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Status of Western Maine Stream Restoration Projects

By Forrest R. Bonney

Caring for Maine's Outdoor Future

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Maine Department of Inland Fisheries
and Wildlife
Division of Fisheries & Wildlife

FISHERY INTERIM SUMMARY REPORT SERIES NO. 08-07
STATUS OF WESTERN MAINE STREAM RESTORATION PROJECTS

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WESTERN MAINE STREAM RESTORATION

INTERIM SUMMARY REPORT NO. 1 (1998-2008)

SUMMARY

Sixteen projects to restore brook trout habitat were constructed on western Maine streams located in Oxford, Franklin, and Somerset counties between 2000 and 2008. These streams have water quality suitable for brook trout but were degraded by historic log drives and other anthropogenic disturbance as indicated by overwidening, entrenchment, a lack of pools, straightening, instability, and/or severe flow fluctuations. These projects were initiated by the Maine Department of Inland Fisheries and Wildlife (MDIFW) and other agencies, private companies, and non-governmental groups to remedy degradation and restore brook trout habitat. This report summarizes the restoration techniques used, monitoring efforts, and funding sources.

Four of the projects involved channel manipulation; six involved building instream or streamside structures that did not involve reshaping of the entire channel; and six involved only the addition of coarse woody debris with no physical alteration of the channel.

Monitoring efforts, which are still underway on most of the projects, indicate that most restoration efforts have been successful to date in improving brook trout habitat and withstanding flows; those few structures that have not been successful have been repaired or rebuilt.

KEY WORDS: BKT, HABITAT ALTERATION, HABITAT EVALUATION, STREAM, STREAM SURVEY, WATER QUALITY

INTRODUCTION

Since 1998, MDIFW has conducted extensive surveys on the main stems of 10 western Maine rivers and streams covering a total length of 122 miles. These surveys were conducted to determine the quantity and quality of fisheries habitat (primarily brook trout) for all life stages; fish species presence and abundance; thermal regimes; water quality; stream types (morphological characteristics); and stream health.

Most of the surveyed streams had a history of log drives, and reaches of all of the surveyed streams were degraded, indicating reduced carrying capacity for native brook trout populations. Anthropogenic land use changes such as those experienced by western Maine streams typically result in accelerated rates of runoff. As streams adjust to accommodate these flows they become unstable, resulting in excessive rates of erosion, over-widened reaches, entrenchment, multiple channels, and loss of sinuosity and pools. Identification of degraded reaches helped us to identify candidates for restoration to benefit fisheries and protect downstream habitat. To that end, several restoration projects – based on the principles of natural channel design - have been undertaken on first to third order[1] western Maine streams (Table 1). Some of the projects included were designed primarily to protect infrastructure such as roadbeds, but also would enhance or restore aquatic habitat as a secondary function. This report summarizes the stream restoration projects undertaken to date in western Maine.

TREATMENT AND EVALUATION METHODS

Treatment types

Stream restoration is expensive and technically challenging. To minimize the chance of structural failure, all in-stream projects were designed by fluvial geomorphologists, who also provided construction-phase oversight. The so-called "chop and drop" operations, which involves the addition of coarse woody debris to streams, were implemented by a contractor who has extensive experience in this field.

A stream-by-stream rationale for restorative actions is presented in Table 2 and a description of the treatment types is presented in Table 3. Many of the projects were undertaken to remedy

[1] A first order stream has no tributaries; a second order stream begins below the confluence of two first order streams, etc.

degradation resulting from log driving or other land use practices, which resulted in overwidened reaches devoid of pools. Chop and drop projects were undertaken to moderate flows as well as to improve brook trout habitat by enriching sterile headwater habitat by retaining organic matter and by creating pools. A few of projects were instituted to reduce sediment transport. The most common treatment strategy was to create pools that benefit brook trout by serving as temperature and cover refuges during periods of low flows, which occur both in the summer and winter. V-shaped rock weirs create large pools – in the order of 2-4 feet deep - whereas other treatments, including paired boulders, coarse woody debris, and rock vanes, create smaller pools. However, pools need not be deep to provide valuable cover; depths of as little as one foot deep are sufficient to provide ideal adult brook trout habitat (Raleigh 1982).

Project costs

Costs, itemized by project and funding sources, are presented in Table 4. Costs are subdivided by project design/oversight, and implementation (construction) phases. A summary table of cost per lineal foot (Table 5) indicates that the addition of coarse woody debris, which involves no instream construction, cost only $3.00 to $4.30 per lineal foot. The cost of three treatment types at the Sandy River (the most expensive of which was 4 rock weirs) averaged $19.85 per lineal foot[2]. South Bog Stream, which had four treatment types, cost $93.00 per lineal foot. The most expensive project was the installation of rock vanes and bar buddies on the Sunday River. In this case, stabilization efforts were concentrated over a relatively short distance along a high bank.

Monitoring Methods

Because many of these restoration techniques are new to Maine waters, several are being monitored for efficacy. A variety of methodologies are being used to evaluate the restoration projects, including measurements of both physical and biological parameters (Table 6). Geomorphic assessment consists of both longitudinal (along the channel) and cross-sectional stream measurements for the length of the study area plus upstream and downstream control sites. These measurements quantify both lateral and elevational changes in the stream channel and are repeated annually to determine changes in the slope, width, and depth of the stream. Annual measurements

[2] Costs are calculated from distances measured from upper and lower project extremities, which includes some non-treated sections. In the case of chop and drop projects, this results in no bias, as the entire reach is treated.

of cross sectional transects are also effective in monitoring changes in pool depths. The evaluation of the keystone riffle/pool sequence requires very detailed measurements because pools are small and numerous. The performance of logs with attached rootwads in trapping sediment is monitored by annual photo documentation. Typically, several additional transects are measured upstream, between, and downstream of the restoration sites as controls. Pebble counts are made annually at all transect sites to monitor changes in substrate size over time. Photographs - looking both upstream and downstream - are taken annually at the transects; separate photographs are taken of the structures.

