The Warner River Watershed Conservation Project
Landowner Site Visit Report

Bassi Property
Tributary of the West Branch
904 Mountain Rd
Bradford, NH
43.26263N -72.03513W
August 17, 2017

local grass roots · TROUT UNLIMITED Basil W. Woods Jr. · FISH AND GAME

Foreword

Thank you for participating in the Landowner Engagement Property Site Visits in 2017. This was our first year with this effort and the preliminary results (both social and biological) have convinced us to expand this project to surrounding towns in the Warner River Watershed in the next few years. Please encourage your neighbors who own frontage along the same stream to reach out to us to participate in a site visit. We hope you enjoyed having us on your property and strongly encourage you to reach out to us to discuss some of the opportunities identified in this report.

This document includes a summary of what we found on your property and recommendations to help further protect, restore, and enhance aquatic habitat to benefit wild brook trout and the quality of water. An appendix is included for landowners to learn more about wild brook trout ecology, features of a healthy stream, and some of the impacts to habitat and water quality we've observed in the Warner River Watershed since 2012.

Warner River Watershed Contact Information

To discuss opportunities for land protection and habitat enhancement and restoration projects, contact:

Ben Nugent
Fisheries Biologist
NH Fish and Game
PO Box 417
New Hampton, NH 03256
(603) 744-5470
benjamin.nugent@wildlife.nh.gov

To learn about volunteer opportunities and sign up to be on our volunteer email list, contact:

George Embley
Conservation Chair
Basil W. Woods, Jr. Trout Unlimited
gtembley@gmail.com

Supporting Websites:

Project Website: http://warnerriverwatershedconservationproject.wordpress.com

Basil W. Woods, Jr. Trout Unlimited Website: http://www.concordtu.org
Basil W. Woods, Jr. Trout Unlimited Facebook: http://www.facebook.com/ConcordTU

New Hampshire Fish and Game Department: http://www.wildlife.state.nh.us

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Project Goal, Support, and Justification

Project Goal

The primary goal of the Warner River Watershed Conservation Project is to ensure the sustainability of wild brook trout throughout the Warner River Watershed by fostering local landowner and citizen stewardship and by implementing sound conservation measures such as habitat protection, restoration and enhancement projects. The practice of maintaining good water quality in our rivers and streams goes hand in hand with brook trout conservation. We recognize for any long term, meaningful stewardship to occur, watershed residents must appreciate the value of supporting these fundamentals because they are worth preserving and not necessarily because regulations exist.

Project Support

Volunteers from the Basil W. Woods, Jr. Trout Unlimited Chapter and other Warner Residents made this effort possible. Without community support, the New Hampshire Fish and Game Department (NHFGD) would not be able to participate in these property specific surveys. In collaboration with the NHFGD, Basil W. Woods, Jr. Trout Unlimited received an Embrace-A-Stream grant from Trout Unlimited National. These funds were used to hire an intern at NHFGD to assemble contact information of landowners who own property along wild brook trout streams in Warner. The NHFGD is funded primarily by fishing and hunting licenses and permit fees, and dedicated federal funds. The remaining funding for Fish and Game comes from a mix of sources; such as OHRV registrations, nonrefunded motorboat gas tax, transfers, other agency income, and periodic funds from the state's general fund (FY2016 and FY2017).

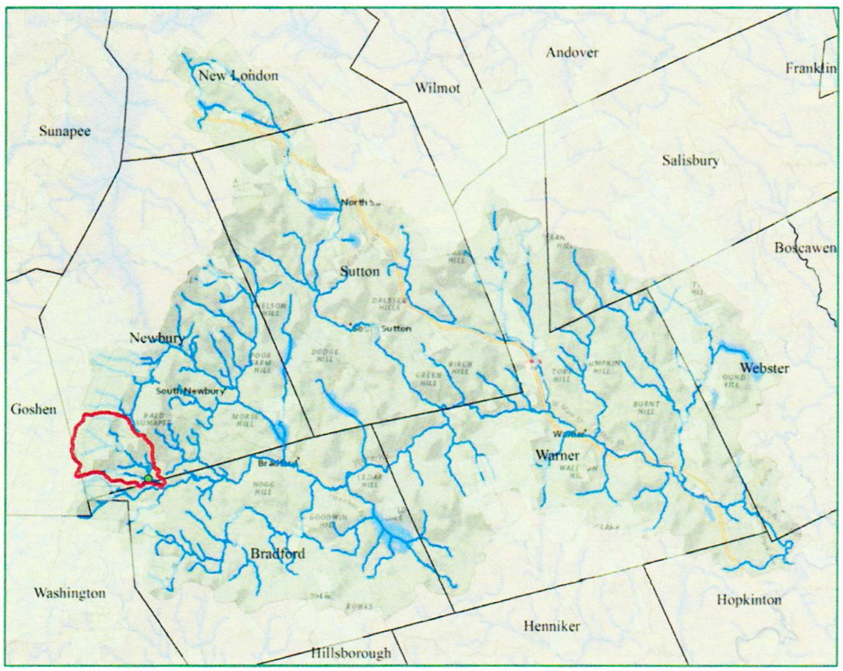
Project Justification

Freshwater habitats are among the most threatened ecosystems in the world. Freshwater fish populations have declined due to impairments associated with dams or other barriers, riparian area encroachment, water withdrawals, stream channel modification, and alterations to spawning and rearing habitat. These declines are expected to be further amplified as increased human population growth brings a greater demand for freshwater, more woodlands are lost to development, invasive species continue to spread, and natural climate patterns are altered.

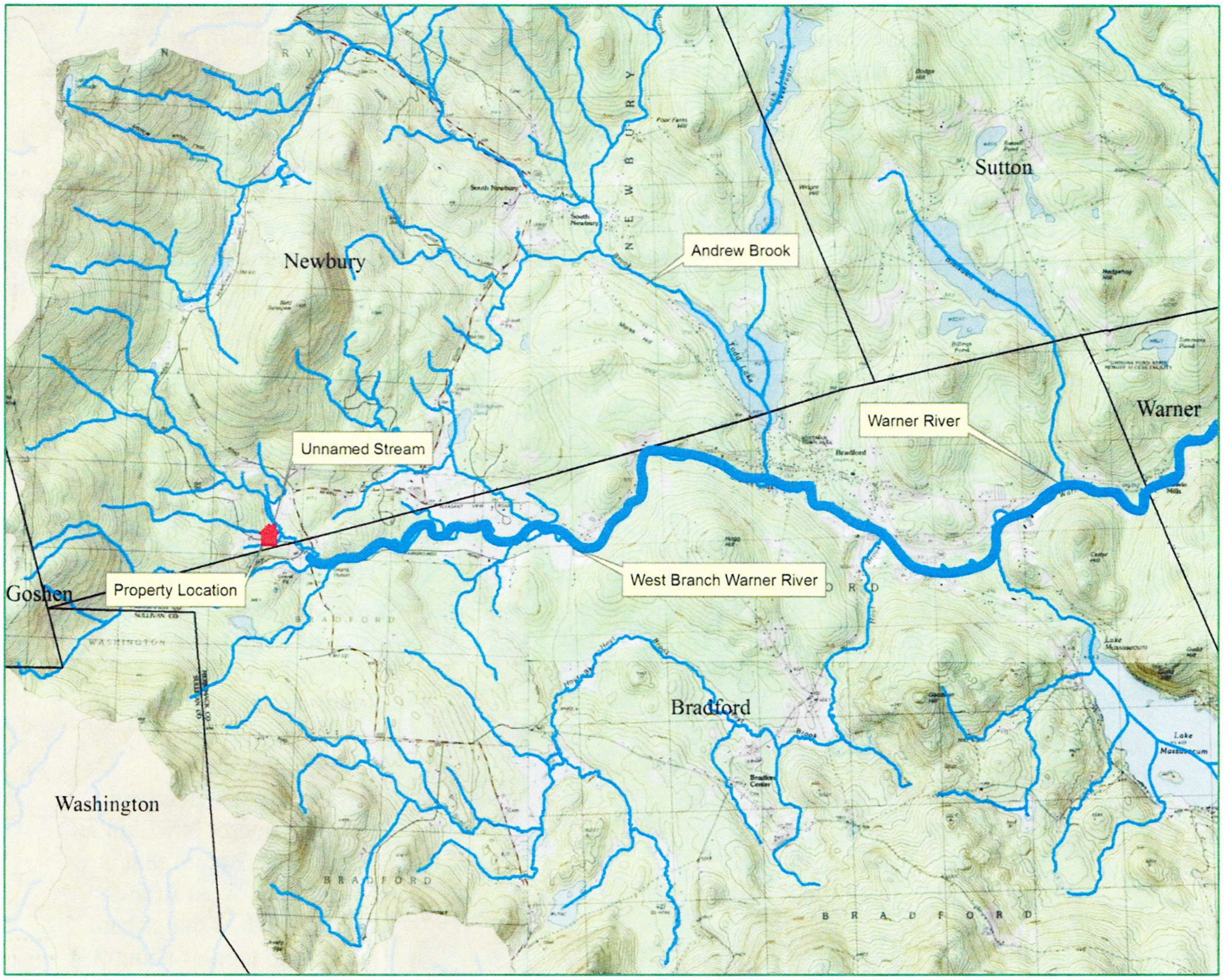
Unfortunately, freshwater habitats specific to New Hampshire are not exempt from these threats. Twenty native fish species have been identified as requiring greater conservation need in the New Hampshire Wildlife Action Plan. The wild brook trout is a species included on this list. As the human population increases, more demands and stresses are placed on aquatic systems and the woodlands they flow through. In 1950, two thirds of New Hampshire had human population densities consistent with a rural classification. Only one third, mostly restricted to the northern part of the state, is expected to have a rural classification by 2030. New Hampshire population growth is expected to be as high as 24% in some counties (SPNHF 2011). New Hampshire forests are projected to be reduced by 225,000 acres by 2030 as well. Between 2002 and 2010, close to 20,000 acres over designated aquifers were converted from natural land cover to urban land uses.

