Lamprey River Watershed

Fish Surveys

Report to the Lamprey River

Advisory Committee

New Hampshire Fish and Game

Inland Fisheries

Fish Conservation Program

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Contents

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, little information is 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 1930s and the mid-1980s, very little information was available on the distribution and status of fish and aquatic habitat in most New Hampshire watersheds. Baseline fish survey data upon which future changes could be compared was clearly needed.

This need for baseline fish survey data was 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 lacked 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 are useful for directing regional conservation efforts, most conservation work is done at the local level. Recognizing 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 might be used as indicators of healthy water quality and good habitat.

4) Recommend potential conservation strategies that will protect aquatic habitats and promote good water quality throughout the Lamprey River watershed.

Methods

Study Area

The Lamprey River watershed drains an area of approximately 554 km^2 (214 mi^2) 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 creates highly suitable aquifers for storing groundwater. The distribution and type of stratified drift aquifers have a major influence on the distribution of cold water stream habitat in southeastern New Hampshire (Fig. 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.

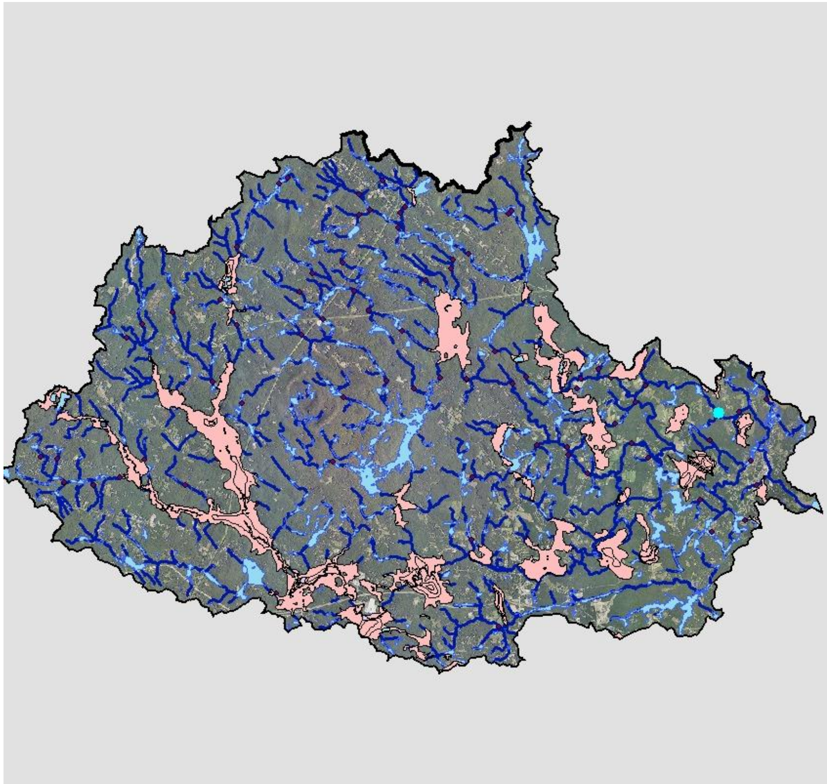

Figure 1: Stratified drift aquifers (pink) in the Lamprey River watershed.

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.

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) (Fig. 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. This model, known as SPARROW, was developed by the US

Environmental Protection Agency (USEPA) and the US Geological Survey (USGS) to monitor nutrient inputs of watersheds throughout the country (USGS 2011) (Fig. 3).