Representative reaches of the treatment and control areas are electrofished annually, but the great extent of natural variability in fish populations from year to year make it difficult to establish cause and effect relationships. Nonetheless, as additional data are gathered, we will evaluate the numbers of fish caught in each treatment area for changes in species abundance and in brook trout age composition.

Aquatic insects were sampled at representative sites because changes in aquatic insect diversity correlate to changes in water velocity and/or substrate size. Samples are typically collected at five locations per event with a 500-micron mesh kick net. The dominance of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddis flies) is indicative of good water quality. Plecoptera in particular require cold water. At chop and drop sites, more intensive monitoring for treatment and seasonal effects on aquatic insect abundance, biomass, and community structure is under way.

The addition of coarse woody debris is intended, in part, to moderate flows by slowing runoff. For this reason, water level gages were installed upstream and downstream of the upper Sunday River chop and drop sites in the spring of 2008 to monitor inflow and outflow. A similar technique will be used at the Branch Brook and Chase Hill Brook sites beginning in 2009.

As mentioned previously, the construction of within-stream structures is technically challenging and each project carries a risk of failure. To date, we have repaired or replaced structures at two sites. At the Sandy River, two rock weirs were damaged by high flows soon after construction and were repaired the next summer; the repaired structures have withstood several high flow events without incident since their repair. Also, through annual monitoring, we found the log wing deflectors at South Bog Stream to be ineffective in maintaining pools. We augmented these structures with rock weirs to create additional pools. Finally, the grade control structures constructed on the Cupsuptic River are trapping sediment as designed, but at a slower rate than anticipated. Overall, though, most of the structures are still functioning as intended several years post-construction.

Evaluation of the chop and drop sites is being conducted by researchers at the University of Maine Department of Wildlife Ecology, who are evaluating the efficacy of coarse woody debris to improve in-stream habitat; a related project involves relocating wild brook trout upstream of impassable barriers into four headwater streams and comparing the restoration potential of wood placement in populated streams to that of stocking trout in vacant habitat (Coghlan et. al 2008). University researchers are also assessing the impacts of riparian forest characteristics on terrestrial invertebrate input, aquatic insect production, and brook trout energetics in headwater streams. Their monitoring consists of pre-treatment surveys of brook trout (abundance, biomass, and size structure), aquatic insects (abundance, biomass, and community structure), streamside salamanders (abundance by species), physical habitat (mean depth, substrate composition, wood load, frequency and aerial coverage of pools, temperature and water chemistry), and geomorphic/hydrologic variables (embeddedness, scour, sediment load, physical measurements, and flows).

Monitoring costs

Project monitoring has been funded for a number of sources, including Maine Department of Transportation mitigation projects and Federal Energy Regulatory Commission relicensing settlement funds (Table 7). MDIFW, supported by the Federal Aid in Sport Fish Restoration Program, Project F-28-P, and volunteers (Table 8), is monitoring a number of sites. Finally, the University of Maine, with funding from the National Fish and Wildlife Foundation (NFWF), is monitoring projects associated with coarse woody debris placement as part of a larger study on ecology and conservation of brook trout in western Maine streams. However, current funding capabilities have not allowed all variables of interest to be monitored at all sites. For example, a number of the reaches where coarse woody debris has been added are not currently being monitored for changes in physical parameters or flow attenuation.

RECOMMENDATIONS

Projects implemented to date have been – at least in the short term – effective in physically restoring stream reaches to their natural dimensions, with assumed benefits to aquatic biota including brook trout. The monitoring methodology used by DIFW and consultants has proven to be effective in documenting treatment effects and should be continued.

Project monitoring is critical in determining the efficacy and longevity of stream restoration projects, yet funding typically does not include financing for monitoring, which can be burdensome because it involves several years' data collection and analysis. Furthermore, many restoration projects do not yield detectable results on fish populations until several years after completion (Sweka and Hartman 2006). We therefore recommend that the monitoring of these projects be completed and that every effort be made to integrate monitoring – including data analysis and report writing - into future restoration funding packages.

ACKNOWLEDGMENTS

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Table 1. Locations, dimensions, and drainage areas of treated rivers and streams.

Name	Town	County	Stream length (mi.)	Stream drainage area (mi^2)	Stream order at work site
Austin Stream	Moscow	Somerset	14.3	90.2	3
Barkers Brook	Newry	Oxford	2.6	3.4	3
Bear River	Newry	Oxford	12.5	43.4	2
Bemis Stream	Township D	Franklin	6.3	11.6	3
Branch B	Newry	Oxford	2.8	9.0	1
Chase Hill B	Newry, Andover	Oxford	3.2	3.2	1
Chase Stream	Moscow	Somerset	5.6	10.3	3
Cold Stream	West Forks, etc.	Somerset	18.0	48.4	4
Cupsuptic River	Upper Cupsuptic	Oxford	19.3	62.5	3
Enchanted Str., E. Br.	Upper Enchanted	Somerset	2.5	6.5	3
Four Ponds Brook	Township D	Franklin	.	4.2	2
South Bog Stream	Rangeley Plt.	Franklin	6.3	17.9	3
Sandy River	Sandy River Plt.	Franklin	65.6	596.0	2
Sunday River, upper	Riley Plt.	Oxford	13.3	51.4	1
Sunday River, lower	Newry	Oxford	13.3	51.4	4

Table 2. Rationale for restorative actions.

