds and large wetland complexes separated by small rocky streams. Fish communities consisted of warmwater species with chain pickerel the most commonly encountered species. Interestingly, this was the only subwatershed where fallfish were not encountered, although this may be due to the lower survey effort.



Most of the Pawtuckaway Pond subwatershed is protected by Pawtuckaway State Park. It is the only subwatershed in the Lamprey River drainage that did not see a significant increase in impervious surface coverage between 1990 (2.7%) and 2010 (5.2%). The Pawtuckaway Pond subwatershed also contains the lowest estimated number of stream crossings (31). Conservation work in this subwatershed should focus on protecting the Back Creek watershed, which would join Pawtuckaway State Park with the Mulligan Forest conservation easement and the patchwork of conservation lands around the Lamontagne Wildlife Management Area to the north (Fig. A.28). This would expand one of the largest blocks of unfragmented forest in southeastern New Hampshire, benefitting water quality, aquatic species, and terrestrial species that require large territories (such as bobcats and black bear). This is also a critical subwatershed for maintaining summer flows in the lower Lamprey River, which may be supplemented with water from Pawtuckaway Pond during drought conditions (NHDES 2011).

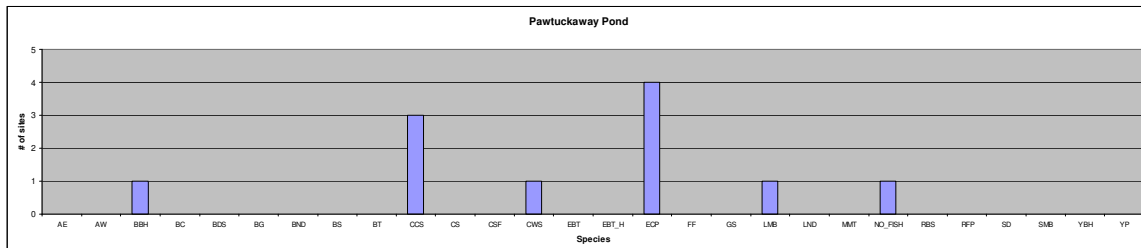


Figure A.26 - Number of species recorded at 6 sites surveyed in the Pawtuckaway Pond subwatershed.

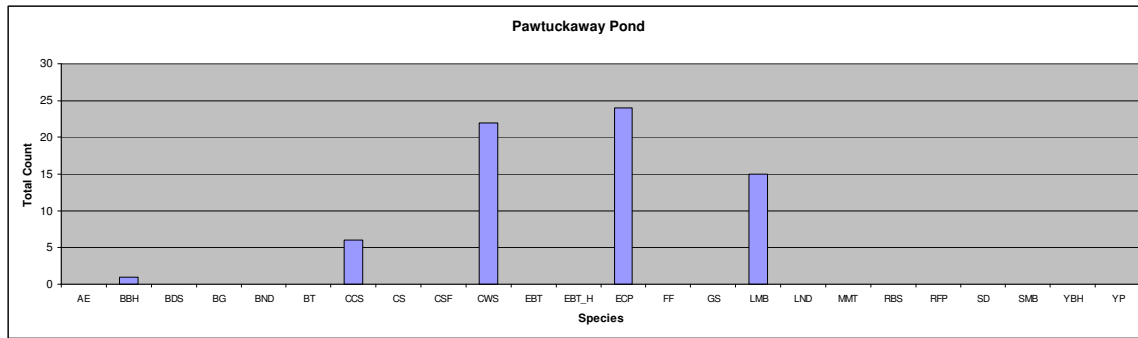


Figure A.27 - Total counts of each species captured at 6 sites in the Pawtuckaway Pond subwatershed.

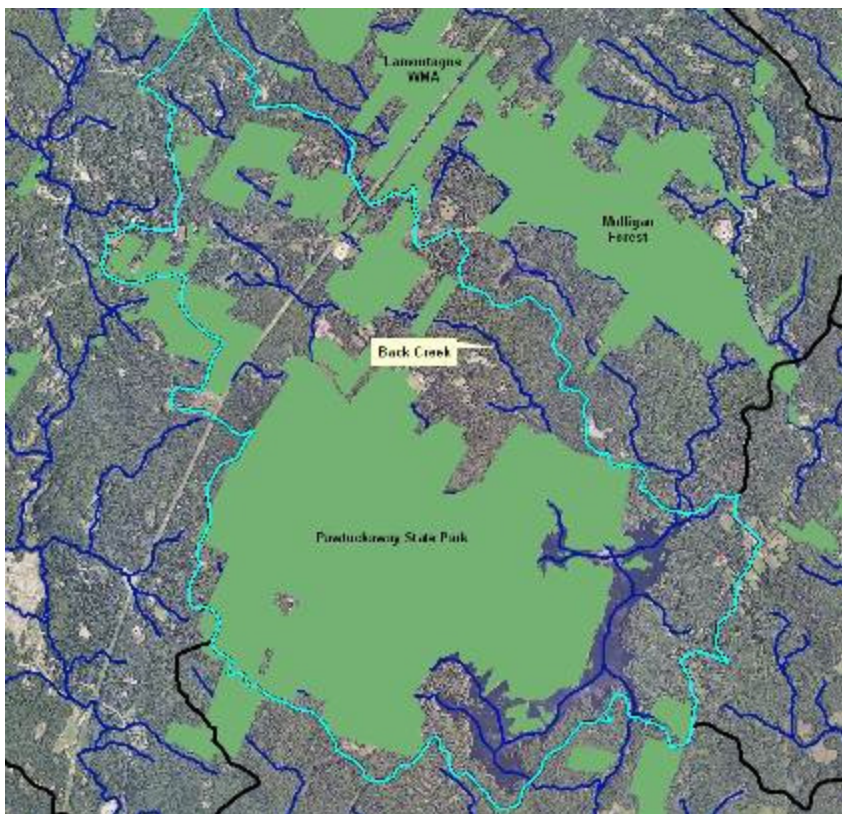
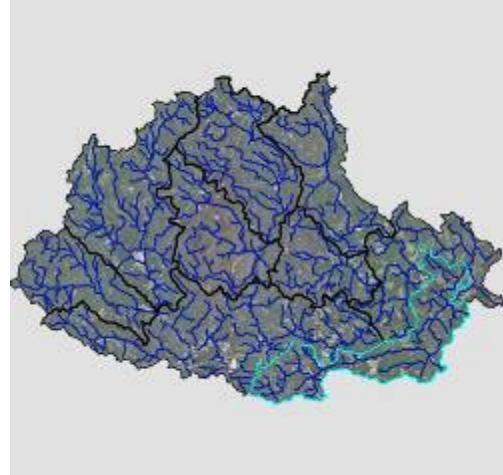


Figure A.28 - Protected land (green) in the Pawtuckaway Pond subwatershed.

## Piscassic River

Seven sites were surveyed in the Piscassic River subwatershed. The Piscassic River is a low gradient, deep, meandering river that is not suitable for backpack electrofishing surveys. Much of the mainstem of the Piscassic River remains relatively unimpacted and large sections have been protected. Thick stands of submerged aquatic vegetation may make the river a stronghold for certain species of concern, including redbfin pickerel, banded sunfish, and possibly bridle shiners. The Piscassic River subwatershed may warrant further surveys with a different method, such as seine or fyke netting.



Fish surveys were conducted on the small tributaries of the Piscassic River, which consisted of beaver influenced wetland streams or small meandering gravel streams through woodlands. Redfin pickerel were found at four of the seven sites and banded sunfish were found at three sites. There are likely abundant populations of these species in the mainstem of the Piscassic River.

While the river itself is largely intact, the tributaries showed signs of impacts from expanding development. Perched culverts, bank erosion, and stormwater runoff impacts were observed at multiple sites. Impervious surfaces increased from 9.6% in 1990 to 19.7% of the subwatershed area in 2010. Although undersized stream crossings were the most common impact in the Piscassic River subwatershed, at least one site demonstrated the severe damage that certain agricultural practices can cause to stream habitat (Fig. A.31). Improving stormwater management, stream crossing design, and riparian zone protection on the tributaries of the Piscassic River will help protect water quality and aquatic habitat in the mainstem.

There are two dams on the Piscassic River, one near the mouth and one at the crossing of Route 87. Fish passage construction or dam removals at these sites would open up a considerable amount of quality spawning habitat for river herring. Eel passage at the lower dam, near the confluence with the Lamprey River in Newmarket, would likely increase the number of eels in the Piscassic River subwatershed. Eels were only observed at two of seven sites, with a total of three individuals counted. One would expect much greater numbers in a watershed that joins the Lamprey River so close to the head of tide.

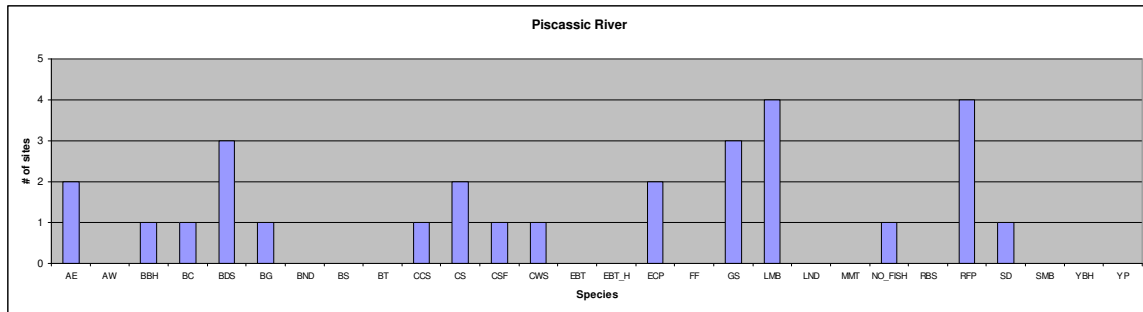


Figure A.29 - Number of species recorded at 7 sites surveyed in the Piscassic River subwatershed.

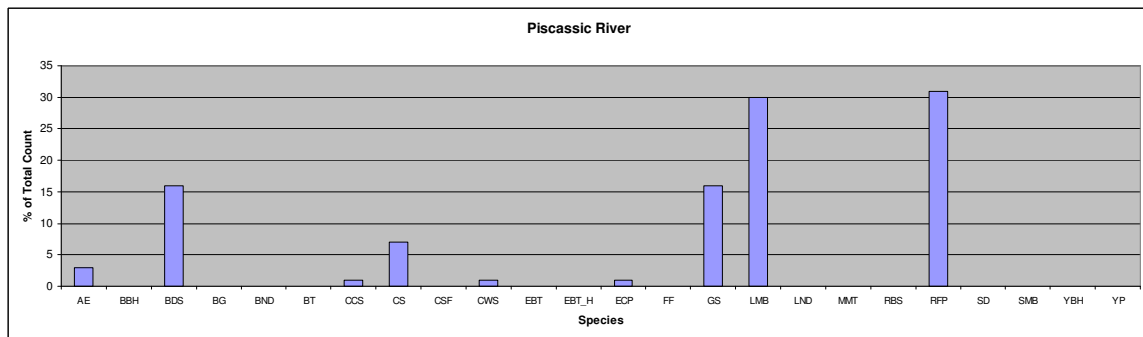


Figure A.30 - Total counts of each species captured at 7 sites in the Piscassic River subwatershed.



Figure A.31 - Livestock grazing in riparian zones can lead to severe stream bank erosion.



## APPENDIX B. Fish Species Profiles

### Alewife (*Alosa pseudoharengus*)



Alewives are members of the herring family. As with all members of the herring family, alewives spend the majority of their lives in the ocean. In the spring, adult alewives move into freshwater, migrating up coastal rivers from North Carolina to Newfoundland. Alewives spawn in lakes, ponds, and slow flowing backwaters of rivers. Juvenile alewives migrate downstream to the ocean in late summer and fall, where they will remain until sexual maturity in 3 to 5 years. Alewife numbers have declined throughout their range to the point that the species is currently a candidate for listing under the federal endangered species act. At normal population levels, alewives are a source of prey for a wide range of species from harbor seals in estuaries to chain pickerel in lakes and ponds.

Of the surveys included in this report, one alewife was recorded just downstream of Packers Falls in Durham. This incidental capture occurred during a seine survey targeting bridle shiners. NHFG has been working to restore river herring to the Lamprey River since the fish ladder was built on the McCallum dam in Newmarket in the 1970's. Each year, alewives are transported from the fish ladder to inaccessible spawning habitat upstream of the Wiswall Dam. Stocking sites include Pawtuckaway Lake and Wadleigh Falls. Installation of a fish ladder at the Wiswall Dam in 2011 provided access to many miles of previously inaccessible spawning habitat. Alewives were observed passing through the fishway by NHFGD biologists in the spring of 2012. Schools of alewives were also observed downstream of the ruined dam at Wadleigh Falls. No alewives were observed passing above Wadleigh Falls. Future surveys should be expected to show a seasonal increase in the presence of alewives in the Lamprey River watershed.

## American Eel (*Anguilla rostrata*)



The American eel is the only catadromous species in New Hampshire waters. Adult eels migrate from freshwater rivers throughout the Atlantic coast to their spawning grounds in the Sargasso Sea. American eel larvae drift on ocean currents back to the coast line, where they migrate up rivers as juvenile eels, known as elvers. Juvenile eels have the ability to ascend obstacles that block other fish species. They can work their way through cracks in dams and climb vertical surfaces with only a trickle of water. However, dams and other barriers have greatly reduced the distribution of eels, which were once present in nearly all freshwater habitat that could be reached from the ocean. Hydropower turbines are a major cause of mortality as the adult eels migrate downstream. Female eels tend to migrate greater distances upstream than males, which usually remain in estuarine habitat. Eels may remain in freshwater for over 20 years before migrating back to the ocean.

American eels are relatively widespread in the Lamprey River watershed, although their abundance drops considerably upstream of the Wiswall Dam. American eels were present at 23 of 105 sites (22%) and accounted for 98 (2.3%) of the 4,226 fish counted in this survey. American eels can be difficult to net in electrofishing surveys, so the actual abundance of American eels is likely higher than what was recorded in this survey. However, eel abundance in the upper Lamprey River and its tributaries is far below what one would expect in an unfragmented river system. Over 67% of the eels counted were captured at the survey site just downstream from the Wiswall Dam. A fish ladder and an

elver trap, monitored by NHFG biologists at the McCallum dam in Newmarket, improves access to freshwater habitat for elvers in the spring until the fish ladder is closed in early summer. The fish ladder built at the Wiswall Dam and the recent removal of the Bunker Pond Dam should improve the accessibility of upstream habitat for American eels in the future. Sites in this survey could potentially be revisited to monitor trends in American eel distribution and abundance.

