Fundy Model Forest

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"The Fundy Model Forest (FMF) is a partnership of 38 organizations that are promoting sustainable forest management practices in the Acadian Forest region."

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"Ecological restoration is a holistic approach not achieved through isolated manipulation of individual elements, but through approaches ensuring that natural ecological processes occur."

National Research Council, 1992

"Clearly, the widespread practice of engineered structural modifications to stream with little or no scientific evidence biological benefits represents a management paradox of immense proportion."

Kauffman, et al., 1997.
Fisheries, Volume 22.

TABLE OF CONTENTS

Table of Contents – Cont'd

EXECUTIVE SUMMARY

Habitat and fish production data for Kennebecasis and Hammond streams within the Fundy Model Forest has been analyzed to (1) identify stream ecoreaches (habitat management units); (2) appreciate Atlantic salmon abundance; (3) estimate potential salmonid production from habitat variables; and (4) suggest a fish and habitat monitoring program. Watershed management suggestions are also offered.

Habitat inventories identified "ecoreaches" with similar geomorphological and temperature conditions within primary stream sections. Potential salmonid production was estimated assuming habitat conditions control the stream density of salmonids.

Kennebecasis basin streams contain 2.8 million square meters (m^2) of habitat, comprised of 10% riffles, 66% runs and 24% pools. The main stem Kennebecasis and its smaller tributaries contain 1.44 million m^2 of aquatic habitat, but only five percent of this area is comprised of riffles, considered productive area for Atlantic salmon juveniles Brook trout habitat is also limited on the main stem Kennebecasis due to limited riparian cover, presence of fine substrates and cool ($\exists$21ºC), rather than cold, water temperatures. Most small tributary streams to the main Kennebecasis and headwaters of sub-basins (Millstream, Trout Creek, Smiths Creek, and South Branch) offer fair to good habitat conditions for trout. Water qualities are favourable to fish production with the unusual exception of low or non-existent flows in the main stem Kennebecasis and South Branch headwaters. Suspended solid concentrations indicate excessive riparian and/or up-slope erosion throughout much of the basin.

Redd counts indicate self-sustaining Atlantic salmon populations in Millstream, Trout Creek, and Smiths Creek, but trend information for salmon or trout juvenile salmonid densities are not available. Juvenile density studies by Fisheries and Oceans Canada indicate a large decline of Atlantic salmon spawning escapement in the main stem Kennebecasis; brook trout density information is limited to UNB estimates in 1996, 1997 and 1998 that found fair to good populations on the upper main stem Kennebecasis and South Branch. Juvenile salmon densities in Smiths Creek appear to have declined substantially since 1997. Annual redd counts and salmonid density studies should be stratified for riffle and run habitat types within ecoreaches.

The counting fence on mainstream Kennebecasis enumerated 127 (1996) and 119 (1997) adult salmon probably destined to spawn in the upper two ecoreaches. The potential egg deposition from these fish would be about 1 egg/m^2, less than one-half the DFO conservation requirement of 2.4 eggs/m^2.

Kennebecasis streams have potential to produce 390 (worst case) to 3936 (best case) adult Atlantic salmon. Production from three large sub-basins (Millstream, Trout Creek and Smiths Creek,) is similar to mainstream production, although the sub-basins have 600,000 m^2 less aquatic habitat. Potential brook trout production (density) is high for headwater Ecoreaches 4 and 5 for main stem Kennebecasis and the upper portions of Ecoreach 3 and associated Stone and McLeod brooks. Trout population potential is also high in Sharp Brook (Millstream tributary); Ecoreach 14 of Trout Brook; McGregor and Sally brooks (Smiths Creek tributaries); and the South Branch.

A monitoring program to assess present fish and habitat conditions, as well as to identify ecological stress, is suggested through assessment of marginal stream temperatures (18-21ºC summer afternoon temperature), fish assemblages, salmonid densities and sedimentation.

Future restoration and conservation activities require a basin restoration "blueprint" or strategic plan accepted by stakeholders and basin resource users and managed by a permanent staff with supporting infrastructure.