Austin Stream	Austin Stream has been degraded by log driving and was overwidened at the treatment reach. The intent of the project was to improve channel function by narrowing the channel, raising the elevation of two riffles to improve the connectivity to the floodplain.
Barker Brook	The treated reach was overwidened and lacked sufficient competency to transport sediment through the system, resulting in aggradation.
Bear River	Mass wasting eroded a steep bank, threatening roadbed and resulting in siltation and aggradation of downstream reaches.
Bemis Stream and Four Ponds Brook	Bemis Stream is a historic brook trout spawning tributary to Mooselookmeguntic Lake that was degraded by log driving and is susceptible to erosive flows. Four Ponds Brook is a tributary to Bemis Stream. Placement of coarse woody debris in the upper reaches of these streams is intended to moderate flows and provide additional habitat for brook trout. There are currently no brook trout in upper Bemis Stream, but we plan to move them from the lower to the upper reaches and monitor their performance in both treated and untreated reaches.
Branch Brook and Chase Hill Brook	Addition of coarse woody debris is intended to moderate high flows that threaten two of Newry's town bridges. Chase Hill Brook is a tributary to Branch Brook
Chase Stream	Degraded by bulldozing, including formation of riparian berms, for flood control.
Cold Stream	Degraded by log driving, this stream has cold ground water, has a native brook trout population, and serves as spawning/nursery habitat for brook trout that migrate from the Kennebec River.
Cupsuptic River	The Cupsuptic River has a native brook trout population but many of the pools have been filled in by sediment. The project is located at the site of an old log driving dam and large amounts of sediment are eroding from this site into down steam pools. This project was initiated to determine whether grade control structures are effective in arresting downstream sediment migration.
Enchanted Stream, East Branch	Degraded by log driving; native brook trout population.
Sandy River	The upper reaches of the Sandy River (above Smalls Falls, an impassible upstream fish barrier) have wild brook trout but the river is degraded from log driving and/or the highway that parallels it. It's proximity to Rt. 4, a major access highway to the Rangeley region, makes it easily accessible to anglers.
South Bog Stream	South Bog Stream has a wild brook trout population and is a spawning tributary to Rangeley Lake. Much of the stream is destabilized, attributed to a history of log driving.
Sunday River	The Sunday River has a history of log driving and the remains of several dams were discovered during the survey. In the lower reaches of the river valley, land uses include agriculture, a ski area, and a golf course. There is a history of flooding, erosion, and avulsions attributed to accelerated rates of runoff. The river supports populations of native brook trout and nonnative rainbow trout.

Table 3. Stream treatment types and description by water.

Treatment type	Description	Function	Stream(s)	Location
Bar buddies	Trees placed along the shoreline and attached to another anchor tree, which is inserted vertically into the substrate; installed between rock vanes.	Reduces erosion along the shoreline; creates cover for aquatic biota, including fish.	Sunday River Bear River	Newry, Oxford Co. Newry, Oxford Co.
Coarse woody debris addition ("chop and drop")	Trees felled across stream at a rate of 200-600 (average 500) stems/mile	Creates stream complexity, traps sediment, moderates flows, adds organic nutrients	Bemis Stream Four Ponds Brook Branch Brook Chase Hill Brook Sunday River	Township D, Franklin Co. Township D, Franklin Co. Newry, Oxford Co. Newry, Oxford Co. Riley Twp., Oxford Co.
Grade control structures	Structures of logs and boulders that cross entrenched streams, allowing flows to overtop	Traps sediment, reconnects stream with floodplain	Cupsuptic River	Upper Cupsuptic, Franklin Co.
Keystone rock structures	Large stones implanted in rows across the channel to form small cascades, thereby controlling the grade and anchoring the riffle structure	Narrows channel, creates riffle/pool sequences, scours small pools	South Bog Stream	Rangeley Plt., Franklin Co.
Logs	Tree boles without root wads	Divert flow to narrow channel	Sandy River	Sandy River Plt.
Log wing deflectors	Triangular, rock-filled log structures with apex pointed into flow	Narrows channel	South Bog Stream Austin Stream	Rangeley Plt.,, Franklin Co. Moscow, Somerset Co.
Paired boulders	Placed side by side in channel with slot to accelerate flow	Scours small pool, provides cover, recruits woody debris	Sandy River	Sandy River Plt.
Rock sills	Rock deflectors extending across most of channel, angled upstream	Diverts flow to encourage meander development in straightened reaches and bank scour to create pools	Enchanted Stream (E Br) Cold Stream	Upper Enchanted Twp., Somerset Co. West Forks Plt., Somerset Co.

Table 3. Stream treatment types and description by water (con't).

Rock vanes	Rock structures originating in the banks, extending a portion of the way across the channel, and sloped upstream	Diverts flow away from the banks to reduce erosion	Sunday River Bear River	Newry, Oxford Co. Newry, Oxford Co.
Rock weir	V-shaped boulder structure with apex upstream; flow diverted to center scours pool immediately downstream	Creates and sustains pools by directing flow to mid-channel	Enchanted Stream (E Br) Cold Stream Sandy River South Bog Stream	Upper Enchanted Twp., Somerset Co. West Forks Plt., Somerset Co. Sandy River Plt., Franklin Co. Rangeley Plt., Franklin Co.
Root wads	Tree boles with roots attached	Protect bank from erosion; trap sediment; provide brook trout cover when roots are submerged	Bear River Cold Stream Enchanted Stream (E Br), Sandy River, South Bog Stream Sunday River	Newry, Oxford Co. West Forks Plt., Somerset Co. Upper Enchanted Twp., Somerset Co. Sandy River Plt., Franklin Co. Rangeley Plt., Franklin Co. Newry, Oxford Co.