Maximum Length: 914mm  
Minimum Length: 90 mm  
Average Length: 334 mm

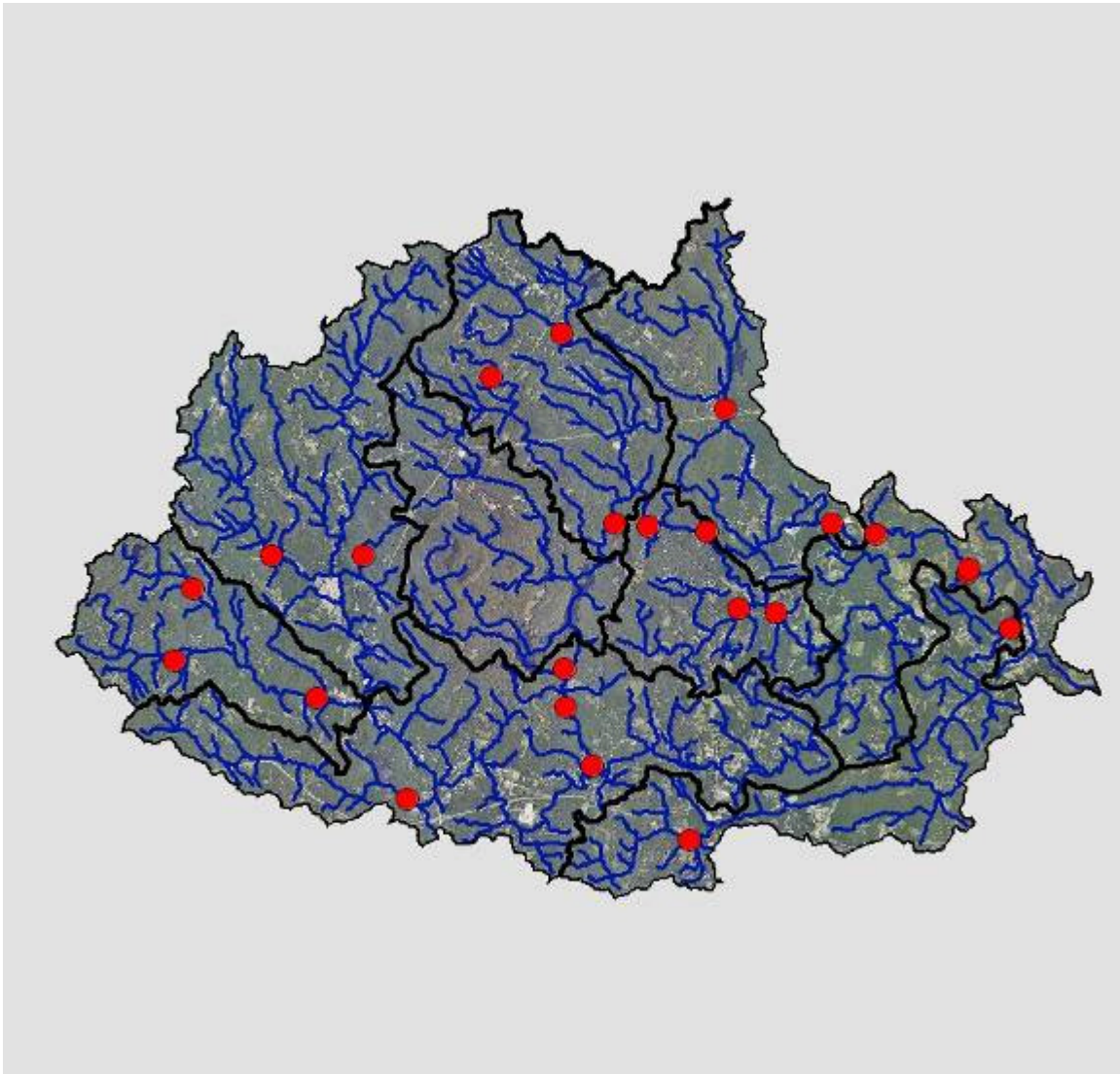


Figure B.1 – Locations of survey sites where American eel were recorded in the Lamprey River watershed.



**Banded Sunfish**  
**(*Enneacanthus obesus*)**  
*Species of Concern*



New Hampshire's smallest sunfish species, banded sunfish inhabit ponds and small streams along the Atlantic coastal plain from Florida to southern New Hampshire. Although locally abundant in some watersheds, banded sunfish are at the northern edge of their range in New Hampshire and their distribution overlaps with some of the most rapidly developing parts of the state. Banded sunfish are found in stands of submerged aquatic vegetation along the margins of lakes, ponds, and slow flowing rivers. They are often surprisingly far upstream in beaver ponds and wetland streams in the headwaters of a watershed. These smaller streams may provide refuge from introduced predators like largemouth bass. Banded sunfish are highly tolerant of acidic water. Little is known about the life history of banded sunfish. Research on the breeding behavior, feeding habits, population dynamics, and dispersal capabilities would be valuable for conserving the species. Their dependence on aquatic vegetation in shallow water makes the species vulnerable to the effects of shoreline development. Banded sunfish have been used for mosquito control in the acidic swamps and cranberry bogs of southeastern Massachusetts.

Banded sunfish were found at 15 of 105 sites (14%) in 7 of 9 subwatersheds. They were often found in small headwater streams and ponds and they appear to be able to survive in the variety of habitat conditions created by beavers. Although they were usually found associated with aquatic vegetation, banded sunfish were also found in shallow, sandy stream channels flowing through thick grassy meadows that emerged after a family of beavers abandoned their dam. They were relatively uncommon at sites where they were



found, accounting for just 1.3% (53) of the total fish count (4,226). The largest number of banded sunfish counted at one site was 13 in unnamed tributaries of the Little River and the Piscassic River. Banded sunfish are likely more abundant than indicated by this survey. A seine net would be a better method for assessing the status of banded sunfish in the muddy, vegetated habitat which it prefers. The relatively undisturbed wetland streams and beaver ponds in the Lamprey River watershed may be an important refuge for banded sunfish in southeastern New Hampshire.

Maximum Length: 78 mm  
Minimum Length: 37 mm  
Average Length: 59 mm

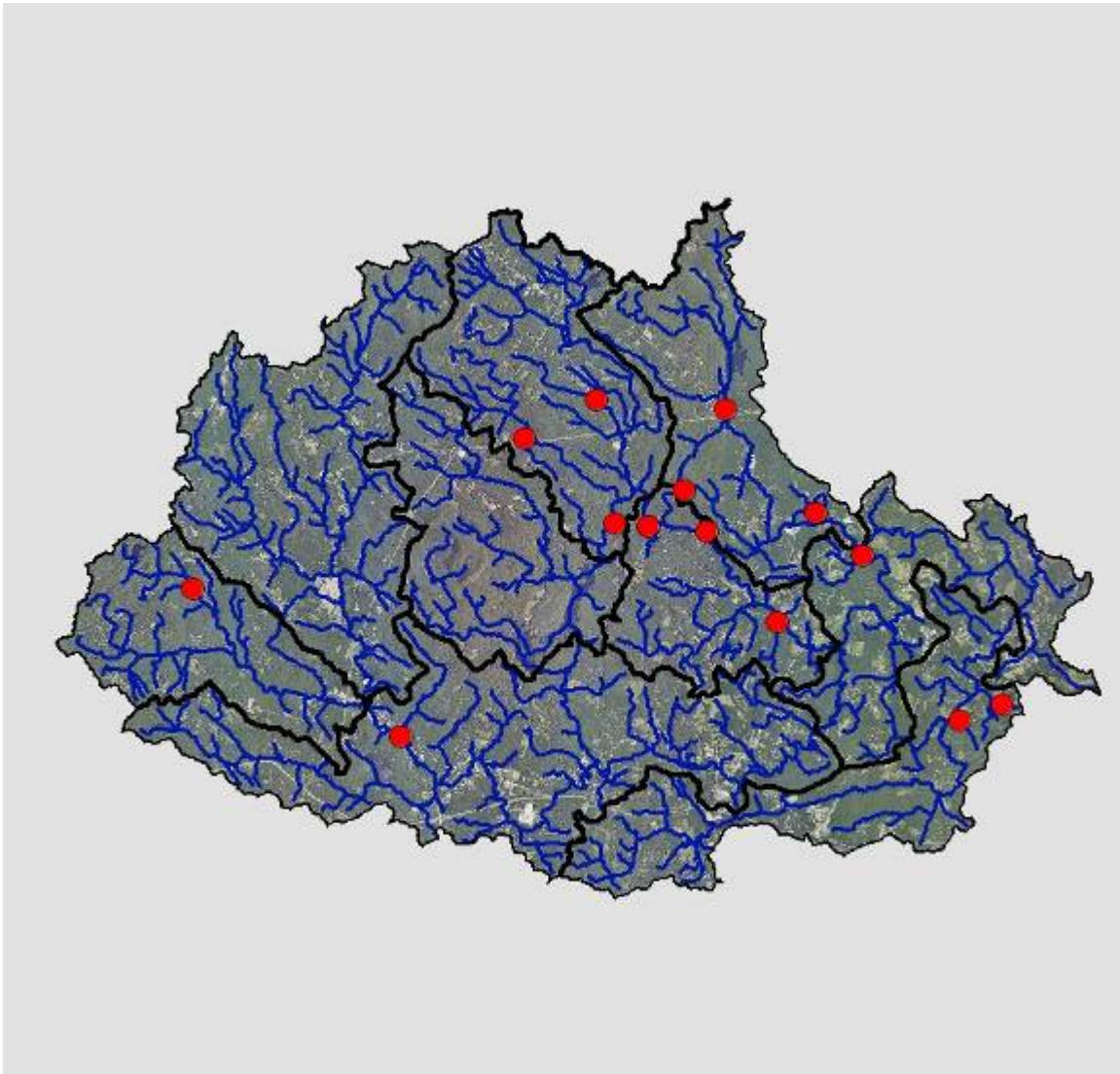


Figure B.2 – Locations of survey sites where banded sunfish were recorded in the Lamprey River watershed.

## **Black Crappie** *(Pomoxis nigromaculatus)*



Black crappie are a species of sunfish native to the Mississippi drainage. They have been introduced to a number of New Hampshire water bodies. They are popular with anglers as an excellent tasting panfish. Black crappie prefer lakes, ponds, and large slow rivers with aquatic vegetation.

Black crappie are not usually captured during electrofishing surveys, but there were three incidental records of black crappie from seine and dip net surveys targeting bridle shiners or other species of concern. These records are from a ponded section of the Lamprey River in Raymond, the North River in Nottingham, and upstream of the McCallum Dam in Newmarket. Black crappie in the North River likely originated from a known population in Pawtuckaway Lake, which drains into the North River from an outlet at the north end of the Lake. The population upstream from the dam in Newmarket is popular with anglers, especially during ice fishing season.

Maximum Length: 51 mm  
Minimum Length: 38 mm  
Average Length: 45 mm

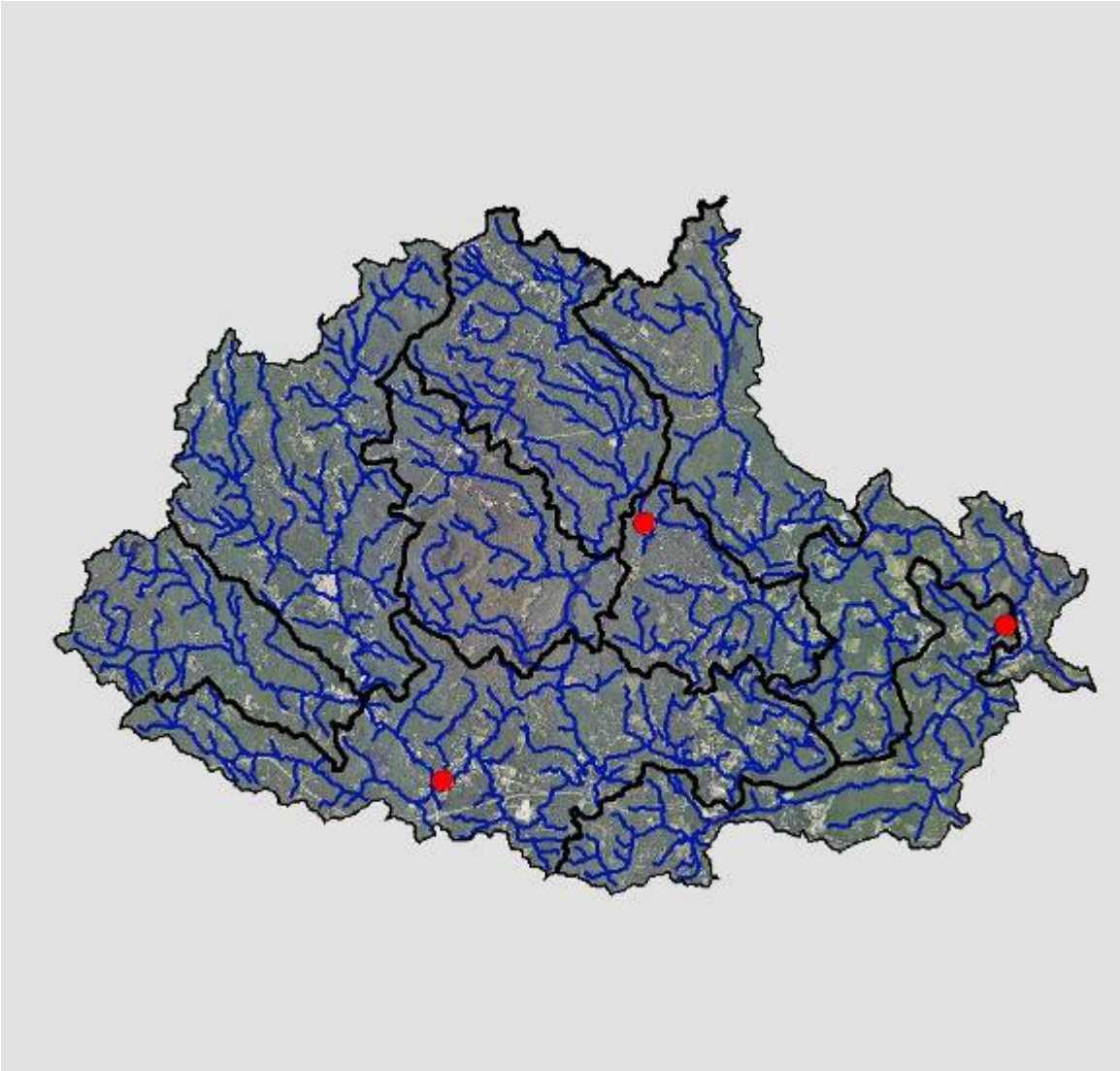


Figure B.3 – Locations of survey sites where black crappie were recorded in the Lamprey River watershed.

## **Blacknose Dace**

**(*Notropis heterolepis*)**



Blacknose dace are found in rocky streams with moderate to swift current. Less streamlined than their relative, the longnose dace, they take advantage of small pools and slower flowing water along the margins of streams with swift current. They feed on a variety of invertebrates and algae. They are more common in small headwater streams than in larger rivers. Often found associated with brook trout, their higher temperature tolerance gives them a wider distribution throughout New Hampshire. They are considered tolerant of pollution and habitat alteration. Blacknose dace may be found in both disturbed and undisturbed habitats.

Blacknose dace are surprisingly rare in the Lamprey River watershed, compared to watersheds to the north and west where they are among the most common species in rocky, headwater streams. Blacknose dace were found in four sites in the Lamprey River watershed, one site in the Little River subwatershed and 3 sites in the Lamprey River Headwaters subwatershed. Two of the sites only recorded one individual. The largest number of blacknose dace (26) was recorded in Hartford Brook. The second largest number (9) was recorded in the Little River.