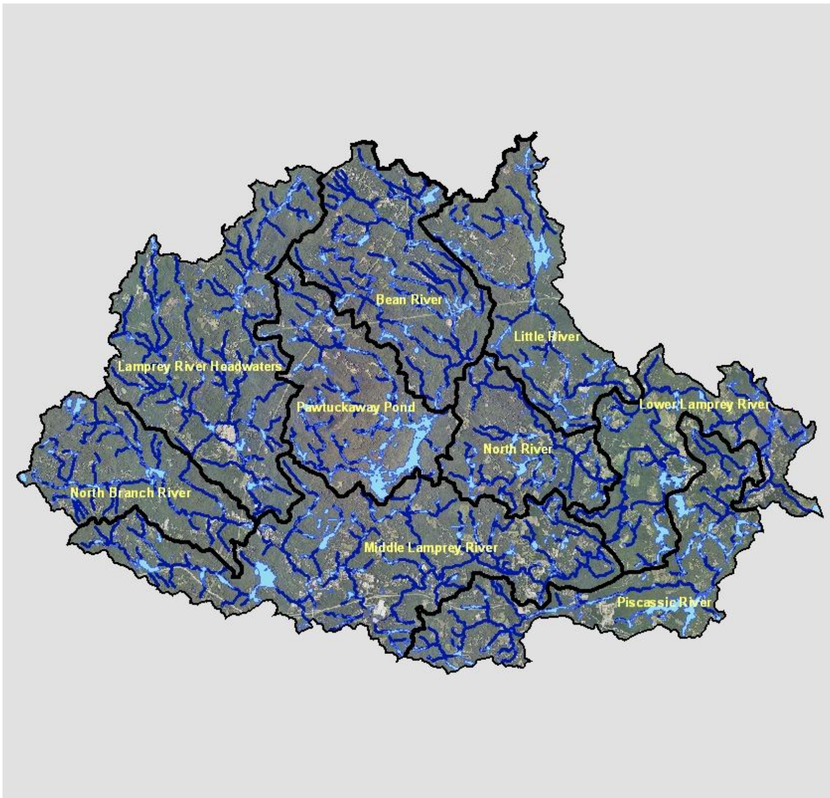

Figure 2: The 9 Subwatersheds (HUC 12) of the Lamprey River watershed.

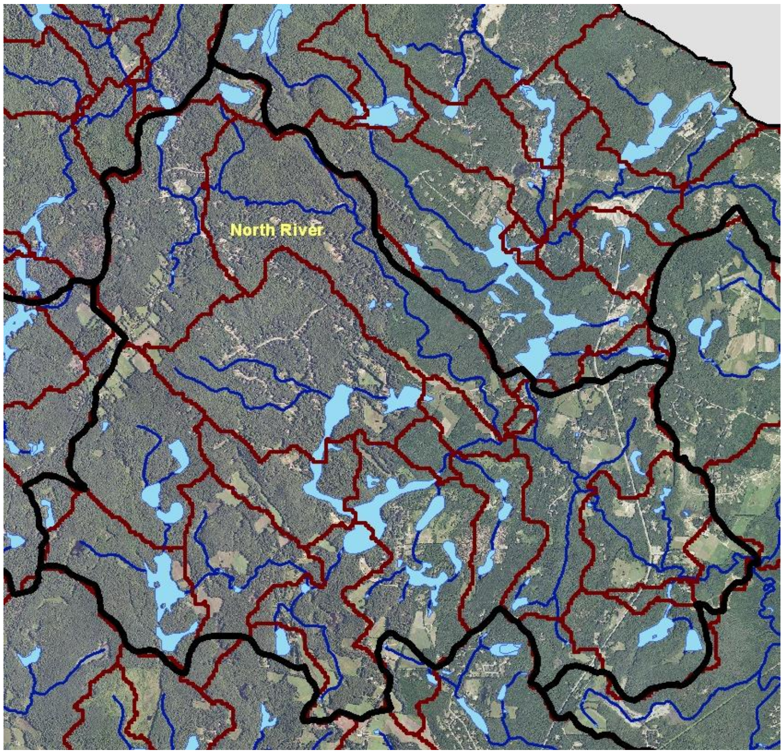

Figure 3: Map of catchments (red) in the North River subwatershed.

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. This ensured that survey sites were distributed throughout each subwatershed and that a variety of habitats were represented. This approach emphasizes small headwater stream habitat, under-represented in previous survey work. Attempts were made to survey every catchment with an established perennial stream. Intermittent streams and those with depths too great for backpack electrofishing units 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 were 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 bridle shiner have been documented in the Lamprey River, but little information existed on the extent of bridle shiner habitat in the Lamprey River watershed. Bridle shiner surveys were conducted by dip net from a canoe or with a ¼" mesh bag seine. Occupied bridle shiner habitat was delineated with a GPS unit and mapped using GIS software.