Table 4. Treatment, costs and funding sources by stream, and project, arranged by year of construction.

Stream	Project	Year	Cost: Design/ oversight	Cost: Implementation	Funded by
Austin Stream	3 log wing deflectors, riffle inverts, channel realignment	2003	$8,500	$123,000	MDOT mitigation monies
Barker Brook	Reconfigure channel, create flood storage capacity	2006	$11,400	$182,000	MDOT mitigation monies Trout Unlimited (Embrace a Stream)
Bear River	Install 4 rock vanes, 2 bar buddies, woody debris	2008	$18,744	$64,383	Town of Newry, Maine
Bemis Stream	2 miles coarse woody debris	2007	$3,930	$16,000	Upper-Middle Dams FERC Relicensing Settlement/FPL Energy Maine Hydro LLC
Branch Brook/Chase Hill Brook	2 miles coarse woody debris	2008		$16,000	Town of Newry, Maine
Chase Stream	18' rock weir for fish passage; 35' of bank stabilized	2002	$4,000	$4,000	MDOT mitigation monies
Cold Stream	1 rock weir, 3 rock sills, coarse woody debris, floodplain formation	2008	$51,000	$107,000	Harris Dam FERC Relicensing Settlement/FPL Energy Maine Hydro LLC
Cupsuptic River	2 grade control structures	2002	$2,500	$7,500	Trout and Salmon Foundation

Table 4. Treatment, costs and funding sources by stream, and project, arranged by year of construction (con't).

			Cost		
Stream	Project	Year	Design/ oversight	Implementation	Funded by
Enchanted Stream, East Branch	2 rock weirs, 2 rock sills, coarse woody debris, floodplain development	2008	$42,500	$86,000	Harris Dam FERC Relicensing Settlement/FPL Energy Maine Hydro LLC
Four Ponds Brook	1 mile coarse woody debris	2007	0	$8,000	Upper-Middle Dams FERC Relicensing Settlement/FPL Energy Maine Hydro LLC
Sandy River	4 rock weirs with rood wads, 4 paired boulders logs	2006	$9,971	$5,000	MDIFW (in kind, implementation) Trout Unlimited (Embrace a Stream), $4,000 Davis Foundation, $2,000 Rangeley Region Guides' and Sportsmen's Assoc., $400
South Bog Stream	Upper – keystone riffle/pool sequence, channel realignment, floodplain formation	2005	$1,200	$24,000	MDOT mitigation monies
South Bog Stream	Middle – 3 rock weirs, logs with rootwads	2006	$10,900	$14,600	USFWS/ FishAmerica Foundation, $10,000 Trout Unlimited (Embrace a Stream), $3,000 Federal Aid in Sport Fish Restoration Program, $9,000
South Bog Stream	Lower – 5 pairs of log deflectors	2004	$5,350	$15,000	Trout and Salmon Foundation, $7,500 Trout Unlimited (Embrace a Stream), $2,200 Rangeley Region Guides' and Sportsmen's Assoc., $10,000
South Bog Stream	Lower – 3 rock weirs	2007	$6,300	$12,185	Upper/Middle Dams FERC Relicensing Settlement
Sunday River (upper)	½ mi. coarse woody debris, 2 tribs	2007	0	$23,530	US Fish and Wildlife Service/Androscoggin River Watershed Council, $22,769 Trout Unlimited (Georges River Chapter), $761

Table 4. Treatment, costs and funding sources by stream, and project, arranged by year of construction (con't).

Stream	Project	Year	Cost Design/ oversight	 Implementation	Funded by
Sunday River (lower)	Six rock veins, 4 bar buddies[3]	2008	$25,617	$82,271	Federal Emergency Management Agency/Maine Emergency Management Agency Local match[4]

[3] Anchor trees driven vertically into the riverbed with root masses protruding.
[4] Town of Newry, Maine; Sunday River Ski Company; Hurricane Island Outward Bound School; local residents; volunteers.

Table 5. Project costs per lineal foot.

Stream	Project type	Project cost	Project length (ft.)	Project cost per linear foot[5]
Austin Stream	3 log deflectors, raised riffle invert	$123,000	680	$181
Barker Brook	Channel reconfiguration	$182,000	1,100	$165
Bear River	4 rock vanes, 2 bar buddies	$83,127	560	$148
Bemis Stream	Coarse woody debris	$19,930	5,280	$4
Chase Stream	Bank stabilization; rock weir for fish passage			
	Total	$8,000	54	$148
Cold Stream	1 rock weir, 3 rock sills, berm removal, cabled logs with root wads, fill removal			
	Total	$158,000	2,400	$66
Cupsuptic River	2 grade control structures	$10,000	832	$12
Enchanted Stream, E Br	2 rock weirs, 2 rock sills, cabled logs with root wads, flood plain development			
	Total	$128,500	510	$252
Four Ponds Brook	Coarse woody debris	$8,000	2,640	$3
South Bog Stream	Keystone riffle/pool sequence, 6 rock weirs,10 log deflectors, 24 cabled logs with root wads			
	Total	$24,000	258	$93
Sandy River	4 rock weirs with root wads 4 paired boulders, 2 cabled logs			
	Total	$14,971	755	$20
Sunday River (upper)	Coarse woody debris[6]	$22,769	5,280	$4
Sunday River (lower)	6 rock vanes and 4 bar buddies	$107,888	400	$270

[5] Rounded to nearest dollar.