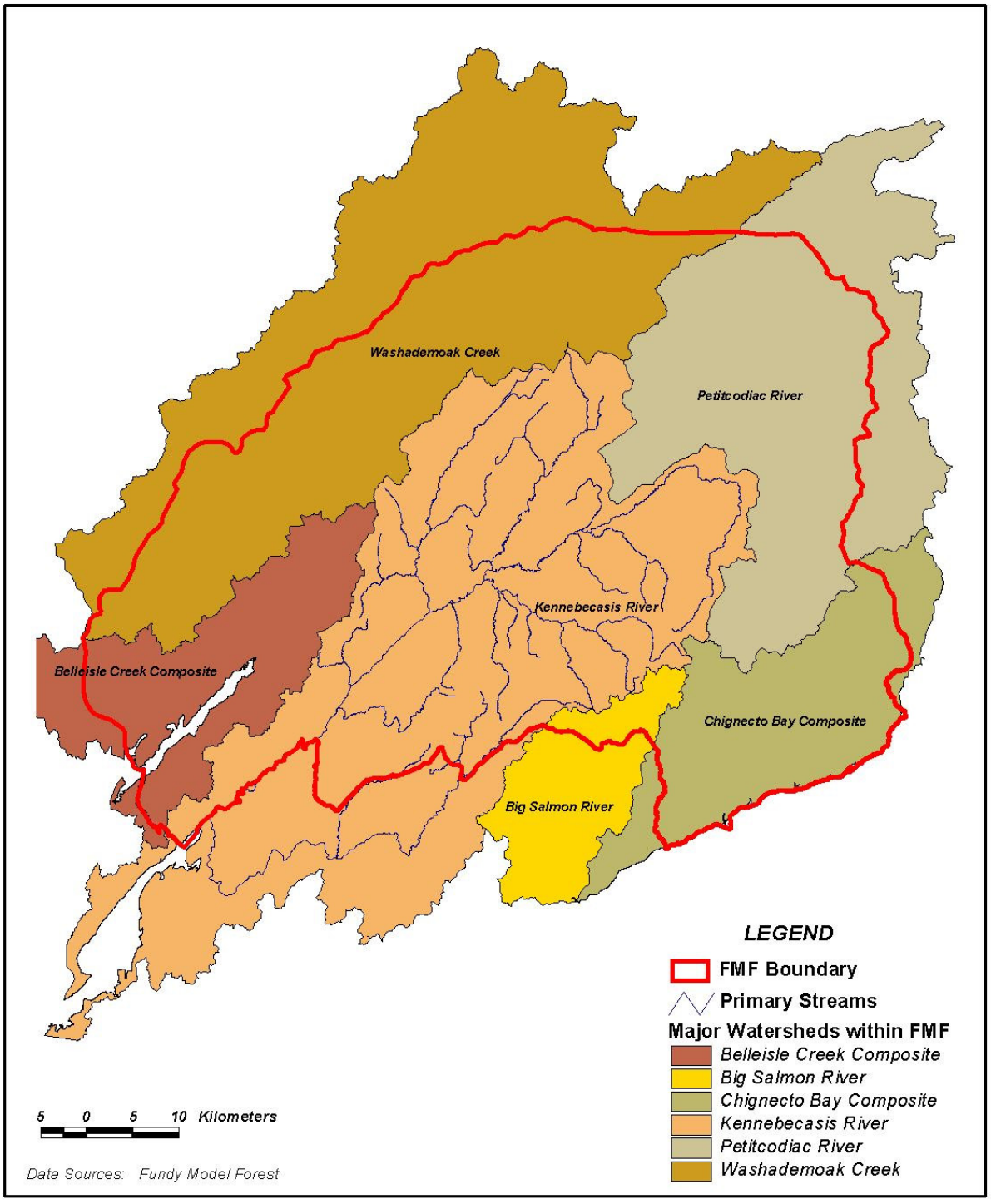
INTRODUCTION

This study assesses past habitat and fish population work on streams in the Kennebecasis River and Hammond River basins within the Fundy Model Forest Hammond River basin (Figure 1). Previous aquatic studies by the University of Moncton researchers are not included.

The purpose of this study is to:

1. analyze available aquatic habitat and fish population data;
2. define stream management units (ecoreaches) important for sampling and monitoring river health, as well as for stratifying management activities;
3. estimate potential salmonid populations based on habitat variables, highlighting those streams or stream sections most productive to salmonids;
4. suggest a basin-wide stream monitoring program for conservation groups to measure the cumulative watershed effects of land-use practices; and
5. suggest strategies and basin locations where watershed conservation groups could direct management efforts.

Figure 1. Kennebecasis and Hammond River streams within the Fundy Model Forest.



METHODS

Habitat, fish population and Atlantic salmon redd count data were obtained from the Kennebecasis Watershed Restoration Committee, the New Brunswick Department of Natural Resources and Energy (DNRE), the Federal Department of Fisheries and Oceans (DFO), University of New Brunswick (UNB), Hammond River Anglers Association and the New Brunswick Aquatic Data Warehouse.

Habitat information was summarized utilizing DNRE's Fishstream I computer program. Potential salmonid production was generated from DNRE's Fishstream II computer program using the basic assumption that habitat conditions control the occurrence or absence of a species at a stream site and can be indicative of fish density (e.g., Clarkson and Wilson, 1995). Since salmonid population estimates stratified by ecoreach or habitat type were unavailable for the Kennebecasis basin streams, production parameters from similar reference streams in northeast New Brunswick were used. Cool water production values were utilized for streams with late afternoon summer temperatures > 21^{o}C whereas coldwater production values were utilized for streams with ≤ 21^{o}C late afternoon summer temperatures.

Ecoreach identification was determined by reviewing field habitat data, digital terrain models, and site visits.

Recommendations for basin-wide monitoring, as well as priority areas for future management initiatives are based on the above information, interviews with watershed group personnel, site visits, and literature reviews.

RESULTS and DISCUSSION

Aquatic Habitat Information

Riffles are the most important production areas for aquatic insects and juvenile salmonids, especially Atlantic salmon. Brook trout require cold (≤18°C, p.m.) summer water temperatures, moderate to abundant overhanging vegetation and substrate cover. A brief description of habitat types and quantities is presented. Specific habitat conditions are detailed in Appendices A and B.

A. Kennebecasis River Basin

1. Main Stem Kennebecasis and Tributaries

This primary stream has 1.44 million m^2 of aquatic habitat comprised of 79% runs (flat, slow moving water), 16% pools and only 5% riffles (Table 1a; Appendix A). Almshouse and Musquash tributaries have limited aquatic area (<35,000 m^2). Moosehorn Creek with 96,000 m^2 (20%) of rifles, but very limited overhanging cover. McLeod Brook has 30,000 m^2 of coldwater habitat with moderate to dense overhanging vegetation. Stone Brook has 23,000 m^2 of coldwater habitat with about one-half with 30% or more overhanging vegetation.

2. Millstream and Tributaries

Main stem Millstream has 303,966 m^2 of aquatic habitat, of which only 13% is riffle type habitat (Table 1a; Appendix A). Tributaries entering Millstream are small (<35,000 m^2) and have only 1% riffle habitat type excepting Mill Brook with 15% riffle area. Overhanging vegetation is very limited in Mill Book, only moderate in Sharp Brook (19,000 m^2) and dense or ideal in McNair Book (16,000 m^2) (Appendix A).

3. Trout Creek and Tributaries

This sub-basin has 373,646 m^2 of aquatic habitat area; riffle areas range from 11 to 32% (Table 1a; Appendix A). Trout Creek and its tributaries have more aquatic habitat diversity than other Kennebecasis sub-basins, yet they have been subject to more severe human abuses. Trout Creek has fluctuating summer water temperatures and sparse overhanging cover, including headwater areas. Ward Creek (88,000 m^2; 11% riffles), Parsons Creek (5,000 m^2; 12% riffles), Mill Brook (12,000 m^2; 3% riffles), Parlee Brook (36,000 m^2; 22 % riffles) and Cedar Camp Brook (53,000 m^2; 12% riffles) have very limited overhanging vegetation (Appendix A).

4. Smiths Creek and Tributaries

Smiths Creek and its coldwater tributaries (McGregor Brook, Windgap Brook and Sally Brook) provide 369,000 m^2 of aquatic habitat (Table 1a; Appendix A). Smiths Creek and Windgap Brook have limited overhanging vegetation, but McGregor Book (10,000 m^2; 19% riffles) and Sally Book (21,000 m^2; 1% riffles) have abundant overhanging vegetation.

McGregor and Sally brooks are important streams requiring additional habitat inventories to assess habitat in headwater areas.

5. South Branch and Negro Brook

South Branch and Negro Brook have 81,000 m^2 of aquatic habitat comprised of 15% and 33% riffle areas, respectively (Table 1a; Appendix A). These coldwater streams may have fair to good production potential for salmonids (pending stable water flows) since overhanging vegetation is moderate to dense, respectively.

