

Restoring Salmonid Aquatic/Riparian Habitat: A Strategic Plan for the Downeast Maine DPS Rivers



“We must be more than careful stewards of the land; we must be constant catalysts for positive change.”

Gifford Pinchot.



Project SHARE



USFWS
Maine Fisheries Resource Office

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Mission Statement

The central purpose and role of Project SHARE is:
To conserve and protect Atlantic salmon habitat in the Machias, East Machias, Pleasant, Narraguagus, and Dennys rivers. This is based on the premise of voluntary participation by area landowners, businesses, as well as local state and federal government, academia, conservation organizations, research and educational interests and any other entity that will enhance the healthy functioning of these riverine ecosystems.

The mission of the U.S. Fish and Wildlife is:
Working with others to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people

Funding for this document was provided by a
Cooperative Conservation Partnership Initiative Grant from
the USDA Natural Resources Conservation Service

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EXECUTIVE SUMMARY

This strategic plan present an approach to restoring salmonid habitat through restoration of stream processes at the sub-watershed scale rather than addressing site specific symptoms of habitat degradation. Our approach is holistic based on the understanding that healthy fish stocks require healthy watersheds. The plan recognizes restoration efforts must take private land ownership and limited resources into account. Selection of high priority focus area recognizes and takes advantage the work of others who created the Machias Corridor project, a permanent conservation easement of riparian areas within the Machias River watershed.

Since 2001 Project SHARE (Salmon Habitat and River Enhancement) has organized aquatic habitat restoration work intended to improve Atlantic salmon populations in the Downeast Distinct Population Segment (DPS) rivers. Initial activities were site specific and limited in scope due to technical ability, capacity, and authority (regulatory permission). Throughout this time, the scale scope and technical complexity of restoration activities have increased. The overreaching goal of the restoration strategy is to improve aquatic and riparian habitat conditions on a watershed scale. The restoration thought process is based on identification of degradation and correction of stream process rather than technical modifications of a site-specific reach to achieve short-term habitat improvements. Assessment of the Downeast DPS rivers suggest that there is no single large-scale site or restoration activity that can account for current declines in fresh-water life stages of Atlantic salmon. Recognition that stream process begins in small headwater streams that influence the entire downstream water course provides the basis for a top-down approach. Therefore, the restoration strategy intends to identify and address multiple habitat threats at many relatively small restoration sites on a watershed scale.

The framework of the Restoration Strategy established an ecosystem approach to holistically restore stream processes. Working within the context of SHARE's mission and authority, specific goals are to increase watershed connectivity (including fish passage), increase instream habitat complexity, decrease anthropogenic sedimentation inputs, and mitigate anthropogenic changes in water chemistry (pH, temperature). The target species are Atlantic salmon (federally endangered) and Eastern brook trout. Identification of high priority sub-watersheds and threats assessment within selected focus areas allows limited resources to be focused in a manner that improves the potential for long-term success and benefit to the resource.

SHARE's capacity, technical abilities, and therefore ability to accomplish restoration goals comes from the cooperation and involvement of member entities. Collaboration has led to increased capacity, funding and technical expertise. The strategy includes educating land use managers, organizing and focusing limited resources to improve aquatic/riparian habitat conditions region-wide, while aggressively and progressively completing most-needed restoration work in high priority watersheds.

INTRODUCTION

Salmonids have evolved over thousands of years and have adapted to local freshwater conditions that are naturally dynamic. Land use changes and anthropogenic modifications to streams have led to decreased watershed connectivity and instream freshwater habitat decline. Some of these changes, although not readily apparent, are the result of historic impacts dating back to the late 1700 and early 1800's. The construction of dams and roads in particular has been identified as principle threats to salmon recovery. As linear systems, rivers and streams are vulnerable to fragmentation. While it is generally recognized that dams and culverts can present barriers to both upstream and downstream fish passage, less obvious disruptions of the continuum of stream ecological processes have not reached a similar level of mainstream awareness among land-use planners, regulators, and conservation groups. Stream process continuity in the form of an altered hydrograph and downstream nutrient, sediment, woody debris and water chemistry transport is similarly vulnerable to disruptions from land-use infrastructure that does not take stream ecological function into account. On a broader scale, Maine and the Downeast salmon rivers are subject to the downwind effects of air pollution and acid rain. Global warming presents a threat to cold water fishes such as Atlantic salmon in watersheds near the southern extent of their range. While a local restoration effort may not be able to address all anthropogenic habitat threats, a holistic watershed approach that is process driven benefits from understanding and taking into account multiple stressors.



Figure 1. Non-point source sedimentation in the Machias River watershed.

Project SHARE was founded in 1994 through the efforts of concerned landowners, salmon anglers, businesses and various government agencies. SHARE's mission centers on cooperatively protecting and enhancing coldwater salmonid habitat at the landscape scale. Beginning in 2001 SHARE has developed an in-house habitat restoration program focusing restoration efforts in the Downeast Region of Maine, particularly the Machias River watershed and corridor. Within high priority subbasins for both Federally-endangered salmon and native Eastern brook trout, specific sites have been prioritized for restoration based on proximity to

mapped salmonid habitat and in collaboration with state and federal agencies. In cooperation with its partners, SHARE identifies threats to habitat connectivity and function and opportunities to restore coldwater refugia and rearing habitat within the current focus area. Subsequently, SHARE carries out cooperative on-the-ground projects that remove those threats and/or restore connectivity and natural stream function.

To date, SHARE's restoration projects have: 1) corrected stream crossings currently hindering movement of resident native brook trout and blocking Atlantic salmon parr from accessing historically-available rearing habitat and coldwater refugia, 2) restored connectivity in tributaries to mainstems containing mapped Atlantic salmon habitat, 3) reestablished bank-full, natural bottom channels at each crossing to restore natural gradient and flow, temperature and sediment regimes, 4) promoted innovative and cost-effective solutions for the landowner related to decreasing road maintenance costs while at the same time improving aquatic habitat for Maine's unique salmonids. Most recently, in collaboration with state and federal agency partners, SHARE is documenting and assessing the impacts of historic and remnant log drive structures that persist as hydrologic checks in the rivers and streams. Pilot projects are underway to enhance pH related water chemistry with terrestrial additions of limestone and instream additions of clam shells.



Figure 2. Stream connectivity restored at road/stream crossing by replacing traditional round culvert with open-bottom arch culvert.

SHARE is presently working on a suite of habitat restoration, fish passage improvement, and stream connectivity projects in the five “Downeast” Atlantic salmon rivers listed under the Endangered Species Act. These projects require an interdisciplinary approach, involving issues in the ecology and management of river systems for migratory diadromous fish and native freshwater organisms co-existing with traditional commercial and recreational land use practices. Given the constraints of limited funding and technical capacity, it is essential that SHARE focuses resources in a cost-effective manner that increases the potential for long-term success of aquatic/riparian habitat restoration activities.

VISION AND OBJECTIVES

The overarching goal of this initiative is to improve riparian and aquatic habitat conditions and natural stream processes in the five Downeast Atlantic salmon DPS watersheds focusing on cold-water salmonids as the target species.

Principle actions that are required to accomplish this goal are:

1. Promoting broad-scale maintenance/recovery of watershed and habitat conditions (Passive Restoration),
2. Completing restoration of priority sub-watersheds (Active Restoration), and
3. Organizing and focusing limited resources to improve aquatic/riparian habitat and watershed condition region-wide, while aggressively and progressively completing most-needed restoration work in high priority watersheds.

Five objectives provide an overall framework for restoration activities:

1. Identify the most biologically beneficial improvements,
2. Identify high priority focus areas where restoration efforts have the greatest potential for long-term biological success,
3. Restore natural processes in a holistic watershed context rather than correcting site-specific symptoms,
4. Account for spatial and temporal habitat needs related to life history requirements of the target species, and
5. Increase rate for completion of high priority restoration in priority sub-watersheds.

Initiative Strategies:

1. Relate watershed restoration to critical or essential habitat of endangered Atlantic salmon and Eastern brook trout,
2. Provide a more consistent process for prioritizing and focusing work,
3. Increase technical/operational capacity for completion of aquatic habitat restoration in the DPS by:
 - a. Maintaining existing and expanding partner involvement,
 - b. Diversify funds sources and leverage funding.
4. Incorporate an educational/outreach component to increase stakeholder awareness of positive and negative impacts that land-use activities have on aquatic/riparian habitat.

The decision making steps associated with on-the-ground implementation of restoration activities are presented with the example of restoring ecological function at road/stream crossings in Figure 3.

Strategic Plan Flowchart for Road/Stream Crossings

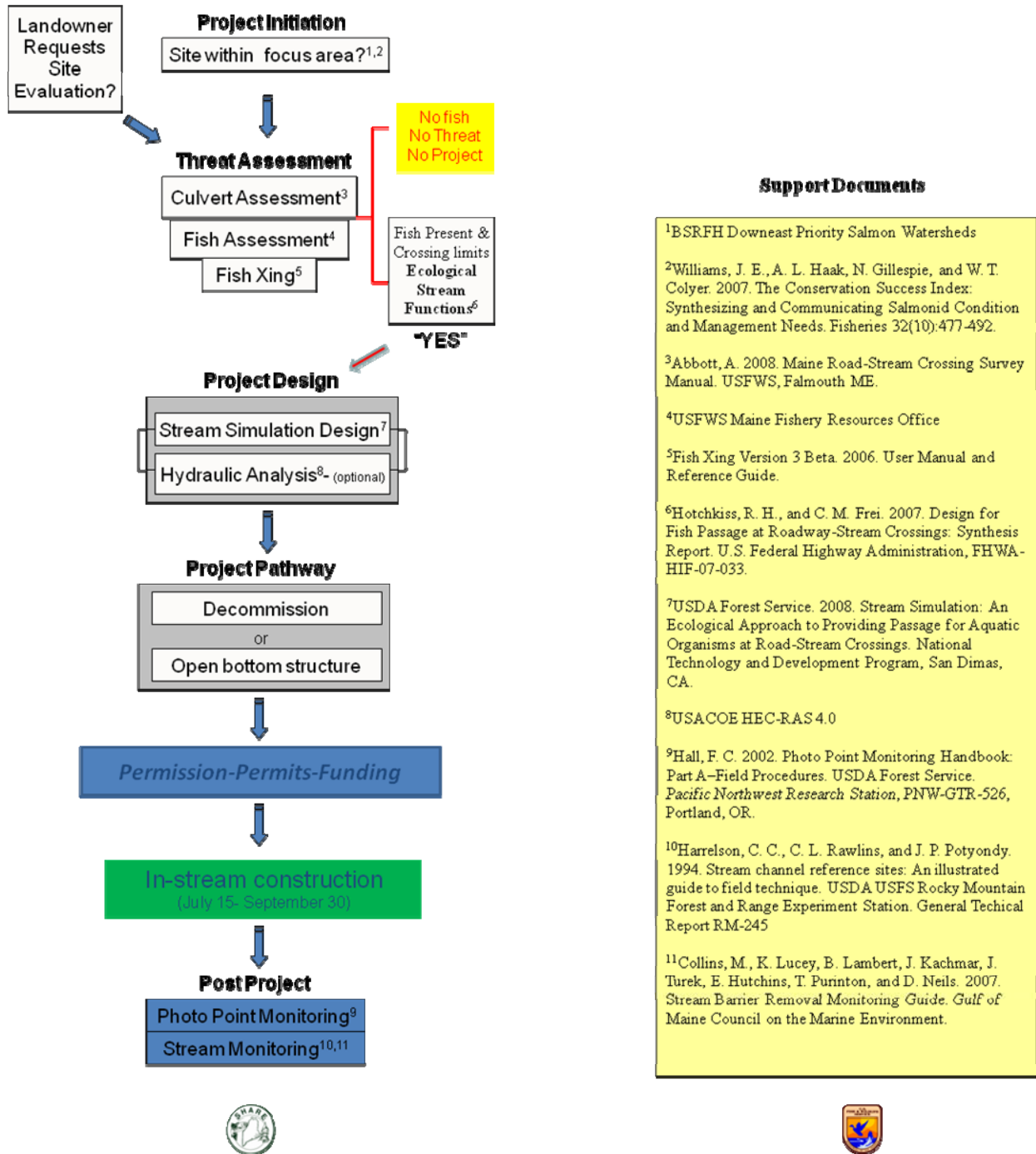


Figure 3. Flowchart for decision making stages for restoration road/stream crossings.