Maximum Length - 93  
Minimum Length - 53  
Average Length – 90



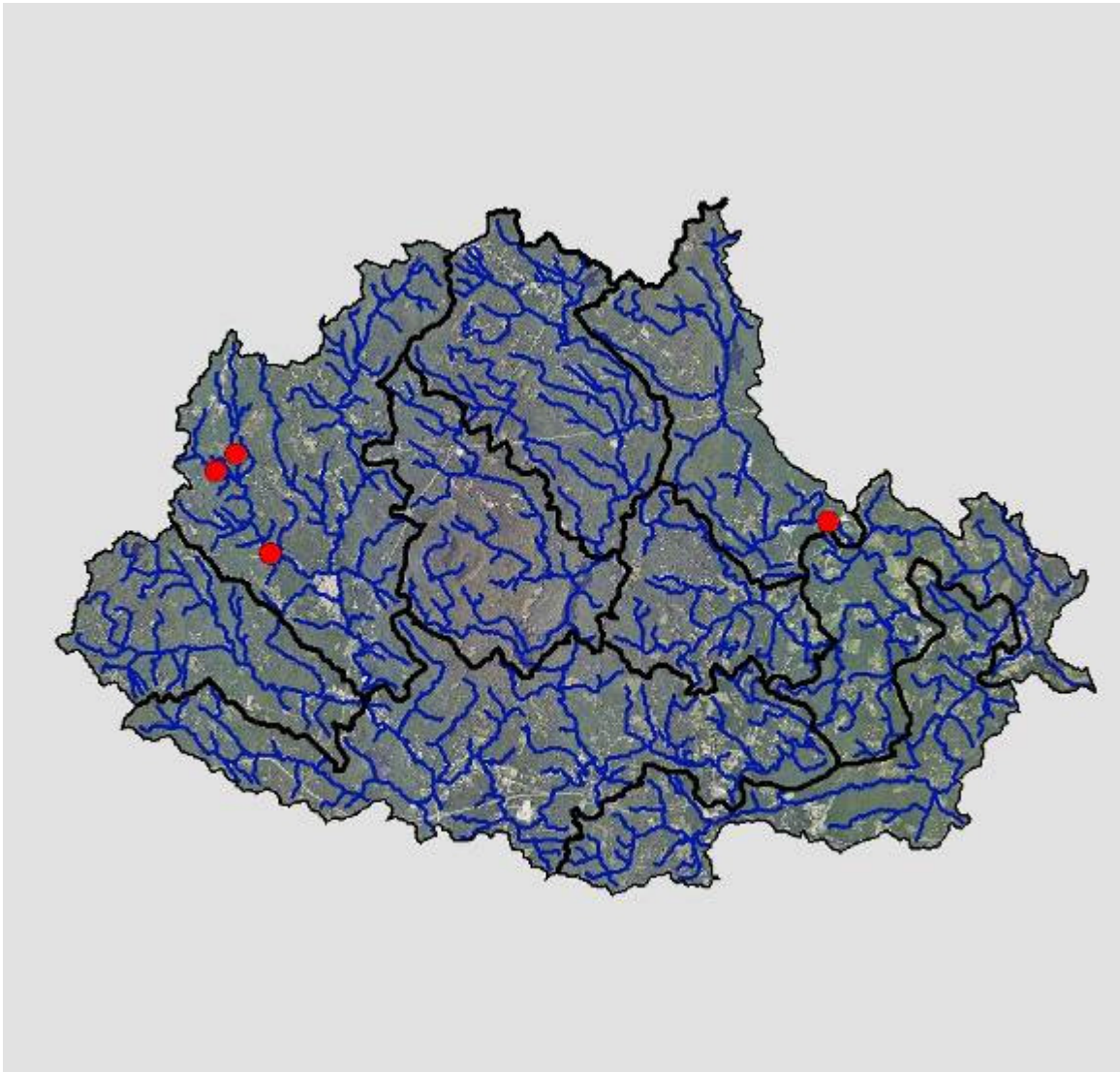


Figure B.4 – Locations of survey sites where blacknose dace were recorded in the Lamprey River watershed.

## Bluegill (*Lepomis macrochirus*)



The bluegill is a species of sunfish that has been introduced into most water bodies in New Hampshire and is now widespread. Bluegill inhabit ponds, lake shores, or slow flowing rivers with aquatic vegetation. They are often found with pumpkinseed sunfish. Bluegill thrive among thick aquatic vegetation where they feed on invertebrates and small fish. Like other sunfish, they lay eggs in shallow circular depressions, excavated by males, along the shoreline. Males aggressively defend their nests. Bluegill females may lay up to 27,000 eggs and they remain reproductively active as long as water temperatures are suitable, which in some years may extend into late fall. Bluegill have a high tolerance for warm water temperatures and are considered tolerant of pollution and habitat alteration (Grabarkiewicz and Davis 2008).

Bluegill sunfish were captured at 9 of 105 sites (9%), three of which were seine surveys. The bluegill captured in rivers or streams were found downstream of a lake, pond or a slow moving section of river. The total number of bluegill recorded was 34, which was 0.8% of the total fish count (4,226). The largest number of bluegill caught at one site was 16 in the upper North River.

Maximum Length: 176 mm  
Minimum Length: 39 mm  
Average Length: 92 mm

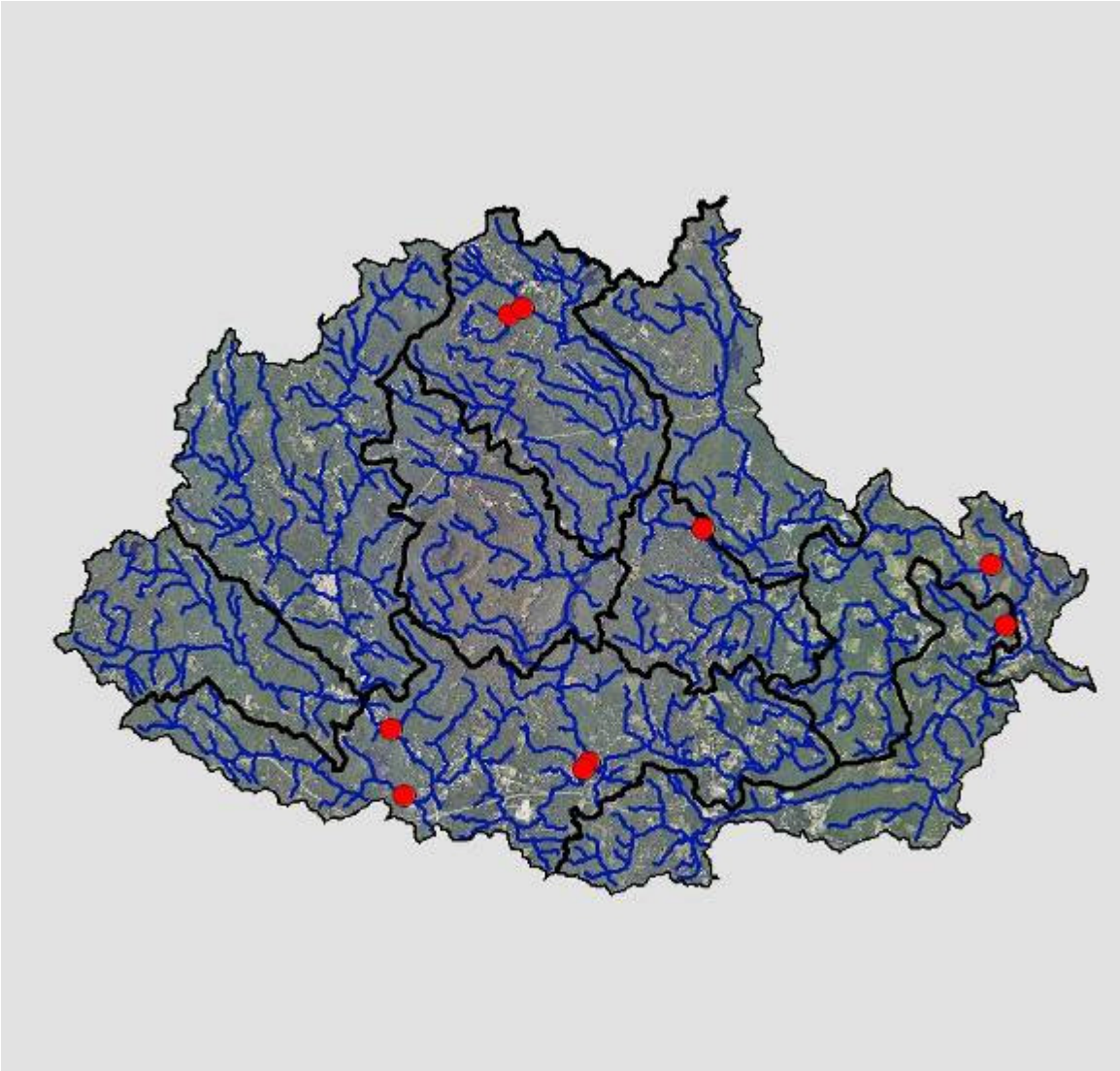


Figure B.5 – Locations of survey sites where bluegill were recorded in the Lamprey River watershed.

**Bridle Shiner**  
**(*Notropis bifrenatus*)**  
*Threatened*



The state threatened bridle shiner is a small, short lived species in the minnow family. Once common in suitable habitat from Ontario south to North Carolina along the east coast, bridle shiner populations have suffered significant declines over the last few decades. There is only one remaining population of bridle shiners in Pennsylvania, where the species was once considered abundant (Finger 2001). Bridle shiners depend on dense communities of submerged aquatic vegetation for survival (Harrington 1946). This habitat may be found along the shorelines and coves of lakes and ponds, the backwaters of larger rivers, and in slow flowing streams.

Bridle shiners use aquatic plants during every phase of their cycle. Spawning bridle shiners congregate in open spaces above dense stands of aquatic plants such as milfoil (*Myrophillum*). Aquatic vegetation with thick foliage, including milfoil, coontail (*ceratophyllum*), and stonewort (*chara*), that grows lower in the water column provides important nursery habitat for recently hatched juvenile bridle shiners. In the Lamprey River, bridle shiners were most often observed among stands of floating heart (*Nymphoides cordata*) and Pondweed (*Potamogeton*). The presence of healthy aquatic plant communities are critical to maintaining the populations of bridle shiners that inhabit the slow moving sections of the Lamprey River in the Middle Lamprey River subwatershed.



Despite an extensive survey effort, the New Hampshire Fish and Game Department (NHFGD) documented bridle shiners at only 6 of 21 sites where they were recorded as present in 1938 (Bailey 1938). The reasons for the apparent extirpations from certain water bodies are not always clear and multiple causes are probable. In some waterbodies, submerged aquatic vegetation has been reduced to just a small fraction of the overall shoreline habitat. The loss of aquatic vegetation is a problem common to lakes and ponds with increasing levels of shoreline development (Radomski and Goeman 2001). Even marginal reductions in aquatic vegetation may make bridle shiners more vulnerable to predators, both native and introduced, possibly reducing the population below the numbers required for replacement. Bridle shiners are known to coexist with bass and other introduced predators, like black crappie, in water bodies with intact shoreline habitat (NHFGD unpublished data). Removal of aquatic vegetation, whether on a small scale to create a beach or dock, or on a large scale, such as herbicide treatments to control invasive aquatic plants or to maintain recreational boating opportunities, will reduce the amount of habitat available to bridle shiners.

In some cases, bridle shiners have adapted to the impounded conditions upstream of a small dam, culvert, or bridge. Drainage of this upstream habitat may extirpate the local population of bridle shiners. Dam removal, culvert, or bridge replacement should proceed with caution in bridle shiner habitat. Sediment deposition upstream of the dam may have filled in the original wetland, pond, or slow flowing stream habitat that the bridle shiners inhabited before the construction of the dam or road. Rapid draining of the impoundment may result in a narrow channel with riffle habitat that is unsuitable for bridle shiners. Draw down of the impoundment should occur slowly to give aquatic plants time to adjust to the new water level.

The Bunker Pond Dam, on the Lamprey River in Epping, was removed in 2011. The bridle shiner population upstream of the dam is now restricted to a small pool upstream of the Route 27 bridge, and a short stretch of river just above the old impoundment. Fortunately, a slow draw down in the spring of 2011 allowed bridle shiners to adjust to the new water level. NHFGD biologists will monitor this population to assess its ability to adapt to the new habitat conditions as the river continues to adjust to the dam removal.

As visual foragers, bridle shiners are sensitive to water clarity and are therefore susceptible to the effects of eutrophication and siltation (Harrington 1946). Declines in water quality have been associated with urbanization, which has been shown to alter fish communities (Weaver and Garman 1994). Eutrophication has the combined effect of reducing visibility, altering aquatic plant communities, and reducing oxygen levels. Bridle shiners are known to exist in dark or tea colored water, yet they are unlikely to persist in areas with chronic turbidity issues resulting from landuse activities in the watershed or persistent boat wakes. Naturally vegetated buffers, with a width of at least 15 m, should be maintained along the shorelines of water bodies known to support bridle shiner habitats (Desbonnet et al. 1994). It is critical to prevent nutrient and sediment loading into bridle shiner habitat from fertilizers, failed septic systems, and stormwater runoff throughout the contributing watershed (Jennings et al. 2003). An increased focus on water quality monitoring on the Lamprey River in the town of Raymond, where bridle shiners occupy only a fraction of the available habitat, may help identify changes in water quality that may be affecting aquatic habitat in that reach.

Maximum Length: 52 mm  
Minimum Length: 38 mm  
Average Length: 48 mm

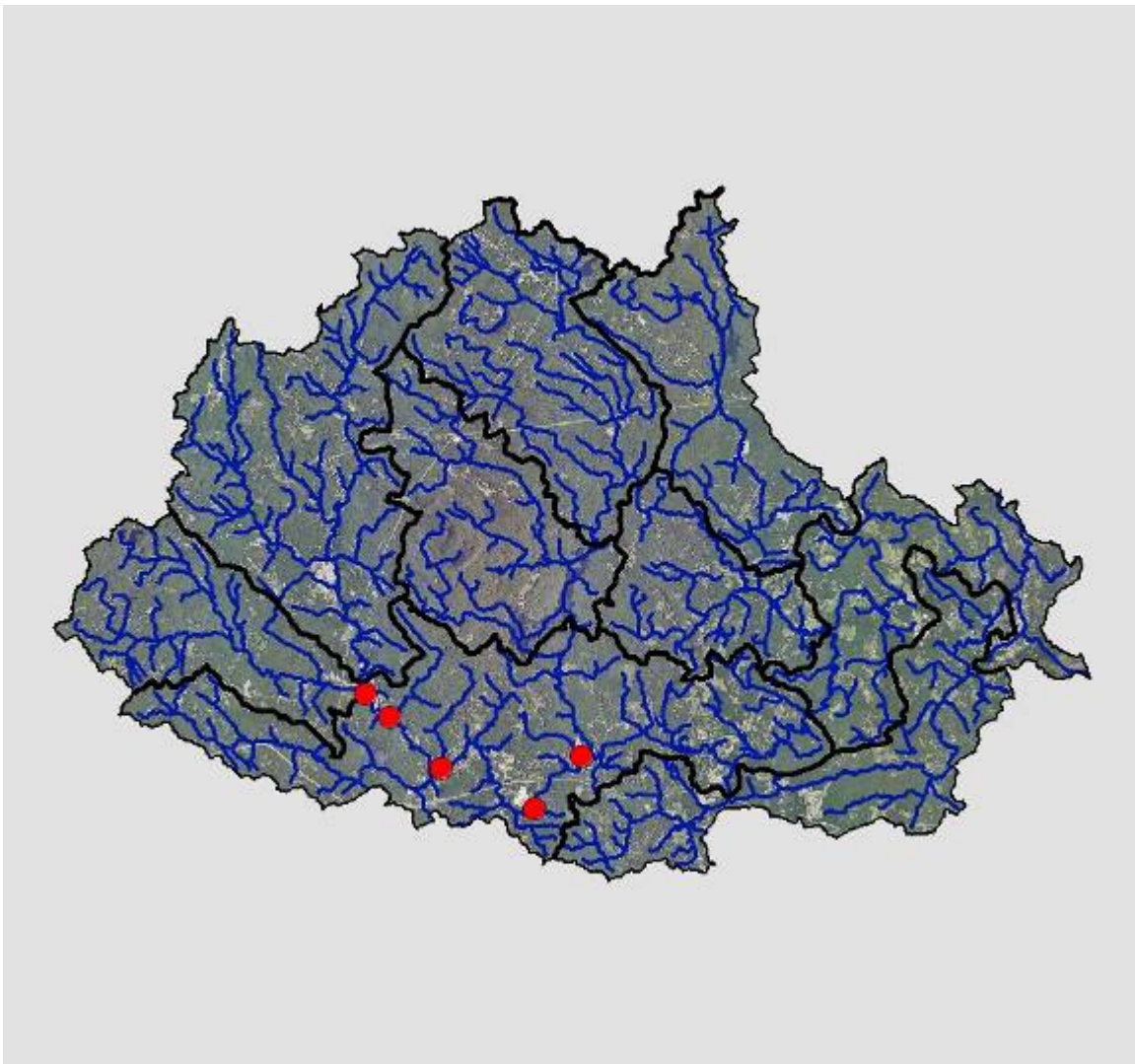


Figure B.6 – Locations of survey sites where bridge shiners were recorded in the Lamprey River watershed.