It is presumed wild brook trout populations in Maine, New Hampshire, Vermont, and New York are more secure than populations southward in the species' range. Despite this, most current populations in New Hampshire are restricted to smaller headwater streams. Their historical presence noted in early precolonial records within lakes, ponds, and our larger rivers are no longer observed. There is limited information available to fully describe the status of wild brook trout populations at the statewide level in New Hampshire. The status of wild Brook Trout is unknown in close to 88% of watersheds in New Hampshire. Despite range wide declines in Brook Trout populations, there has been little concerted effort to identify and protect coldwater stream habitat in the northeast. An organized, watershed approach to aquatic habitat conservation offers the best chance to protect the remaining habitat intact and to reverse declines in areas already degraded. This watershed scale approach also benefits other vulnerable aquatic habitats and emphasizes the connection between land use choices, clean water, and healthy fish communities.

Watershed Address



We commonly associate where we live by a town boundary and street address. Not much thought may be given to how one's property is situated in reference to watershed boundaries. By considering where you live within a watershed your decisions on how to manage your property might incorporate additional perspectives. Your property is within an Unnamed Stream that is part of the West Branch Watershed. Your stream drains an area of about 2.9 $miles^2$. Land uses within the watershed include forest lands 2.7$miles^2$ (94.1%), agricultural lands .14 $miles^2$ (4.7%), and developed lands .026 $miles^2$ (0.9%). The headwaters of your stream flow from the eastern slopes of Mt. Sunapee State Park and the southern slope of Bald Sunapee. It joins several other streams near Box Corner and becomes the West Branch of the Warner River.



Your stream drains both the eastern slopes of Mt. Sunapee as well as the southern slopes of Bald Sunapee. It joins several other streams near Box Corner and becomes the West Branch of the Warner River. South of Lake Todd, the West Branch joins Andrew Brook to become the Warner River. Your stream is one of the many cold water tributaries that support wild brook trout populations in the Watershed.

The 149mile^2 Warner River Watershed encompasses parts of ten towns and contains approximately 209 miles of rivers and streams before flowing into the Contoocook River in Hopkinton. Wild brook trout were found at two thirds of all survey locations throughout the watershed. Summaries of the results and other useful information can be found on our project website here (http://warnerriverwatershedconservationproject.wordpress.com/).

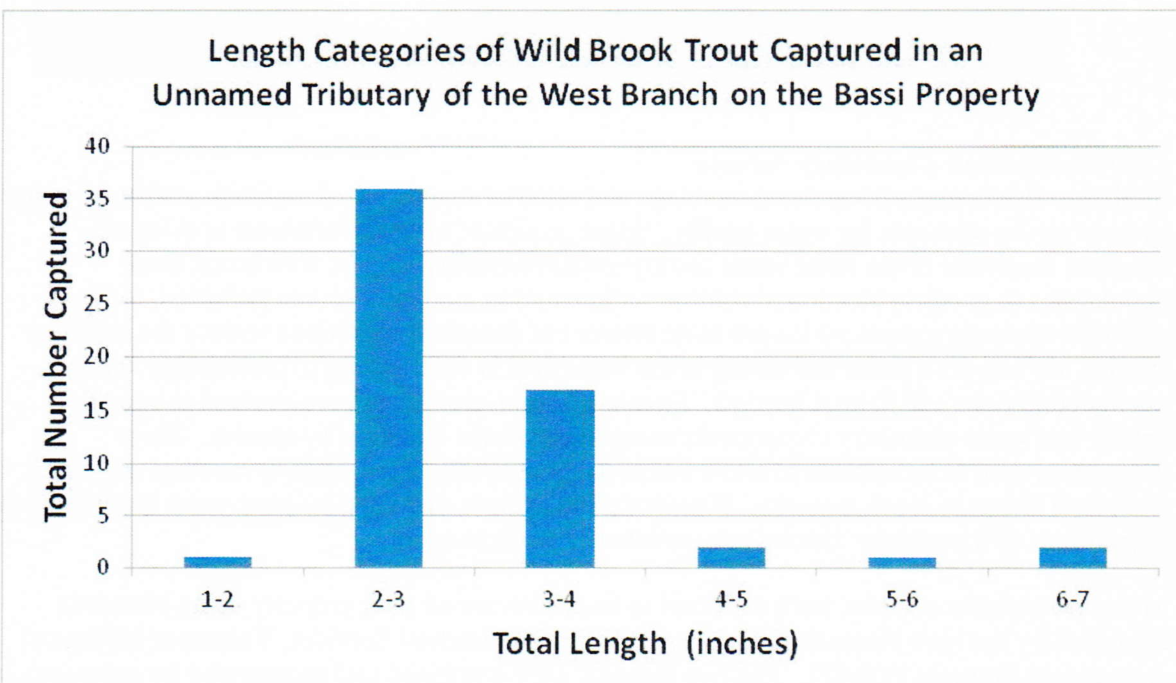
Property Survey Results

Fish Community Surveys

Using standardized NHFGD sampling techniques, a stream length of 100 meters was targeted using a backpack electrofishing unit to capture fish in the study area. Fish were removed from the stream using dip nets and held in buckets until they could be processed (measured and weighed) before being returned to the stream. Given the size of the Unnamed Brook, the stream length electrofished usually includes enough habitat variety that we can expect to capture all the different fish species that are present in the stream.

Electrofishing Summary

Stream Name: Unnamed Tributary of the West Branch
Date Sampled: August 17, 2017
Time: 1000h
Weather: clear, hot
Voltage: 300 V
Effort: 1018 seconds
Stream Flow: typical summer low
Stream Length: 100 meters (328 feet)
Average Width: 2.43 meters (8 feet)
Surface Area: 243 meters^2 (290.6 yard^2)
Species Captured: Brook Trout (n=59)
Species Captured: Black Nosed Dace (n=13)
Brook Trout Density: 0.24 brook trout/meter^2 (0.20 brook trout/yard^2)
Brook Trout Biomass: 15.4kg/hectare (13.8pounds/surface acre)



We often associate high biodiversity with healthy ecosystems. This is sometimes misleading when it comes to wild brook trout streams. The natural condition of these streams is to have low biodiversity and frequently only a single species. This is not a sign of habitat impairment, but rather the natural condition. The total number of wild brook trout on your property is very impressive. **By far, the density of wild brook trout on your property was the highest recorded of all survey locations in 2017.** Although analyzing the age structure of brook trout was beyond the scope of this assessment, the length-frequency of brook trout captured indicates suitable habitat for both adult and juvenile brook trout.

Macroinvertebrate Community Surveys

Similar to fish communities, the assemblage and relative abundance of macroinvertebrates in our streams can be sentinels for water quality. Some groups of macroinvertebrate species are sensitive to several of the same water quality impairments that impact wild brook trout populations (e.g. eutrophication, turbidity, sedimentation, nonpoint source pollution, etc.). If macroinvertebrate species which are more tolerant of disturbed conditions replace the sensitive species, we can get a sense something in the watershed is contributing to undesirable water quality conditions and habitat impacts. Stream macroinvertebrates have evolved to specific habitat and water chemistry components in aquatic systems that vary by species. These parameters need to be suitable to allow adults to successfully breed, eggs to incubate and hatch, and larval stages to reach maturity. If part of a life cycle is disrupted by poor water quality, local populations of a particular species may eventually cease to exist.

Macroinvertebrate samples were collected at five locations on your property using protocols identified by the New Hampshire Department of Environmental Services, Volunteer Biological Assessment Program (VBAP). The five samples were combined and enumerated by order (e.g.