TARGET SPECIES

The primary focus of Project SHARE's restoration program is to support recovery of the Gulf of Maine DPS of Atlantic salmon, listed as endangered under the Endangered Species Act (ESA) and eastern brook trout, a native species identified in steep decline throughout its range by the Eastern Brook Trout Joint Venture.



Figure 4. Salmonid yoy residing in restored stream channel.

Additional diadromous species and native aquatic species will also benefit from improved stream connectivity and habitat conditions. Other native fishes identified within the targeted focus areas include: American eel (diadromous), red breast sunfish, black nose dace, brown bullhead, creek chub, common shiner, banded killifish, nine-spine stickleback, fine scaled dace, northern red bellied dace, and white sucker. The watersheds also contain several introduced species including: golden shiner, chain pickerel, yellow perch, and small mouth bass. While process-based restoration decisions are intended to specifically benefit and enhance target species, decisions should take into account impacts to the entire community structure including the potential of using improvements to cold-water riverine habitats as a means of controlling non-native introduced warm-water species.

DESCRIPTION OF WATERSHEDS

The geographic focus of Project SHARE's restoration activity as delineated in SHARE's mission statement is the five Downeast Atlantic salmon DPS watersheds which are located in Washington and Hancock Counties, Maine. The watersheds include the Dennys, East Machias, Machias, Pleasant, and Narraguagus Rivers. Detailed summaries of watershed attributes are available from the Old ASC booklet reports- (Baum and Beland 1982, Baum et al. 1982, Beland et al. 1982, Fletcher et al. 1982). The following are representative excerpts of specific relevance to this strategic plan.

Machias River

There are no natural obstructions on the Machias River of sufficient magnitude to prevent the migration of various species of fish at all times. The natural falls at the head of tide in Machias are a deterrent to fish movement during high spring flows. Alewives and an occasional shad are known to migrate through the Machias gorge. As the remains of former dams deteriorate, passage should improve. The lowermost dam at the head of Machias gorge was breached by ice and spring freshets in 1970. Fish passage to the river above the gorge is now provided via the west channel. The center channel, location of the now unused fishway, provides passage at some water levels. In 1973, the base of the roadway leading to the upper end of Joe's Island was washed out, dewatering the flowage behind the Whitneyville dam. The roadway crossing the Whitneyville canal was not replaced and the St. Regis Paper Company, as owner, removed the Whitneyville dam. Long-range plans indicate little need for other dams in the drainage. The company breached or removed dams and water control devices at the Third and Fourth Machias Lakes, Sabao Lake, and the First Chain Lake during 1974. At the present time the river is obstruction-free (for the first time since 1842).

The Machias River watershed is essentially a clean, unpolluted river system. Only in the lower five miles of the river will domestic sewage be found. The interceptor sewer system and waste water treatment plant in Machias has been in operation since August 1, 1974 and the treated waters from this activated sludge, secondary treatment plant have greatly improved the water quality of the estuary and freshwater sections of the lower river. The Maine Department of Environmental Protection, Augusta, Maine, should be consulted regarding published records and classification of the waters of the Machias River drainage. The present statutory classification reflects conditions prior to the activation of the above treatment system. The pristine Class A waters of the river and tributaries above Whitneyville, and the Class B2 waters from the Whitneyville dam site downstream to the site of the former Harwood Dam in Machias remain unchanged. However, the Class C waters from Harwood Dam to the head of tide and the Class SC tidewaters of the town of Machias may warrant upgrading. The ten-acre bark dump at Whitneyville, a product of pulp debarking between 1949 and 1969, undoubtedly continues to alter the chemistry of the waters in the lower river through the leaching of tannin and lignin products and is in part responsible for the Class B2 rating below the Whitneyville dam site.

Intensive forest practices, particularly log skidding and bulldozing of clear cut tracts, has created siltation problems at times. Responsible forest management rather than regulations is the practical preventative measure for siltation. Various insecticide, herbicide and preservative chemicals used in forest management, agricultural activities, highway and utility right-of-way clearing, and bridge and utility pole timber treatment, may pose problems as pollutants should they reach the waters of the Machias River system. Responsible application is the only assurance that toxic chemicals will not become harmful additives. The rapid permeability of the sands and gravels of the watershed barrens and adjacent forested areas can allow rapid entry of forest and agricultural spray residues into the rivers and streams of the area. Upon reaching the water, these residues may cause mortality or problems of physiological stress to aquatic organisms.

East Machias River

The first upstream dam (was) is a potential problem, where flow regulating gates were once used to vent discharges in excess of the capacity of a downriver hydro-electric generating station. While the plant has been dismantled the gates are operable and could be used to obstruct river flows. This facility is owned and operated by the town of East Machias through the Board of Selectmen's authorization to the town's Fish Committee. The town of East Machias also owns the dam at the outlet of Gardner Lake. In 1976, two obstructions formerly used to control the lake level and outflow were removed or altered to insure accessibility of the lake area to all species of fish attempting to move into the lake from the outlet, Chase's Mill Stream. A Denil fish-way was constructed by the Maine Department of Marine Resources (MDMR) on the right bank of the uppermost obstruction. The breaching of the abandoned dam below the bridge makes Gardner Lake completely accessible for the first time in a quarter-century. Although the fish-way was constructed primarily for enhancement of the commercial anadromous alewife fishery, the fish passage facility also accommodates other resident and anadromous fish species. The owner of the dam is responsible for the manipulation of Gardner Lake water levels through removal or installation of dam-boards in the outlet dam. Coordinating drawdown rates with inflow, evaporation, rainfall, and other factors can be complex. However, maintenance of a stable lake level and insuring an acceptable and continuous outflow will be expected of the owner by shoreline property owners, boating enthusiasts, and anglers. Regulated flows through the fish-way will insure a minimum flow into Chase's Mill Stream while preventing excess lake drawdown. Any discharge, except emergency and high lake level venting via outlets other than Chase's Mill Stream, may conflict with lake level stabilization and fish migration.

The Maine Department of Inland Fisheries and Wildlife (MDIFW) maintains a water control dam at the outlet of Crawford Lake to stabilize lake levels. Maintenance of this flowage is part of the Wildlife Division's waterfowl management program. A fish-way provides passage for fish over the structure as well as insuring a minimum metered outflow to the river during periods when the lake level is below spillway height. Deterioration of the fish-way may require dismantling or breaching of the dam should the MDIFW discontinue maintenance. A water control dam and fish-way constructed for the MDIFW at the outlet of 280-acre Barrows Lake in 1965 continues to regulate stream flow below Barrows Lake. This abandoned structure is deteriorating rapidly and the fish-way is inoperative. The structure is not considered to be a significant factor in the management of the drainage's fisheries and neither removal nor repair is warranted.

Specific measurements or studies of water chemistry in the East Machias River have not been made. Measurements of pH, color, turbidity, and dissolved oxygen determinations have been made routinely during surveys of the lakes of the drainage. Similar observations on water quality of this stream and those in adjoining watersheds are lacking. However, the waters of the East Machias are normally discolored by organic materials from the extensive low lands and swamp-bordered lakes common to the drainage. The pH is expected to be acidic and within the range common to the coastal sections of eastern Maine. High summer water temperatures are a limiting factor in salmonid management for the drainage. A recording thermometer at Northern Stream, the outlet of Love Lake, has recorded water temperatures as high as 84 °F. The main river water temperatures are an important factor in the success of the widely distributed warmwater game species.

Narraguagus River

At one time the Narraguagus River was obstructed by numerous dams used to control river flow for the operation of mills and the transportation of logs. There were five dams within one mile of tidewater as early as 1874. In the spring of 1942 heavy ice jams swept away the three remaining wooden dams in Cherryfield, and the salmon runs commenced to improve rapidly (Rounsefell and Bond 1949). The last impassable dam was breached in 1951. Today there are two man-made obstructions in the Narraguagus River watershed and both are equipped with Denil fish-ways. Stillwater Dam was constructed in 1961 by the U.S. Army Corps of Engineers as a means of flood control in Cherryfield. The dam is unique in that it was designed to reduce flood damage through the control of ice rather than water. Although most fish utilize the fish-way at this dam, Atlantic salmon have been observed swimming over the sloping spillway at certain water levels. A structure, Bog Brook Dam, to control the headwaters of a small tributary to the East Branch of the Narraguagus River was completed in 1969. This dam created a flowage of 565 acres and was funded through a legislative appropriation and the Federal Government through the Anadromous Fisheries Act of 1965, at a total cost of \$43,000. A metered flow of 10 c.f.s. through the fish-way was designed to benefit salmon spawning and nursery areas of the Narraguagus River below Beddington. In addition, the flowage is used by spawning alewives and nesting waterfowl. Another water control structure was completed in 1970 at the outlet of Narraguagus Lake. Like the Bog Brook structure, this dam was designed to provide an additional 10 c.f.s. to salmon spawning and nursery areas in Spring River and the West Branch of the Narraguagus River. The \$22,000 expended to construct this dam was provided by a legislative appropriation matched by the Federal Government through the Dingell-Johnson Act. The continued cost of maintenance and repairs to this structure could not be justified; therefore, the Narraguagus Lake dam was removed during the summer of 1981.

Pollution from domestic sewage sources is not a significant problem to the aquatic life in the Narraguagus River. The waters of the mainstem and West Branch of the Narraguagus River are classified as Class A by the State of Maine (M.R.S.A. Title 38, Chapter 3). From the confluence of the main stem and West Branch to the railroad bridge in Cherryfield the river is Class B1, while from the railroad bridge to tidewater it is Class B2. The tidewater section of the river in the town of Cherryfield is Class SC. Limited water quality data for the Narraguagus River has been published by Taylor (1973).

Pleasant River

The entire length of the main stem Pleasant River is available to most anadromous fish species for migration, spawning, and rearing of juveniles. The newest and lowermost obstruction, a hydro-electric redevelopment project at the Old Hathaway Dam site in Columbia Falls has since been removed. At Saco Falls in Columbia, a bypass channel and Denil fish-way were constructed in 1955 to improve fish passage around this natural obstruction. A few years later, further improvements were made to the upper section of the bypass channel when V-notch weirs were constructed to slow and deepen the flow of water. The remains of the Saco Dam are found a few hundred yards upstream, but it is not a barrier to migration. The Pleasant River Lake dam is the furthest upstream obstruction on the river. A Denil fish-way provided fish passage into the lake. In recent years, this dam and fish-way have deteriorated such that the fish-way is no longer functional and both structures are currently in need of repair. In addition, a great deal of difficulty has been encountered in utilizing this dam for water control for the river because of vandalism and destruction.