## Brook trout (*Salvelinus fontinalis*)



Brook trout are members of the salmon family, although they are more closely related to Arctic char and lake trout than they are to salmon. Adapted to coldwater streams, brook trout are rarely found in waters that exceed an average monthly temperature of 20°C (68°F) in July or August. Brook trout are powerful swimmers and are often found in steep, cascading mountain streams where no other fish are present. Though some individuals may live their entire lives in one small stream, radiotagged brook trout have been documented to move many miles in search of thermal refuge, spawning habitat, or quality foraging areas. Brook trout are “sit and wait” predators, usually taking up residence in a pool where they feed on both aquatic and terrestrial invertebrates. Spiders, beetles, and other terrestrial invertebrates that fall into streams are an important part of brook trout diets, especially in the spring. Brook trout seek out gravel beds with upwelling groundwater, often in small headwater streams, for spawning. Eggs are laid in small excavated nests in gravel, called redds, where they incubate through the winter and hatch in the early spring. Brook trout are more common in northern New Hampshire where cooler summer air temperatures maintain suitable summer water temperatures. As one moves south, brook trout become increasingly dependent on groundwater streams as a steady source of cool water in the summer.

Brook trout are sensitive to habitat disturbance. An intact riparian zone provides both shade and prey in the form of terrestrial invertebrates. Removal of streamside vegetation may cause a stream to become too warm to support brook trout. Impervious surfaces and

undersized culvers increase peak flows and cause erosion and sediment deposition, which may fill pool habitat and bury spawning gravel. Fragmentation is an important limiting factor when it comes to maintaining healthy brook trout populations because impassable stream crossings prevent brook trout from accessing critical habitat, like a cold stream in the summer or spawning habitat in the fall. Promoting groundwater recharge by limiting impervious surfaces and using LID Stormwater practices is critical for protecting brook trout populations in the remaining spring fed streams of southern New Hampshire.

Wild brook trout are rare in the Lamprey River watershed. They are restricted to small, spring fed streams in the North Branch River, Lamprey River Headwaters, North River, Middle Lamprey, and Lower Lamprey River subwatersheds. Brook trout were documented at 11 of 105 sites, although some of those sites contained hatchery raised trout. Of the sites where wild trout were captured, only 6 streams contained both juvenile trout and suitable habitat to support naturally reproducing brook trout populations. Of these 6 streams, two showed evidence of habitat degradation and fragmentation from driveway or road crossings.

Table B.1 – Number of brook trout caught in streams with evidence of natural reproduction.

<b>Stream Name</b>	<b>Town</b>	<b># of trout</b>
Wednesday Hill Brook	Lee	70
Aunt Mary Brook	Candia	30
Rum Brook	Epping	28
Unnamed stream (Little River subwatershed)	Lee	21
Unnamed stream (North River subwatershed)	Lee	8
Unnamed stream (Lamprey River Headwaters subwatershed)	Raymond	7

Max length: 268 mm (10.5”) (stocked)

Min Length: 35 mm (1.5”)

Average Length: 98 mm (7”)



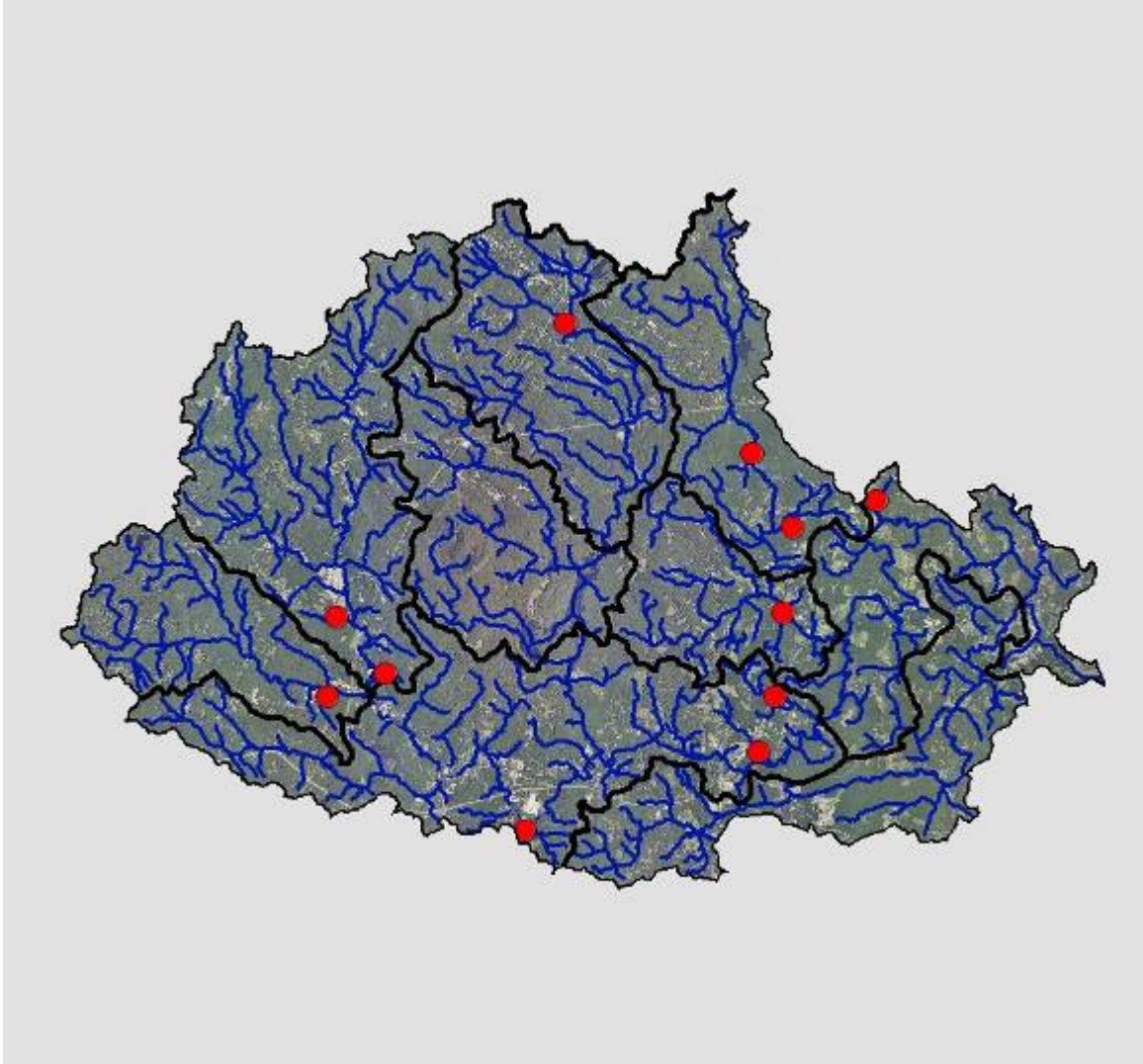


Figure B.7 – Locations of survey sites where brook trout were recorded in the Lamprey River watershed.

## **Brown Bullhead** *(Ameiurus nebulosus)*



The brown bullhead is a member of the catfish family that is native to New Hampshire. It prefers lakes, ponds, and slow moving sections of rivers and streams. However, brown bullhead are widespread throughout New Hampshire and may be found in almost any habitat, including faster flowing streams with rocky substrate. Brown bullhead are extremely resilient and can tolerate dissolved oxygen levels of less than 1 part per million. For this reason, they are not a good indicator of water quality. Brown bullhead survives in low oxygen conditions by gulping air into its air bladder and breathing through its skin. It may lie dormant for days in the mud of a dried up pond or stream.

Brown bullhead were often captured in sections of stream just below or above beaver ponds or wetlands. Their numbers are likely under represented in the survey because of their preference for deeper water with a muddy bottom, which is a habitat that is difficult to sample by backpack electrofishing. Brown bullhead were captured at 22 of 105 sites (21%) with a total of 66 individuals counted, which is 1.6% of the total fish count (4,226).

Maximum Length: 194 mm  
Minimum Length: 73 mm  
Average Length: 126 mm

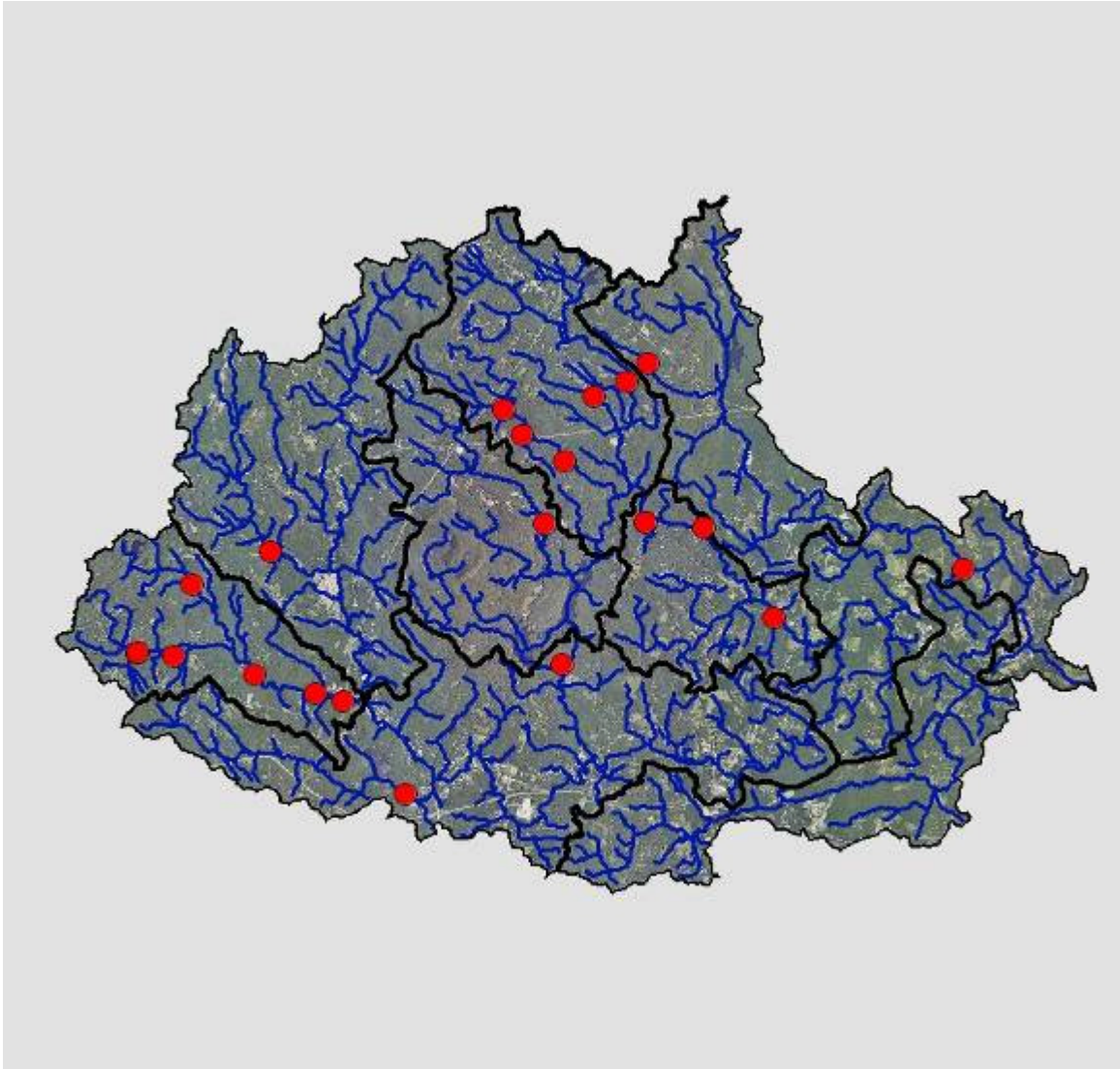


Figure B.8 – Locations of survey sites where brown bullhead were recorded in the Lamprey River watershed.

## Chain pickerel (*Esox niger*)



Chain pickerel are found throughout New Hampshire, usually associated with aquatic vegetation, which they use as cover for ambushing prey. They are voracious predators of other fish species, as well as snakes, frogs, ducklings, and even muskrats. Chain pickerel spawn in wetlands and marshy backwaters just after ice melt. Early spawning is an adaptation which allows their young to grow large enough to feed on the young of other fish species, which hatch later in the spring. Chain pickerel are a relatively short lived but fast growing species, reaching lengths of up to 600 mm (2 feet) in their third year. Although they are usually associated with slow flowing backwaters and ponds, they are strong swimmers and may sometimes be found in faster flowing habitat. Chain pickerel, or the pike family in general, are considered moderately tolerant of pollution and habitat disturbance. As visual predators, they may be impacted by excessive turbidity or the loss of aquatic vegetation.

Chain pickerel were found at 31 of 105 sites (30% of the total) in all 9 subwatersheds of the Lamprey River Watershed. Although it was the fourth most commonly encountered species, it was not one of the most numerous. A total of 59 chain pickerel were counted at all sites combined, which was 1.4% of the total number of fish counted. The largest number counted at one site was 10 in a small unnamed brook in the Pawtuckaway Pond subwatershed. As a predator at the top of the food chain, it is not surprising that they are less abundant than their prey. Their widespread distribution is a reflection of the abundant wetland stream habitat in the Lamprey River watershed. The largest chain



pickerel (285 mm) was captured below an impounded section of the stream that drains Onway Lake, at the site of an old mill structure.