RESULTS / DISCUSSION

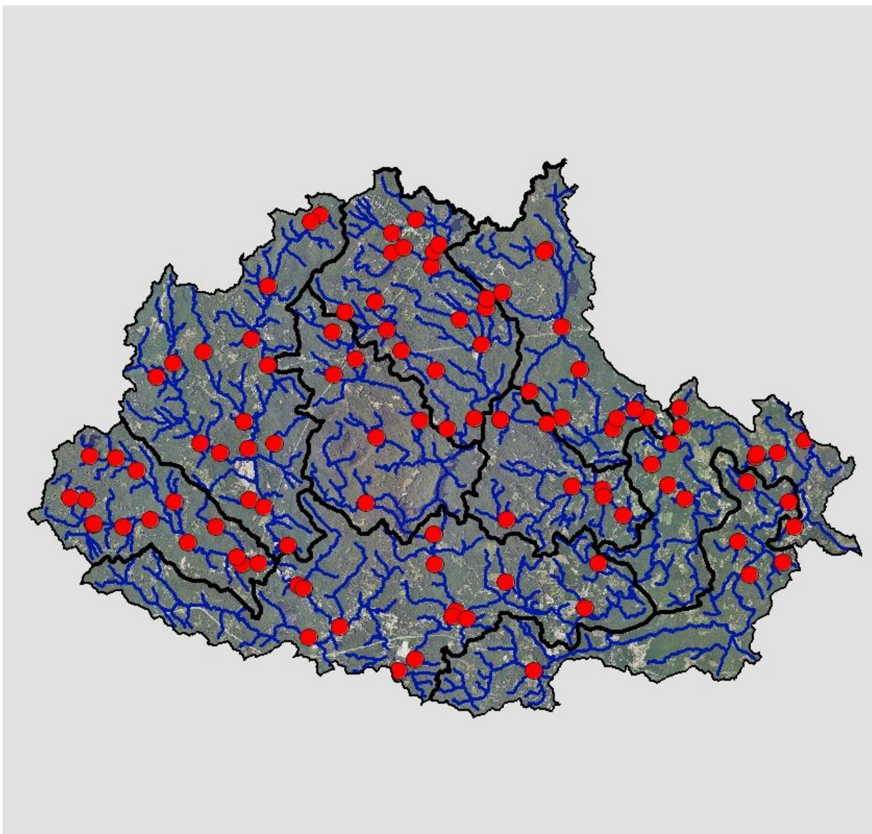

Figure 4: Map showing locations of 105 fish survey sites in the Lamprey River watershed.

A total of 105 survey sites contained adequate data for use in this report (Fig. 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.

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%

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.

The total number of fish species recorded was 25, not including hatchery stocked fish. In all, 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 warm water 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 thirteen 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 four.

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 fewer 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 accounted for over 30% of all fish counted in the survey. Most of the main stem river in the middle and lower Lamprey River subwatersheds was too deep for electrofishing. Shallow, rocky sections of river provide important habitat for fish such as longnose dace that prefer turbulent water and depend on spaces between rocks and boulders for shelter.