Beaver dams are frequently found on the Pleasant River and its tributaries. As obstructions to migration, they are only partial and are of short-term duration as they usually wash out with the spring runoff. However, these dams frequently inundate salmonid spawning and nursery areas, temporarily changing the habitat from riffles to pools and reducing production. Since 1975, the Salmon Commission has requested and received approval to keep townships along the Pleasant River open to beaver trapping each winter. North Branch Stream is the only tributary to the Pleasant River having a significant natural obstruction. A 12-foot vertical ledge falls, a complete obstruction to salmon migration, is located one-tenth of a mile upstream from its confluence with the river in the town of Columbia. There is a small amount of spawning and nursery area above the falls.

Point source pollutants in the Pleasant River are considered to be minimal. Domestic pollution is present in minor quantities that have little harmful effects on aquatic life. The waters of the Pleasant River are classified as Class B1 from Pleasant River Lake downstream (except for a 1,000 foot stretch above tidewater as Class B2) and Class SC in tidal waters in the town of Columbia Falls (M.R.S.A., Title 38, Chapter 3). Agricultural sprays, used mainly on blueberry crops, constitute a pollutant of undetermined magnitude. Herbicides are also used along highway right-of-ways by the Maine Department of Transportation and other private landowners.

Dennys River

All natural and man-made obstructions in the Dennys River drainage, except two, have been made passable to migratory fishes. The two exceptions are on tributaries of Lake Meddybemps. At some unknown time, a 600-foot rock and gravel-fill rockwall, with remnants indicating an original width of 16 feet, was erected at the north end of Lake Meddybemps. This structure in Baileyville effectively retains Lake Meddybemps water, preventing their outflow into the channel of Stony Brook, which flows easterly into the St. Croix River. One must surmise that the rockwall was placed to prevent waters from entering Stony Brook in order to maintain the level

of the lake and outflow at Meddybemps, and may have been erected by individuals owning the flowage rights prior to the 1800's. A natural falls on Sixteenth Stream, below Pleasant Lake in Alexander, effectively prevents the upstream migration of most fish species.

A nature falls on Cathance Stream below the Marion Road has been bypassed through the construction of a small 48-foot Denil fishway that permits fish to migrate upstream around the 9-foot ledge obstruction. This fishway was built in 1962. A water control dam and a fishway was constructed at the outlet of Cathance Lake in 1961 and has been maintained and operated by the Salmon Commission to the present time. The 40-foot long Denil fishway at the center of a 90-foot wide spillway has served its purpose. Designed to provide a constant outflow from the lake and to stabilize the lake level, it permits the unimpeded migration of fish over the 5-foot vertical barrier.

Between 1947 and 1973, the water rights at the outlet of Lake Meddybemps were exercised in the operation of a hydro-electric generating facility immediately above the Route 191 bridge at Meddybemps. During this period fish were obstructed in their upstream movement, and subjected to prolonged periods of dewatering. Although there was a sufficient amount of stored water available, it was common practice for the facility to be operated for a few hours during the evening peak demand period, and then to be completely shut down for the remainder of the day. Once the operating "head" was used, the facility was completely inactivated, the dam was closed for the season, and the river remained dewatered for prolonged periods. The purchase of the existing water rights and the construction of a water control dam and Denil fish-way at the outlet of Meddybemps Lake in 1973-74 has done much to stabilize the levels of the lake and provide storage for metered flows to alleviate the nemesis of low water on the Dennys River.

Prior to 1958, the remains of a rock-filled, low crib-dam and debris above the Route 86 bridge over Cathance Stream in Marion constituted a total obstruction to fish movement. The St. Regis Paper Company caused the debris to be moved aside, opening a channel in the stream bed. During the summer of 1963, the 4-foot ledge, exposed because of the dam's removal, was dynamited to lessen the obstruction to alewife migrations. Additional work over a period of years now assures unobstructed movement of all migratory species at normal water levels experienced during migration periods. The MDIFW, Wildlife Division, maintains a water-level control structure at Great Works Wildlife Management Area in Edmunds. This flowage is maintained by an 8-foot high roll dam which has an overflow type fish-way. While the remains of former dams on Cathance Stream and the main stem of the Dennys are still visible, they present no problem to fish passage. The last such obstacle to fish passage on the Dennys River was removed by dynamiting in 1930 (Goodwin 1942).

The Dennys River drainage is a relatively unpolluted, almost pristine, fluvial environment. Under the standards established by Maine Statutes, the waters of the drainage above the Route 1 bridge between Dennysville and Edmunds are Class A. Downstream the waters are Class B2 as far as the head of tide and the tidal waters are Class SB1. Tidal waters immediately west of Hinkley Point have been classed as SC, which may be the result of debris from decades of forest industry activity in the drainage. Much of the debris is in the form of sawdust and bark deposits.

Land-use Activity in Priority Focus Areas

Lumbering has been a dominant land-use activity in Maine as well as the Downeast DPS watersheds that dates historically back prior to the Revolutionary War. Settlers first arrived in the Machias area in 1765 (Whittier 1926). The first recorded impact to the East Machias River was construction of the upper dam (1765-1766) followed by the Unity Mill in 1766 or 1767. The lower dam was constructed in 1804. By 1820 there were 726 sawmills and 524 grist mills in the State of Maine (Smith 1972). Farming was the principle occupation followed by lumbering. The lumber industry relied on rivers and streams providing power for the mills and the transportation system. Nearly all of the mills were water-powered. The first steam-powered mill was built in Maine in 1820 (Wood 1935). Dry Town (T12R10,WELS) in Aroostook County was identified as the only township in Maine where there wasn't a stream of sufficient capacity to drive pine logs to a mill.

Although spruce was the dominant forest type, pine was the principle product harvested in the early 1800's. As a result, by the beginning of the Civil War relatively little of Maine's forest wealth had been touched. During this time period, several major changes occurred in the logging industry. The advent of the steam engine modernized the industry. Loggers moved farther into the wilderness as farming had cleared forest land and harvest of pine was completed lower in the watershed. The industry began to rely on forest surveys to identify marketable tracts of timber. Between 1860 and 1890, the quantity of wood and location near a drivable stream were the most important considerations influencing a harvesting decision. During the winter, crews would cut the timber and drag huge logs to yards on the streams where they would wait for the spring freshet. In 1860, Washington County had 103 establishments in the lumber industry. (Wood 1935). Historic records estimate 3,000 men and 1,000 horses worked Washington County forests in 1870. The last "good year" on the Machias River was 1872. In 1879, 2 million feet of lumber was driven from 5th Machias Lake to Whitneyville. By 1885, the port of Cherryfield was "about done." What little was sawed in Cherryfield remained in the area as "the river was quite denude of lumber." The Machias River cut was 32 million feet in 1888, while the Narraguagus River cut was down to 13 ½ million feet.

The biggest years of production in the Maine lumber industry to date were 1890-1910, with a transition from pine to markets that included spruce and pulp. Virgin forests in the state of Maine continued to produce individual "master" trees producing 2,000 – 3,000 board feet of lumber. In 1872, a Master Pine measuring 5' 8" across the butt and first log 17' long produced 6,532 board feet of lumber. In 1884, a Master Pine located in T36 Washington County was cut into 17 logs measuring 294' total length. The pine produced 2,950 board feet of sound lumber. The sizes of the logs provide some inferences as to water requirements for driving logs to mills downstream. As timber stands adjacent main stems and large tributaries were depleted, logging operations moved upstream. Splash dams consisting of logs and log/stone cribs became necessary. As operations continued upstream into headwaters, dynamite was used to widen smaller streams.

Early logging operations were associated with a variety of environmental impacts. Large, stream-side trees were the first to be felled by loggers, removing trees whose roots supported stream banks and that would have eventually become large woody debris. The loss of both functions inevitably reduced stream channel stability and increased bed and bank erosion. During

and after spring ice breakup, log drives on streams swollen with melting snow and early season rains carried enormous volumes of wood to downstream mills. Dams were used on many headwater lakes to store water, raise levels, and regulate outflow. On smaller streams, “splash” dams were built to store water (and energy) for the drive. These splash dams were deliberately breached by releasing blocks, removing a key log, or setting off a well-placed charge of black powder, sending a torrent of water and logs downstream (Irland 1999, Verry 1986, Williams 1976). The log and pulpwood drives must have had a devastating impact on stream-channel stability and aquatic habitat quality in some stream and river reaches. At the mills, booms that were used to capture and store logs also fouled the water and riverbeds with tannins, loose bark, and “sinkers.” In addition, mill waste and sawdust were commonly discarded directly into rivers (National Research Council 2004).

Figure 5. Picture of Crews breaking up a log jam at Grover Pitch “The Pit” on Old Stream with Poles and Peaveys (1965). Photo from (Anonymous 1966).



The end of the log driving era (circa 1970) initiated a change in infrastructure for the commercial forests that introduced a new threat to Atlantic salmon recovery. Extensive road building as a means of transporting logs to market began Downeast in the 1970s. Early roads were located adjacent to streams impinging riparian function. Road density tied to transport efficiency without consideration to the ecological impact. Engineering specifications for determining adequate size for culverts were based on the need to pass water during high flow and not on needs to maintain ecological function. Limited road maintenance, tied to limited funding, resulted in high levels of sediment deposited in streams. Catastrophic washouts of undersized culverts are not uncommon. As a result, a high percentage (90%+) of traditional round culverts become barriers to fish passage. Anthropogenic sedimentation often leads to braided channels and loss of riffle/pool sequences downstream of road crossings. As a result, there remains a legacy of anthropogenic impacts to streams located in otherwise undeveloped watersheds.

PRIORITIZATION OF ACTIVE HABITAT RESTORATION

SHARE has been active in habitat restoration activities since 2001. Until recently, project prioritization was based on site specific characteristics, such as location in the watershed, proximity to water body, distance upstream from known Atlantic salmon habitat, type of problem, and size (magnitude) of problem (Appendix A). Although targeted towards sub-watersheds identified as higher priority for Atlantic salmon, site selection had an element of opportunism based on funding sources and landowner cooperation. While this site specific (non-focused approach addresses immediate site specific problems, it does not address larger watershed scale issues with regard to landscape related processes.

In recent years SHARE's active restoration activity has evolved towards a decision-making process based on principles of strategic habitat conservation aimed at correcting stream processes on a landscape scale. Active restoration is targeted intervention with integrated project activities specifically designed to re-establish the natural stream processes needed for aquatic habitat recovery. Site selection for targeted restoration activity takes into account a hierarchy of restoration priorities. Project activities fall into one of four general categories, ranked as follows:

1. Fish passage - access to historic habitats,
2. Restoration of stream process (ie. natural hydrology, nutrient and sediment transport),
3. Stabilize anthropomorphic habitat degradation (principally sedimentation),
4. Enhance and restore instream habitat - pools, water chemistry, etc.