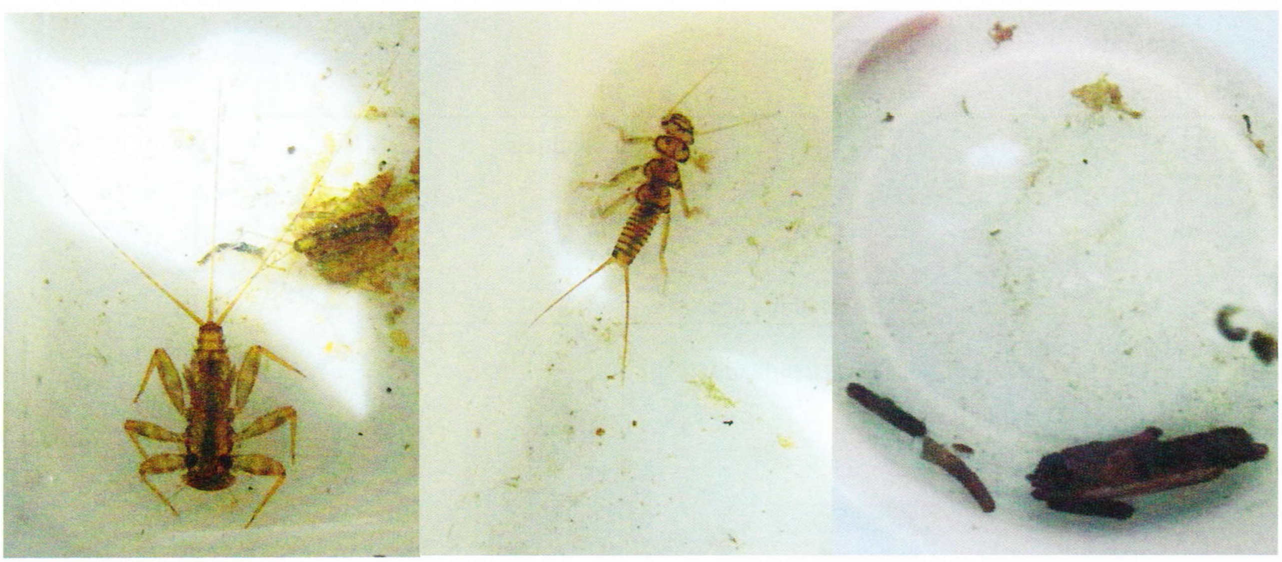
mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera), dragonflies/damselflies (Odonata), etc.). Predefined tolerance values (specific to each group of macroinvertebrate) were then used to develop a biotic score based on the total number of each group represented in the sample. The total biotic scores of each group found was then divided by the total number of individuals found for all different groups for a biological water quality score (VBAP Score). These scores can be used to classify the survey location into three different categories for water quality (excellent, good, and fairly poor).

Based on Group Tolerance Values and total number of each group present

$$\text{Water Quality Score} = \frac{\text{Total Biotic Score}}{\text{Total \# of individuals for all groups}}$$

Water Quality Score
0 – 3.5 Excellent >3.5 - 4.8 Good > 4.8 Fairly Poor

Macroinvertebrate sampling is a good way for property owners to monitor water quality on their properties. Once familiar with identification, minimal equipment is required to complete this assessment. Periodic surveys will help detect any shift in order presence and abundance signaling a potential impairment.



Mayfly larvae (left), stonefly larvae (center) and caddisfly larvae (right) collected during the aquatic macroinvertebrate assessment on your property. These aquatic phases can last several years before they emerge into their adult, flying stage. The assemblage and number of different macroinvertebrates indicate the stream has excellent water quality.

Macroinvertebrate Sampling Results

Order	Common Name	Tolerance Value	*	Number Found	=	Biotic Score
Ephemeroptera	Mayfly	3	*	7	=	21
Plecoptera	Stonefly	1	*	6	=	6
Trichoptera	Caddisfly	4	*	4	=	16
Odonata	Dragonfly	3	*		=	
	Damselfly	7	*		=	
Diptera	Blackfly	7	*		=	
	Midge	6	*	1	=	6
	True Fly	4	*	1	=	4
Megaloptera	Alderfly	4	*		=	
	Hellgrammite	0	*		=	
Coleoptera	Riffle Beetle	4	*	7	=	28
	Water Penny	4	*		=	
	Beetle Like	7	*		=	
Decapoda	Crayfish	6	*		=	
Basommatophora	Snails	7	*		=	
Oligochaeta	Worms	8	*		=	
Amphipoda	Scuds	8	*		=	
Isopoda	Sow bug	7	*		=	
Unionoida	Mussels	8	*		=	

Total # Individuals 26

Total Biotic Score 81

Final Biotic Score = Total Biotic Score / Total # Individuals = 81 / 26 = **3.12 Excellent Water Quality**

Water Quality Score	Rating
0-3.5	Excellent
>3.5-4.8	Good
>4.8	Fairly Poor

Water Quality Surveys (November 27, 2017)

Lower Survey Location				
Dissolved Oxygen (mg/L)	Water Temperature °F (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)
9.0	39.02 (3.9)	5.43	16	0.86
Middle Survey Location				
Dissolved Oxygen (mg/L)	Water Temperature °F (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)
9.9	37.9 (3.3)	6.04	11	0.28
Upper Survey Location				
Dissolved Oxygen (mg/L)	Water Temperature °F (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)
9.7	38.3 (3.5)	6.16	11	0.19

Dissolved oxygen, water temperature, pH, conductivity, and turbidity values were measured at three sites along your property on November 27, 2017. These values help provide numeric values to describe the physical and chemical conditions in a stream. In some instances there are established parameters for these values which indicate suitable conditions for aquatic life or where impairments exist. Ideally, these values would have been measured in mid-summer to detect any potential variable which could impact brook trout populations (primarily hot water temperatures or low dissolved oxygen values). Due to equipment availability, we were not able to acquire the equipment until later in the year so some of the measurements, mainly temperature and dissolved oxygen, are not as informative as if they were measured in the middle of summer. It would be helpful to make an effort to try to capture water quality values during the summer.

Fortunately, the water sampling results indicate conditions were suitable for brook trout survival on your property. All parameters measured were within suitable levels and we suspect most brook trout were able to find ample refuge during the extended season with minimal rainfall. Where state water quality standards exist, levels for dissolved oxygen indicate values consistent with Class A surface water quality. State guidance levels for conductivity and turbidity were also below levels indicative of impairment to water quality. The parameters we measured are summarized below. While pH values indicate a low to moderate impact, brook trout are somewhat tolerable of slightly acidic streams. Further investigations upstream may help determine if there is a point source that is impacting the pH or if it is a factor of the geologic and atmospheric conditions.

Dissolved oxygen (DO) is necessary for the survival and growth of aquatic organisms. The nexus between dissolved oxygen levels and aquatic ecosystems is so vital this value is one of the most regularly monitored metrics used to determine health and water quality. DO levels are reported in milligrams of oxygen gas per liter of water (mg/L) or the percentage of DO relative to complete saturation (100%) at a specific water temperature. Natural conditions and human activity can influence dissolved oxygen in a stream system. Dissolved oxygen is introduced into streams through the atmosphere and aquatic plant respiration. Streams with good flow rates, containing rapids and waterfalls allowing air to diffuse with the water often have suitable levels of oxygen for aquatic organisms. Water temperature can also influence the amount of dissolved oxygen present. Cooler temperatures support higher saturation of oxygen. As water temperatures warm, the ability to contain dissolved oxygen is reduced. In nutrient rich systems, aquatic plant and algal growth is promoted. Initially this may help increase dissolved oxygen as respiration occurs. Eventually, as the plants and algae begin to breakdown, dissolved oxygen will be lost to assist in this decomposition process. The condition is amplified when nutrients from stormwater runoff, fertilizers, and faulty septic systems are released into the aquatic system.

Brook trout require a high level of dissolved oxygen in the streams they inhabit. Their survival, growth, swimming speed, and reproduction are dependent on suitable levels of oxygen. The actual level of oxygen needed is dependent on water temperature. As stream temperatures warm, more dissolved oxygen is needed. In streams with a water temperature of 60°F (15°C), the dissolved oxygen concentration should not be less than 5mg/L with an optimal level of 7mg/L. In warmer streams, concentrations should be at least 9mg/L. In New Hampshire, water quality standards for dissolved oxygen are divided into Class A and Class B waters.

NH Surface Water Quality Standard Category	Minimum DO Level
Class A	6 mg/L
Class B	5 mg/L

Water temperature influences the reproductive and metabolic processes of aquatic organisms. Fish and macroinvertebrate species have their own specific water temperature preference ranges, explaining their presence (or absence) in a stream system. Temperatures are influenced by both natural and human induced conditions. Natural factors that influence water temperature include good water infusion and wetland influences. Streams that contain a constant supply of groundwater that was allowed to infiltrate the forest floor and enter the water table tend to have consistently cool temperatures. The recharge rate of ground water provides for ample flow during periods of limited rain. Streams influenced by natural wetlands are inclined to be warmer from solar radiation. Standing water in wetlands is exposed to the sun and warmed before flowing into streams. The rate of how these two natural influences affect stream water temperatures can be amplified by human actions. As more impervious surfaces (material that prevents rain to naturally infiltrate the ground) are installed along the landscape, more water is conveyed immediately to stream systems and prevented from infiltrating the ground. Wetlands made bigger in size by dams will increase the surface area of water that can be warmed by solar radiation. The removal of streamside forests by human activity will also expose streams to solar warming.

Brook trout have evolved to occupy streams which remain cool. In this condition, brook trout have the ability to be the dominate species. The metabolic rates of most other stream dwelling fish species favor warmer conditions to efficiently consume and convert forage into energy.

When stream temperatures are increased, these fish species can now begin to compete with brook trout for forage and space. Although the optimal range of temperature for brook trout is between 52°F (11°C) and 66°F (19°C), the species can tolerate warmer temperatures for short periods of time, provided there is suitable dissolved oxygen. While there is no numerical standard for water temperature in New Hampshire, the New Hampshire Department of Environmental Services is currently collecting fish and temperature information which will help develop an assessment tool to evaluate impacts to the biological integrity of a stream or river from modifications to water temperatures.