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, warm water streams. Signs of old mill structures or roads at natural constrictions are common in the stream channel at the outflows of wetlands, just before the stream becomes higher gradient. Ponded sections of stream are difficult to survey, but species that inhabit these areas can be inferred by sampling the higher gradient sections between the ponds. These stream reaches, especially in smaller watersheds, can 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 can contain silt or fine sand and shallow areas can support stands of aquatic vegetation such as pond lily, floating heart, or pickerel weed. As flow increases, the channel can 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 substrates composed of 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 main river 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 and slower flowing sections tend to support sunfish species, golden shiners, largemouth bass, and other warm water 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 was 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 are spring fed streams. 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^{0}C (68^{0}F) or cooler in the months of July and August, these streams provide 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 appear on most maps. Unlike the cold water 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 was more focused on headwater streams 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 (FFF) electrofishing surveys conducted by NHFG in the mid-1980s. Of the 105 sites in this survey, 67 sites had watershed areas smaller than 8 km^2 (5 mi^2). Watershed areas for each site ranged from 471.20 km^2 (181.93 mi^2) to 0.63 km^2 (0.24 mi^2). The average watershed area was 43.68 km^2 (16.86 mi^2). 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 smaller than 0.8 $km^{2\,(}$0.5 mi^2), 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 surveys were conducted at sites with watersheds larger than 25.9 km^2 (10 $mi.^2$). Margined madtoms were not recorded by NHFG in the 1980s. Margined madtoms 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. Margined madtoms prefer rocky, riffle habitat and might 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 prevalent 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 provides an excellent baseline on which future trends in fish distribution can be compared: the larger river habitat focus of the NHDES Baseline Fish Community surveys, the medium sized wadable stream focus of the FFF surveys, and the small headwater stream focus of this survey.

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, eastern brook trout were present at 11 of 105 sites (10%). 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 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 smaller than 90 mm in length, indicating that natural reproduction was occurring in the stream. Other streams 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 represented a small percentage of the fish captured and were not indicative of a resident population. The possibility that these were hatchery stocked fish could not be ruled out. Spring fed streams are very rare in the Lamprey River watershed (Fig 5).

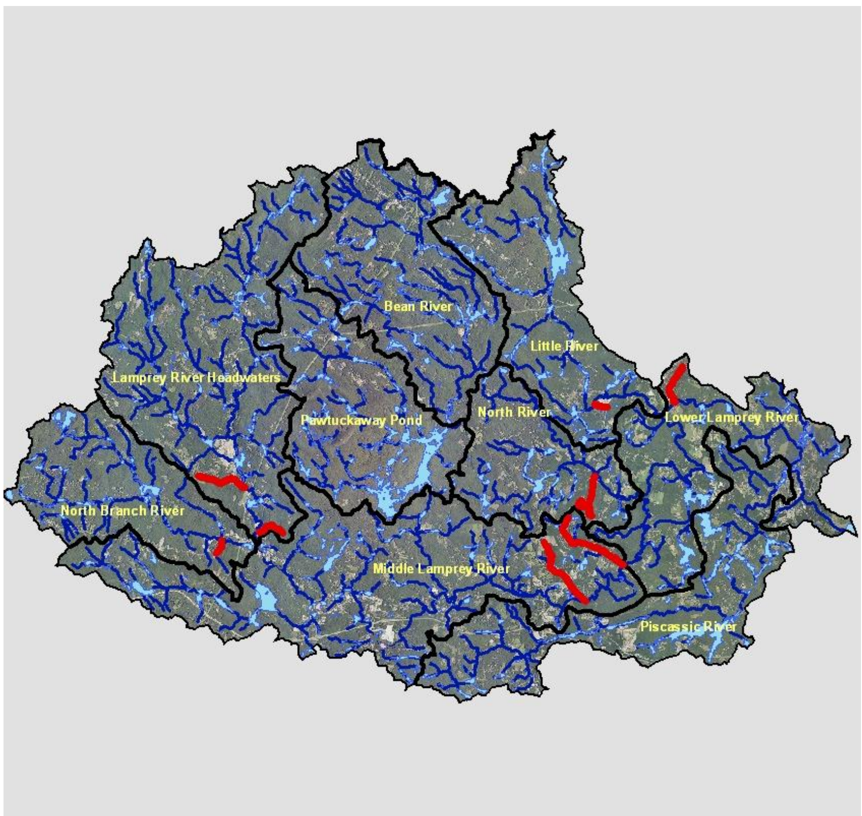

Figure 5: Spring fed stream habitat (red) supporting brook trout populations in the Lamprey River watershed.