Prioritization of these activities is implemented within targeted focus areas pre-selected in consultation with state and federal resource agencies. (Watershed prioritization maps of each of the DPS listed Atlantic salmon watersheds are found in Appendix A.) High priority sub-watershed focus areas identified to date for active habitat restoration include: Old Stream West Branch Machias River, Crooked River, Mopang Stream, Machias River Corridor above Rt. 9, and the Narraguagus River above Rt. 9. These moderately healthy sub-watersheds with high security to future threats provide the greatest opportunity for long-term conservation success and cost-effective investments.

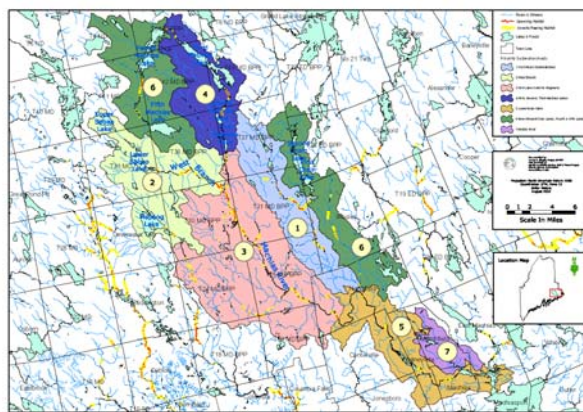


Figure 6. Prioritization of sub-watersheds within the Machias River Watershed.

This sub-watershed scale-based implementation strategy is consistent with strategies proposed by the Eastern Brook Trout Joint Venture (Williams et al. 2007) where conservation success indexes (CSI) have been used to establish sub-watershed scale management priorities for protection, restoration, reintroduction and monitoring activities. Watersheds with high population and habitat integrity, coupled with high future security rank high for active restoration. Furthermore, watersheds where target species are absent or severely limited, but habitat integrity remains high and protection from future habitat degradation is in place are targeted for reintroduction of native salmonids.

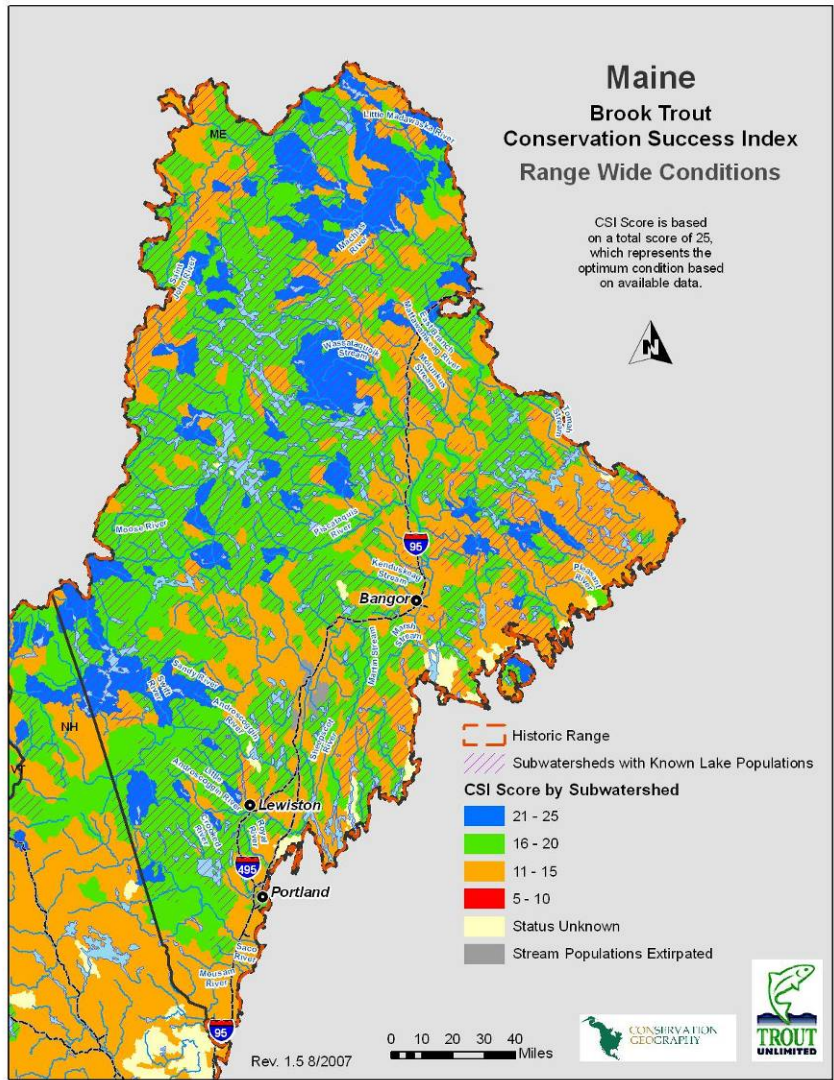


Figure 7. Eastern Brook Trout Conservation Success Index for Maine.

IDENTIFIED THREATS

The Final Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon (*Salmo salar*) (National Marine Fisheries Service and U. S. Fish and Wildlife Service 2005) includes a threats assessment that identifies threats to Atlantic salmon freshwater productivity. A review of status and threats for the Eastern Brook Trout Joint Venture (Williams et al. 2007) identifies a similar list of primary threats to brook trout: i.e. beavers, land management practices, urbanization, water chemistry (temperature and pH), stream fragmentation (dams and roads), and non-native species. We will limit our discussion to threats identified as high priority for action to reverse the decline of native salmonid populations in focus areas of concern to Project SHARE and within the realm of SHARE's mission scope and capacity. Loss of habitat connectivity and the obstruction of fish passage in the form of dams and undersized culverts at road crossings are considered principle threats to Atlantic salmon recovery. Habitat integrity and water quality have been impacted from local as well as regional land use patterns resulting in acidified water and associated aluminum toxicity, sedimentation, and elevated water temperatures. Numerous additional threats (i.e. avian predators, non-native fishes, water withdrawal, and marine survival) that have been identified are beyond the scope of SHARE's mission or authority. We anticipate additional threats will be evaluated as new restoration focus areas are established and/or information is gathered identifying threats within established focus areas.

Dams on Maine's Salmon Rivers and Their Legacies

Dams are a major cause of salmon declines worldwide (NRC); possibly the single most important class of impediments to salmon recovery that can be influenced by human actions in the short and medium terms. Dams have two major effects on anadromous fishes such as salmon. They prevent or impede fish passage up and down river, and they change or destroy habitat (American Rivers et al. 1999, Heinz Center 2002, NRC 1996a, NWPPC 2000). The first effect, especially the blocking of upstream migration of adults, has long been recognized, even in the writings of Atkins (1874) and Kendall (1935).

Figure 8. Looking upstream to fish barrier beaver dam built on top of remnant log drive dam just above 1st Lake Old Stream (Oct. 2007). Photo by Scott Craig

Although fish-passage facilities can alleviate the difficulties that adults have in upstream migration, the effects of



dams on the downstream migration of smolts has been recognized only recently, and they are more difficult to reverse. The slow-moving current in pools behind dams confuses smolts during migration, increase the energetic costs of their movement, and can increase predation on them. The dams can injure smolts or block their passage. Though smolts do swim, their travel time to the estuary can be greatly increased as a result of dams, as has been shown on the Columbia River system in the Pacific Northwest (National Marine Fisheries Service 2000b). Although the western dams are larger than those in Maine, effects documented in the West are likely to occur to some degree on dammed streams in Maine.

The second effect needs wider recognition. By creating pools behind them, dams change habitat by eliminating flowing water and riffles. They flood riparian habitats, and they change the patterns of sedimentation and erosion. Dams usually cause changes in water temperatures and chemistry, and reservoirs behind dams are often stratified, while undammed rivers usually are not (American Rivers et al. 1999, Heinz Center 2002). In addition, the large woody debris, gravel, and sediment that were formerly carried down the river and that provided spawning and rearing habitat, as well as cues that helped adults to return home to their natal streams, are now stopped by dams. As a result, these altered habitats are less suitable for spawning and juvenile rearing. Rivers behind dams become pools, more like lakes than rivers. Most anadromous salmonids are not adapted to such habitats. Other species of vertebrates and invertebrates that can thrive in lakes proliferate and thereby change the prey resources available to salmon, as well as the number and kinds of their competitors and predators.

Maine's rivers and streams have many hundreds of dams. Not all dams are necessarily large and completely impervious barriers to fish, especially in Maine. Even the relatively large wood and concrete Edwards Dam on the Kennebec River, which was removed in 1999, had previously been breached by high flows. Thus, the upstream habitat had been available (at least to the next dam) for adult salmon for periods of up to 12 months. Other Maine dams are smaller, and many are made entirely of wood. Those often allow some passage during periods of moderate-to-high flow, thus allowing some downstream passage of small fish. Many are not maintained and have deteriorated to varying degrees. Other dams in Maine are breached, over-washed, or even washed out during periods of high flows. In addition, the majority of dams in Maine are not registered nor is there a central location documenting dam locations. Therefore, simple inspection of maps that illustrate dam placement is not sufficient to assess the availability of habitat to migratory fishes or the quality of that habitat in Maine.

Excerpts from the Final Recovery Plan (NMFS and USFWS 2005) summarize the current impact of dams as a threat to Atlantic salmon passage. Historically, dams were a major cause of the decline of Atlantic salmon runs in many Maine rivers and streams. At one time, dams existed at various times on all eight rivers within the DPS known to still support wild Atlantic salmon. Dams were constructed to produce electricity, operate mills, transport logs and as ice control structures. Historic records indicate that many of the old, low-head timber-crib dams had significant leakage and were not complete barriers to fish passage. In the late 1940s, the presence of dams on the Narraguagus, Machias, East Machias and Pleasant rivers was identified as a threat to the continued existence of Atlantic salmon in those rivers (Rounsefell and Bond 1949). According to Rounsefell and Bond (1949), the Atlantic salmon run in the Dennys River was

almost always in peril during the 1880's because of dams. Today, most of the dams on DPS rivers have either been removed or breached and no longer threaten salmon migration. Coopers Mills Dam on the Sheepscot River and the Stillwater Dam on the Narraguagus are the only remaining dams with potential to significantly obstruct access to valuable spawning and rearing habitat. All other obstructions on these rivers (e.g., ice-control dam in Cherryfield, Meddybemps Lake outlet dam) have fishways. The efficiency of these fishways has not been well documented (Baum et al. 1992). The USFWS and NMFS have concluded that manmade obstructions to passage (specifically dams) are not a high level threat to Atlantic salmon survival in the eight DPS salmon rivers (NMFS and USFWS 2005).

Although dams on main-stems and major tributaries on the Downeast DPS rivers have been breached and no longer present a threat to passage of Atlantic salmon, there may be a legacy of instream channel alterations remaining on the landscape. Oral history interviews and review of historic references document the location of numerous dam sites on the Downeast rivers that were principally used during the era of log drives and water powered mills (Appendix I).

Figure 9. Remnant Dam at the outlet of Fourth Machias Lake. This structure is not in the State or National Dam Database. Picture is looking north across river. (Oct 2007) Photo by Scott Craig



Preliminary investigation of aerial photography and ground-truthing several historic sites suggest that impacts to the river channel are still apparent. Remnant hydraulic checks and stream channel evolution through partially-breached remnant reservoirs may be an explanation for a number of the "back water" channel reaches that are apparent on the landscape. While the impact of remnant dams on stream channels may not be a threat to fish passage, they appear to be a constraint on other aspects of stream connectivity including: channel bank full width, water depth, current velocity, sediment and nutrient transport. The ecological impacts of remnant dams and historic dam removals do not appear to be documented. Therefore, we will attempt to draw inferences from impacts of dams and present day dam removals.