The acidity in water is measured by **pH**. This measurement is based on a scale from 0 to 14. A value of 7 is considered neutral (neither acidic nor alkaline), with values less than 7 increasing in acidic conditions and values greater than 7 increasing in alkaline conditions. These values are naturally influenced by geology, soils, and organic acids as well as through acid deposition and other human disturbances. Acid deposition is primarily a human caused consequence from the burning of fossil fuels and the release of sulfur dioxides (SO_2) and nitrogen oxides (NO_x) into the atmosphere. These compounds mix with moisture in the atmosphere and fall to the ground. The effect can be magnified when snowmelt occurs; providing an instantaneous release of acidic compounds into stream systems. Aquatic species have evolved to occupy habitats with specific pH ranges. When values are outside of preferred ranges, reproduction and growth are effected and physiological stress is increased. Reduced pH values can also release metals such as aluminum found in soils into streams, impacting brook trout development. The presence of nearby wetlands can influence pH values. Natural tannic and humic acids present in wetlands reduce pH values. Brook trout are considered to be fairly tolerant of low pH conditions. The optimal range of pH values for brook trout is 6.5-8.0 with a tolerance range of 4.0 to 9.5. State water quality standards for pH values in New Hampshire have been defined. These values are intended for areas without a wetland influence.

pH Units	Category
<5.0	High Impact
5.0 – 5.9	Moderate to High Impact
6.0 – 6.4	Normal; Low Impact
6.5 – 8.0	Normal
6.1 – 8.0	Satisfactory

Conductivity provides a numerical value to describe how water can carry electrical current by measuring the amount of charged particles (free ions) in a waterbody. Manganese and iron deposits from bedrock are examples of naturally occurring charged particles but this measurement also incorporates the presence of materials from human sources. Conductivity values increase when runoff from road salting, faulty septic systems and agricultural activities enter stream systems. Elevated levels of chlorides, introduced during winter maintenance, can be toxic to aquatic organisms, particularly freshwater plants and invertebrates. Introduced materials from faulty septic systems and agricultural runoff often contain materials which promote algal growth and eventual dissolved oxygen level reductions. In watersheds with a high percentage of impervious surfaces, stormwater runoff rates are expected to increase the amount of particles entering streams, subsequently elevating conductivity values.

New Hampshire does not have surface water quality standards for conductivity values. The state Consolidated Assessment and Listing Methodology (CALM) provides guidance to use conductance as a way to predict compliance for chloride and categories for potential impacts.

Specific Conductance (µS/cm)	Category
0 – 100	Normal
101 – 200	Low Impact
201 – 500	Moderate Impact
> 501	High Impact
>835	Exceeding chronic chloride standard

Turbidity measures the amount of suspended particles in water. These particles include clay, silt, algae, suspended sediment, and decaying plant material. Suspended particles absorb more heat in water, increasing water temperature while decreasing dissolved oxygen concentrations. Dissolved oxygen is further decreased when increased turbidity blocks sunlight and slows aquatic plant respiration. Increased turbidity can have lethal, sub lethal and/or behavioral impacts to brook trout populations. Suspended particles eventually falling to the streambed can impact fish eggs and macroinvertebrate populations. The material can also attach to the gills of fish, increasing the chance of diseases and reducing egg and larval development. For state enforcement purposes, if a discharge causes or contributes to the increase in turbidity of 10 NTUs or more above the turbidity of the receiving water upstream of the discharge, or otherwise outside of the visible discharge, a violation of the turbidity standard shall be deemed to have occurred.

An example of one of the 59 wild brook trout caught in the Unnamed Stream on your property.

Site Observations and Recommendations

Comments recorded at site: *This survey location had a very high density of eastern brook trout (n=59) and a small component of black nosed dace (n=13). The size classes were heavily weighted towards 2-3 inch fish (36) and 3-4 inch fish (17). Although other size classes were present, these two sizes accounted for the majority (89.8%) of the sample of brook trout. At the upper edge of our survey area was a 4 foot high log jam that has created a temporary barrier to fish movement. Eventually, this will wash out in a high water event. Undercut banks and several deep pools held many of the fish we sampled and comprises a significant habitat component. The remains of a collapsed log bridge are present. This bridge is not impeding aquatic organism passage and could be left in the water in lieu of any artificial wood additions. There is also evidence of a prior maple sugaring operation that has left many feet of tubing along the banks of the stream. This should be removed for both natural and visual benefits. Downstream of our survey location, the stream completely dries up and reappears 200 ft downstream. Along the southern edge of this area is a mowed field with no canopy adjacent to the stream. The disappearing stream probably is related to both the geology of the area but also having complete sun exposure for long periods of the day.*

This area held many trout as it provides a deep pool, undercut banks and gravel areas for spawning.

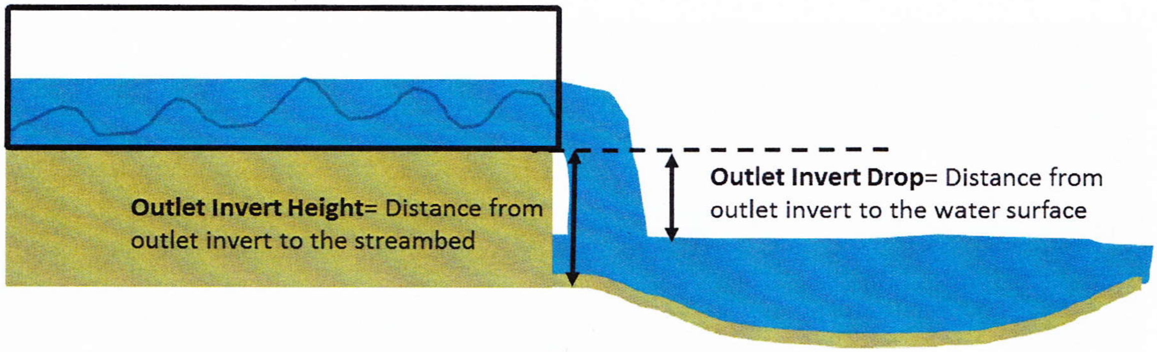
The primary concern noted during the site visit involves the southern (field side) riparian area of the brook. The desire to have views and open access is understood and appreciated. As more and more field is abandoned and reverts back to forests, we lose a component of habitat diversity. New Hampshire is currently around 87% forested, so losing field to forest can be seen as a real loss. Yet, in this particular location, allowing the riparian area to revegetate will address the direct sun the brook receives all day, the warming of the water and the disappearance of the stream completely for 200 feet. Reducing the mowing and increasing the forested cover in this area will increase the resiliency of the wild brook trout population. More mid-level bushes and shrubs will help maintain or enhance stream water temperatures by providing more shade. Although more of a long term strategy, by allowing the southern riparian area to revegetate with larger trees will eventually increase the amount of wood that falls into the brook. Wood that falls into a stream can help enhance stream characteristics and habitat by creating pools, trapping sediments and nutrients, promoting macroinvertebrate diversity, and providing overhead cover from predators. Larger wood material can help dissipate erosive flows by encouraging higher flows to the outside floodplains. Landowners may think that they are helping clean up a stream by removing woody material that falls in it. This is not the case. Any natural wood material (trees, sticks, even leaves) should be left to remain in streams because they provide several benefits. The Warner River Watershed Conservation Project would be happy to help install plantings and offer funding support to purchase the appropriate material. See contact

This area is "downstream" from our survey area and borders the open mowed field. Due to its southern orientation, it receives direct sun most of the day. Here is an example of where there's an opportunity to restore the riparian area along the southern side of your stream. This riparian area should be able to reestablish on its own but this process can be accelerated by planting natural vegetation. This area creates a barrier to fish movement, stopping fish in the wetlands downstream from accessing this cold water refuge during the warm summer months.

information on page 2 to reach out for support and guidance. More information about wood in streams can be found in the *Characteristics of a Healthy Stream* section in the appendix.

Important habitat features can be created by fallen wood. Here, high flow events have accumulated wood behind the birch tree (center background). This helps dissipate erosive energy by pushing flows into the flood plain. Although fish may have a difficult time moving upstream from this wood jam, this impact is temporary and will eventually shift during another high flow event.

When we observed a stream crossing (bridge or culvert) during a property assessment, we informally evaluated the crossing to determine if the structure was impacting fish movement or altering the aquatic habitat. The impacts associated with undersized stream crossings are some of the most common impacts observed throughout New Hampshire's landscape. When streams are forced to flow through a constriction (e.g. small culvert or bridge set on narrow abutments), sediments carried by flood flows are deposited upstream of the structure and erosion is increased downstream. Overtime, the increased downstream erosion rates from undersized culverts often result in the culvert to be elevated or perched above the stream channel. This makes it difficult for fish to move to areas upstream of the crossing and may prevent fish from accessing a preferred area to spawn or access areas with cooler water temperatures in the summer season. If something catastrophic (i.e. extreme drought, chemical spill, or some other impact to water quality) occurred above a perched culvert, it would be difficult for individuals downstream to move upstream and recolonize that area.



Overtime, the increase in downstream erosion rates resulting from undersized culverts can decrease the streambed elevation below the crossing. This leads to a hanging culvert and a waterfall with an outlet invert drop. Fish and other aquatic organisms have difficulty moving upstream in these situations. The outlet invert height should equal the streambed elevation in order to accommodate fish passage.

Although there were no culverts in our survey area, there is evidence of prior logging activity. This old log bridge has decayed and began to fall into the stream. It is not creating a barrier to fish movement and instead has benefitted the habitat by increasing the amount of large wood in the stream. These wood additions benefit the stream by slowing stream velocity upstream and depositing sediment, create habitat for macroinvertebrates and allows the stream to access the floodplain easier. Given the wood from the bridge is functioning as fallen trees, there is no immediate recommendation to remove this material.