6. Basin-wide Habitat Quality for Atlantic Salmon

Main stem Kennebecasis and small tributaries have very limited habitat area for juvenile Atlantic salmon production; only five percent or 97,000 m^2 of habitat can be considered as good production area (Table 1a; Appendix A). Fair to good production areas for Atlantic salmon are also limited in Millstream (59,000 m^2), Trout Creek (82,000 m^2), Smith Creek (30,000 m^2) and South Branch (14,000 m^2). Trout Creek's larger and diversified habitat indicate that, potentially, it is the most important sub-basin for Atlantic salmon production

A site survey in September 2001 found main stem Kennebecasis headwaters without surface flow with virtually no aquatic habitat from the confluence of the Big Spring at Portagevale upstream to Goshen. Land-use practices, especially forest harvesting, may be partially responsible for degrading this important salmonid production area.

B. Hammond River Basin

1. Hammond Mainstream Headwaters (above Hillsdale)

Aquatic habitat is limited to 72,000 m^2 on the mainstream Hammond River above Hillsdale. Riffle areas account for only 22% of the habitat (Table 1b; Appendix B). About 12,000 m^2 of the habitat are covered by 40% or more overhanging vegetation. This may not be a coldwater stream.

2. North Branch Hammond River

North Branch waters contain 45,000 m^2 of aquatic habitat, but riffle types comprise 32% of the habitat types. (Table 1b; Appendix B). About 11,000 m^2 of the habitat types present are covered with 40% or more overhanging vegetation suggesting a cool water stream.

Water Quality

There have been several water sampling programs for Kennebcasis streams since 1994. The following parameters are presented below to assess water quality conditions for aquatic life in the absence of industrial pollution: oxygen, temperature, alkalinity, total phosphate and suspended solids.

A. Oxygen and Temperature

Oxygen is usually considered the most important factor for supporting aquatic life. Oxygen concentrations throughout basin streams represent saturated (ideal) conditions, the result of atmospheric pressure on revolving surface waters, absence of industrial pollution and photosynthesis by green plants.

Summer stream temperatures determine the presence of brook trout. Trout avoid areas with temperatures above 21^{o}C unless groundwater sources are present to provide areas of refuge. Most summer temperatures in Kennebecasis basin streams are suitable for brook trout excepting the main stem Kennebecasis below the South Branch confluence and the lower reaches of Trout Creek, Smiths Creek and Millstream. Temperatures are suitable for Atlantic salmon.

B. Alkalinity

Alkalinity of water is a measure of water's capacity to neutralize acids, for example, to buffer acid rain. Alkalinity is expressed as mg/l of calcium carbonate. Kennebecasis basin waters have relatively high alkalinities (ranging from 50 to 150 mg/l) compared to most other New Brunswick waters. Higher alkalinity enhances growth and development of aquatic life.

C. Total Phosphate

High phosphate levels (0.015 to 0.06 mg/l) of Kennebecasis streams (perhaps the highest levels for streams in New Brunswick) are very beneficial to aquatic life. The phosphate occurs from leaching or agricultural drainage. Phosphates, which are usually the single most limiting nutrient in aquatic life, are utilized by aquatic plants, subsequently benefiting insect and fish production. Higher alkalinities improve phosphate utilization by aquatic life, further enhancing production.

D. Suspended Solids

Suspended solids are suspended and colloidal matter in water that diminishes the penetration of light, often called turbidity. Clay, silt, erosion, sewage, industrial waste from mining, logging, or shoreline development can influence suspended solids or turbidity. Suspended solids are rarely directly lethal to aquatic life, but the duration and quantity of suspended solids can have devastating effects on aquatic insects and fish (Newcombe and MacDonald, 1991).

Suspended solids are generally high (30 mg/l or more) for most Kennebecasis streams; the location, extent and sources of suspended sediments should be a high priority for study. A monitoring program is suggested in a subsequent section of this report.

Ecoreach Identification

"Ecoreaches" are streams or stream sections with similar geomorphological and temperature conditions (Vanotte, 1980; (Frissell, et al., 1986; Whittier and Hughes, 1988). They represent unique, individual management and sampling units as their uniform habitat controls the presence and abundance of aquatic insects and fish (Clarkson and Wilson, 1995; Hooper, 1997).

A. Main Stem Kennebecasis River

Five ecoreaches or management units have been identified from the 1994 habitat surveys, the digital terrain model and site visits (Figure 2 and Table 2). Each ecoreach provides similar habitat features throughout that determine aquatic species presence, size and abundance. For example, the lower three main stem ecoreaches below the South Branch confluence provide fall, winter and spring habitat for salmonids, but poor summer habitat due to warm temperatures, absence of cover and small substrate, excepting the upper reaches of Ecoreach 3 that exhibits marginal temperatures. Main stem Ecoreaches 4 and 5 provide good summer habitat for salmonids due to cold temperatures, overhanging cover and larger substrate. However, Ecoreach 5 is especially vulnerable to dewatering during the late summer and winter months, a condition that could nullify any salmonid production.