Figure 10. Aerial photography of Canaan Dam to 1st Lake Old Stream utilized May 1996 gray scale images. Over-widened channel and outline of historic reservoir are apparent in the aerial photography decades after the dam was removed.

The ecology of riverine systems is influenced by its flow regime. Physical and biological characteristics of the river are influenced by the range in magnitude, regularity, and frequency of water transport down a river channel both seasonally and over longer periods of time. Because a river system is dynamic, a river can support a wide diversity of species, all of which have evolved to live in a river's variable flow (Higgs 2002). Dams alter a river's flow regime by blocking transport, storing water in a reservoir that transforms the lotic environment to an artificial limnetic environment. Consequently, altered fluctuations in flow by dams can result in an aquatic community limited to a few generalists that are able to withstand the altered flow conditions of the river. Species composition favors slower-moving aquatic species better adapted to lake-like limnetic habitats. Dams present a block to sediment transport, depositing the natural bed load behind the dam altering the physical characteristics of the stream bed (Kondolf 1997). In turn, sediment accumulation in the reservoir limits the amount and type of sediment transported downstream of the dam. The water emerging from a dam is known as clear water releases that are "sediment starved". Clear water releases from dams carry less sediment which leads to increased current velocity. Downstream of the dam, sediment starved water regains sediment equilibrium by increased erosion of stream banks and incision of the channel. In addition, reservoirs buffer flow and the natural peaks in seasonal hydrographs affecting the ability to transport larger size classes of bed material downstream causing channels to rise.

The impacts of dam removal are poorly understood, in part because such removal projects have rarely been carefully documented or analyzed (Doyle et al. 2002). Dam removal can have significant ecological benefits, including the return of a more naturalized flow, temperature regime, and sediment transport to the river system (Higgs 2002). Up-stream of the dam site, larger size classes of bed material (gravel, cobble, boulders) previously covered by fine sediment may be exposed as increased current velocities wash fine sediment downstream. Restoration of

the natural hydrograph also increases the mobility of larger size class particles. The percentage of rocky substrate relative to silt and mud found in the Woolen Mills Dam Reservoir (Wisconsin) increased post dam removal ((Kanehl, et al, 1997). Dam removal can also affect a river's temperature. Transforming an impoundment to a narrower channel increases current velocity and allows reestablishment of the riparian buffer providing shade. A study of the Salling Dam removal project in Michigan estimated that dam removal would result in a 3' Celsius reduction in downstream water temperature (Higgs 2002). As a result, dam removal may displace warm-water species that prefer a lake-like environment promoting the recovery of native cold-water species such as salmonids, shad, and alewife. Dam removal may restore the system to a pre-dam flow regime that favors the return of native species that depend on riverine habitat conditions (Hill et al, 1993, Kanehl, P.D. et al. 1989).

Dam removal represents a large and instantaneous change in base level as compared to natural rates and scales of normal river change (Doyle, et al. 2002). The reservoir and potentially the upstream main stem channel and tributaries respond to base level lowering over time through channel incision, following a well-established pattern of adjustments over time termed channel evolution. Observations of dam breaching in Wisconsin describe the channel forming process (Doyle et al. 2002). Removal of 2.5 meters of a 3.5 meter dam initiated upstream channel incision through sediments in the reservoir (Figure 10). Within hours of the breaching, a headcut formed immediately upstream of the dam site and began migrating upstream. Channel development was completely governed by the rate of migration of the headcut. Negligible change occurred to the channel upstream of the headcut. Channel development downstream of the headcut followed the Channel Evolution Model. Following initial channel incision, the channel widened via mass wasting of the banks. Mass wasting occurred at very low bank heights and angles due to the level of saturation of reservoir sediment and the complete lack of vegetation immediately following removal.

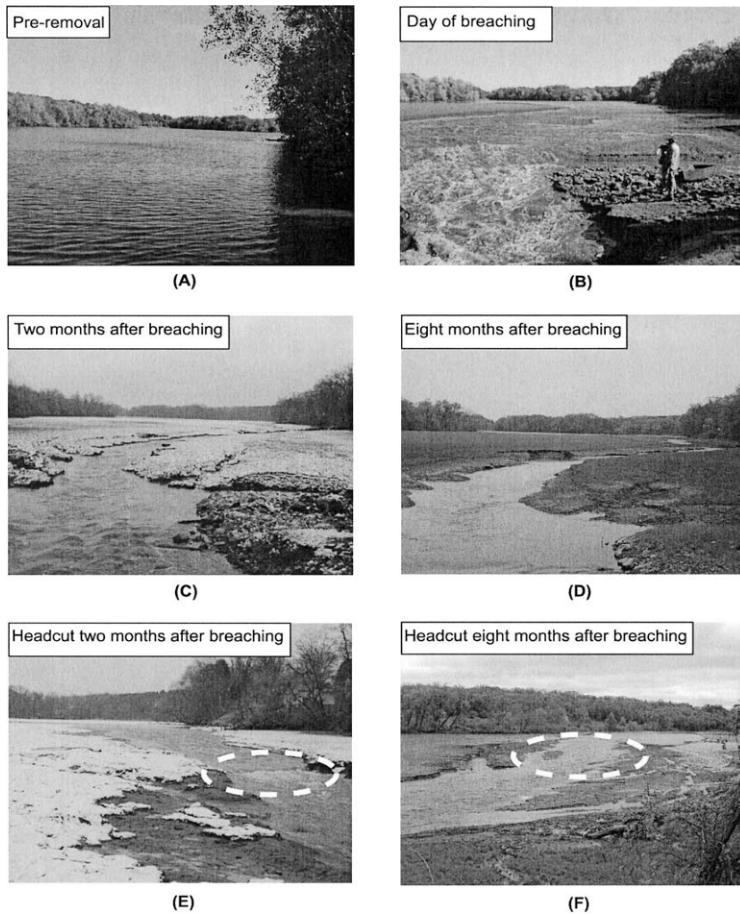


Figure 11. Channel Development on the Koshkonong River, Wisconsin following breaching of dam (Doyle et al 2002). (A) Reservoir before removal (photo taken from dam facing upstream). (B) Channel incision into reservoir sediment the day of breaching, September 2000. Note formation of headcut. (C) Channel in November 2000. Note deepening and narrowing of channel. (D) Channel in May 2001. (E) Headcut in November 2000 (facing upstream), with headcut circled in photo. (F) Headcut in May 2001 (facing upstream) approximately 400 meters upstream of dam, with headcut circled in photo. Note that flow is converging at headcut from wide water surface to narrow, deeper flow downstream of headcut.

These observations are not consistent with previous assumptions that post dam removal channels will mimic the natural pre-dam conditions. Post-dam-removal channels do not necessarily return to the pre-dam channel location, form, alignment or grade immediately and may never do so. Following initial development of the post-dam channel via channel incision, further erosion of reservoir sediment becomes more difficult as sediment settles, builds cohesion, dewater, and reestablishes vegetation. Observations of small dam removal in Wisconsin suggest that a large portion of the reservoir sediment outside of the developing channel may be relatively stable and may become the long-term floodplain.

Roads – the new subtle but pervasive impact

Although the National Research Council (2003) report did not assess risks to salmon for road-habitat impacts (Table 1), they did state (pg. 174) that, other than dams, roads and road-stream crossings were second only to dams for their adverse effects to aquatic habitat. The Council noted a shift from more intensive land use activities that cause catastrophic habitat disturbance to a more subtle but pervasive one: "Acute disturbance from log drives and the toxic effects of point source discharges have been replaced by the chronic effects of road networks." With the exception of large dams on the lower reaches of rivers, no human alteration of the landscape has a greater, more ubiquitous impact on aquatic habitat than roads.

Table 1. Summary of proportional risk assessment scores as related to source impacts and abiotic factors described in NRC (2004, page 117).

Impact Source	Abiotic Factors (3)			Abiotic Impact Sum	Cumulative %
	Water Quality	Habitat	Passage		
Dams	3.4%	10.1%	14.3%	27.7%	73%
Roads	1.7%	N/A	1.9%	3.5%	9%
Agriculture	1.7%	2.5%		4.2%	11%
Logging	0.4%	1.7%	0.3%	2.4%	6%
Total	7.1%	14.3%	16.5%	37.9%	100%

N/A = Although the NRC (2003) provides no risk assessment score for road-habitat impacts, they postulate this impact is second only to dams-habitat (see page 174). Thus, we postulate that road-habitat impacts would be slightly less than 10.0% (dams-habitat= 10.1%).

“Every road-stream crossing has the potential to be a barrier to fish passage and a major source of sediment. A well-designed road, either paved or unpaved, has a slight crown along the centerline to direct rain or snowmelt off to the sides. In some cases, stormwater flows harmlessly off into the adjacent forest or fields and is termed "country drainage" by engineers. More often it is collected in ditches or swales that parallel the road, sometimes for long distances. As the volume and velocity of flow increases so does the quantity of sediment that can be transported. Clay, silt, and fine sand that accumulates in road ditches is the first to be transported to streams during rain and snowmelt events. Sand that washes into streams and rivers can result in turbidity problems and habitat embeddedness. This is especially noticeable in the Sheepscot River because it has a higher road density and more stream crossings than the other salmon rivers. Soil particles

carry nutrients, metals, and other potential nonpoint source (NPS) pollutants on their charged surfaces. In addition, fine sediment increases turbidity in streams. Unless deliberate efforts are made to divert or store water and sediment along the way, they flow unimpeded into streams at every road crossing (National Resource Council 2003).” The harsh winter conditions in Maine require road maintenance measures such as salt or sand in order to be able to allow safe travel by automobile. Dill et al. (2002) attributed problems related to winter treatment of roads to melt ice and snow. Salt washes into streams and occasionally pollutes ground water, whereas sand can chronically enter streams through ditches and at road crossings. Sand that remains on the roads after the end of the season is generally swept off the roadways onto the shoulders. Sometimes this sand is collected and disposed of as inert fill. Even in large forested areas with low road densities, the alteration of natural pathways of flow can be very significant. Removing forest cover increases the amount of precipitation reaching the surface. The earthwork, compaction, and surfacing (e.g. crushed stone, clay caps, bank-run gravel) needed to construct roads greatly limits the rate at which water can enter the soil. As a result, larger quantities of lower-quality water are generated, concentrated, and directed downstream. These pulses of storm water and sediment can destabilize stream channels, fill or cover redds, and contribute to eutrophication and/or acidification of streams.