Landowner Site Visit Summary Sheet
Property Owner: Bassi
Watershed Address: Upper Warner River Watershed
Mailing Address: 904 Mountain Rd
Date of Site Visit: July 17, 2017
Fish Species (and total number found): Wild Brook Trout (59), Blacknose Dace (13)
Macroinvertebrate Water Quality Score: 3.12 Category: Excellent Water Quality
Water Quality Results (November 27, 2017)

Lower Survey Location				
Dissolved Oxygen (mg/L)	Water Temperature °F (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)
9.0	39.02 (3.9)	5.43	16	0.86
Middle Survey Location				
Dissolved Oxygen (mg/L)	Water Temperature °F (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)
9.9	37.9 (3.3)	6.04	11	0.28
Upper Survey Location				
Dissolved Oxygen (mg/L)	Water Temperature °F (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)
9.7	38.3 (3.5)	6.16	11	0.19

Concerns with Water Quality Results: Conductivity and Turbidity meet or exceed state guidelines and standards. The pH levels are indicative of a low to moderate impact, potentially due to the natural geology or influence from an upland wetland. It would be helpful to retest the water quality of the stream to gain a more accurate snapshot of the most stressful time of year for brook trout, particularly for the dissolved oxygen and temperature metrics.

Final Recommendations: Curtail mowing of the lower field adjacent to the stream and allow the area to revegetate naturally. This direct sunlight has a significant effect on the disappearance of the stream as well as the temperature, movement barriers and connectivity of the stream. The old maple sugaring tubing could be removed from the stream and riparian area to improve the aesthetics of the stream.

Habitat Enhancement Opportunities: Allow for riparian area on southern side of stream to regrow. The time for the riparian area to become reestablished can be reduced by tree and bush planting. The stream may also respond well to instream wood additions. Contact the Warner River Watershed Project for assistance in wood addition projects and/or selecting the proper plants (for assistance in planting and paying for materials see contact information section on page 2).

Project Involvement: Sign up to participate in volunteer activities with the Warner River Watershed Conservation Project. These activities include fish, macroinvertebrate, and water quality monitoring, public engagement and outreach, and assisting with habitat restoration projects. Encourage your neighbors to sign up for property site visits.

Landowner Stewardship and Resources

The partners in the Warner River Watershed Project hope this summary report and the 2016 site visit help landowners feel an increased value for their property given it supports wild brook trout populations. We further hope landowners are now more aware of this value and better equipped to consider watershed health when making land use management decision on your property. Here are some general guidelines and resources to help protect your valued stream.

Guidelines

- **Conserving land from development around headwater streams** will allow for the natural processes which prevent flooding, maintain water quality, quantity, and temperature, recycle nutrients, and provide food and habitat at the source and downstream. Maintaining intact, undeveloped headwaters may also buffer the predicted higher temperatures and increased flooding and rainfall associated with climate change.

- **Incorporating headwater stream protection into town and regional planning** through conservation easements and zoning ordinances will have lasting benefits by conserving species, protecting water quality and preventing flood damage. Although the Warner River Watershed Conservation Project supports the belief that greater stewardship will result with the individual appreciation of supporting these fundamentals, and not because regulations exist, we encourage you to be attentive and vocal at community meetings about projects which could benefit or harm aquatic habitats.

- When possible, **keep development, permanent roads, and driveways at least 300 feet away from streams**. Suggested development buffers vary, but a minimum of 300 feet is commonly recommended for protecting wildlife habitat along stream corridors. The benefits of riparian buffers increase with their width.

- **Maintain pervious (permeable) surfaces on as much of the landscape as possible**. Natural ground is the best filter for storm water, but pervious pavement (as opposed to typical pavement) can reduce stream contamination from storm water in developed areas. Watersheds with as little as 4% of their land area in buildings and pavement have degraded headwater stream habitat.

- **Avoid the use of fertilizers or pesticides near any stream or wetland habitat**. Many pesticides are toxic to aquatic organisms. Excess nutrients from fertilizers pollute water by reducing oxygen levels, killing fish and other species.

- **Avoid culverts, drains or ditches which discharge storm water directly into streams**. Instead, apply designs which filter storm water into the ground, including porous pavement, gravel wetlands, or tree box filters. The UNH Stormwater Center is an excellent resource for the latest research in stormwater management.

- **Properly sized and installed stream crossings are critical for restoring or maintaining the function of streams of all sizes**. Before installing any stream crossing associated with development, consult the New Hampshire Stream Crossing Guidelines available from the UNH Stream & Wetland Restoration Institute and follow all NH wetland laws. For crossings associated with timber harvesting, see best management practice references below.

- **Timber harvesting around headwater and small streams should maintain enough shade and large trees** to maintain stream temperatures, filter run-off, and allow for woody material (dead and dying trees, leaves, branches) to naturally fall into streams. For headwater streams, buffers that maintain about 60% of the canopy in a zone as wide as the height of a mature tree (100 feet) are likely to maintain cold water temperatures and woody material in the stream. In larger streams, riparian buffers of 300 feet or more provide more effective wildlife travel corridors and habitat.
    - **Maintaining dead standing trees, overhanging vegetation and downed branches and trees** to provide moist cover and shade for wildlife and insects;
    - **Maintaining downed logs** in streams to enhance trout pool habitat;

- **Consult a licensed New Hampshire forester before conducting a timber harvest on your property**. Understand and follow all laws pertaining to tree harvesting near wetlands and waterbodies. Follow established best management practices, and harvest timber near headwater streams only when the soils are either frozen (winter) or very dry (summer).

- **Consult with the local Natural Resource Conservation Service (NRCS) field office to develop a conservation plan.** Private landowners may be eligible to participate in the Environmental Quality Incentive Program (EQIP). This program offers technical and planning assistance to design conservation practices that protect air, water, and soil health. Financial assistance may be available to support these efforts. Instream wood loading and riparian area revegetation are some of practices that may be supported through this program. Aside from aquatic habitat projects, landowner may learn about other opportunities to improve the terrestrial and landscape components of their properties. Members of the Warner River Watershed Conservation Project are looking for landowners willing to participate in this activity.

Resources

Forestry

- Good Forestry in the Granite State, 2nd edition (https://extension.unh.edu/goodforestry/index.htm)
- Best Management Practices for Forestry: Protecting NH's Water Quality, UNH Cooperative Extension (https://extension.unh.edu/resources/files/Resource000248_Rep267.pdf)
- Best Management Practices for Erosion Control on Timber Harvesting Operations in N.H (https://extension.unh.edu/resources/files/Resource000247_Rep266.pdf)

General Guidance

- My Healthy Stream, Trout Unlimited (http://www.tu.org/sites/default/files/My%20Healthy%20Stream_0.pdf)
- Headwater Streams, UNH Cooperative Extension (https://extension.unh.edu/Headwater-Streams)
- Living in Harmony with Streams: A Citizen's Handbook to How Streams Work (http://www.winooskiriver.org/images/userfiles/files/Stream%20Guide%201-25-2012%20FINAL.pdf)
- Wild Brook Trout Conservation Strategy, Eastern Brook Trout Joint Venture (http://easternbrooktrout.org/reports/ebtjv-conservation-strategy/view)

Stream Restoration/Enhancement

- NH Guidelines for Naturalized River Channel Design and Bank Stabilization (http://www.des.nh.gov/organization/commissioner/pip/publications/wd/documents/r-wd-06-37.pdf)
- Stream Restoration Design Handbook, Natural Resource Conservation Service (http://www.nae.usace.army.mil/Portals/74/docs/regulatory/NaturalizedRiver/NRCS_StreamRestoration.pdf)
- Guidelines for Wood Additions on First and Second Order Streams, Natural Resource Conservation Service (https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=stelprdb1081452&ext=pdf)

Stormwater Management and Flood Hazards

- Flood Hazards, Rivers and the Clean Water Act, VT Dept. of Environmental Conservation (http://www.nae.usace.army.mil/Portals/74/docs/regulatory/NaturalizedRiver/FloodHazards_CWA.pdf)
- New Hampshire Homeowner's Guide to Stormwater Management, NH Department of Environmental Services (http://soaknh.org/wp-content/uploads/2016/04/NH-Homeowner-Guide-2016.pdf)
- New Hampshire Stormwater Manual, NH Department of Environmental Services (https://www.des.nh.gov/organization/divisions/water/stormwater/manual.htm)

- Landscaping at the Water's Edge, UNH Cooperative Extension (https://extension.unh.edu/Landscaping-Waters-Edge-Publications)
- NH Soak Up the Rain, NH Department of Environmental Services (http://soaknh.org/)
- Manual of Best Management Practices (BMPs) for Agriculture in New Hampshire, NH Department of Agriculture (https://www.agriculture.nh.gov/publications-forms/documents/bmp-manual.pdf)