Maps of stratified drift aquifers were utilized to predict the locations of other potential spring fed streams. Interestingly, the presence of a stratified drift aquifer in an area did 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 had suitable water temperature and habitat conditions that merited 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 was found to be proximity to other spring fed streams. More cold water streams were probably missed by this survey, because their small size made them difficult to find. Most of the sites where brook trout were found had watershed areas of less than 1 $mi.^2$. 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.

Two clusters of spring fed streams could be considered focus areas within the Lamprey River watershed. One is near the borders of the towns of Candia, Deerfield and Raymond. The streams in this area likely receive groundwater from the valley drift aquifers in this region. The second focus area is along the Route 125 corridor. This area lies within about 1 mile east and west of the road, where glacioestuarine deltas have created productive aquifers and supply groundwater to abundant brook trout populations (Fig 6). 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 might respond well to restoration, but their long term viability should be assessed before resources are invested into restoring streams that might not have suitable habitat to support brook trout over the long term.

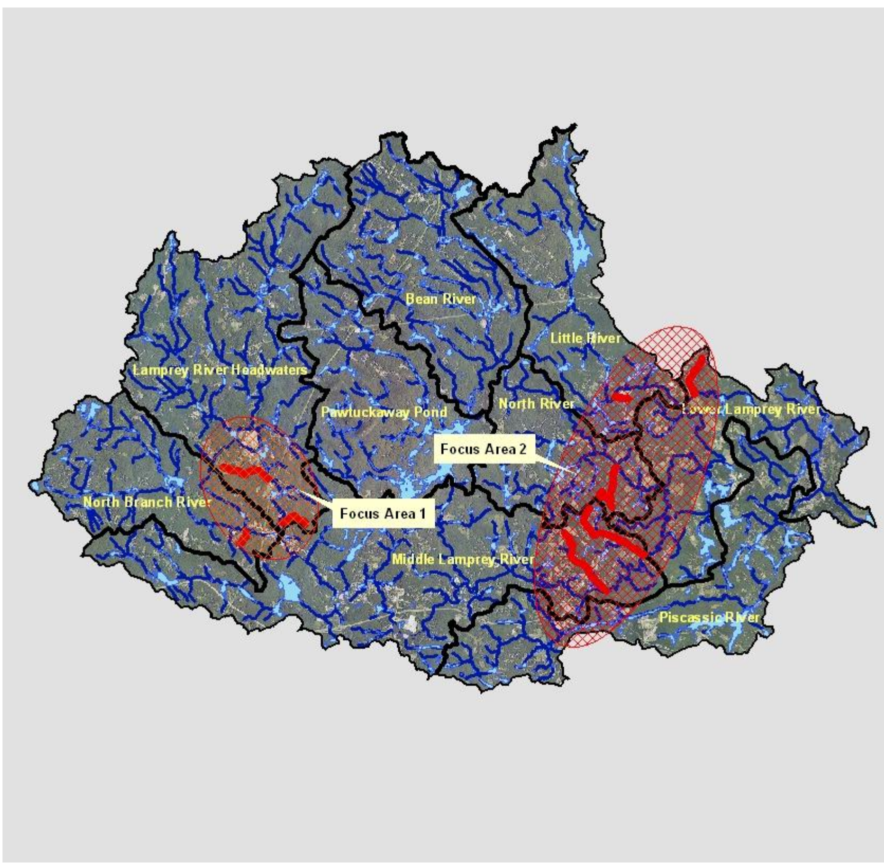

Figure 6: Potential cold water stream focus areas in the Lamprey River watershed

Focus area two (FY2) contains streams that are known to support healthy brook trout populations. The watersheds of these streams should be protected. More undiscovered brook trout streams in FY2 are likely due to the productive nature of aquifers in this area. Much of the Route 125 corridor is zoned for commercial development. Careful consideration should be given to all streams within FY2 during the permitting process to ensure that future development does not extirpate undocumented brook trout populations (refer to Recommendations).

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 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 becomes more difficult as the distance between areas of suitable habitat increases. Bridle shiners were commonly associated with creek chubsuckers, golden shiners, juvenile largemouth bass, yellow perch, chain pickerel, bluegill, and pumpkinseed sunfish.