Embeddedness, the presence of fine sediment filling the voids of larger stream bed material, has been identified as a threat to spawning and parr rearing habitat (Atkinson personal communication). In the eastern woodlands, 99 percent of sediment originates on logging roads (Hartung and Kress 1977). Road crossings are the most pervasive non-point source pollution sites in Maine Atlantic salmon DPS watersheds (Dill et al., 2002; Project SHARE database). If un-surfaced or rocked roads get used during wet periods, it may increase sediment delivery by pumping fines from the road bed which then are contributed to adjacent streams. Dill et al. (2002) found that, although un-surfaced roads may get little use in winter, they are still "prone to non-point source (NPS) pollution due to erosion on the road surfaces, roadside ditches, or bank erosion at stream crossings." Undersized culverts at road/stream crossings further impact stream connectivity. Halsted (2002) explained that: crossing structures that are undersized act as dams in the river, which cause the river to compensate by altering the natural channel and often contribute to bank scour upstream and downstream of the crossing. Undersized crossings can also create a buildup of sediment upstream causing unnatural braiding to occur. Road crossings are often the place where sediment from roadside ditches flows into streams. In worst case scenarios, culverts used to route streams under roads may plug and fail, washing sediment from the road prism into the water course below (NRC, 2003). The National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS & USFWS, 2004) also express concern over significant problems for fish passage that culverts may pose: "Other obstructions to passage, including poorly designed road-crossings and culverts, remain a potential hindrance to salmon recovery. Improperly placed or designed culverts can create barriers to fish passage through hanging outfalls, increased water velocities or insufficient water velocity and quantity within the culvert."

Rieman et al. (2002) used road density as a proxy for cumulative watershed effects in Pacific northwest bull trout watersheds and found that population levels were inversely proportional to road densities. Haynes et al. (1996), in a regional study of public lands in the Columbia Basin,

determined that bull trout were absent in watersheds with more than 1.5 miles of road per square mile of watershed area and that "the higher the road density, the lower the proportion of sub-watersheds that support strong populations of key salmonids." The National Marine Fisheries Service (NMFS, 1996) defined properly functioning aquatic conditions for Pacific salmon watersheds as having less than 2.5 miles per square mile, with no or few streamside roads. There is currently no recognized threshold for road density in Maine and accurate road maps for conducting road density calculations are not available for Atlantic salmon watersheds. Application of road density criteria from a NOAA guidance document (1996) using the best available road density data available suggest that road densities within selected restoration focus areas are indeed high (Figure 12). Extensive on-the-ground assessments of road/stream crossings

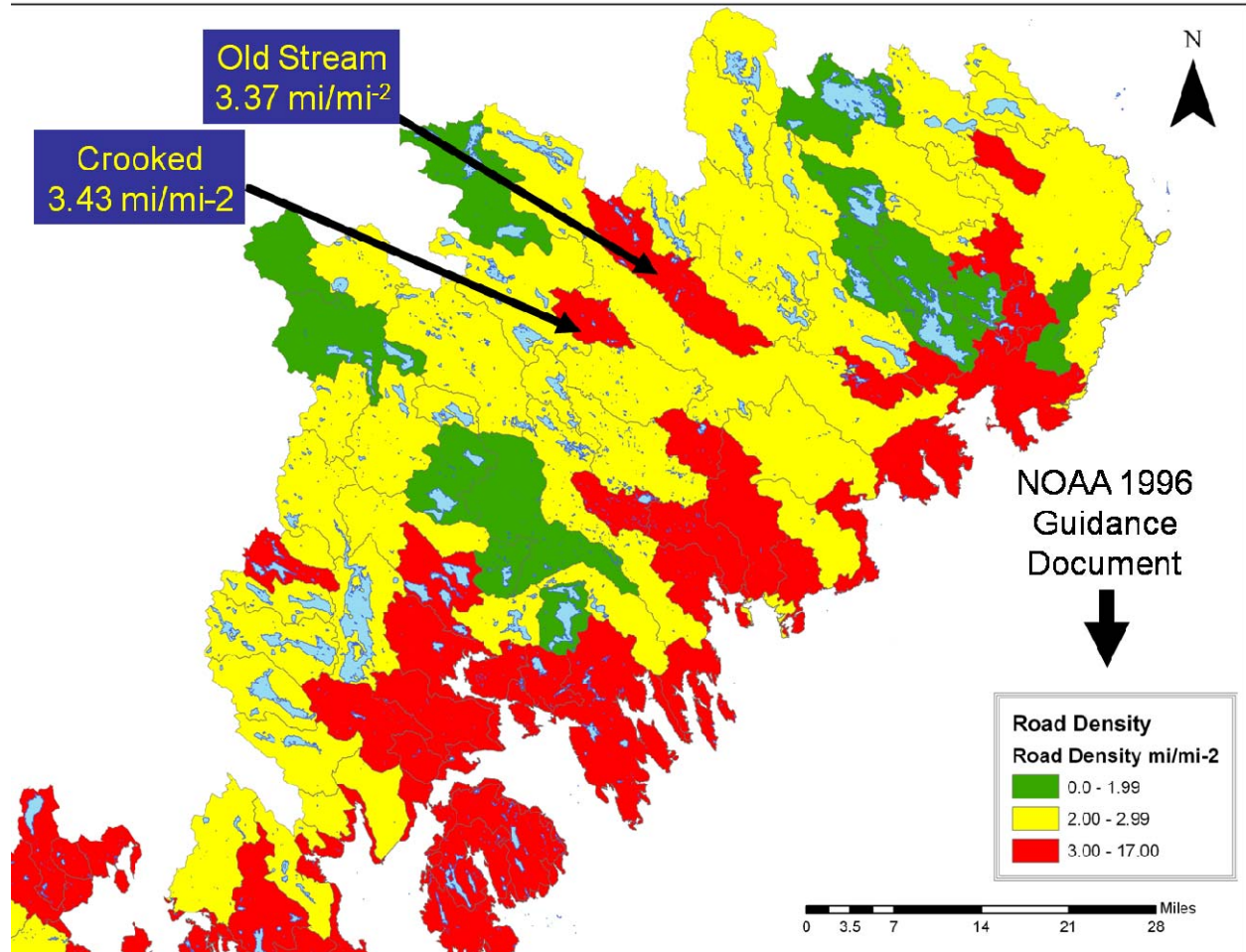


Figure 12: Road densities in sub-watersheds of Downeast Maine.

within the Old Stream and East Branch Machias focus areas suggest that previously available data underestimate the actual miles of gravel roads that exist in these focus areas and in fact do not take into account winter roads or skidder trails within the watersheds where commercial forest operations are the primary land use. NRC (2003) predicted that road networks are likely to expand as rural populations grow and development progresses in Maine DPS Atlantic salmon watersheds.

A wide range of Best Management Practices (BMPs) can be used to prevent and minimize the adverse impacts of roads on aquatic habitat. They include, but are not limited to: (1) careful route planning to keep roads on resistant terrain and minimize the number of road/stream crossings, (2) bridge and culvert designs with hydraulic characteristics that permit fish passage in both directions for different life stages, (3) bioengineering techniques to stabilize embankments (either cut or fill slopes) associated with road construction, (4) storm water management practices to eliminate or reduce the hydraulic connections between roads and streams, (5) aggressive soil erosion control on new construction or unstable areas, and (6) regular preventive maintenance to prevent debris dams or beaver from blocking culverts. Although unglamorous, the last item is especially important to maintaining aquatic habitat quality. When a culvert is blocked, the road embankment becomes an earthen dam at least until the water flows over the road or pressure causes the saturated fill to give way. When the embankment fails it sends a torrent of water, sediment, and debris downstream. In areas with multiple road/stream crossings this can lead to a domino effect involving downstream structures. When true-cost accounting of long-term forest management is used, due diligence with BMPs and preventive maintenance is a bargain compared to replacing culverts, bridges, and road fills, dealing with enforcement orders and law suits for environmental and property damage, and the increased risk of motor vehicle accidents.

Unfortunately, current road BMPs tend to address minimizing the impacts of roads as non-point sources of sediment. Although there is an intent to address stream connectivity as it relates to fish passage, specific standards for fish passage are not included in Maine DEP or Maine Forest Service BMP manuals. Restoration of stream process and the broader topic of ecological connectivity (natural hydrology, sediment, nutrient and LWD transport) are not clearly understood at this time. As noted previously, the NRC (2003) recognizes the road network as a chronic, subtle and pervasive threat that replaced the more acute threats of the log-drive era. Although most dams have been removed from main stem rivers and large tributaries in the Downeast DPS rivers, culverts associated with commercial forest infrastructure as well as public roads continue to fragment first and second order streams. Comprehensive assessments of road/stream crossings have been completed on the Old Steam and West Branch Machias focus areas. Analysis of these data show that 90% + of traditional round culverts are in fact barriers to fish passage to some degree (complete barriers, seasonal barriers, or barriers to certain size classes). Small barriers have a wide variety of negative impacts on salmon and resident fish (O'hanley and Tomberlin 2005) such as:

- 1 Isolate populations and limit ability to move to find areas of clean spawning gravel and summer cool temperatures.
- 2 Complete passage block to high quality spawning or rearing habitat in tributaries.
- 3 Reduce and skew distribution of resident fish which can cause an increased risk of extinction due to isolation and reduced gene flow which can reduce population viability.
- 4 Increase level of inbreeding of resident fish.
- 5 Reduce both upstream and downstream nutrient flow.
- 6 Artificially select for stronger swimmers.

Loss of Habitat complexity

The Downeast DPS salmon rivers appear to be pristine and natural with little development in the watersheds and intact riparian buffers. It is generally understood that there are centuries-old impacts to the watersheds and rivers; however, there is little data supporting specific alterations. Most of the historic record was oral and has been lost over time. State and federal biologists have mapped the presence of spawning and parr rearing habitat in each of the DPS salmon rivers. It is common knowledge that Atlantic salmon habitat is disbursed between areas of unsuitable habitat including suspicious, but unexplained, dead waters. Similarly it is known that log drives occurred on each of the Downeast rivers and major tributaries until the end of that era with the last drive on the Machias River in 1971 and assumed that the drives had impacts to channel morphology and stream bed complexity. Company records of the Machias Lumber Company document the establishment of the Old Stream Dam and River Improvement Company, Machias Lake Dam and Improvement Company and Mopang Dam and Improvement Company (Figure 12). Although evidence of stream channel alterations is evident throughout the Downeast watersheds, documentation of site specific alterations is minimal either in historic documents or recent habitat surveys.

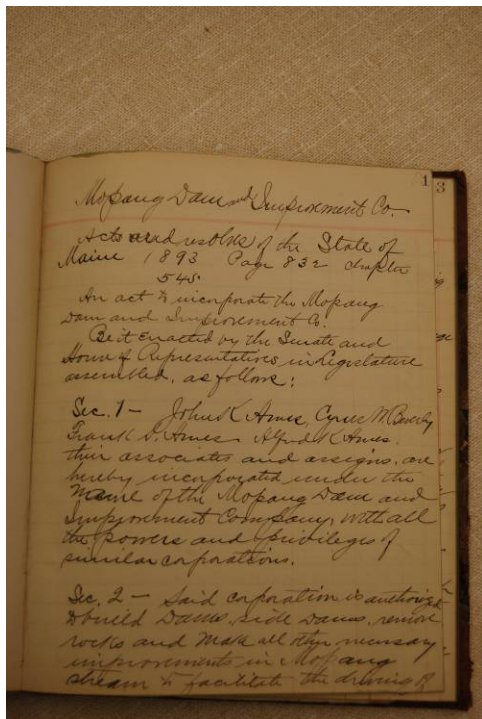


Figure 13. Ledger of the Mopang Dam and Improvement Company (1892).