B. Millstream

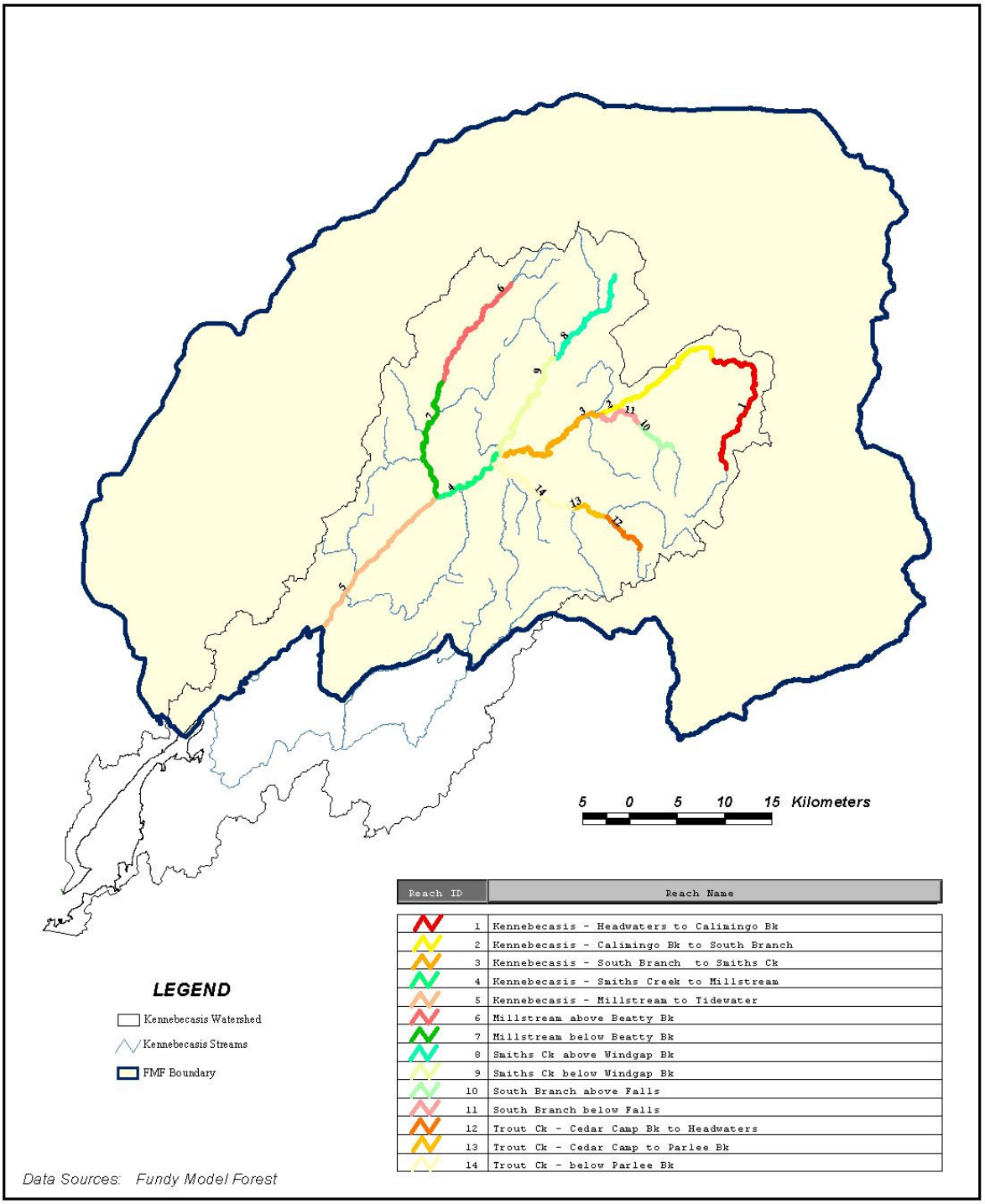
Millstream's two ecoreaches are separated at the Beatty Brook confluence (Figure 2 and Table 2). The lower ecoreach has warm summer temperatures, a slight gradient, sand and gravel substrate, and is vulnerable to stream bank erosion. The upper ecoreach has a moderate gradient, frequent riffle areas, larger substrate, good stream bank integrity, and cold waters.

C. Trout Creek

This sub-basin's varied geomorphological conditions provides three ecoreaches or management / sampling units: below Parlee Brook confluence (Ecoreach 12), above Parlee Brook confluence (and including Parlee Brook) to Trout Creek falls (Ecoreach 13) and above Trout Creek falls including Cedar Camp Brook (Ecoreach 14).

Ecoreach 12 has unusual summer temperature fluctuations probably due to instream, riparian and upslope activities. Ecoreach 13 has cool summer temperatures while Ecoreach 14 has cold temperatures, less gradient, small substrate, and narrow bank channel width.

Figure 2. Ecoreach locations for streams within the Kennebecasis River basin.



Reach ID	Reach Name
1	Kennebecasis - Headwaters to Calimingo Bk
2	Kennebecasis - Calimingo Bk to South Branch
3	Kennebecasis - South Branch to Smiths Ck
4	Kennebecasis - Smiths Creek to Millstream
5	Kennebecasis - Millstream to Tidewater
6	Millstream above Beatty Bk
7	Millstream below Beatty Bk
8	Smiths Ck above Windgap Bk
9	Smiths Ck below Windgap Bk
10	South Branch above Falls
11	South Branch below Falls
12	Trout Ck - Cedar Camp Bk to Headwaters
13	Trout Ck - Cedar Camp to Parlee Bk
14	Trout Ck - below Parlee Bk

D. Smiths Creek

Ecoreach 8 and 9 are separated by Windgap Brook. The lower ecoreach has a slight gradient and is characterized by meandering stream channel, fine substrate, few riffles areas and warm (>21^{o}C) summer temperatures. The upper reach has cold summer temperatures, more frequent riffles, and narrow stable stream banks.

E. South Branch

A ledge falls and steep valley slope separate Ecoreaches 10 and 11 on South Branch. The lower ecoreach has a meandering channel through a floodplain, fine substrate, and numerous pools and runs. The upper ecoreach has a higher gradient, larger substrate and more riffles. Both ecoreaches have cold summer temperatures.

Fish Population Information

A. Species Present

1.	Native Salmonids:	Brook trout (*Salvelinue fontinalis*); Atlantic salmon (*Salmo salar*)
2.	Non-native Salmonids: (probably not self-sustaining)	Rainbow trout (*Oncorhynchas mykiss*) Brown trout (*Salmo trutta*)
3.	"Potential" Game Fish:	Chain pickerel (*Esox niger*) Burbot (*Lota lota*) Brown bullhead (*Ictalurus nebulosis*) American eel (*Anguilla rostrata*) American smelt(*Osmerus mordax*)
4.	Sucker and Minnow Species:	White sucker (*Catostomus commersoni*) Longnose sucker (*Catostomus catostomus*) Pearl dace (*Phoxinus margarita*) Finescale dace (*Phoxinus neogaeus*) Blacknose dace (*Rhinichthys atratulus*)

		Common shiner (*Notropis cornutus*) Golden shiner (*Notemigonus chrysoleucas*)
5.	Anadromous Species:	Blueback herring (*Alosa aestivalis*) Gaspereau (*Alosa pseudoharengus*) Lamprey eel (*Petromyzon marinus*) Shortnose sturgeon (*Acipenser brevirostrum*)
6.	Other Species:	Slimy sculpin (*Cottus cognatus*)

B. Atlantic Salmon Redd Counts

Female Atlantic salmon excavate one or more nests or "redds" in gravel and rubble substrate to deposit their eggs. The freshly excavated redds can be identified by their rounded or elliptical shape, light substrate color, and elevated appearance. Redd counts provide an index of female spawning escapement.