[6] One-half mile sections of each of two tributaries.

Table 6. Methods and duration of monitoring. Number (No.) refers to the number of parameters measured or sampled annually.

	Cross-sectional transects		Longitudinal profile		Pebble counts		Electrofishing sites		Macro-invertebrate collections		Photo record
Stream	No.	Year(s)[7]	No.	Year(s)	No.	Year(s)	No.	Year(s)	No.	Year(s)	Year(s)
Austin Stream	3	2003-2005	1	2003-2005	3	2003-2005	0		0		2003-2005
Barker Brook	5	2007-2012	1	2007-2012	3	2007-2012	0		0		2007-2012
Bemis Stream							3	2008-2010	3	2008-2010	
Branch/Chase Hill Bk	3	2008-	1	2008-	1	2008-	2	2008-2010	2	2008-2010	2008-
Cold Stream	9	2008-2011	1	2008-2011	4	2009-2011	2	2009-2011	2	2009-2011	2008-2011
Cupsuptic R	8	2000-2007	1	2001, 2002	2-3	2000, 2002			1	2003, 2004	
Enchanted Str, E Br	9	2008-2011	1	2008-2011	4	2009-2011	2	2009-2011	2	2009-2011	2008-2011
Four Ponds Brook							2	2008-2010	2	2008-2010	
Sandy River	12	2006-2008	0		12	2006-2008	1-3	2006-2008	1	2006	2006-2008
South Bog Str: Upper	5	2003-2008	1	2003-2008	5	2005-2008	1	2004-2008	1	2003-2008	2007-2008
Middle	7	2003-2008	1	2003	7	2005-2008	1-2	2004-2008	1		2007-2008
Lower	9	2003-2008	0		9	2005-2008	1	2005-2008			2007-2008
Sunday R tribs							3	2008-2010	3	2008-2010	

[7] Not all transects were measured all years.

Table 7. Monitoring duration, costs, and funding sources.

Stream	Duration (years)	Cost	Funding Source	Monitoring conducted by
Austin Stream	5	$11,355	MDOT	Parish Geomorphic Ltd., Georgetown, Ontario, Canada
Barker Brook	5	$18,310	MDOT	Parish Geomorphic Ltd., Georgetown, Ontario, Canada
Bemis Stream	3	$12,000	NFWF	University of Maine, Orono, ME
Branch Brook/Chase Hill Brook	3	$8,000	NFWF	Field Geology Services, Farmington, ME Fiddlehead Environmental Consulting, Harrison, ME University of Maine, Orono, ME
Cold Stream	3	$5,000	Harris Dam FERC Relicensing Settlement/FPLE	FPL Energy Field Geology Services, Farmington, ME Ben Hayes, Ph.D., Mifflinburg, PA
Cupsuptic River	7	$8,000	Sport Fish Restoration Federal Match	MDIFW Volunteers, RRGSA
Enchanted Stream, E Branch	3	$5,000	Harris Dam FERC Relicensing Settlement/FPLE	FPL Energy Field Geology Services Ben Hayes
Four Ponds Brook	3	$8,000	NFWF	Field Geology Services University of Maine
South Bog Stream, Upper	5	$5,500	MDOT	MDIFW Volunteers, RRGSA
South Bog Stream, Middle and Lower	5	$4,438	MDIFW	MDIFW Volunteers, RRGSA
Sandy River	3	$2,270	Sport Fish Restoration Federal Match	MDIFW Volunteers, RRGSA
Sunday River (upper)	3	$12,000	NFWF	Field Geology Services Fiddlehead Environmental Consulting University of Maine

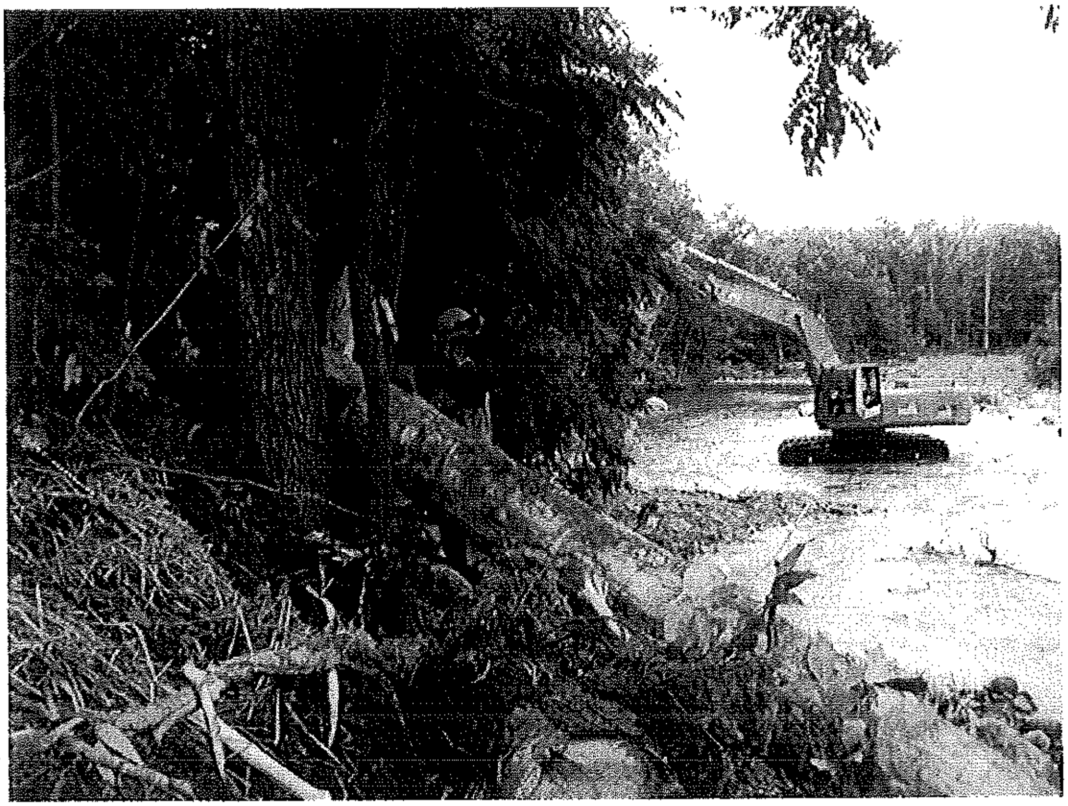
FPLE: FPL Energy Maine Hydro LLC, Augusta, ME
MDIFW: Maine Dept. Inland Fisheries & Wildlife, Augusta, ME and Strong, ME
MDOT: Maine Dept. of Transportation, Augusta, ME
NFWF: National Fish and Wildlife Foundation, Washington, DC
RRGSA: Rangeley Region Guides' and Sportsmen's Association, Rangeley, ME