Maximum length: 285 mm

Minimum length: 54 mm

Average Length: 92 mm

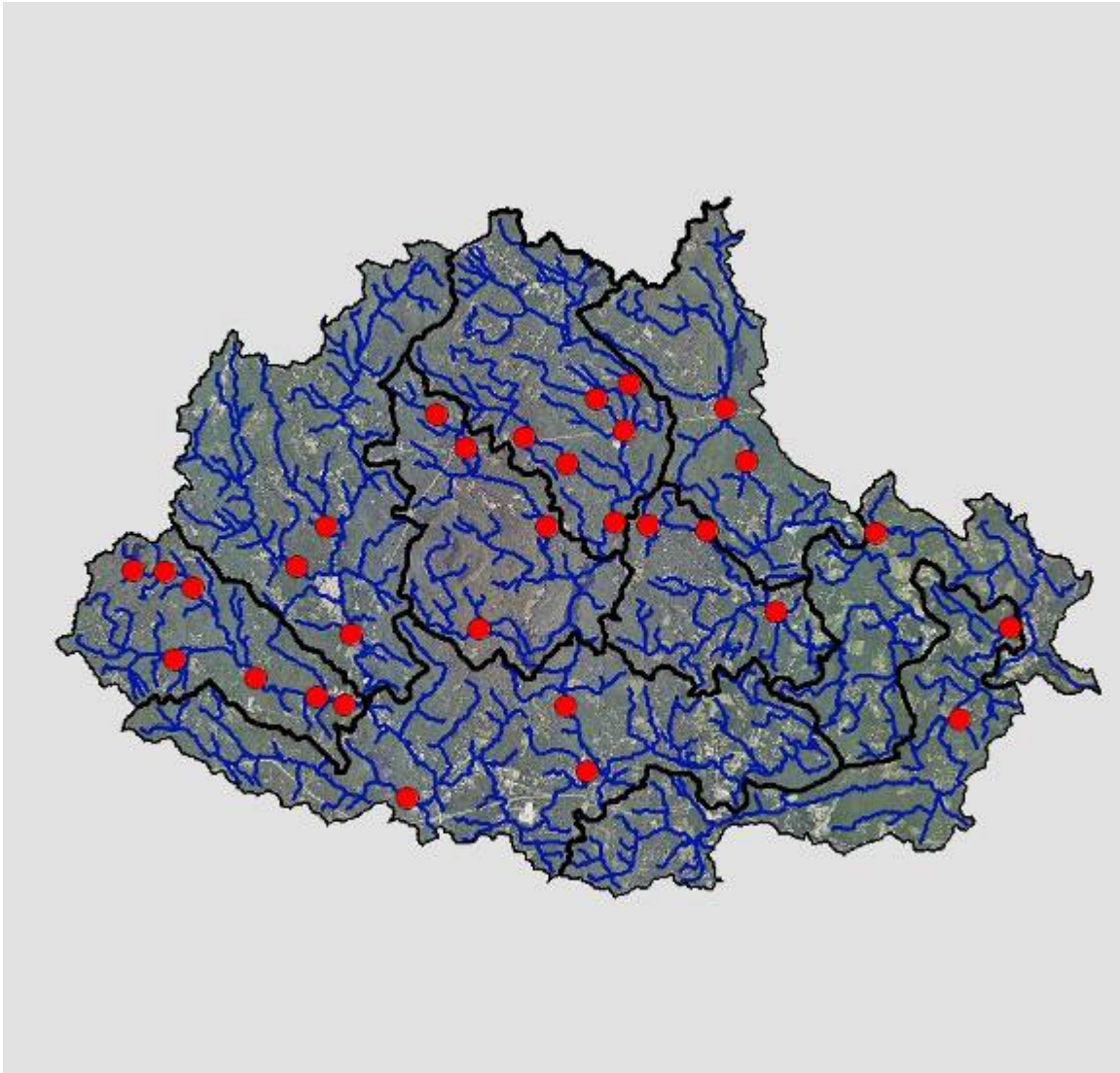


Figure B.9 – Locations of survey sites where chain pickerel were recorded in the Lamprey River watershed.

## Common Shiner (*Luxilus cornutus*)



Common shiners are found in small streams to medium sized rivers with unvegetated, gravel to rubble bottoms. They are a short lived species, rarely exceeding 200 mm in length. They tend to concentrate in pool habitat. Common shiners lay adhesive eggs in nests which they excavate in sand or gravel. They have also been known to lay eggs in the nests of other fish species. At first glance, common shiner habitat appears suitable for brook trout, but a higher temperature tolerance and a more omnivorous diet allows common shiners to thrive in warmer streams. During periods of high turbidity, common shiners have been found to shift from feeding on small invertebrates to a diet of plant matter. Its tolerance of warm temperatures and its adaptable foraging strategy make the common shiner relatively tolerant of habitat disturbance.

The common shiner was the 5<sup>th</sup> most common species found in the Lamprey River watershed. It was recorded at 30 of 105 sites in every subwatershed except for Pawtuckaway Pond. Common shiners were the second most numerous species captured at a total of 791 (19%) of the 4,226 fish counted in this survey. Fallfish, which are often associated with common shiners, were the most numerous species found in the survey. Fallfish and common shiners are difficult to tell apart at small sizes, so total counts of these species should be viewed with caution. The high abundance is somewhat skewed by the large number (282) of individuals captured in the rocky, riffle/pool habitat below the Bunker Pond Dam, before it was removed in 2011. The second largest number of common shiners captured was 94 in the North River.

Maximum Length: 190  
Minimum Length: 27  
Average Length: 92 mm

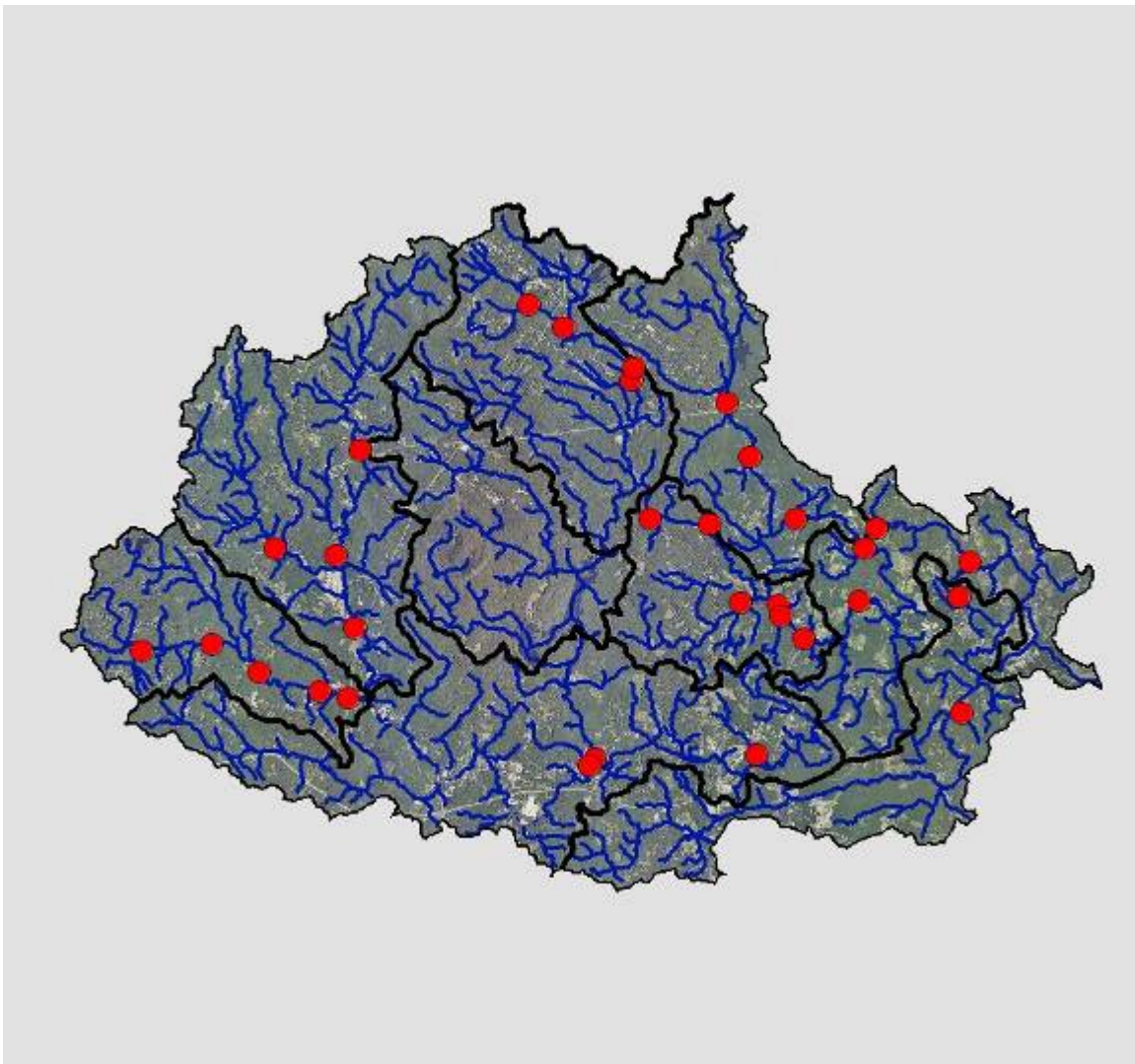


Figure B.10 – Locations of survey sites where common shiners were recorded in the Lamprey River watershed.

**Common white sucker**  
**(*Catostomus commersoni*)**



Common white suckers are one of New Hampshire's most common fish species. Extremely adaptable, they can be found in almost any habitat type. Larger individuals prefer lakes, ponds, or deeper sections of rivers and streams. White suckers migrate into swift flowing streams with gravel bottoms to spawn. Juvenile suckers are found in streams of all sizes where they forage along the bottom for invertebrates and algae. As a relatively long lived and abundant species, white suckers have the potential to be indicators of aquatic ecosystem health, but their value as indicators is offset by their tolerance of low oxygen levels and habitat disturbance. White suckers are an important forage species for many predators. Adult white suckers are generally between 255 and 460 mm (10 to 18 inches), but some individuals can grow as large as 600 mm (about 2 feet) in length.

White sucker was the second most common fish encountered in this survey. It was captured in 39 of 105 sites (37%) and all 9 HUC12 subwatersheds in a wide variety of habitats. A total of 506 individuals were counted at the 39 sites, which is 12% of the total number of fish captured. The average length was 92 mm, which suggests that the majority of white suckers captured in this survey were juveniles. Adult white suckers tend to inhabit deeper water which is difficult to electrofish. The largest white sucker captured was 350 mm and the smallest was 24 mm. The majority of the large suckers sampled were found in relatively wide sections of the mainstem Lamprey and North Rivers with deeper pools.



Maximum Length: 350 mm  
Minimum Length: 24 mm  
Average Length: 91 mm

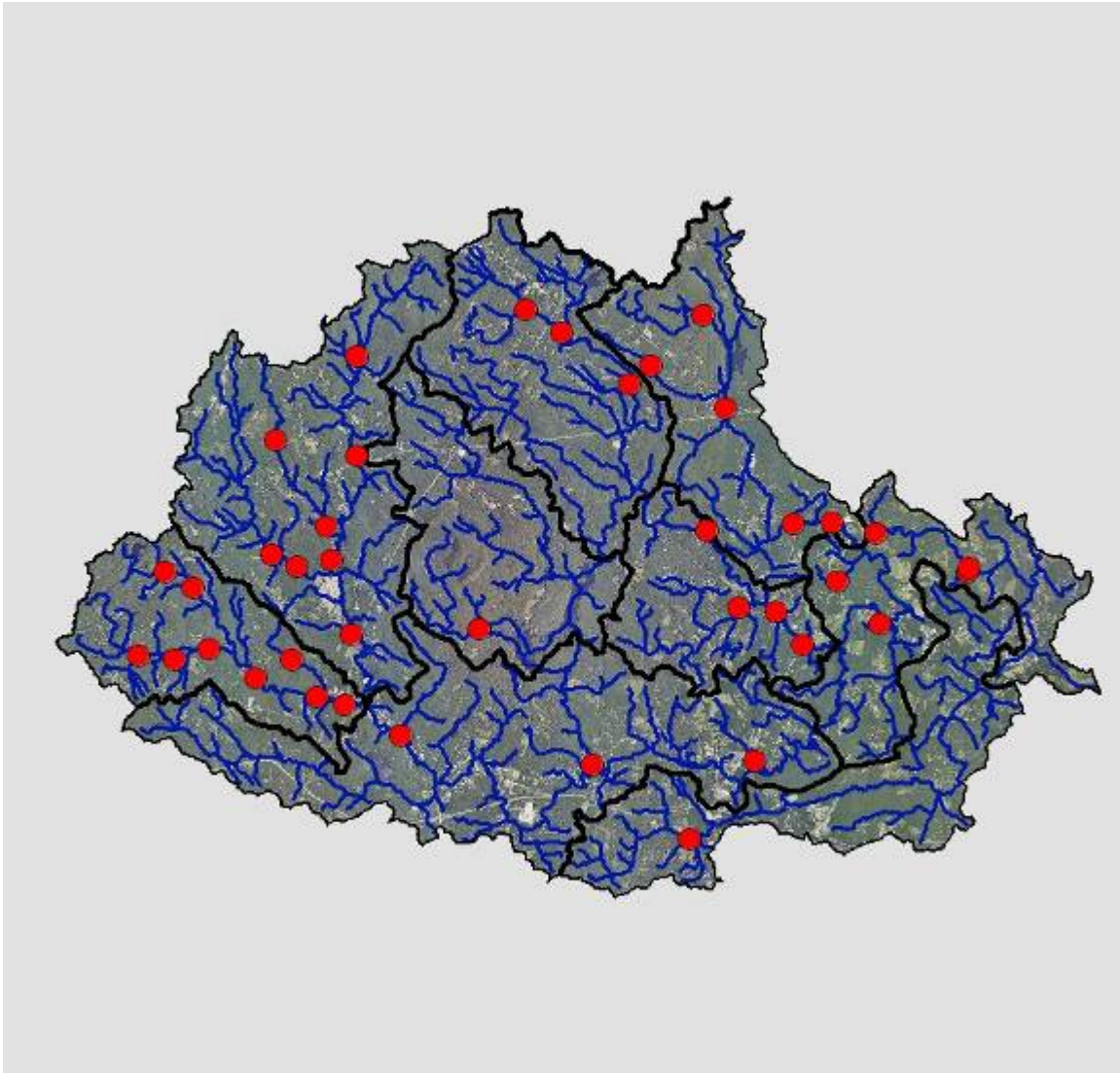


Figure B.11 – Locations of survey sites where common white suckers were recorded in the Lamprey River watershed.

## Creek Chubsucker (*Erimyzon oblongus*)



Creek chubsuckers are found in slow flowing rivers and streams with muddy bottom and aquatic vegetation. Like the white sucker, the creek chubsucker spawns over gravel bottom in swift current. Creek chubsuckers feed on a variety of invertebrates found on the bottom and among aquatic plants. Juvenile Creek chubsuckers were frequently observed feeding in small schools during surveys for bridle shiners on the Lamprey River in Raymond. Creek chubsuckers are considered moderately pollution tolerant, but intolerant of habitat disturbance (Grabarkiewicz and Davis 2008). As more visual foragers than common white suckers, they may be more sensitive to turbidity.

Creek chubsuckers were widespread throughout the Lamprey River watershed in suitable low gradient, wetland stream or river habitat. They were often found associated with other fish species, such as common sunfish (pumpkinseed), juvenile largemouth bass, and golden shiners, which depend on aquatic vegetation for food and shelter. As juveniles, creek chubsuckers have a black lateral band and may be confused with bridle shiners. The top two fish in the picture above are creek chubsuckers, while the bottom fish is a bridle shiner. Note that the black lateral band extends through the eye in the bridle shiner, but not in the juvenile creek chubsucker.

Creek chubsuckers were found in 23 of 105 (22%) sites in all 9 subwatersheds. A total of 88 (2.1%) creek chubsuckers were counted out of a total fish count of 4,226 at all survey

sites combined. The largest number captured at one site was 20 in the lower North Branch River.

Maximum Length: 163 mm

Minimum Length: 33 mm

Average Length: 89 mm.