The farthest upstream and most abundant population was found in Raymond near the confluence of the Lamprey River and the North Branch River (Fig. 7). This reach was divided from the next population downstream by a short section of higher gradient river habitat with boulder and gravel substrate. Bridle shiners could possibly disperse downstream from Reach 1 to Reach 2. Bridle 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 few houses were visible from the river.

Figure 7: Bridle shiner habitat (purple) in the Lamprey River near the confluence with the North Branch River in Raymond (Reaches 1 and 2).

The next site downstream (Reach 3) is upstream of the Main Street bridge in Raymond (Fig. 8). Bridle 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 bridle 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.

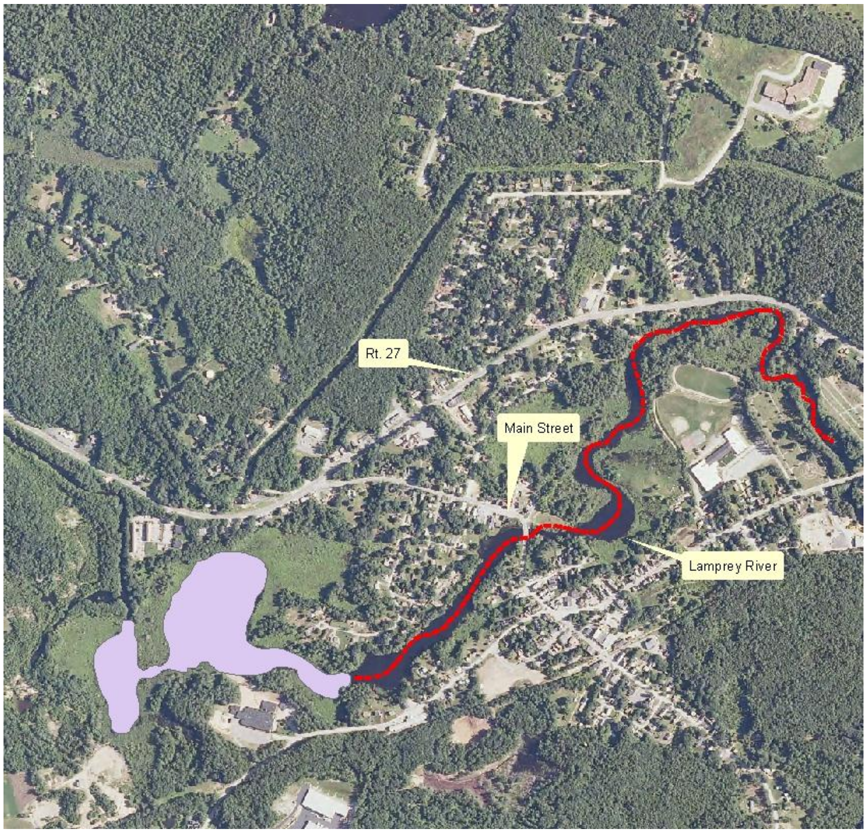

Figure 8: Bridle shiner habitat (purple) in the Lamprey River near the center of Raymond (Reach 3). The red dotted line shows the section of river with suitable, but unoccupied bridle shiner habitat.

Reach 4 was similar to Reach 3, with bridle 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. Bridle shiners were less easily observed and appeared to be less abundant in reaches 3 and 4 compared to reaches 1 and 2.

Many bridle shiners (120) were captured with a seine net upstream of the Route 27 bridge in Epping (Fig. 9). Bridle 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. Bridle shiners were present in this pool and in the river channel just upstream of the drained impoundment. The slow draw down most likely allowed bridle 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 bridle shiners. NHFGD will monitor this site to see if the changing habitat conditions after the dam removal will continue to support the bridle shiner population.

Figure 9: 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.

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

Bridle shiners were collected by Harrington (1946) below Packers Falls during his research on the life history of the species. No bridle shiners were observed or captured anywhere between Packers Falls and the McCallen Dam in Newmarket in four surveys conducted between 2005 and 2011. This is a large area with apparently suitable habitat and the possibility that bridle shiners were missed in these surveys cannot be ruled out.