Kale Gullett, Natural Resources Conservation Service (NRCS) biologist, provided the following observations following a tour of the Machias River: “This trip provided invaluable insight into the effects and legacy of log driving on Downeast Maine riverine habitat (personal communication). Channel substrates consist of extremely large boulders, numerous deposits of granitic sands and small gravels, and erratically-sized and located cobble and gravel bars. In

general, there appeared to be a paucity of spawning-sized substrates and, when present, cobbles and gravels were embedded. Past timber harvest activities appear to have significantly disrupted pool-riffle sequences on this reach of the Machias River, simplified instream habitat, and likely contributed to population decreases of Atlantic salmon over time. By comparison, the geomorphology and habitat of the Crooked River above its confluence with the mainstem Machias River upstream of Route 9 differed with respect to channel structure and habitat quality. The channel bed exhibited better representation of all substrate size classes, and pool-riffle sequences appeared to be much more regular and predictable than those on the Machias River. These basic building blocks of aquatic habitat are essential in supporting an assemblage of species and life stages, riparian vegetation that influences channel shape and position, and interactions between the stream channel and adjacent floodplain. In addition, the group observed a former side channel along the left bank of the river just downstream of the Route 9 bridge that had been blocked off by a line of boulders placed at the upstream inlet (Figure 14).



Figure 14. Boulders blocking side channel of Machias River.

These practices were commonly employed by log drivers to prohibit logs from being lost down side channels or providing secondary flow paths that could lead to the formation of logjams.”

Water Chemistry

Acidification has been identified as one of the most significant water quality threats to the Gulf of Maine Distinct Population Segment of Atlantic Salmon (*Salmo salar*) (NMFS and USFWS 2005). The NMFS, USFWS and the NRC (2004) have concluded that water quality issues related to acidification (low pH and calcium ion concentrations, elevated aluminum ion concentrations) pose a high level threat to the survival and recovery of the DPS. Environmental impacts of acidification are complex and far reaching, including deforestation, deterioration of buildings and historical artifacts, loss of fish populations, and heavy metal contamination of aquatic ecosystems. The earliest recorded impact of acid deposition on a fishery was the decline in Atlantic salmon observed in a few rivers in southern Norway in the 1920's (Jensen and Snekvik 1972). Loss of fish populations attributed to acidification of surface waters has been documented in the United States (Schofield 1976; Pfiesser and Festa 1980; Haines and Baker

1986), Canada (Beamish and Harvey 1972; Beamish 1974a, 1976; Beamish et al. 1975; Watt et al. 1983), and Scotland (Turnpenny et al. 1988). Recruitment failure has been identified as an important factor responsible for the disappearance of fish populations in soft, acidic waters (Schofield 1976, see reviews by Fromm 1980; Haines 1981; Harvey 1982; Peterson et al. 1982; Dillon et al. 1984; Baker and Schofield 1985). The deposition of atmospheric pollutants including acid occurs in an episodic pattern which often coincides with the reproductive cycles of some fishes (Peterson et al. 1982). Major decreases in pH occur in lakes and rivers during the autumn, a season of frequent rains in temperate climates. The autumn pH decrease coincides with the spawning and early embryonic development of many autumn-spawning cold-water fishes, including brook trout and Atlantic salmon. A second major depression of pH in streams occurs in the spring as a result of snow melt and spring rains. The spring pH depression coincides with the late-eyed stage, hatching, and yolk-sac stages of autumn-spawning salmonids.

Evidence that pH/aluminum-related water chemistry may be impacting Atlantic salmon recovery has been documented in the Downeast DPS rivers. Haines and Akielaszek (1984) determines the pH of the Machias and Narraguagus Rivers is generally between 6 and 7, which is suitable for healthy fish populations, but declined below pH 6 during episodic spring rain events. Several tributaries exhibited signs of chronic acidification below pH 6 and occasionally below pH 5. Haines *et al.* (1990) documented a pH related fish kill of Atlantic salmon in Sinclair Brook during the winter of 1986-87 when pH was recorded near 5. Beland *et al.* (1995) recorded pH of several tributaries of the Narraguagus River documenting pH values as low as 4.3. The study determined the Pleasant River was even more acidic than the Narraguagus River with main stem pH values as low as 4.1. Recent water chemistry assessments of the Crooked River watershed have documented pH and monometric aluminum concentrations at levels considered stressful to salmonids (Figure 15).

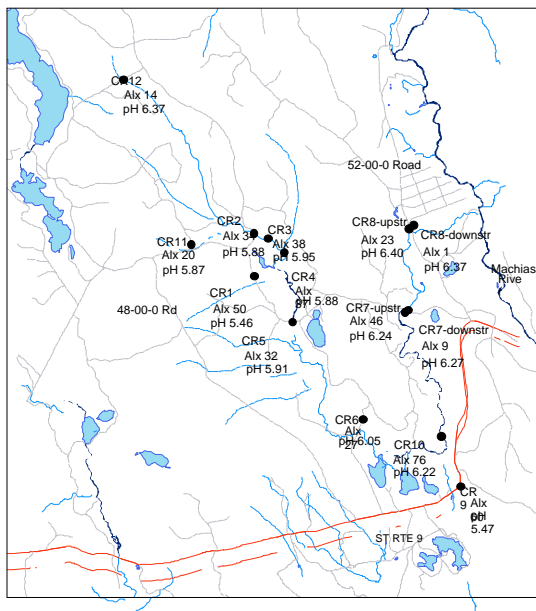


Figure 15. Crooked River Chemistry Survey

May 2008 monitoring sites

The effect of acid deposition on aquatic ecosystems is influenced by the geology of the watershed (Norton 1982). Watersheds underlain with soils or rock with a high acid-neutralizing capacity (e.g. carbonates and bicarbonates) are relatively immune from the consequences of acid precipitation. Areas consisting of slow-weathering bedrock (e.g. granite, quartz, and quartz sandstone) covered by shallow acidic soils have low buffering capacity and are particularly sensitive to acidification. Geology of the five Downeast DPS rivers is principally dominated by bedrock and surficial geology with low buffering capacity. The Deblois Pluton underlying a large portion of the Machias River Watershed exemplifies slow weathering granite with low buffering capacity. In contrast, the Flume Ridge Formation in the headwaters of the Old Stream watershed is a carbonaceous sedimentary deposit from a remnant sea floor. Their respective contributions to surface water buffering capacity has been classified into a range of acid (pH) sensitivity guilds (Figure 16).

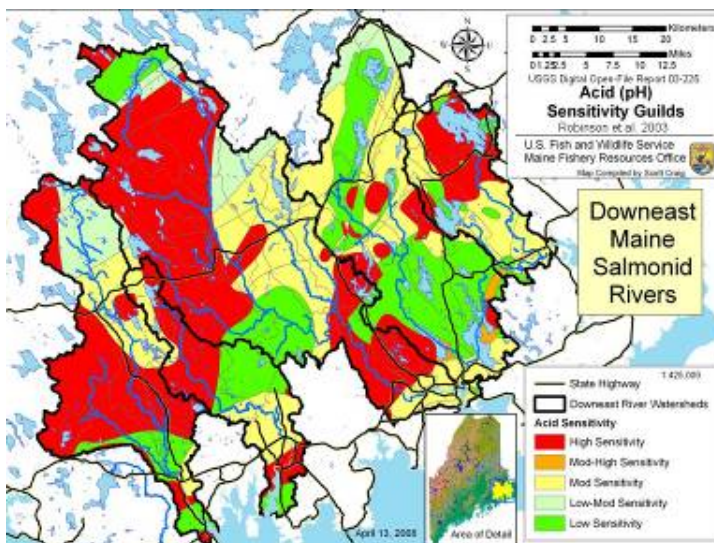


Figure 16. Bedrock lithology. Potential problem areas for low pH. (Robinson and Kapo 2003)

The U.S. Fish and Wildlife Service Maine Fisheries Resource Office (MFRO) and Project SHARE have conducted water chemistry monitoring as part of restoration focus area assessment. Similar to previous assessments in the Downeast rivers, we have found that pH is quite variable both spatially and temporally. When overlaid on bedrock acid sensitivity guilds it becomes apparent that the Machias River is also susceptible to episodic declines in pH. Of particular concern are the areas above Rt. 9 underlain by the Deblois Pluto. Head water tributaries in this vicinity experience declines in pH in the low 5's and upper 4 range (Figure 16). In Downeast Maine, pH appears to be a limiting factor for fish distribution and species composition in headwater tributaries. USFWS MEFRO upper headwater fish assessments from 2006-2008 measured pH prior to conducting surveys. When comparing pH at sites with "fish observed" versus "not observed", mean pH values were significantly different at 6.1 and 5.4, respectively. Since multiple factors (drainage area, habitat quality, fish passage etc.) can influence "fish presence", it is not surprising that the variance was also significantly different. See table 2.

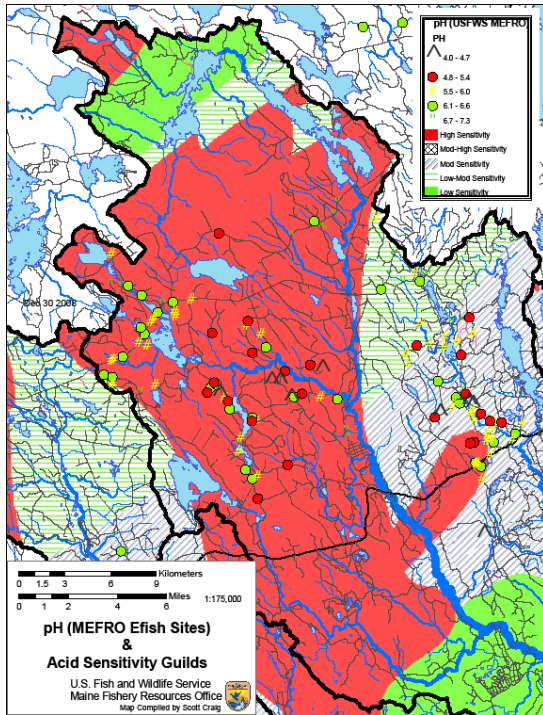


Figure 17. The relationship of site-specific pH values to bedrock acid sensitivity guilds in the Machias River.

Table 2. pH values and statistical results at sites with “Fish Observed” vs. “Not Observed”.

<i>pH Values</i>	<i>Fish Not Observed</i>	<i>Fish Observed</i>
Mean	5.4	6.1
Variance	0.62	0.31
Observations	31	103
F-Test for variance	p<0.01	
t-test	p<0.01	

The lowest pH value where fish were observed was 4.7. Brook trout appear to be least sensitive

to pH as they were the only species to occur at values below 5 (pH). See figure 17 for distribution of all pH data (n=134).