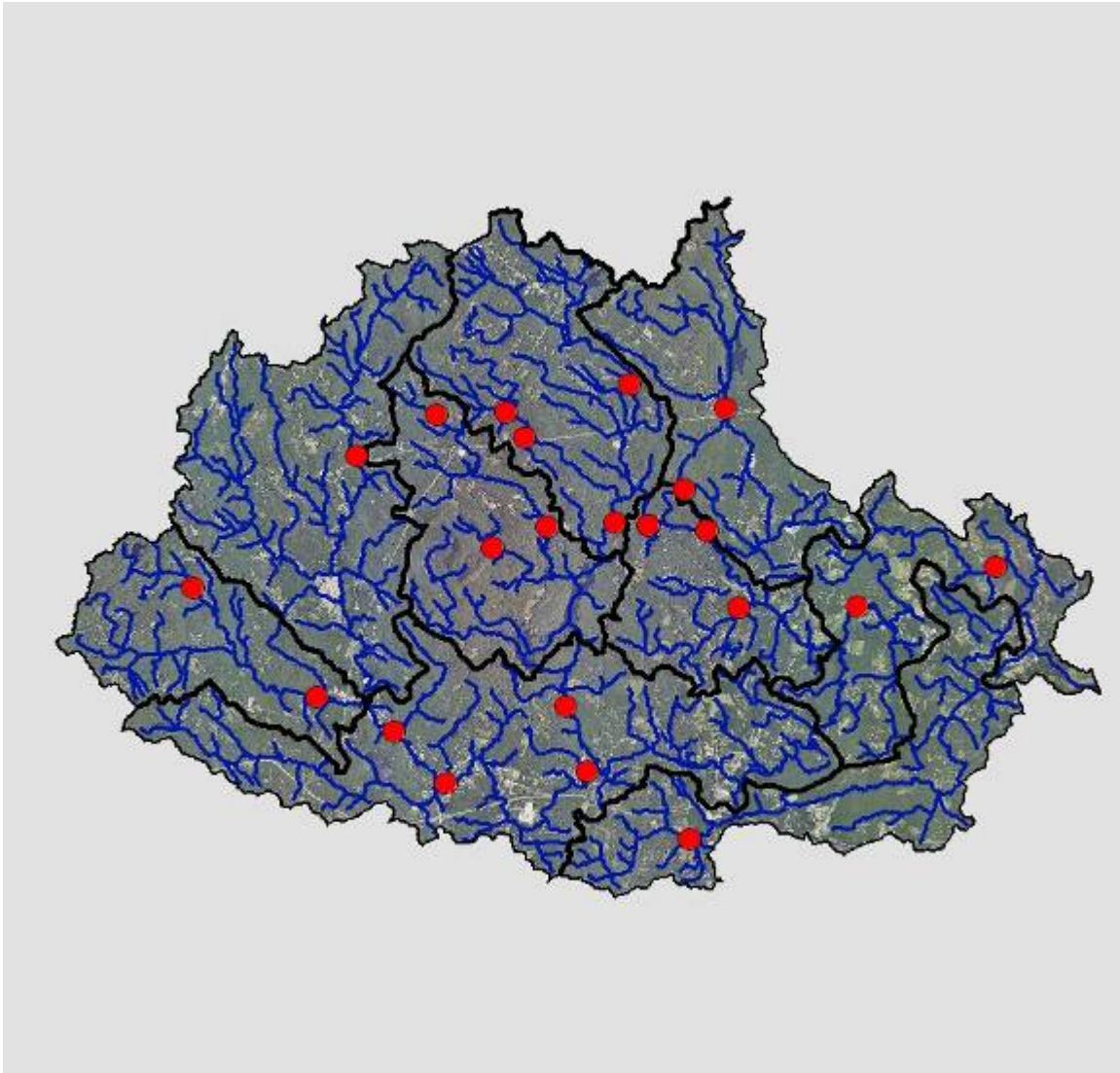


Figure B.12 – Locations of survey sites where creek chubsuckers were recorded in the Lamprey River watershed.

**Fallfish**  
**(*Semotilus corporalis*)**



The fallfish is New Hampshire's largest minnow species and one of the most common fish species in the state. It can grow to 255 mm (10") in length and live over 10 years. It can be found in nearly any river or stream, but it is most abundant in medium sized rivers with a mix of rocky and gravel substrate. Fallfish males build nest mounds out of pebbles, one stone at a time. Spawning is communal, although usually initiated by the nest builder, with a number of females and surrounding males using a single nest. Larger individuals may move into smaller streams to spawn. Fallfish are generally considered indicators of river and stream habitat with year round flow.

Fallfish were the most commonly encountered species in this survey (43 of 105 sites or 43%). They were also the most abundant, with 1,238 fallfish counted (30.2% of the total number of fish). Juvenile fallfish are easily confused with common shiners, so the exact number may not be accurate, but there is no question that fallfish are among the most abundant fish species in the Lamprey River watershed. They were not found in two of the 9 subwatersheds (Piscassic River and Pawtuckaway Pond), but fewer sites were surveyed in these watersheds. Their abundance and distribution makes them an important source of forage for both aquatic and terrestrial species. The largest number of fallfish sampled at one site was 333 in the Lower Lamprey River downstream of Lee Hook Road.

Maximum length: 228 mm



Minimum Length: 20 mm  
Average Length: 92 mm

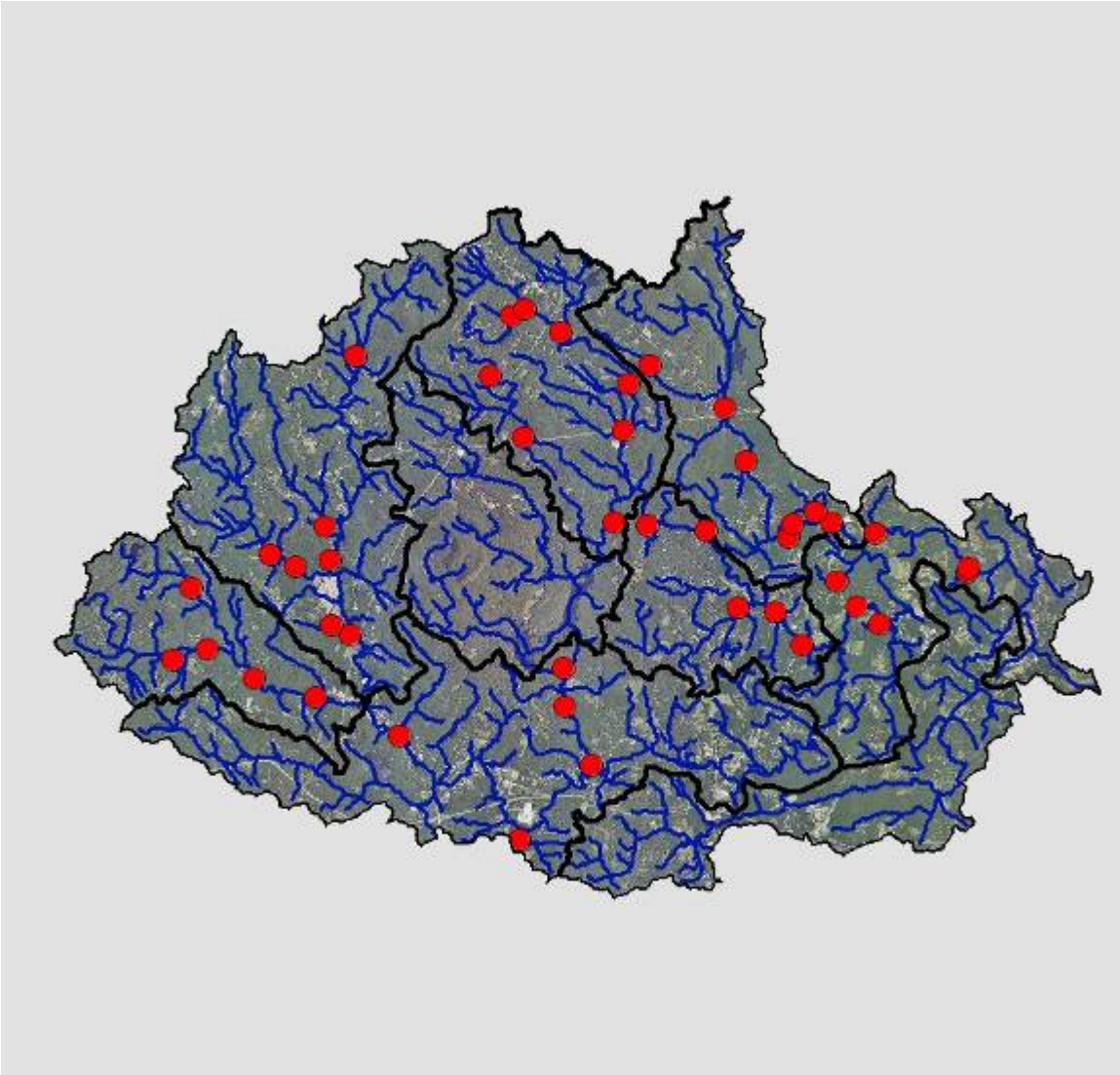


Figure B.13 – Locations of survey sites where fallfish were recorded in the Lamprey River watershed.

## Golden Shiner (*Notemigonus crysoleucas*)



Golden shiners are a common minnow species found throughout New Hampshire. They are usually associated with aquatic vegetation in lakes, ponds, or slow moving sections of rivers and streams. Golden shiners lay adhesive eggs that stick to stands of aquatic vegetation. Extremely prolific, the female golden shiner can lay 200,000 eggs multiple times during the growing season. Golden shiners are capable of both filter feeding and catching small invertebrates or fish. Plant material makes up a large portion of their diet. It is widely used as bait by anglers.

Golden shiners were the third most commonly encountered species, behind fallfish and white sucker. Not typically associated with the wadeable streams that are suitable for electrofishing, golden shiners in this survey were usually encountered in the outlet streams of active or abandoned beaver impoundments, wetlands, or ponds with abundant aquatic vegetation. Their widespread distribution reflects the abundant warm water vegetated stream habitat throughout the Lamprey River watershed. Golden shiners are usually extremely abundant in suitable habitat. The relatively low numbers in this survey (total count of 126 or 3% of the total number of fish recorded) are because most of the individuals captured were likely washed down from suitable habitat upstream.

The largest number of golden shiners captured at one site was 40 captured in a ponded section of the upper North Branch River. The largest individual was captured below Onway Lake.

Maximum Length: 156 mm

Minimum length: 30 mm

Average Length: 91 mm

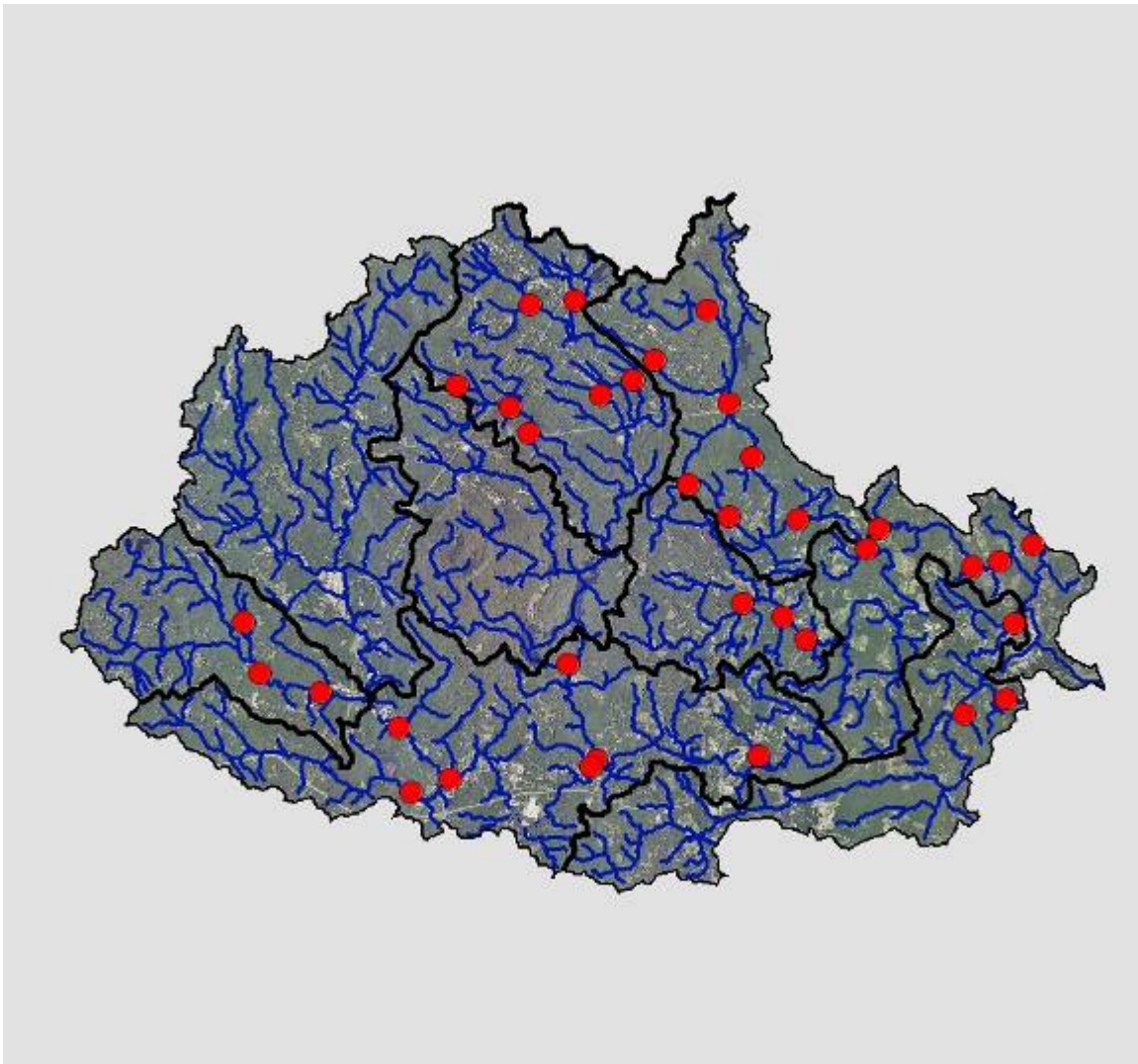


Figure B.14 – Locations of survey sites where golden shiners were recorded in the Lamprey River watershed.



## **Largemouth Bass** **(*Micropterus salmoides*)**



Largemouth bass are native to the Mississippi drainage and the coastal watersheds of the southeastern United States. It has been widely introduced into the water bodies of New Hampshire and is now common. Largemouth bass prefer weedy backwaters, ponds, and lake shores with aquatic vegetation and a muddy bottom. They are often associated with golden shiners, brown bullheads, chain pickerel, and bluegill. Like the other members of the sunfish family, largemouth bass males defend a nest in shallow water during the spring. Largemouth bass have a higher tolerance for warm temperatures than smallmouth bass. They may be found in shallow water well into the summer after smallmouth bass have moved into deeper water away from shore. The record largemouth bass taken by angling in New Hampshire was 10.5 pounds.

Largemouth bass were found throughout the Lamprey River watershed in all 9 subwatersheds. At 29 of 105 sites (28%), it was among the most commonly encountered species in the survey. Similar to golden shiners, largemouth bass encountered in this survey were usually downstream of a pond or wetland with more suitable habitat. The total number of largemouth bass captured was 92, which was just 2.2% of the total number of fish captured in this survey (4,226). This number would have been significantly greater if the survey had included lake and pond habitat in the Lamprey River watershed. The greatest number of individuals captured at one site was 20 in the Piscassic River. Only one of the bass captured was over 121 mm (4.75 in), which suggests that the bass encountered in this survey were juveniles often trapped in the



shallow pools of streams connecting larger ponds or wetland systems. The only adult bass measured was caught below the Wiswall Dam with a length of 251 mm (10”).