Table 8. Number of hours volunteers contributed to monitoring of stream restoration sites.

Stream	Year	No. volunteers	Total no. hours	Monetary value of volunteer hours[8]
Cupsuptic River	2001	6	72	$1,098.00
	2002	4	48	$732.00
	2003	4	48	$732.00
	2004	4	48	$732.00
	2005	4	48	$732.00
	2006	4	48	$732.00
	2007	4	48	$732.00
	All			**$5,490.00**
Sandy River	2006	3	30	$457.50
	2007	3	30	$457.50
	2008	3	30	$457.50
	All			**$1,372.50**
South Bog Stream	2004	4	45	$686.25
	2005	4	45	$686.25
	2006	4	50	$762.50
	2007	4	50	$762.50
	2008	4	50	$762.50
	All			**$3,660.00**
All	**All**			**$10,522.50**

[8] Based on a 2006 Maine hourly value of $15.25. Source: Independent Sector

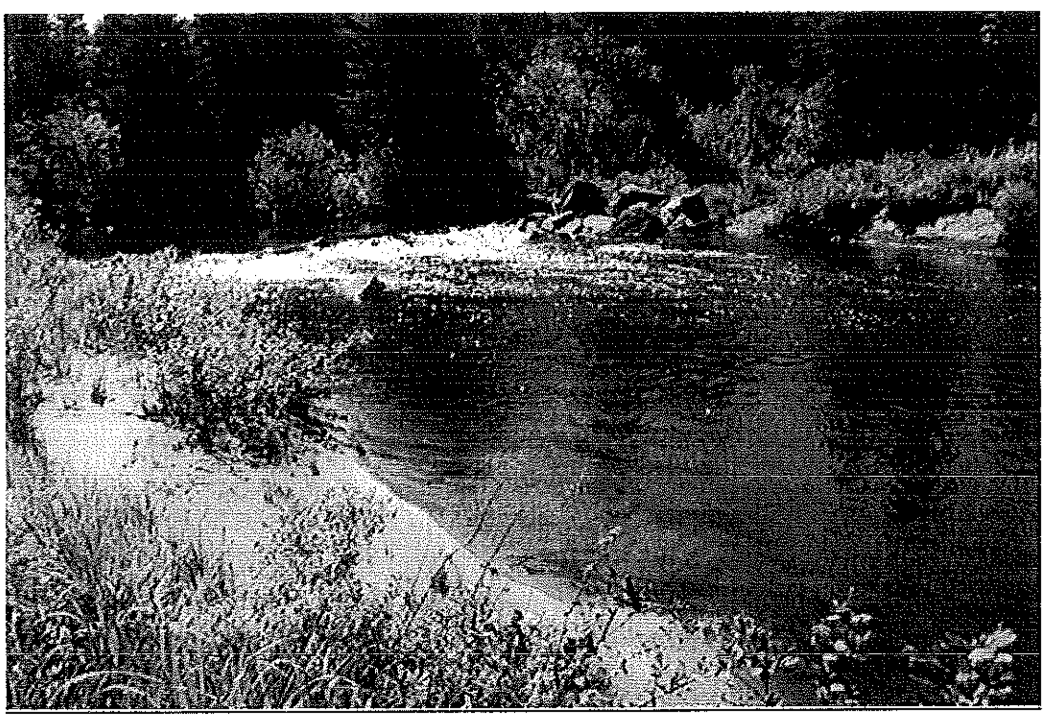
Appendix 1. Photos of representative structures.