Redd counts occurred in 1997, 1999 and 2000 on various sections of Trout Creek, Smiths Creek and Millstream (Appendix C). Most "index" section counts are not directly comparable, but the counts do provide information that adult Atlantic salmon returns to Trout Creek in 1997, 1999 and 2000 were substantial, as were returns to Millstream in 2000 and Smiths Creek in 1997 and 2000.

Redd index counts should be continued annually on specific Kennebecasis basin stream sections with good spawning habitat to monitor spawning escapement and redd count trends. These parameters can often be correlated with the following year fingerling densities.

Redd counts are not required, in future, for Wards Creek or Parlee Brook. Smiths Creek counts are required only for SFGA sections 14 and 15. Trout Creek redd counts are required from SFGA sections 1 and 2 (Ecoreach 13), and 4 and 5 (Ecoreach 12). A redd count index section is required in main stem Kennebecasis Ecoreach 4, perhaps from the Trans-Canada Highway bridge downstream to the South Branch confluence.

C. Upstream Salmonid Migrations at the McCully Station Counting Fence

The University of New Brunswick operated the McCully Station counting fence on main stem Kennebecasis from May through November, 1996 to 1998. Adult Atlantic salmon and brook trout migrating upstream were counted and sampled for age and growth. Some brook trout were radio-tagged to trace their migration within the Kennebecasis basin (Sparkes, 2000).

Fence counts for Atlantic salmon in 1996 and 1997 were similar with 82 and 71 grilse and 45 and 48 large salmon (Table 3). The 1998 fence count for salmon was minimal in October when partial upstream fish movements were assessed due to high flows. The estimated habitat area that could be seeded by female salmon counted in 1996 and 1997 is about 150,000 to 200,000 m^2. Assuming most of the salmon could have spawned above the South Branch in Ecoreach 4, there could have been an egg deposition of only 1 per 100 m^2, less than one-half the DFO conservation requirement of 2.4 eggs per m^2.

Brook trout migrants ranged between 1,620 and 2,016 fish during the 1996 to 1998 trapping periods (Table 3). High flows in June and July of 1996 and 1997 may account for lower counts of trout than in 1998. Most brook trout were two or three years old and exhibited a mean length of approximately 20 cm (Curry, 2000).

D. Stream Population Studies (Electrofishing)

There are 21 electrofishing sites in the Kennebecasis River basin, but only four DFO sites (Smiths Creek, South Branch and main stem Kennebecasis) have been sampled annually. Ideally, electrofishing sites should sample single habitat types in each stream ecoreach. Salmonid populations estimated in one ecoreach usually cannot be compared with populations in other ecoreaches because of different habitat characteristics.

A brief summary of DFO, UNB and Sussex Fish and Game Association (SFGA) stations follows; unfortunately, multiple habitat types have been sampled within individual DFO and SGFA sites. Past and new electrofishing stations should be GPS identified.

1. Main Stem Kennebecasis

Ecoreaches 1 and 2 below the Smiths Creek confluence near Norton were fished only in 1994 (Table 4). One riffle and one run electrofishing station is required for each ecoreach to determine juvenile salmon abundance as well as the abundance of competitive and predator fish species.

Ecoreach 3 has two electrofishing stations (SFGA-19 and UNB-31) located on McLeod and Stone brooks. Trout densities for McLeod Brook were very high (69 0+ age and 28 yearling and older trout per 100 m^2) in 1996, but lower trout densities were sampled in 1997 and 1998 (Table 4). The Stone Brook site (UNB-31) exhibited faie to good densities of fingerling (10-32/100m2) and yearlings and older (10 to 26 fish/100m^2) (Table 4). McLeod and Stone brooks are small coldwater streams that provide important summer rearing habitat for resident or transient trout in Ecoreaches 3 and 4.

Ecoreach 4, between the confluence of the South Branch and Calimingo Brook, has one DFO electrofishing site (DFO-15; 1981 to 2001) and one UNB sites (UNB-30; 1996 to 1998). The DFO site combines habitat types (riffles, runs, pools), but may offer trend information for juvenile salmon densities. Fingerling (0+ age) salmon densities were good (> 40 per 100 m^2) from 1990 until 1998, but disappointing thereafter. Larger parr (1+ and 2+ age) densities have declined below 10 fish per 100 m^2 since 1995. Larger parr densities are not a good juvenile density indicator for Kennebecaisi streams because of their mobility and preference for gravel/rock-rubble riffles that are not abundant in Kenebecasis habitats. The UNB "electrofishing station" (UNB-30) in Ecoreach 4 did sample individual pools, runs and riffles; Atlantic salmon density data is only available from UNB (Dr. Allen Curry). Trout density (Curry, 2000) was fair (fingerlings, 10 to 37 fish /100m^2; yearlings and older, 20 to 24 fish/100m^2).

Ecoreach 5 (Calimingo Brook confluence to headwaters) contains one SFGA electrofishing station (SFGA-8) sampled in 1994 and one DFO station (DFO-14)

sampled annually since 1981 (Table 4). Fingerling salmon populations have remained very low since 1981 indicating little adult salmon spawning in Ecoreach 5. Larger parr densities have been variable, the lowest densities reflecting low water or no water conditions. Brook trout and other species information may be present in the DFO data; this information should be provided or if it is already available, added as no catch in appropriate databases.

2. Millstream

Ecoreach 6 (below Beatty Brook confluence) was electrofished only in 1994 and at two different locations (SFGA 1 and 2); juvenile salmon populations were fair to good at about 16 fingerlings and 16 parr per 100 m^2 at SFGA station (SFGA-2) (Table 5).

Ecoreach 7 has two electrofishing sites, but only DFO site-13 has multi-year data (1996 – 1998) (Table 5). This station and SFGA-2 station in Ecoreach 6 should be relocated to include sampling of independent riffle and run habitat types.

3. Trout Creek

There are three ecoreaches for Trout Creek; the first ecoreach (below Parlee Brook) has three electrofishing station sites since 1994 (SFGA-6, -7 and -21) (Table 6). The Wards Creek stations (SFGA-7 and -21) should be discontinued, but SFGA-6 should be continued if new trend information is comparable with previous years. This station was last sampled in 1998 when juvenile Atlantic salmon densities were 6.5 fingerlings and 15.8 larger parr per 100 m^2 (Table 6). Two additional stations should be established, i.e. one each to sample run and riffle salmonid densities near the SFGA-6 site.