State Programs

- Shoreland Program, NH Department of Environmental Services (https://www.des.nh.gov/organization/divisions/water/wetlands/cspa/)
- Wetlands Bureau, NH Department of Environmental Services (https://www.des.nh.gov/organization/divisions/water/wetlands/)
- Rivers Management and Protection Program, NH Department of Environmental Services (https://www.des.nh.gov/organization/divisions/water/wmb/rivers/index.htm)
- 2015 Wildlife Life Action Plan, NH Fish and Game Department (http://www.wildlife.state.nh.us/wildlife/wap.html)
- 2015 Wildlife Life Action Plan Town Maps, NH Fish and Game Department (http://www.wildlife.state.nh.us/maps/wap.html)
- NH Natural Heritage Bureau, NH Division of Forests & Lands (http://www.nhdfl.org/about-forests-and-lands/bureaus/natural-heritage-bureau/)

Federal Programs

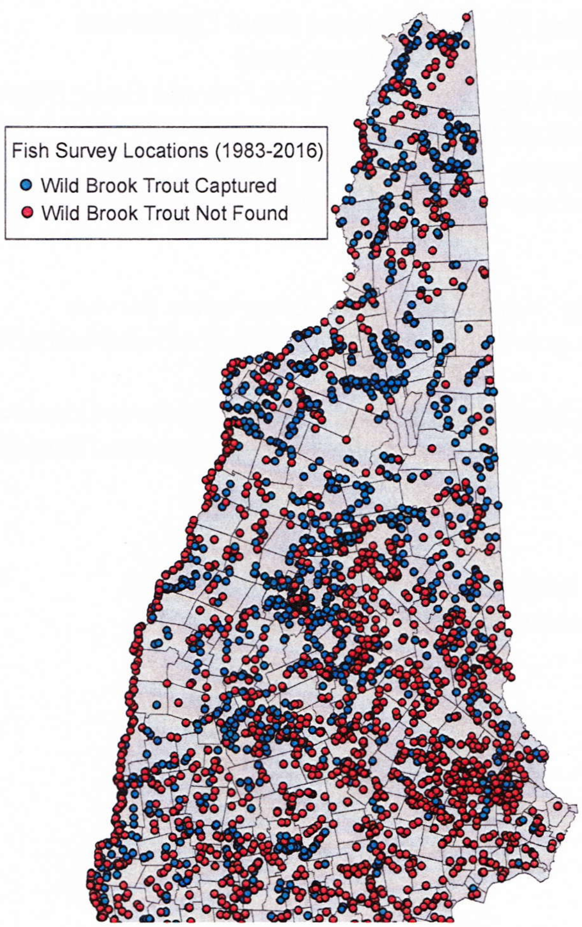
- Five Steps to Assistance, Natural Resource Conservation Service (https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/home/?cid=stelprdb1193811)
- Environmental Quality Incentives Program, Natural Resource Conservation Service (https://www.nrcs.usda.gov/wps/portal/nrcs/main/nh/programs/financial/eqip/)

These resources and more are available on our project website here.
(http://warnerriverwatershedconservationproject.wordpress.com)

Wild Brook Trout Ecology

Distribution

The native range of brook trout spans from Georgia to southeastern Canada and westward to some watersheds around the Great Lakes area. In New Hampshire wild brook trout are more common in the central and northern part of the state where air temperatures tend to be inherently cooler. Populations in southern New Hampshire are found in streams strongly influenced by ground water and springs. These southern populations tend to be isolated and likely have little interactions with populations from other areas, making them particularly vulnerable. If a catastrophic event occurred and the population was removed, the chance of the stream being recolonized is minimal. The Warner River Watershed is situated close to the northern-southern divide where brook trout are more common to the north and found less frequently to the south.



Wild brook trout distribution (based on fish surveys since 1983) throughout New Hampshire

Habitat Requirements

While brook trout can inhabit both flowing and ponded waters, they are more commonly associated with flowing riverine habitats in New Hampshire. These habitats must provide conditions with high dissolved oxygen and cool water temperatures. It is rare to observe brook trout in waters where summer water temperatures routinely exceed 70°F. In New Hampshire, brook trout are most commonly found in small to medium sized rivers and streams. While once found in larger river systems, their occurrence is now considered very rare. These systems now contain species which can out compete and prey upon brook trout. They lack either suitable temperatures or habitat variability for the species. Brook trout require a combination of different habitat types within rivers and streams. Preferred habitat types can change based on the age or size of the brook trout. Generally, a river or stream with a mixture of pools, riffles, and runs enhanced by undercut banks and fallen trees will support wild brook trout. Brook trout and other aquatic organisms benefit from a well-established riparian buffer where pollutants associated with stormwater runoff are filtered, the stream is shaded and cooled, high flows have access to floodplains (to help dissipate erosive flows), and mature trees can fall into the stream to enhance habitat features.

Life History

Brook trout are members of the Salmonidae family and the Salvelinus (or charr) subfamily, although they are more closely related to Arctic char and lake trout than they are to salmon. Their adaptation to streams with cool summer water temperatures makes them vulnerable to deforestation along streams and rivers which could increase water temperatures to intolerable levels. Brook trout are powerful swimmers and are often found in steep, cascading mountain streams where no other fish species are present. Though some individuals may live their entire lives in one small stream, radio-tagged brook trout in New Hampshire have been documented to move many miles in search of thermal refuge, spawning habitat, and foraging areas. They are a relatively short lived species, rarely exceeding 5 years of age in the wild.

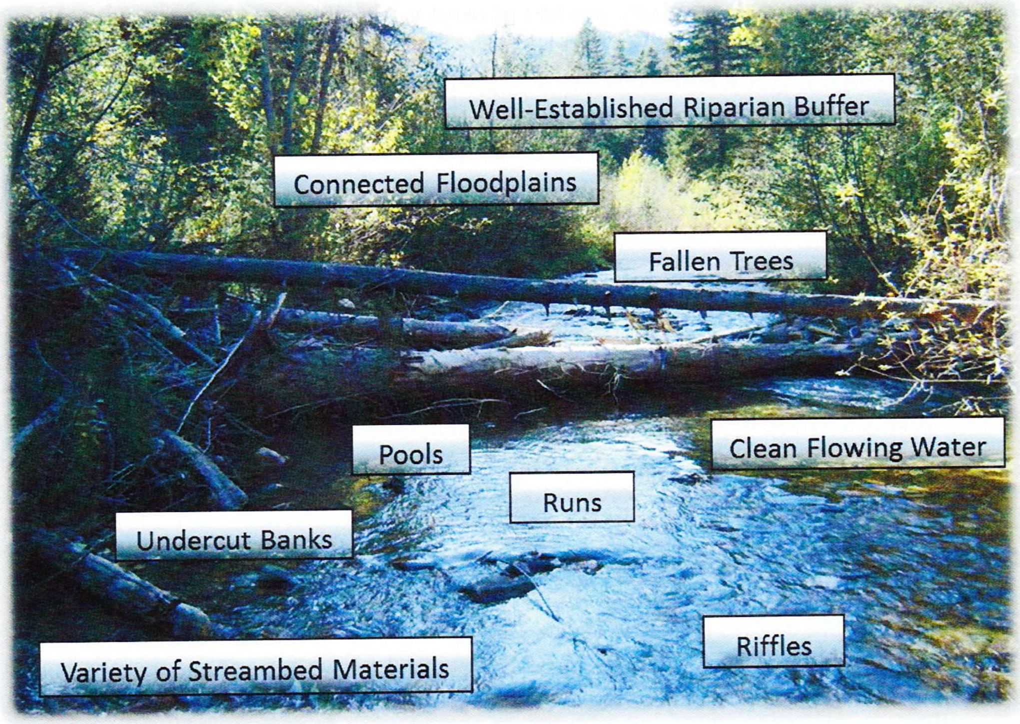
Brook trout are efficient predators, usually taking up residence in a pool where they feed on both aquatic and terrestrial invertebrates. Often, adult brook trout will feed in sections of faster flows where boulders and rocks break up the strength of the current. Young-of-the-year brook trout typically occupy stream edges where current is less strong but food sources are readily carried downstream to them. Brook trout feed on essentially all life stages (adult, nymph, larvae) of aquatic macroinvertebrates. Rivers and streams with high sedimentation rates can impact aquatic macroinvertebrates. Mayflies, caddisflies, stoneflies, and other aquatic macroinvertebrates develop and mature under rocks and gravel and within the spaces between them. Sand or silt can cover and embed these areas making it difficult for macroinvertebrates to survive. Terrestrial invertebrates, including beetles, caterpillars, spiders, and grasshoppers, provide a significant source of energy during the growing season, while fish and aquatic invertebrates become the main food source during winter. Well-established, overhanging trees and shrubs provide a steady source of terrestrial invertebrates that are consumed by brook trout as they fall into streams.

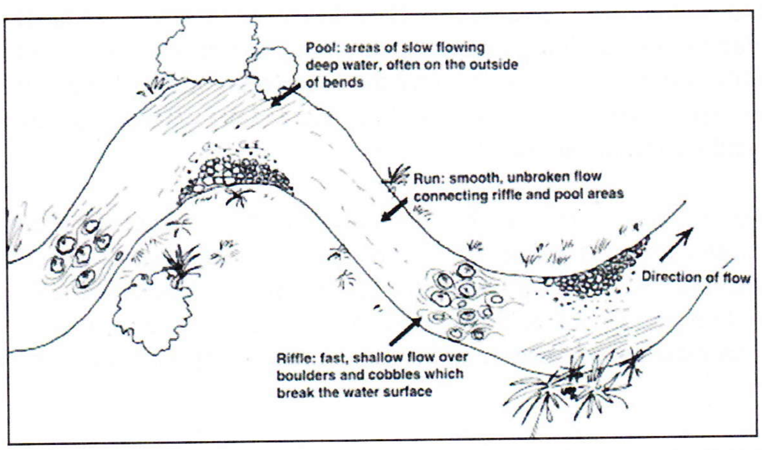
Reproduction

Brook trout seek out gravel beds with upwelling groundwater, often in small headwater streams, for spawning in the fall season. These areas tend not to freeze during the winter months. Female brook trout found in our streams can have between 100 and 400 eggs, depending on the size of the fish. Eggs are laid in small excavated nests in gravel, called redds, where they are then recovered by the female and incubate through the winter and hatch in the early spring. Excessive sedimentation from upland erosion and road runoff can embed or cover spawning substrates. This can reduce spawning success and recruitment rates.