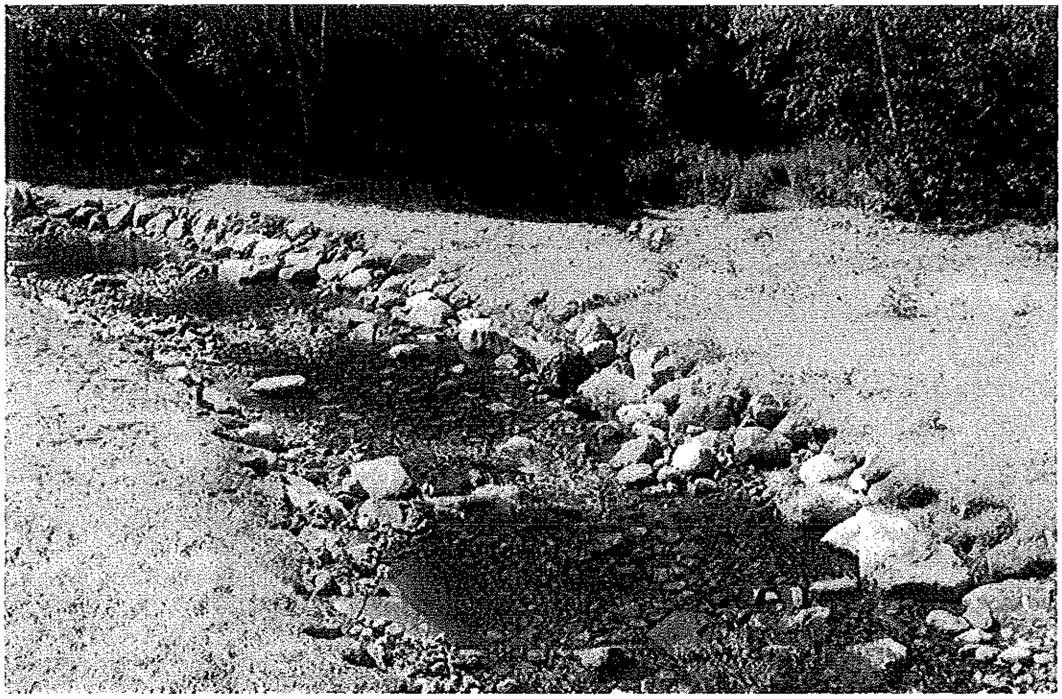
Bar buddies being placed between rock vanes in Sunday River, 2008, to stabilize shoreline.

Newly-cut coarse woody debris, upper Sunday River, 2007.

Coarse woody debris, upper Sunday River, 2008, one year after placement, showing consolidation of stems, resultant pool formation, and trapping of organic material.



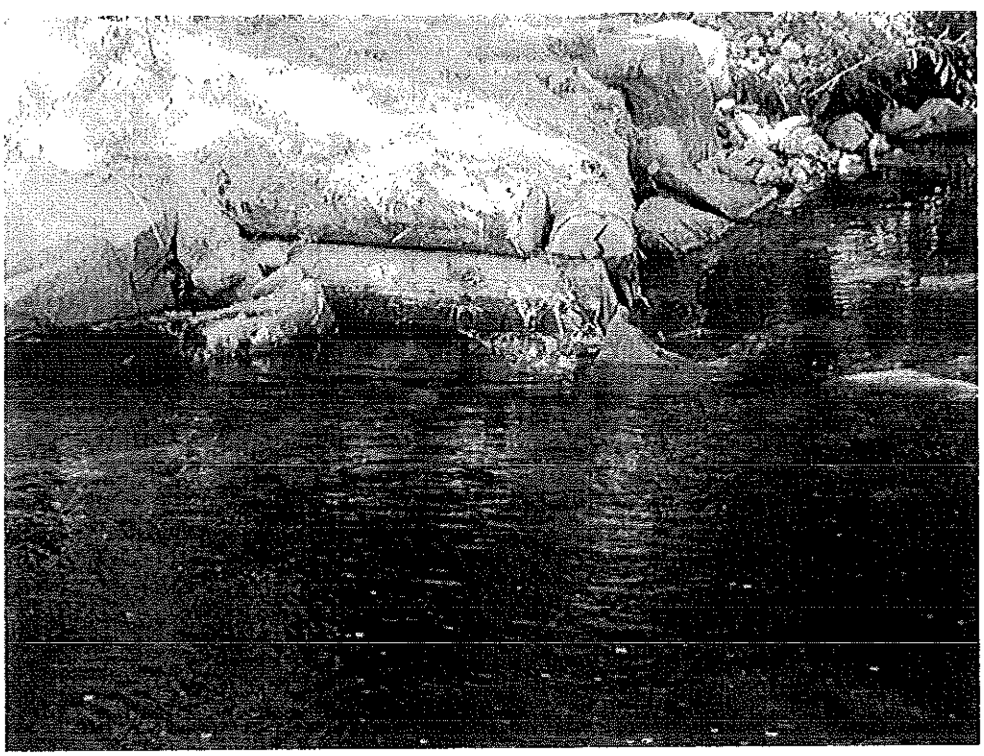
Grade control structure, Cupsuptic River, showing accumulated downstream sediment.



Newly-constructed keystone rock structures, South Bog Stream, built to create riffle-pool sequences.

Keystone rock structures, South Bog Stream, four years after construction, showing concentrated flow and riffle-pool sequence.