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 $mi.^2$ (17.56 km^2), with the smallest at 0.37 mi.^{2} (0.96 km^2) and the largest at 25.69 (66.54 km^2). 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 might represent some of the least impacted banded sunfish habitat in southeastern New Hampshire.

Redfin pickerel were found in even smaller streams than were banded sunfish. The average watershed size at the 11 sites where redfin pickerel were found was 3.8 mi.^{2} (9.8 km^2). The largest watershed size was 24.32 mi.^{2} (63.99 km^2). Six of the 11 locations had watershed sizes of less than 1 mi.^{2} (2.59 km^2). 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 might be found at very low flows in fragmented habitat. Water might be turbid or clear, but redfin pickerel seem less dependent 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 main stem of the Piscassic River would likely yield more redfin pickerel specimens.

Swamp darters 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 swamp darters 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

Diadromous fish spend part of their lives in fresh water and part in salt water. There were two diadromous species recorded in this survey: alewife and American eel. The solitary 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 individuals in 8 of 9 subwatersheds. The abundance of eels at each site decreased significantly upstream of the Wiswall Dam. Fifty-three eels were counted at the site just below the Wiswall Dam in Durham, 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.

Following surveys that were completed in 2011, two major changes occurred on the Lamprey River with respect to diadromous fish; a fish ladder was installed at the Wiswall Dam in Durham 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 might 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 might be the next upstream barrier to river herring in the Lamprey River. A small rock ramp or natural fishway at this site might 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 examples of habitat degradation exist within these upper subwatersheds, the Middle Lamprey River subwatershed exhibits impacts to aquatic habitat that are more widespread. Smaller streams become noticeably degraded as the density of development increases around the main population center in the town of Raymond. The main stem 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 main stem rivers remains mostly undeveloped until one reaches the town of Newmarket. However, the smaller streams within these subwatersheds have become increasingly fragmented. Great strides have been 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 Shoreland Water Quality Protection Act does not apply to 1^{st}, 2^{nd}, or 3^{rd} order streams. The small size of most headwater streams makes them vulnerable to human impacts. Numerous examples of species endemic to headwater streams that have been extirpated or greatly reduced in number exist nationally. 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 might 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. Stormwater 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 percentage 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 (Fig. 10). Once a stream crossing becomes perched, it will remain a barrier to aquatic organism passage until it is replaced with an appropriately sized crossing.

Figure 10: Impassable culvert (perched) on Woodman Brook in the Lower Lamprey River subwatershed.

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 was directed around or through the freshly deposited sediment (Fig. 11).

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 causing a tremendous amount of excess sediment to move 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 (Nedeau 2011).

Figure 11: 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. Poor 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 (Fig. 12). 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. Excess nitrogen and turbidity there, attributed largely to nonpoint source pollution, have caused the decline of eel grass beds (PREP 2009).

Figure 12: The tail end of a pipe that directs stormwater runoff into Dudley Brook.

The amount of impervious surface is 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 experienced 10% increases in impervious surface coverage since 1990. Aquatic invertebrate communities and brook trout populations begin to show signs of degradation in watersheds with less than 5% impervious surface coverage. The amount of impervious surface in the Middle Lamprey River subwatershed was 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.

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. The practice of clearing natural vegetation 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. Cattle have eroded banks by walking in streams. In addition, potential runoff from fields treated with fertilizer and pesticides was noted at some sites.

Dams

Many dams are found throughout the watershed. Some are very old mill dams in ruins and their remains have little if any impact on the movement of fish and other aquatic species. Others are larger and of more recent construction. Their presence prevents upstream fish passage. Impoundments upstream of dams might increase water temperatures below the dam and cause water quality problems 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 might be approaching a tipping point. The amount of impervious surface in eight of the nine subwatersheds that make up the Lamprey River watershed has 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. Permanent 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 how to approach 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

Standard practice among developers has been 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. Where runoff has not been directed to streams, 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 largely based on the principal that stormwater should be filtered through natural soils 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. LID practices increase onsite infiltration of stormwater and improve groundwater recharge rates. The University of New Hampshire (UNH) Stormwater Center is a valuable local resource for technical assistance on LID practices such as porous asphalt, gravel wetlands, rain gardens, bioretention systems, and tree filters.