Examples of Other Fish Species found with Brook Trout

Characteristics of a Healthy Stream





Two examples of stream habitat features which support healthy fish communities, including wild brook trout. These features provide habitat variety which accommodates multiple age classes that have unique habitat preferences. Streams with these components help maintain good water quality for aquatic ecosystems, human recreation, and drinking water supplies.

The presence of wild brook trout in a stream can be indicative of a healthy aquatic ecosystem. Wild brook trout have a complex life cycle requiring habitat variety, pristine water quality, and cool water temperatures in the summer. As brook trout grow and mature, their habitat preference can change. Beyond the presence of brook trout, there are several habitat features that promote good water quality and healthy aquatic ecosystems. The image above indicates micro habitats within a stream system which brook trout and other fish species occupy at different life stages. Wild brook trout are better supported in habitats with a variety of different features. Streams with one unique habitat feature can limit brook trout production. Streams lacking these beneficial features tend to be wide, shallow, and slow moving.

The Benefits of Riparian Areas

Riparian areas are those lands located next to a stream or waterbody. They are influenced by or they have an influence upon a stream or water body. Riparian areas support many different functions: removing sediment, phosphorus and nitrogen; stabilizing shorelines; reducing flood waters; moderating water temperatures; affording wildlife travel corridors; supporting in-stream and terrestrial habitat; and providing recreational opportunities.

Several features in riparian areas make them attractive to a wide diversity of wildlife. The stream course creates a natural opening in the forest, allowing sunlight to reach the ground. The greater warmth and light allows multiple layers of vegetation to develop along the shoreline. Mosses, lichens, ferns, and flowers take hold on the ground. A variety of shrubs, vines and trees create a layering of vegetation up to the forest canopy. This vertical diversity of vegetation supports a diversity of wildlife from salamanders, beetles, and weasels on the forest floor to songbirds, bats, and raptors in the over story. Riparian areas tend to have an abundance of cavity trees and woody debris. Dead, dying and downed woody material is important for many of New Hampshire's wildlife species. Bats roost under the loose bark of dying trees, while flycatchers, kingfishers, osprey, and other birds use snags along the water as feeding perches. Riparian areas are used by birds and mammals as travel corridors.

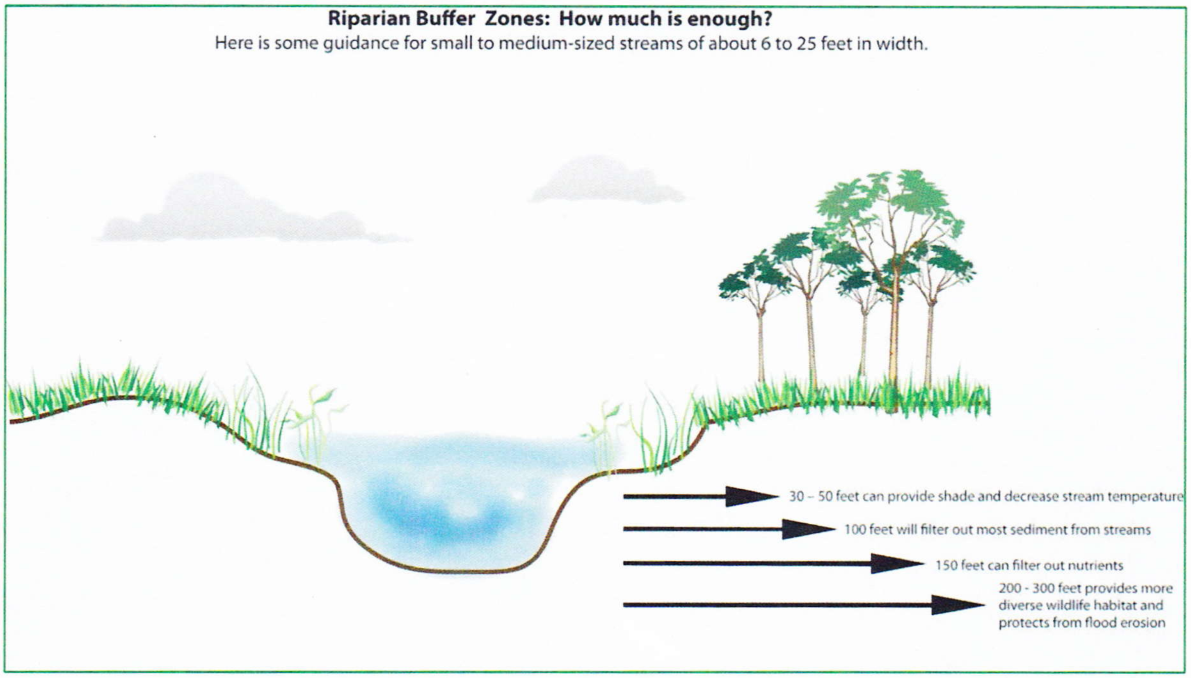
The presence of water adds diversity to the forested environment. Some species depend on both the forest and the water for food and shelter. Leaves, twigs, and other organic matter from streamside vegetation is a major food source for in-stream invertebrates, the foundation of the aquatic food web. The prevalence of fallen logs and cool shade creates a moist, micro-climate for salamanders. An established riparian area also creates the opportunity for trees to fall into rivers and streams.

The width of a riparian area depends, in part, on the functions and values being protected. A stream which serves as the headwaters of a drinking water supply may need a large buffer to protect water quality. Riparian area dimensions are also influenced by the unique site conditions such as stream size, soil type, bank slope, and associated vegetation.

To protect multiple values, including fish and wildlife habitat, riparian areas should encompass adjacent spring seeps, wetlands, riparian vegetation, and wet or highly erodible soils. Therefore riparian areas will vary in width up and down the length of a water body. Riparian areas should be large enough to protect the designated values and to maintain their ecological functions.

Forested buffers of 100 feet along a stream may be sufficient to protect water quality. Larger buffers are often required to maintain suitable habitat for invertebrates and fish (>100 feet) and birds and mammals (200-600 feet). These values represent the best case scenarios for buffer width. It is understood these ranges may not be obtainable in residential areas where existing houses and other structures are present.

The Warner River Watershed Conservation Project is happy to help support riparian area revegetation projects. We can supply both materials and volunteers to replant these areas. Please consider reaching out to us if you feel there's an opportunity for this type of restoration project on your property.



Riparian areas serve several beneficial functions. These functions increase as the riparian area widens. Source: Trout Unlimited's My Healthy Stream

The Benefits of Fallen Trees

As a consequence of stream encroachment from development and logging, riparian areas with a high percentage of older trees are not very common in New Hampshire. Trees permitted to reach mature size and then fall into rivers and streams provide unique features of stream habitat while performing several functions benefiting watershed health and function. Larger wood in rivers and streams enhances habitat by creating pools, trapping sediments and providing overhead cover for fish. Organic matter (leaves, sticks, pine needles, etc.) are collected in areas of wood, further increasing the protective cover for brook trout and other fish species. Wood present within and along streams also disperses erosive flows by forcing higher water into the floodplains.

Over time, as riparian areas are allowed to slowly regrow, trees will eventual fall back into our rivers and streams. To speed up this process, groups are cutting trees slightly away from the immediate riparian area and installing the wood material in appropriate areas. Subsequent fish community sampling after these projects indicate a positive response in both trout size and overall trout abundance. This type of activity requires a permit from the New Hampshire Department of Environmental Services. The Warner River Watershed Conservation Project is happy to support and facilitate this form of habitat enhancement on your property. We would selectively harvest trees in strategic locations and provide volunteers to maneuver the wood into position. Please consider reaching out to us if you feel there's an opportunity for this type of habitat enhancement project on your property.

Instream wood addition projects, such as this one performed in northern New Hampshire, provide habitat variety and protective cover for wild brook trout.

The Benefits of Microhabitats (Pools, riffles, runs, undercut banks, etc.)

Wild brook trout and other aquatic species benefit from areas that offer a variety in habitat types within a river and stream. Riffles, rapids, chutes, and falls help carry food to feeding fish and some macroinvertebrates while also increasing dissolved oxygen levels from aeration. Such areas help reduce the sedimentation of fine particles as the current conveys them further downstream. Undercut banks and overhanging vegetation provide ambush points and protective overhead cover from predators. Runs are typically areas with current but the water's surface is not agitated. These areas are often contain clean gravel used for spawning and are often occupied by juvenile trout. Pools are often preferred areas for larger brook trout and also provide areas of refuge during drought and winter conditions.