Ecoreach 13 has had three electrofishing stations (SFGA-5, -18 and -20), but only the SFGA-5 station (Parlee Brook) was fished consistently from 1994 to 1998; yearling brook trout abundance was fair to good (3.1 to 12.9 fish per 100 m^2). The SFGA-5

site should be maintained, but the SFGA stations 18 and 20 sites should be discontinued and replaced with one station to sample riffle habitat type and one station to sample run habitat type near the SFGA-5 site. Ecoreach 13 stations are especially important to estimate Atlantic juvenile populations on the Kennebecasis basins most productive tributary.

Ecoreach 14 has one SFGA station (SFGA- 4) fished from 1994 to 1997; fingerlings and yearling and older trout populations were good ranging from 9.0 to 25.1 (fingerlings) and 4.3 to 26.2 (yearlings) fish per 100 m^2, respectively (Table 6).

It appears that few Atlantic salmon adults or juveniles enter Cedar Camp Brook and that Trout Creek falls prevents upstream salmon migration. The SFGA station 4 should be continued to provide brook trout trend information.

4. Smiths Creek

Windgap Brook separates Ecoreaches 8 and 9 on Smiths Creek. Only one electrofishing site (DFO-17) on Ecoreach 9 provides trend information for salmonid densities (Table 7). Juvenile salmon densities have been low (0.3 - 8.3 fingerlings per 100 m^2 and 0.3 - 8.3 larger parr per 100 m^2). Station DFO-17 combines pool, run and riffle habitat types and may not accurately reflect juvenile salmon densities. Redd counts undertaken in 1998, 1999 and 2000 on Ecoreach 9 suggest spawning escapement maybe sufficient to provide higher densities of juvenile salmon.

Two electrofishing stations should be established on each of Smith Creek's ecoreaches to sample salmonid densities in riffle and run habitat types. The existing DFO-17 site should also be fished annually until it can be determined whether trend information is being provided.

5. South Branch

The South Branch falls separate Ecoreaches 10 (lower) and 11 (upper). The lower ecoreach was electrofished at one site (SFGA-9) in 1994 only (Table 8). The upper ecoreach (11) has two electrofishing sites (DFO-16 and UNB-31). The UNB site represents a composite of 4 pools, 3 runs and 3 riffle replicates, combined to provide salmonid densities (Table 8). The DFO-16 site contains riffle, run and pool habitat types.

Brook trout densities at the SFGA-9 site in 1994 were fair to good (7.2 fingerlings and 22.6 yearlings per 100 m^2), as were yearling salmon densities (6.8 fish per 100 m^2) (Table 8). Ecoreach 10 appears to be an important salmonid production area for the South Branch and main stem Kennebecasis.

Ecoreach 11, above South Branch falls, has density information since 1981 for juvenile salmon, and perhaps trout, from DFO-16 site. Juvenile salmon populations have remained low at DFO-16 site indicating the South Branch receives little adult salmon spawning. Moreover, unusual low flows do not favor production; perhaps, low summer water flows may reduce or eliminate habitat availability. The combined UNB electrofishing stations (UNB-31) suggest fair to good densities of fingerling brook trout (10 - 12 per 100 m^2) and older trout (10 - 28 fish per 100 m^2) (Table 8). The UNB station(s) contained large salmon parr, but no fingerling parr.

Potential Salmonid Production

A. Kennebecasis River Basin

1. Main Stem Kennebecasis

The main Kennebecasis River and smaller tributaries (Moosehorn Creek, Almshouse Brook, Musquash Brook, McLeod Brook and Stone Brook) have habitat potential to

produce 174 to 2,073 adult Atlantic salmon depending on freshwater smolt production and pos- smolt survival at sea (Tables 9 and 10; Appendix D). Ecoreach 1 (Millstream downstream to head of tide) may offer important juvenile salmon rearing area depending on the abundance of competitive or predator species such as chain pickerel. Atlantic salmon juvenile production is substantial if adults or juveniles can access the habitat available in Moosehorn Creek. Upper portions of Ecoreach 3 (below South Branch confluence) and all portions of Ecoreach 4 (below Calamingo Brook confluence) offer best production potential for adult salmon considering the quantity and quality of habitat available. Although Ecoreach 5 (headwaters) has potential to produce up to 200 adult salmon, its variable surface flows in September and, perhaps winter months, seriously impact salmonid production.

Main stem Kennebecasis Ecoreaches 1, 2, and 3 represent poor summer habitat for brook trout with predicted densities of 1.3 - 2.6 fingerlings/100 m^2 and 0.28-1.45 yearlings and older trout per 100 m^2. The McLeod Brook tributary (Ecoreach 3) offers excellent habitat for fingerling trout (36.1 fish/100 m^2) as does Stone Brook in Ecoreach 4 at 27 fingerlings / m^2 (Table 9). Ecoreaches 3 and 4, including Stone and McLeod brooks, support over 50% of the main stem Kennebecasis' salmonid production, but contain only 22% of the habitat (Table 9; Appendix D). The UNB 1996-1998 electrofishing sites produced similar fingerling densities in 1997 as those predicted above, but 1996 and 1998 fingerling and yearling densities were higher (Table 4).

2. Millstream

Atlantic salmon production potential is similar in Ecoreaches 6 and 7 or about 30 to 250 adults per ecoreach (Table 9; Appendix D). Brook trout production in Ecoreach 6 is very low (0.5 fingerlings and 0.8 yearlings and older/100 m^2), but fair above the Beatty Brook confluence (Ecoreach 7) at 4.3 fingerlings and 6.5 yearlings and older per100 m^2 (Table 9). Sharp and McNair brooks offer good habitat for fingerling trout whereas Mill Brook has poor habitat conditions for fingerling and older trout.

3. Trout Creek

The Trout Creek sub-basin has potential to produce 73 to 538 adult salmon from its 374,000 m^2 of habitat area (Tables 9; Appendix D). The lower ecoreach, below the Parlee Brook confluence, offers the largest quantity of habitat, but habitat quality is poor compared with habitat quality in upstream Ecoreaches 13 and 14.

Brook trout potential production is highest in headwaters Ecoreach 14, above Trout Creek falls where yearling production is predicted at 10 yearlings /100 m^2 (Table 9). Cedar Camp Brook, also in Ecoreach 14, offers fair habitat for trout production.