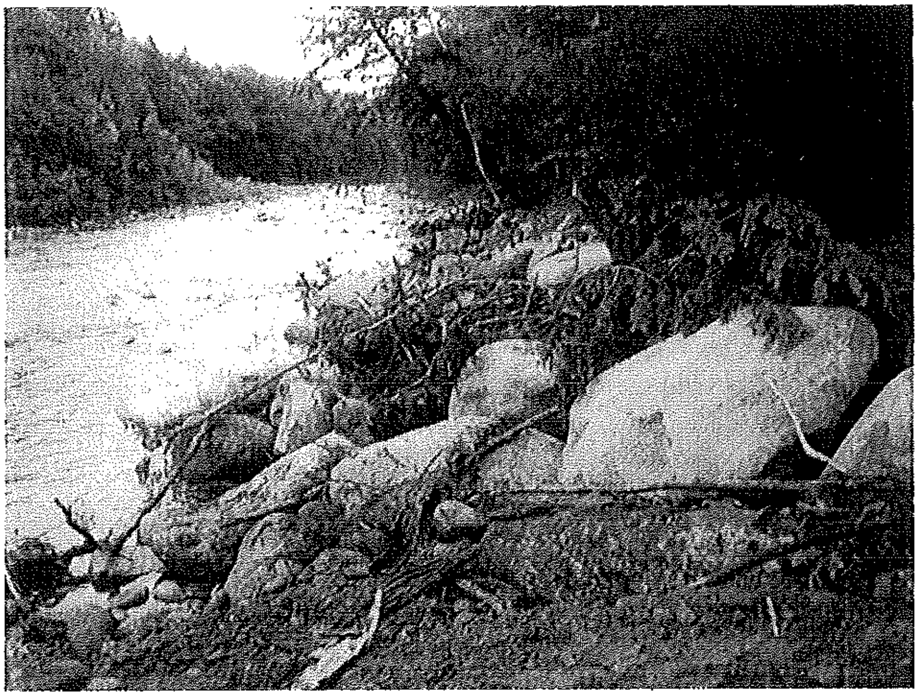
Cabled log, Sandy River, placed in 2007 to divert flow and narrow channel.



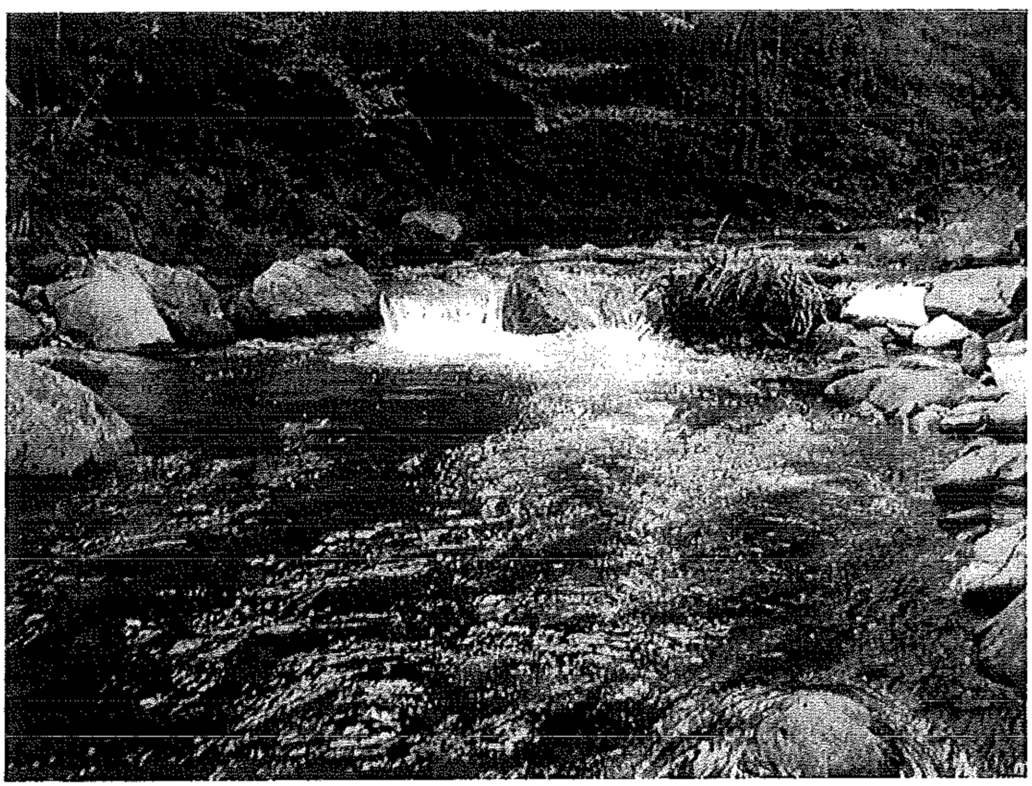
Log wing deflector, South Bog Stream, installed 2004 to narrow channel and trap sediment.

Paired boulders, Sandy River, showing scoured pool, "tailings", and recruited woody debris.

Rock sill, East Branch Enchanted Stream, constructed 2008 to encourage meander development and to scour pools.



Rock vanes, Sunday River, installed 2008 to divert flow away from bank, trap sediment, narrow stream, and create pools.



Rock weir, Sandy River, constructed 2007, with embedded root wad, showing scoured pool.

Root wads, South Bog Stream, placed to trap sediment and narrow an overwidened reach.

COOPERATIVE

STATE SPORT FISH RESTORATION FEDERAL

PROJECT

This report has been funded in part by the Federal Aid in Sport Fish Restoration Program. This is a cooperative effort involving federal and state government agencies. The program is designed to increase sport fishing and boating opportunities through the wise investment of anglers' and boaters' tax dollars in state sport fishery projects. This program which was funded in 1950 was named the Dingell-Johnson Act in recognition of the congressmen who spearheaded this effort. In 1984 this act was amended through the Wallop-Breaux Amendment (also named for the congressional sponsors) and provided a threefold increase in Federal monies for sportfish restoration, aquatic education and motorboat access.

The Program is an outstanding example of a "user pays-user benefits", or "user fee" program. In this case, anglers and boaters are the users. Briefly, anglers and boaters are responsible for payment of fishing tackle excise taxes, motorboat fuel taxes, and import duties on tackle and boats. These monies are collected by the sport fishing industry, deposited in the Department of Treasury, and are allocated the year following collection to state fishery agencies for sport fisheries and boating access projects. Generally, each project must be evaluated and approved by the U.S. Fish and Wildlife Service (USFWS). The benefits provided by these projects to users complete the cycle between "user pays — user benefits".

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