Threats to Brook Trout and Observed Impacts to Warner River Watershed Water Quality

It is rare a single action immediately reduces the condition of stream habitat and water quality. Usually, stream habitats and water quality degrade slowly and silently overtime as a result of multiple minor impacts throughout the watershed. Without active monitoring, degradation is difficult to recognize.

Survey crews have documented several alterations to the habitat and water quality within the Warner River Watershed. Alterations range from clearly visible current impacts, to historic land use practices which altered the landscape and its drainage for an incalculable period of time. Potential impacts to wild brook trout as well as to other fish species were recorded at every survey location.

Loss of Riparian Buffers

Locations along an unnamed wild brook trout stream (left) and the Lane River (right), both in Sutton where riparian areas have been removed. The natural stream bank stability, filtering ability and shading of a stream has been reduced. Boulders have been placed overtime along this location of the Lane River to prevent damage to the adjacent field.

The lack of riparian vegetation, as a result of logging, lawns or adjacent road and parking lot proximity, were some of the most routinely noted impacts recorded within the Lower Warner River and Lane River Watersheds. This impact is likely one of the most commonly noted threats to wild brook trout populations throughout New Hampshire. Impacts associated with erosion (scouring, sediment deposition, etc.) were routinely observed at these locations. Here it was common to observe finer materials (silt and sand) embedding larger substrate. This can have an impact on stream macroinvertebrate communities and brook trout spawning locations. Excessive sedimentation and the subsequent increase of substrate embeddedness can also lead to an increase in stream width and a decrease in depth. When a riparian buffer is removed, the cooling ability from shading can also be reduced. As a stream flows through a watershed, the accumulation of sun exposed areas may increase stream temperatures to a point undesirable for wild brook trout. Other commonly occurring observations noted were perched culverts, extensive stream bank armoring using riprap, stormwater drainage entering streams and litter.

Bank Stabilization

Bank armoring to protect impacts to shorelines often goes hand in hand with the lack of a well-established riparian buffer. When a vegetated riparian buffer is removed, the natural armoring ability found from rooted material is lost. The shorelines then become much more mobile and easier to move during higher flows. Often, heavy rock material is placed adjacent to or upstream of lawns, fields, crossing structures (culverts and bridges) and areas where streams flow close to roads. This armoring deflects erosive flows away from the shoreline protecting nearby areas from scouring. Unfortunately, armoring usually prevents the stream from accessing its floodplain where some erosive flow can be dissipated. Instead, erosive flow is passed further downstream to other shoreline areas. This impact can be amplified if armoring has resulted in a reduction of the stream channel width during flood flows.

Examples of shoreline bank armoring on Bartlett Brook in Warner (left) and Lion Brook (New London). During high flows, the stream is precluded from accessing its floodplain where the velocity of flows could be naturally reduced. Instead, erosive flows continue to downstream areas.

Adjacent Historical Land Uses

As with most of New Hampshire, much of the land within the area was cleared for cropland and livestock grazing. In as early as the 17th century, the water retaining ability of old growth forests with thick layers of moss and detritus was becoming altered by the hand of man. The once slow absorption of water from rain and snowmelt which kept water tables high throughout the year was replaced by readily drained plowed fields carrying sediment laden runoff to aquatic systems. It is likely these streams were afforded minimal riparian buffers. The loss of recharge to water tables caused stream flow rates to drop in the summer months. Countless streams were reconfigured to generate water powered mills, creating impoundments that resulted in warmer water temperatures and fragmentation of aquatic habitats. In streams where log drives occurred, channels were straightened and boulders were removed to facilitate the progression of logs moving downstream. Signs of these historical practices were observed at several of the surveyed locations. Stonewalls, barbed wire, and mill structures were frequently documented.

Although this section of Ballard Brook in Warner now flows through a well forested canopy, the stonewall present here is a telltale sign of the land around the brook once being cleared for agricultural purposes.

The impacts on aquatic systems associated with modern day activities can be very similar to those which occurred centuries ago. Increased concentrations of impervious surfaces prohibit rain and snowmelt to infiltrate soils and recharge ground waters. Instead, streams become flashy; significantly increasing in flow rate directly after storms or melting events and then quickly returning to low flow levels. These large flushes of high water can increase erosion and sedimentation rates on streams. Additionally, runoff from impervious surfaces can introduce quick bursts of nutrients, petroleum hydrocarbons, warmer water temperatures, sand, chlorides, etc., into aquatic systems. Even low percentages of impervious surfaces (as low as 4% of watersheds) can significantly influence the presence or absence of wild brook trout and other sensitive species. Stormwater drainage systems that convey runoff directly into streams were routinely observed during surveys within the watershed.

Stormwater drainage systems were often associated with road/stream crossings or areas where development left minimal riparian buffer. Drainage from impervious surfaces should be directed away from aquatic systems to reduce the negative impact on aquatic communities.

Drainages directed into Silver Brook at the Mink Hill Lane crossing in Warner. In some cases, runoff management as shown here may compromise the integrity of the stream crossing structure. Sediments scoured from the gravel road are carried directly into the stream. These types of drainages should be directed away from the stream to prevent channel widening and impacts to fish and macroinvertebrate communities associated with sedimentation.

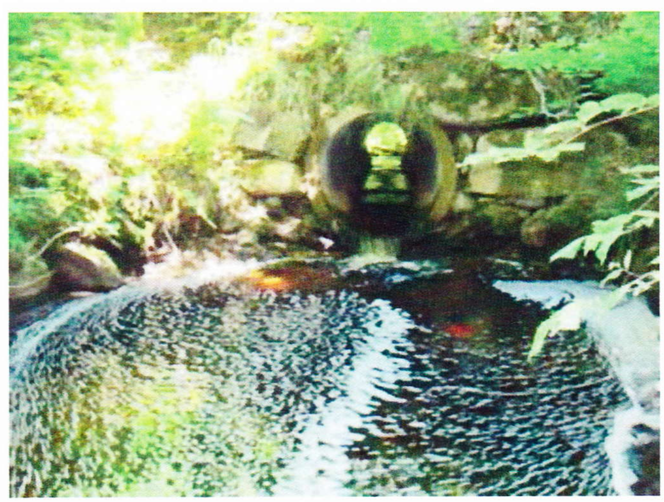
Road Stream Crossings

There is a wide variety in the condition and level of impact of stream crossing structures throughout the Warner River Watershed. The partners of the Warner River Watershed Conservation Project recently completed road stream crossing assessments on public roads throughout the watershed. Some crossings were inconceivably constructed of granite slab archways installed many decades, if not centuries ago and still appear to be in good condition. In some instances, stream crossings that were designed exclusively to accommodate the passage of water flow can alter stream habitat and aquatic communities. In addition to the ability for a crossing to facilitate the passage of a certain rate of flow (specified storm event), stream crossing design should also consider the specific geomorphic properties of the stream in question. Natural stream systems are in states of evolution or adjustment. Beyond water, streams are employed to convey organic (wood, leaves) and inorganic (sand) material. Several impacts related to crossing designs that do not incorporate the geomorphology of a stream include: culvert perching, scouring and sedimentation, blockage, undermining, road overtopping, and failure. Although the capital costs associated with a geomorphic design consideration are expected to be greater, it is expected costs related to maintenance and replacement would be far less.

The most suitable stream crossing for fish is one which does not exist. Road design should first consider ways to avoid streams. If a stream crossing is unavoidable, designs should attempt to make the crossing invisible to the stream. Flow rate, sediment transport, gradient, water temperature, and substrate should be identical within the crossing structure to the referenced condition of the stream. Impacts to fish communities and habitat result when the conditions become altered. Undersized culverts that constrict streams and increase flow rates (particularly during storm flow events) often create scour pools (or perching) at the culvert outlet. Over time, these can become barriers to fish movement. Such a scenario was observed at some of the surveyed locations. If a fish manages to access the culvert, flows may be too overwhelming for the fish to navigate through it. The creation of barriers can lead to wild brook trout not being able to access more desirable habitats for spawning, refuge from warm water temperatures, forage areas, etc. As a result, the population could dwindle or disappear.

Wild brook trout are not thought of as migratory fish and subsequently not often considered during road design. However, radio telemetry studies in New Hampshire have shown larger wild trout can move over 20 miles in a single year. When a population becomes isolated, concerns regarding gene flow are also present. If a catastrophic event (acid flush event from snowmelt, extreme drought year, large plumes of sediment) occurred upstream of an impassable barrier (i.e. dam, perched stream crossing) that decimates a wild brook trout population, fish may not be able to repopulate the area.

A watershed wide assessment of crossings was initiated in 2014 by the Basil W. Woods, Jr. Chapter of Trout Unlimited. A summary of surveys will soon be available for communities. Collected measurements at these crossings can be incorporated into scoring systems, which rank crossings according to failure vulnerability, impediment to fish movement, and level of impact on the stream's natural geomorphic process. This assessment is expected to be helpful to both towns within the watershed and the NH Department of Transportation to help prioritize crossing replacement. Conservation commissions, Trout Unlimited chapters, and the NH Fish and Game Department can also use this information in concert with existing fish survey data to help prioritize restoration actions.



Examples of undersized culverts on Kings Brook at Poor Farm Rd in Sutton (left) and an unnamed stream at Basin Hill Rd in Warner (right). Crossings not designed with the accommodation of fish passage and sediment conveyance make it difficult for fish to access more desirable habitats, increase erosion and sedimentation rates, and have an increased likelihood of failing.