4. Smiths Creek

Smiths Creek Ecoreaches 8 and 9 have sufficient habitat to produce 60-579 adult salmon (Table 9 and 10; Appendix D). Ecoreach 8, below Windgap Brook, has poor habitat for brook trout excepting McGregor Brook that has good to excellent production potential at 10.6 fingerlings and 21.2 yearlings and older trout per 100 m^2. Sally Brook's habitat, within upstream Ecoreach 9, has outstanding brook trout production: 30 fingerlings and 22 yearlings and older/100 m^2 (Table 9; Appendix D). Sally Brook may be the Kennebcasis basin's most productive stream considering the habitat area available.

5. South Branch

The South Branch may not be able to support a self sustaining Atlantic salmon population without juvenile recruitment from main stem Kennebecasis; adult salmon production potential is only 16-141 fish (Table 9; Appendix D).

Potential production of brook trout is high for both South Branch ecoreaches and especially high for Negro Brook: 41 fingerlings and 22 yearlings or older per 100 m^2 (Table 9; Appendix D). Ecoreach 10, below South Branch Falls, has extensive

habitat that offers good yearling and older potential production: 12.7 fish per 100 m^2. This should be an excellent angling stream.

UNB electrofishing studies during 1996-1998 estimate 10 to 30 fingerlings and 10 to 28 yearlings per 100 m^2 within Ecoreach 11 waters; overall predicted fingerling densities were similar, but predicted yearling densities were lower (Table 8 and 9).

B. Hammond River Basin

1. Main Stem Hammond River (above Hillsdale)

Habitat areas for this headwater area of the Hammond River basin are limited; adult salmon production is estimated to range between 12-117 fish per year whereas brook trout production may be low at 6 fingerlings and 2.6 yearlings and older fish per 100 m^2, assuming this area has cool water temperatures. (Table 10; Appendix E).

2. North Branch Hammond River

Atlantic salmon production potential (12-109) is limited as are brook trout yearlings and older production at 1300 fish or 2.9 trout per 100 m^2. Fingerling brook trout potential production is fair to good at 9 fish per 100 m^2 (Table 10; Appendix E). Fowler Brook's extensive ledge substrate offers very poor trout and salmon habitat. The North Branch is assumed to have cool summer water temperatures.

Fish and Habitat Monitoring Program

A fish and habitat monitoring program should be implemented in the Kennebecasis River basin, especially for streams sensitive to change by land use practises. The program, managed by a watershed coalition group, would monitor ecological stress by measuring including temperature change, fish density, fish assemblages and siltation. These activities should be undertaken in

addition to previously discussed fish population monitoring activities (electrofishing and redd surveys). Coalition group involvement with stakeholders and government agencies ensures economical operations and a teamwork approach to understanding environmental conditions in the basin.

Habitat or aquatic life degradations may be occurring or increasing, but there is no monitoring program. Moreover, current and past protection or restoration measures (e.g. "no kill zone" and riparian plantings) are not being measured for success or failure. DFO's annual electrofishing program is not stratified to account for various habitat types. DNRE's redd counts are not annual and may not be not undertaken on similar stream sections each year. DOE's water classification program samples too infrequently those key parameters to detect habitat change.

Simple, measurable performances indicators, such as temperature, fish assemblages and fish densities, and sediments, can be utilized to monitor adverse land-use practices and restoration programs. For any monitoring program, objectives and parameters should be subject to modification, i.e. adaptive management.

A. Suggested Approach

The most sensitive, as well as the most productive streams, within the Kennebecasis basin ecoreaches should be priority for monitoring considering soils, riparian buffers, marginal temperatures (18º-21ºC, late afternoon), planned land use activities and past/present in-stream, riparian and upslope restoration projects.

1. Performance Indicators

Temperature monitor placement is required to assess maximum and mean daily temperatures for marginal coldwater (18º-21ºC, late afternoon) streams. Brook trout are especially vulnerable in marginal streams.

Fish assemblages and relative production should be assessed by electrofishing, utilizing one of several indicator species: the % abundance of wild salmonids (or

slimy sculpins or blacknose dace) and the abundance of non-salmonids measured in riffles and runs. Salmonid abundance (or sculpin or blacknose dace) should be 60% of the standing crop (ideal) and non-salmonids should be less than 10% of the standing crop. Indicator species densities could be good ($\exists$20 fish/100 m^2), fair (10-20 fish/100 m^2) or poor (10 fish/100 m^2), for example.

Siltation should be measured using three indicators:
a) suspended solids (associated with turbidity meter readings initially)
b) substrate embeddedness (vibert boxes)
c) aerial flights over basin streams within 12 hours after a substantial rainfall to pinpoint" erosional sources; sources could then be addressed directly with best management practices.

Suspended solids, measured at least weekly during spring through fall, would establish background and natural levels; the duration and quantity of suspended solids should be evaluated employing the Newcombe-MacDonald method. Substrate embeddedness, measured from replicate riffle samples throughout the basin would establish background levels to compare future values particularly where planned land-use practices or restoration efforts are anticipated or undertaken.

2. Program Review

Watershed conservation groups have qualified personnel for data collection and analysis. Overtime, the monitoring goals, objectives and/or performance indicators should be modified as necessary based on new information.

3. Who pays?

The major users and beneficiaries of Kennebecasis River basin resources (e.g. timber, agricultural) should be primary contributors to the monitoring program. The program outlined above may cost between $20,000 and $30,000 per year

depending on personnel and equipment available from the lead watershed group and government/private stakeholders.

Table 1a. Types and quantity of aquatic habitat for the Kennebecasis River streams within the Fundy Model Forest.

MAIN STREAM	TRIBUTARY	STREAM			HABITAT TYPES		
		Length (km)	Portion Surveyed (km)	Total Aquatic Habitat (m^2)	Riffles (%)	Runs (%)	Pool (%)
1. Kennebecasis		73.6	51.2	1,436,513	5	79	16
	Almshouse Brook	5.3	2.1	15,562	1	54	45
	Moosehorn Creek	15.4	8.0	95,789	20	67	13
	Musquash Brook	8.2	3.2	11,976	10	43	47
	Stone Brook	8.3	2.8	23,691	1	84	15
	McLeod Brook	7.3	5.4	30,399	6	80	14
	Moosehorn Creek	4.9	0.1	864	0	0	100
	SUBTOTAL	123.0	72.8	1,614,794	6	78	16
2. Millstream		25.5	20.3	303,966	13	44	43
	Mill Brook	8.4	2.8	26,946	15	43	42
	Sharp Brook	7.4	2.7	18,944	1	81	18
	McNair Brook	5.9	2.3	16,239	1	25	74
	SUBTOTAL	47.2	28.1	36,095	16	51	33
3. Trout Creek		18.5	13.9	179,991	32	45	23
	Ward Creek	11.6	8.3	87,707	11	71	18
	Parsons Brook	5.0	3.1	5,125	12	71	17
	Mill Brook	4.1	2.2	12,147	3	85	12
	Parlee Brook	8.9	3.5	36,071	22	57	21
	Cedar Camp Brook	11.0	5.5	52,605	12	57	31
	SUBTOTAL	**59.1**	**36.5**	**373,646**	**22**	**56**	**22**
4. Smith Creek		21.7	20.7	311,744	8	50	42
	McGregor Brook	6.2	1.9	10,275	19	43	38
	Windgap Brook	7.2	3.4	25,815	16	76	8
	Sally Brook	6.7	2.3	20,919	1	59	40

Table 1a. Types and quantity of aquatic habitat for the Kennebecasis River streams within the Fundy Model Forest.