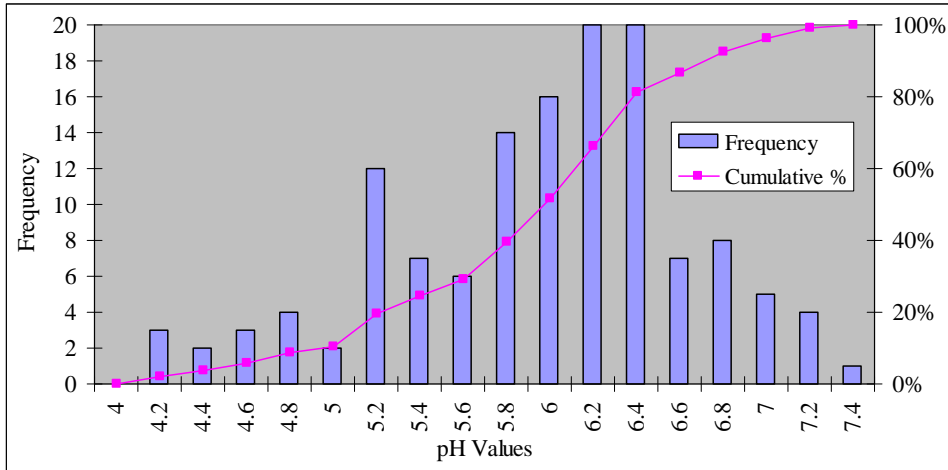
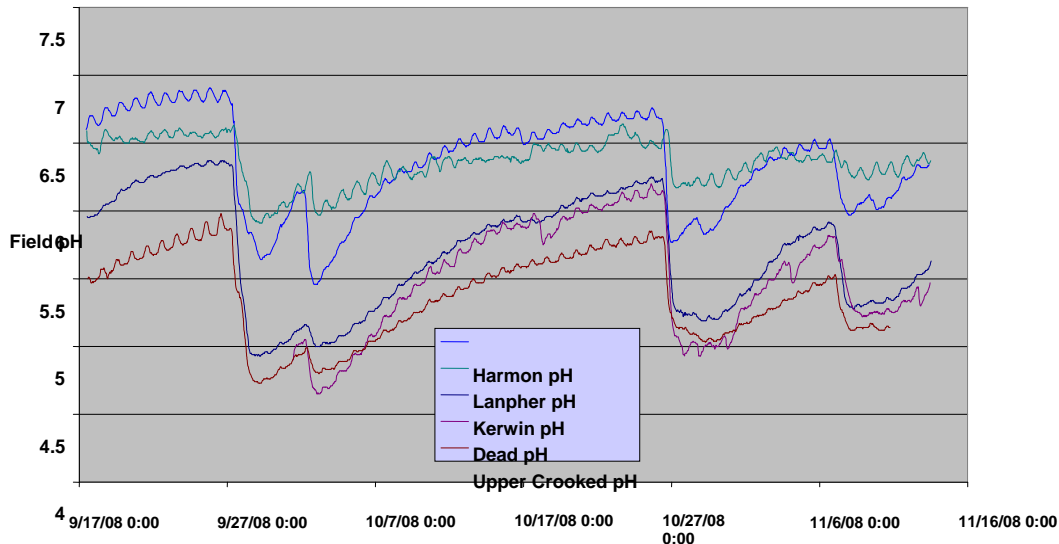


Figure 18. Distribution of pH measurements taken at 134 MEFRO upper headwater electrofishing sites in the Narraguagus, Machias, and East Machias Rivers. Fish were not observed at pH values < 4.7

Continuous recording data sondes placed in several tributaries Downeast document that pH depressions last several weeks following high water storm events (Figure 19). Patterns of pH depression are similar between tributaries; however there is a distinct variation in the range of pH between tributaries. We believe the range of pH for a tributary is directly linked to bedrock geology and its contribution to buffer capacity. Given the extent of documentation of low pH and elevated monometric aluminum in headwater tributaries within restoration focus areas in the Machias River and the duration of pH depressions, we believe mitigation of pH-related water chemistry is a priority action for watershed assessment and restoration.

Figure 19. Continuous recording data sondes Fall 2008



METHODS

Restoration of Stream Connectivity and Complexity

Roni et al (2002) ranked barrier removal the most important type of restoration activity in their prioritization hierarchy due to its high cost-effectiveness (over instream structure placement and sediment reduction). Undersized round culverts on lower order streams and remnant dams from the log drive era present the most prevalent anthropogenic barriers to stream connectivity and fish passage in the Downeast DPS rivers. Impacts include low flow passage barriers, leap barriers, and high flow velocity barriers which disrupt upstream passage of most age classes under most flow conditions. Other disruptions of stream connectivity include sediment, nutrient and LWD transport, creation of backwaters which alter hydrology diminishing peak flow, decreases stream power and capacity to move bed load.

Assessment of connectivity barriers requires on-the-ground site visits to document the location and specific impacts each barrier is presenting. We are currently using the Maine Road-Stream Crossing Survey Manual (Abbot 2008) and Maine Dam & Barrier Survey Manual (Abbot 2008) to inventory barriers. These manuals were created by an inter-disciplinary team in order to unify assessment methods across the State of Maine. The manuals are presented in their entirety as Appendices B and C of this document. Site specific data is further assessed using metrics developed for the Vermont Geomorphic Assessment protocols (Appendix D) and FishXing, a fish passage modeling program developed by the US Forest Service (Appendix E).

Stream crossing connectivity projects are utilizing the best available method that provides unimpeded passage for aquatic organisms, promotes better transport of sediments and large woody material, minimizes culvert failure risk, and diminishes maintenance costs over time.

Undersized, hung (i.e., culvert outlet lip is elevated above downstream water surface), and damaged culverts are replaced with oversized open-arch culverts, bridges, or removable crossing structures that provide improved passage of both aquatic organisms and materials moved by water. Key objectives to site specific decisions include:

- Decommission roads no longer needed and recreate natural channel configuration
- Open bottom arch culverts or bridges placed when permanent roads are required
- Structure width designed to be 1.2 x the bank-full-width through crossings
- Culverts set at proper elevation to eliminate backwaters and prevent scouring
- Remove chronic sediment sources which reduce fish habitat quality and quantity.
- Identify locations of remaining log culverts and remove those that are failing.

Stream Stream Design Methodology (Appendix F) is presently used as the basis for re-establishing natural stream channel characteristics at road crossings. This same methodology is appropriate for re-establishing the natural longitudinal profile and cross-sectional morphology with the removal of remnant dams.

Site restoration typically involves staging multiple components of a single site over time. In the cases of restoration of a road/stream crossing or removal of a hydraulic check caused by a remnant dam, step #1 involves removing the hydraulic check and re-establishing natural channel morphology at the site. Further instream channel work upstream or downstream of the site is typically schedule a year or two following initial site work to allow channel adjustment to occur. For removal of small dams, Doyle (2002) advises “If the bed of the channel is allowed to degrade following dam removal to some equilibrium point, then stabilization efforts on the developing banks and the reservoir sediments are likely to be successful. Establishing the equilibrium grade of the new channel must precede manipulation of channel widths.”

Whether it is in association with the removal of a site-specific hydraulic check or a stand-alone project, in-stream channel work involves the restoration of stream complexity. Stream function that generally requires restoration includes re-establishing riffle-pool sequences, cover, and reduction of stream channel width where over-widening has occurred. Treatments include addition of large woody debris (LWD), boulder additions, and root wad and woody bank material placement. Appendix H includes references which address principles of design considerations for stream complexity restoration.

Successful stream restoration requires a monitoring component. It also requires a realization that change may take several years, or in the case of restoration of riparian canopy may take decades to occur. The Gulf of Maine Program has published a Stream Barrier Removal Guide (Appendix J) which provides methodology to document changes to stream morphology and success of stream restoration projects. Although specifically intended for monitoring of barrier removal, the guide is useful for standardizing protocols for additional channel restoration efforts. Specific methodologies incorporated into SHARE’s restoration program include:

- Bench marked photo points for photographic comparison of site changes over time
- Bench marked longitudinal profiles
- Bench marked cross-sectional transects of reference channels

- Pebble counts to document changes in stream bed material
- Placement of erosion control pins in the channel thalweg at site locations with excessive amounts of road sediment downstream of road/stream crossings

In addition to monitoring changes in channel morphology, the USFWS MFRO is monitoring water temperature before and after site restoration with remote continuous recording temperature loggers. Biological monitoring of changes to salmonid presence and community structure is the ultimate goal for restoration efforts intended to benefit restoration of endangered Atlantic salmon populations. Electrofishing is beyond the capacity and permit authority of Project SHARE under Section 10 of the Endangered Species Act. SHARE relies on USFWS and MDMR fisheries biologists to assist with monitoring changes in the fisheries community structure under the authority of their Section 10 permits.

Water Chemistry Enhancement

Mitigation of pH/aluminum related water chemistry ideally requires a landscape scale program to address a watershed scale threat. To date we have not had the information required nor funds necessary to initiate a watershed scale program. Efforts to date have been scaled to develop pilot projects on a site-specific scale in an attempt to develop cost-effective means of mitigating water chemistry. Terrestrial applications of limestone as part of road/stream crossings has shown some potential for program scale application. We are also working toward approval of a pilot project to place clam shells (a biological form of calcium carbonate) in-stream as a method to mitigate low pH and elevated aluminum. It is clear that localized applications near or in bodies of water are not sufficient and some form of larger scale terrestrial application will be required. Our intent is to continue implementing small-scale localized pilot projects in an effort to gain information toward developing a water chemistry mitigation program. If successful and permit authority is granted, this section of the strategic plan will be amended to incorporate successful strategies.

PARTNERS

Project SHARE – Steven Koenig, Executive Director of SHARE, acts as general contractor site restoration projects with direct responsibility for developing restoration partnerships (particularly authorization from private land owners), restoration projects and site selection, fund raising and administration, and hiring contractors.

U.S. Fish and Wildlife Service (USFWS) – Maine Fisheries Resource Office (MFRO) – Scott Craig, biologist, co-manages the restoration projects. The MFRO provides much of the biological assessment and monitoring that supports decision making for restoration projects. In addition, the USFWS is a funding source for fish passage-related projects. Biological assessments of fish community structure and removal of fishes from construction sites via electrofishing are conducted by USFWS biologists under the authority of their Section 10 permit.

Natural Resources Conservation Service (NRCS) - NRCS provides funding and technical assistance for habitat restoration activities. Engineers and technical staff survey and design road crossing replacements. NRCS staff also provide on-site supervision for Wildlife Habitat Incentives Program funded projects.

Maine Department of Marine Resources (MDMR) – Salmon biologists with the MDMR provide advice and technical assistance. Biological assessments of fish community structure and removal of fishes from construction sites via electrofishing are conducted by MDMR biologists under the authority of their Section 10 permit. MDMR provides funding for general support as well as habitat restoration projects.

Washington County Soil and Water Conservation District WCSWCD – The WCSWCD provides technical and funding assistance to Project SHARE. In addition, WCSWCD manages restoration projects similar to that which SHARE engages in.

Landowners – Habitat restoration activities are principally conducted on private lands and state-owned land managed by the Maine Department of Conservation. All activities are conducted on a voluntary basis. Memorandums of Agreement have been established between SHARE and landowners which outline the cooperative nature of the restoration efforts. Landowners/land managers currently partnered with SHARE include: Maine Department of Conservation, Wagner Land Management, American Forestry Management, Cherryfield Foods, Jasper Wyman & Son, Timbervest, LLC., Malcolm and Barbara French, and Downeast Lakes Land Trust.

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APPENDIXES

- A. SHARE Restoration Handbook
- B. Maine Road Crossing Assessment Protocol
- C. Maine Dam and Natural Barrier assessment Protocol
- D. Vermont Stream Geomorphic Assessment Appendix G
- E. FishXing
- F. Stream Simulation Crossing Design
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