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 can 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 main stem 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 might 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 those 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/.

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 were 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/.

Riparian Zone Protection

Although the riparian zone was largely intact at most survey sites, many areas were 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 meters from the stream bank on both sides of the stream or river should be protected. A 15 m buffer provides a basic level of protection for water quality and in-stream 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 might 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 landowner rights. Outreach on the value of headwater streams, including intermittent streams, and the importance of riparian zones to water quality might 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 13 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 (Fig 1; Fig 5). Accomplishing a watershed approach to conservation will require that towns coordinate through regional planning commissions, such as the SNHPC, to avoid the patchwork of zoning ordinances that result in sprawling development.

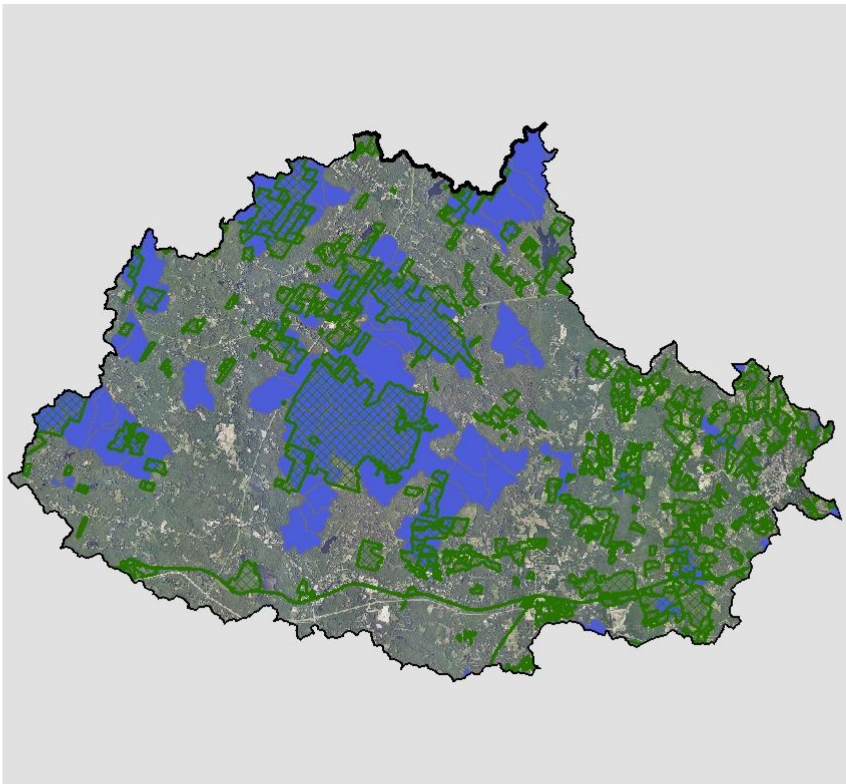

Figure 13: Remaining catchments with less than 6% impervious surface coverage (blue) in the Lamprey River watershed. Existing conservation land is outlined in green.

Priority for land protection should be given to watersheds and shoreline habitat where bridle shiners and brook trout have been documented. Secondary consideration should be given to habitat that supports banded sunfish, redfin pickerel, and swamp darter. Larger watersheds that contain relatively unfragmented forests, especially in areas adjacent to 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.

Funding Sources and Potential Partnerships

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

Eastern Brook Trout Joint Venture:
Funding for 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 might also be interested in sponsoring a local stream restoration.

CONCLUSION

Few watersheds in New Hampshire can 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 bridle shiner, banded sunfish, redfin pickerel, and swamp darter. Wild brook trout populations are restricted to isolated cold water 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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