Maximum Length: 251 mm

Minimum Length: 30 mm

Average Length: 91 mm

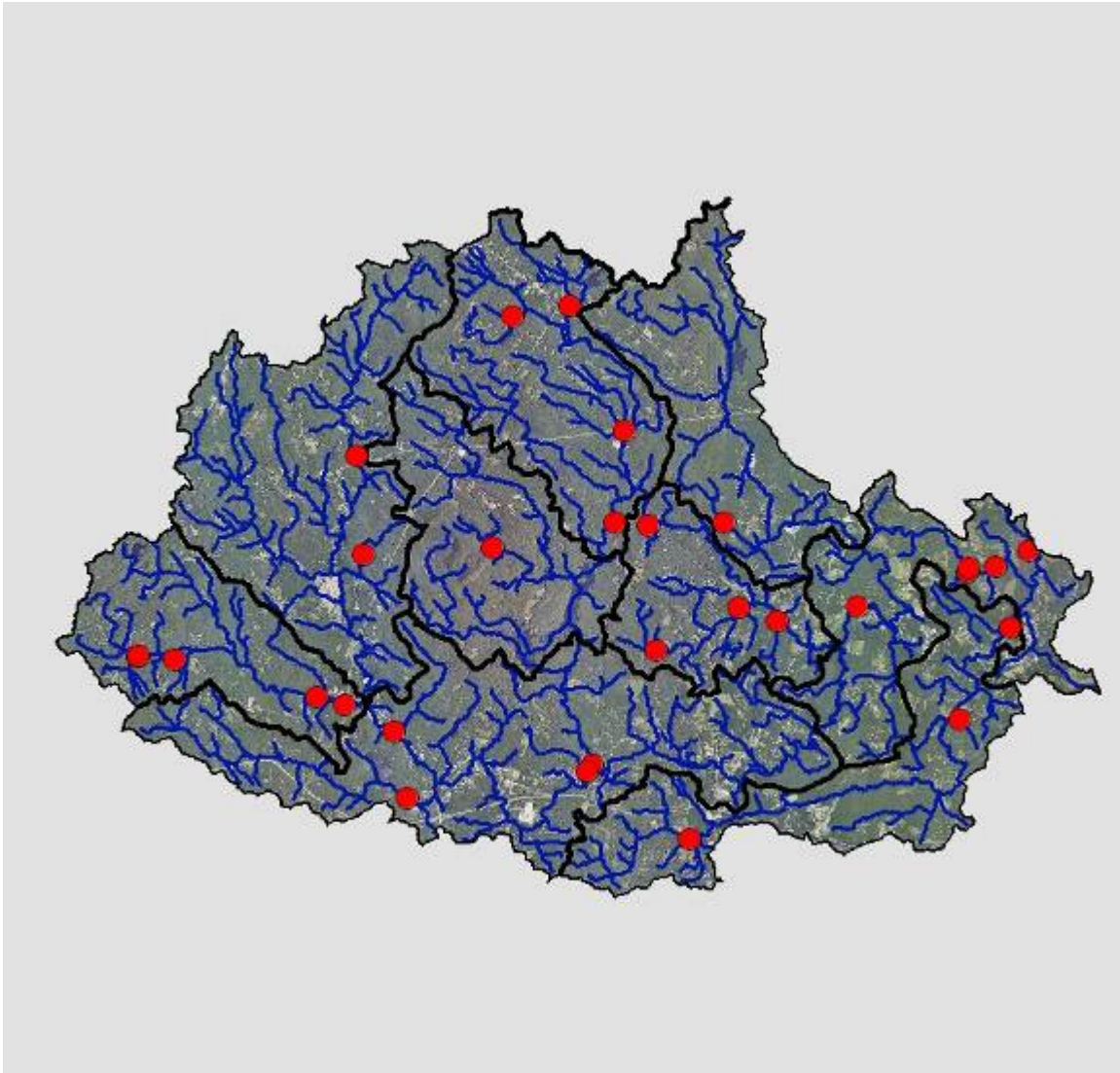


Figure B.15 – Locations of survey sites where largemouth bass were recorded in the Lamprey River watershed.

## Longnose Dace (*Rhinichthys cataractae*)



Longnose dace inhabit swift flowing riffle sections of rivers and streams with boulder, cobble, and gravel substrate. Their streamlined shape and small air bladders make them well adapted to living along the bottom in flowing water. They feed on invertebrates in the crevasses between rocks and boulders. During spawning in late May and early June, males defend territories where females lay adhesive eggs in protected cavities between rocks. Longnose dace generally prefer flows greater than 45 cm/sec and temperatures that below 23<sup>0</sup>C.

Longnose dace were found at 16 of 105 sites (15%). Although it was not one of the most common species encountered, it was relatively widespread, occurring in 7 of 9 subwatersheds. Longnose dace were not captured in watersheds with an area less than 10 km<sup>2</sup>, except for Dudley Brook, in Raymond, which was sampled at its confluence with the Lamprey River. Due to their specific flow requirements and preference for cool water relative to many of the other resident fish species in the Lamprey River drainage, longnose dace could be used as an indicator species.

If landuse changes, such as an increase in impervious surfaces, or an increase in water withdrawals begins to reduce summer flows, one would expect a reduction in the distribution of longnose dace, especially populations in the upper watershed. Longnose dace are also vulnerable to sedimentation that fills the interstitial spaces between cobble and boulders. This survey provides a baseline upon which to compare the status of

longnose dace in future surveys. Particular focus should be given to watersheds that undergo rapid development.

A total of 287 longnose dace were counted (6.8%), 117 of which were caught at one lower river site downstream from Lee Hook Road. Excluding this site, the average number of longnose dace captured per site was 11.

Maximum Length: 145 mm

Minimum Length: 36 mm

Average Length: 95 mm

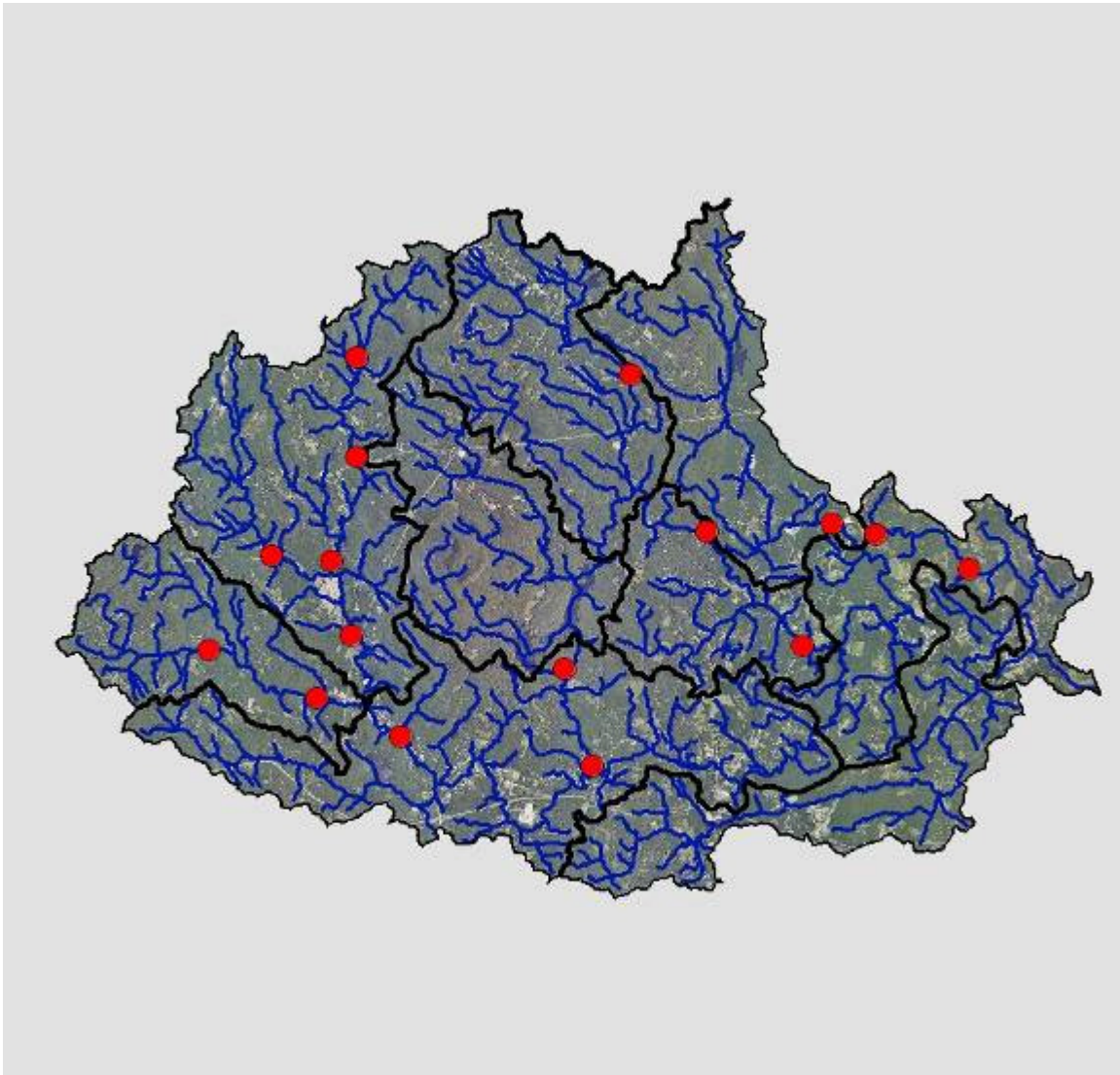


Figure B.16 – Locations of survey sites where longnose dace were recorded in the Lamprey River watershed.

## **Margined Madtom** *(Noturus insignis)*



Margined madtom is a small species of catfish native to rivers and streams on the eastern slope of the Appalachian Mountains from New York south to Georgia. It was likely introduced into New Hampshire due to its past use as a bait fish. The use of margined madtom as bait is now illegal. Margined madtoms live in rocky sections of medium sized rivers, where they can be locally very abundant. Female madtoms lay clusters of eggs under stones in the quiet sections of riffles, after which the eggs are defended by the males. Madtoms feed on invertebrates living in the spaces between rocks and boulders. They are considered moderately tolerant of pollution.

Margined madtoms were found at 10 of 105 sites (10%). Eight of the 10 records were from the North Branch River and Lamprey River Headwaters subwatersheds, with just one record each from the Middle and Lower Lamprey River subwatersheds. Margined madtoms were locally abundant in Hartford Brook, in Deerfield, with 66 individuals counted. Margined madtoms may be increasing their range in the watershed. No margined madtoms were recorded in 16 electrofishing surveys conducted in the Lamprey River watershed between 1984 and 1986. A total of 139 margined madtoms (3.3% of the total for all fish) were counted in this survey.

Maximum Length: 145 mm  
Minimum Length: 14 mm  
Average Length: 97 mm



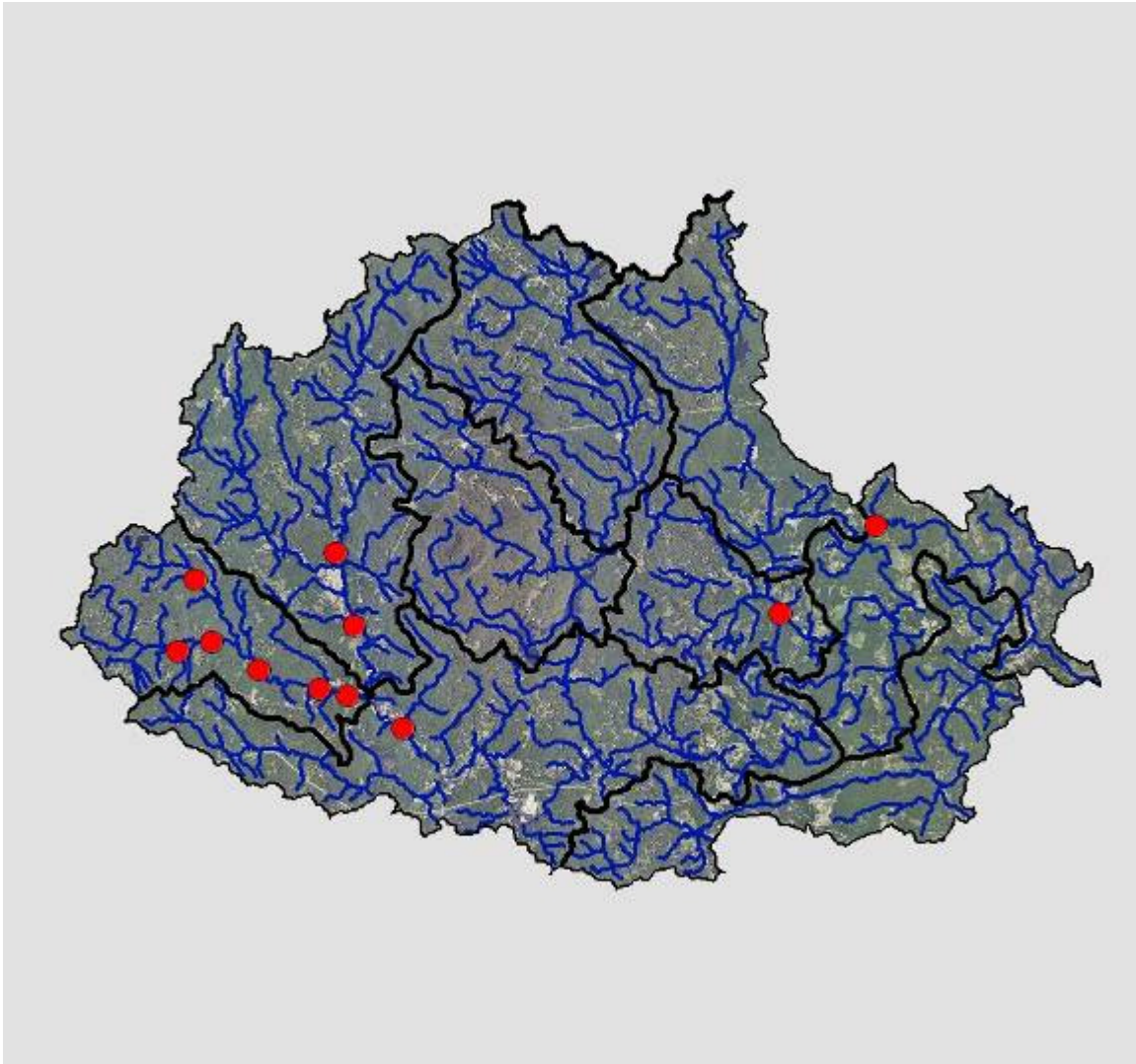


Figure B.17 – Locations of survey sites where margined madtoms were recorded in the Lamprey River watershed.

**Pumpkinseed (Common Sunfish)**  
**(*Lepomis gibbosus*)**



Pumpkinseed sunfish, also known as common sunfish, are an adaptable species capable of living in both lacustrine and riverine habitats. They are usually found associated with aquatic vegetation, although in rivers they may be found in the pools of faster moving sections of river if there are slower flowing reaches near by. Pumpkinseed males excavate a circular nest in shallow water, often in groups or colonies. Females spawn with males in multiple nests where the eggs are aggressively defended by the males until they hatch.

In the Lamprey River pumpkinseeds were usually found in slow flowing water with aquatic vegetation. Individuals captured in higher gradient, faster flowing reaches were usually found below a pond or wetland, often with beaver activity. Pumpkinseed sunfish were found at 25 (24%) of 105 sites in all 9 subwatersheds. A total of 149 (3.5%) pumpkinseeds were counted out of a total fish count of 4,226. The greatest number of individuals captured at one site was 80 at the upstream end of a wetland in the upper North Branch River. The second most pumpkinseeds captured was 15 at the site of an old mill downstream from Onway Lake.

Maximum Length: 186 mm  
Minimum Length: 39 mm  
Average Length: 87mm

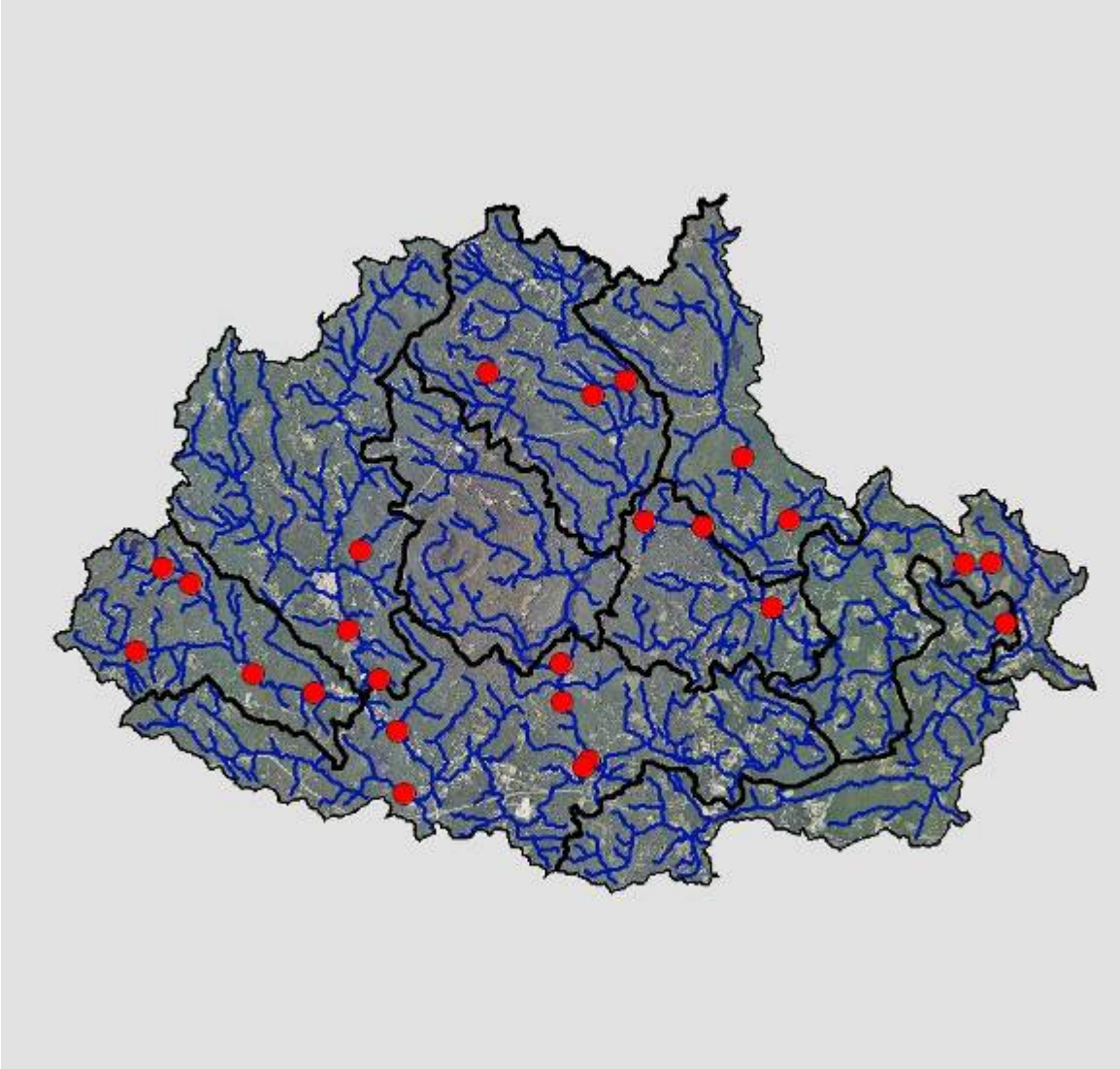


Figure B.18 – Locations of survey sites where pumpkinseeds (common sunfish) were recorded in the Lamprey River watershed.

**Redbreast sunfish**  
**(*Lepomis auritus*)**



Redbreast sunfish are native to New Hampshire and can be found throughout the state, although it is more common in southern watersheds. Unlike the other sunfish species found in New Hampshire, redbreast sunfish are less dependent on aquatic vegetation as habitat. They prefer slow to moderate flowing sections of medium to larger sized rivers, where they take advantage of fallen trees, overhanging shrubs, or large boulders for cover. Spawning takes place in shallow water in a nest excavated by the male. As visual predators with a diet of invertebrates, redbreast sunfish may be vulnerable to extended periods of high turbidity.

Redbreast sunfish occurred at 5 of 105 sites (5%). The five records occurred in 3 subwatersheds: the Middle Lamprey River, the North River, and the Lower Lamprey River. A total of 69 redbreast sunfish were counted, which was 1.6% of the total fish count (4,226). The largest number of redbreast sunfish counted at one site was 30 captured below the bunker pond dam in Epping, before the dam was removed in 2011.

Maximum Length: 173 mm  
Minimum Length: 30 mm  
Average Length: 95 mm



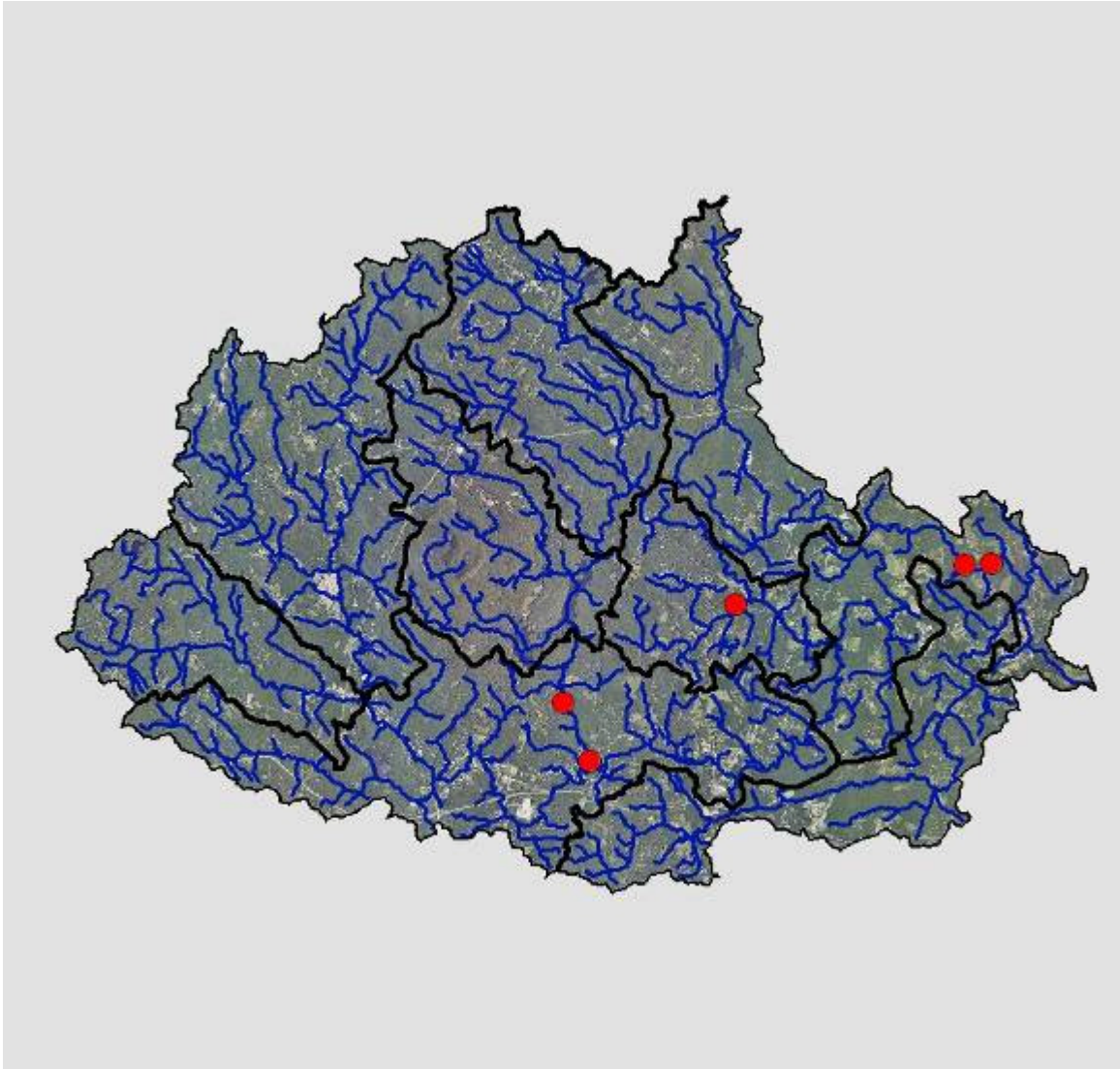


Figure B.19 – Locations of survey sites where redbreast sunfish were recorded in the Lamprey River watershed.

**Redfin pickerel**  
**(*Esox americanus americanus*)**  
*Species of Concern*



Redfin pickerel are the smallest member of the pike family, attaining a maximum length of about 12 inches. They are native to the Atlantic coastal plain and reach the northern extent of their range in New Hampshire. There are a few isolated populations in Maine, where the species is listed as State Endangered. In New Hampshire, the species is restricted to lower elevation rivers and streams along the coastal plain in the lower Merrimack and southern coastal drainages. It frequents shallow weedy backwaters in stands of aquatic vegetation or thick overhanging grasses and shrubs. It is often found in smaller watersheds than the chain pickerel. In New Hampshire it is frequently found in streams flowing through abandoned beaver ponds in very small watersheds that may dry up in some years. Redfin pickerel spawn in early spring by laying strings of eggs over vegetation or submerged branches in shallow water. Although redfin pickerel are relatively common in southern New England, populations in New Hampshire are limited to the southeastern corner of New Hampshire where aquatic habitats are rapidly becoming degraded due to increasing development pressure.

Redfin pickerel were found at 10 of 105 sites (10%). Their distribution was restricted to lower elevation sites in the Middle Lamprey River, Piscassic River, North River, and Lower Lamprey River subwatersheds. The Piscassic River subwatershed appears to have widespread suitable habitat for redfin pickerel and is probably more common than indicated by this survey. Redfin pickerel were found in or near wetland habitat as well as in very small streams. They were found in both clear, cold streams, as well as muddy turbid water. Many of the sites where redfin pickerel were found showed signs habitat

degradation in the form of riparian vegetation removal, bank erosion, and undersized/perched culverts. A total of 58 redfin pickerel were captured (1.4% of the fish total). The largest number of individuals captured at one site was 20 in the Piscassic River subwatershed.

Maximum Length: 190 mm

Minimum Length: 54 mm

Average Length: 106 mm

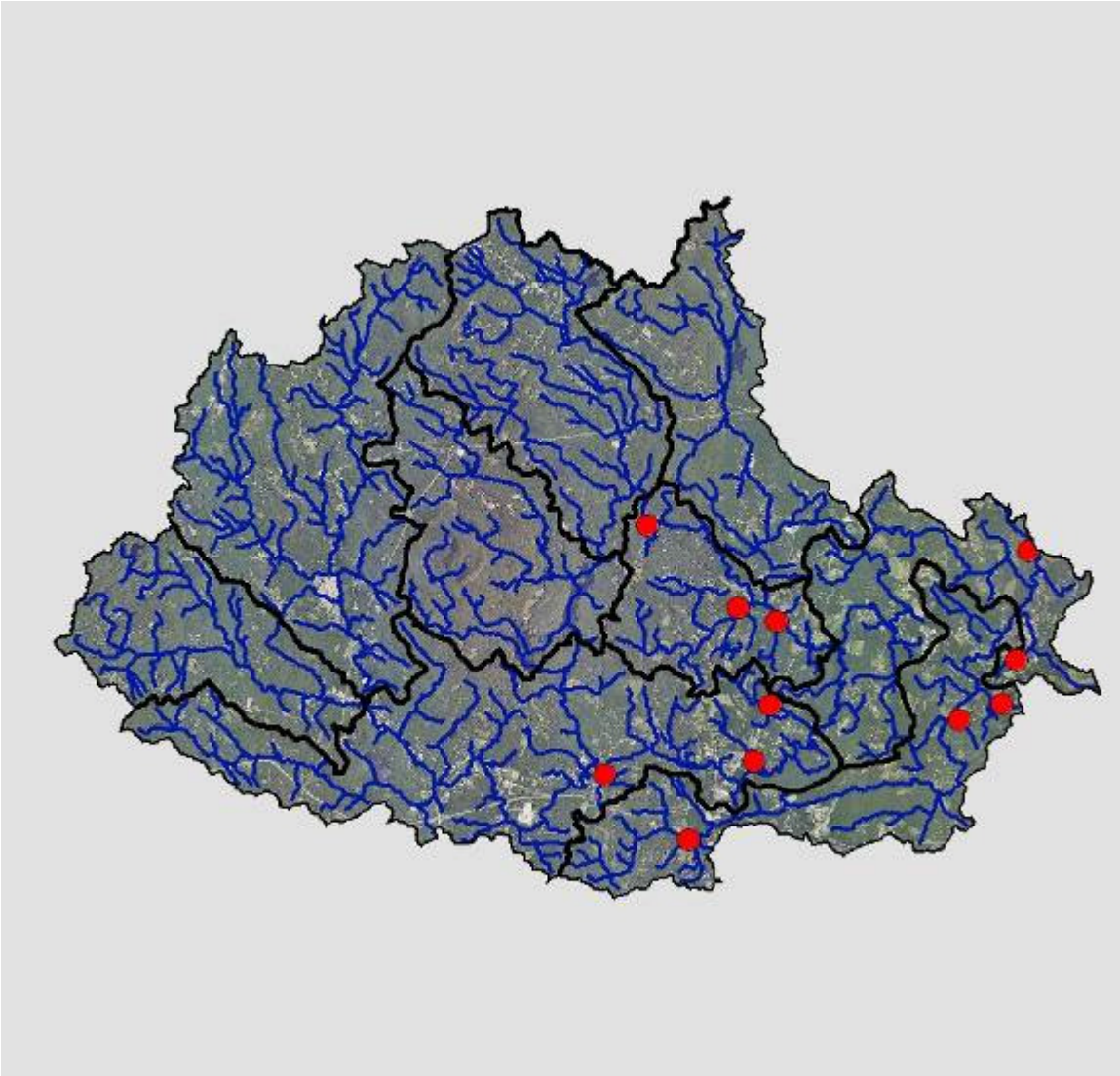


Figure B.20 – Locations of survey sites where redfin pickerel were recorded in the Lamprey River watershed.



**Smallmouth Bass**  
**(*Micropterus dolomieu*)**





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