MAIN STREAM	TRIBUTARY	STREAM			HABITAT TYPES		
		Length (km)	Portion Surveyed (km)	Total Aquatic Habitat (m^2)	Riffles (%)	Runs (%)	Pool (%)
	SUBTOTAL	**41.8**	**28.3**	**368,755**	**8**	**59**	**33**
5. South Branch		12.1	7.3	73,444	15	42	43
	Negro Brook	3.3	1.2	7,284	33	66	1
	SUBTOTAL	**15.4**	**8.5**	**80,728**	**17**	**44**	**39**
	BASIN TOTAL	**286.5**	**174.2**	**2,804,018**	**10**	**66**	**24**

Table 1b. Types and quantities of aquatic habitat for Hammond Rivers stream within the Fundy Model Forest.

MAIN STREAM	TRIBUTARY	STREAM			HABITAT TYPES			
		Length (km)	Portion Surveyed (km)	Total Aquatic Habitat (m^2)	Riffles (%)	Runs (%)	Pool (%)	Sheet (%)
Hammond River	Headwaters above Hillsdale	22.0	13.1	71,925	22	70	8	-
	Fowler Brook	5.2	1.2	3,256	6	16	3	78
	SUBTOTAL	**27.2**	**14.3**	**75,161**				
	North Branch	13.1	8.2	44,999	32	60	8	0
	BASIN TOTAL	**40.3**	**22.5**	**119,160**				

Table 2. Suggested ecoreaches (fishery management units) for streams and stream reaches on the Kennebecasis River basin. Electrofishing stations and Atlantic salmon redd count sections are also noted, if present.

STREAM OR TRIBUTARY	NUMBER	ECOREACH LOCATION	GEOMORPHOLOGICAL AND OTHER CHARACTERISTICS
1. Kennebecasis River	1	Head of Tide to Millstream confluence	- Slight gradient, wide floodplain valley - Very few riffles, long runs and occasional pools - Silt / sand substrate - One DFO electrofishing site (DFO-14) - Brook trout wintering area
	2	Millstream confluence to Smith Creek confluence	- Steeper gradient; narrow floodplain, - Some short riffles, frequent deep pools - Sand / gravel substrate - No electrofishing sites - Best salmon angling area
	3	Smith Creek confluence upstream to South Branch confluence	- Very slight gradient, meandering stream and extensive floodplain - Deep runs and pools - Silt / sand substrate - No electrofishing sites - Some angling in May / June
	4	South Branch confluence upstream to Calimingo Brook	- Moderate gradient; stream valley low, but confined on North side - Riffles, runs and pools - Gravel and rubble substrate - One SFGA electrofishing site (SFGA-15); six UNB electrofishing sites - Abundant groundwater discharge
	5	Calimingo Brook upstream to Montgomery Brook confluence	- Stream confined within steep valley; streambed dry during low water periods - Riffles, runs and pools; gravel, rubble and some rock substrate - One DFO electrofishing site (DFO-14)
2. Millstream	6	Kennebecasis River confluence upstream to Beatty Brook confluence	- Slight gradient - Shallow runs and pools; sand and gravel substrate, occasional rubble - Two SFGA electrofishing sites (SFGA-1 and 2)

Table 2. Suggested ecoreaches (fishery management units) for streams and stream reaches on the Kennebecasis River basin. Electrofishing stations and Atlantic salmon redd count sections are also noted, if present.

STREAM OR TRIBUTARY	NUMBER	ECOREACH LOCATION	GEOMORPHOLOGICAL AND OTHER CHARACTERISTICS
	7	Beatty Brook confluence upstream to Wright Brook confluence	- Moderate gradient - Riffles, long runs and pools; gravel and rubble substrate - One DFO electrofishing site (DFO-13), one SFGA electrofishing site (SFGA-3) - Redd count reach
3. Smith Creek	8	Kennebecasis confluence upstream to Windgap Brook	- Slight gradient; meandering stream - Runs and pools; sand / gravel and some rubble substrate; - One DFO electrofishing site (DFO-17) and one SFGA eletrofishing site (SFGA-11) - Redd count reach.
	9	Windgap Brook confluence to headwaters	- Long runs, pools, occasional riffles; gravel substrate with sand - One SFGA electrofishing site (SFGA-10); redd count reach
4. South Branch	10	Kennebecasis confluence upstream to falls and hatchery discharge	- Valley floodplain - Some meandering, long runs, pools; sand and some gravel substrate, some silt; - One SFGA electrofishing site (SFGA-9)
	11	Falls upstream to Headwaters	- Moderate gradient; narrowed stream - Riffles, pools and runs; gravel, some rubble substrate; - One DFO eletrofishing site (DFO-16); six UNB electrofishing sites -

Table 2. Suggested ecoreaches (fishery management units) for streams and stream reaches on the Kennebecasis River basin. Electrofishing stations and Atlantic salmon redd count sections are also noted, if present.

STREAM OR TRIBUTARY	NUMBER	ECOREACH LOCATION	GEOMORPHOLOGICAL AND OTHER CHARACTERISTICS
5. Trout Creek	12	Kennebecasis River confluence upstream to Parlee Brook confluence	- Slight gradient, valley lowland - Long runs and pools, short riffle; more riffles near Mill Brook; sand / gravel substrate - One SFGA electrofishing site (SFGA-6) - Redd count reach
	13	Parlee Brook confluence to Cedar Camp Brook confluence and falls	- Steeper gradient; steep valley; stream narrows - Riffles, runs, pools, occasional rapids; gravel / rubble/ rock substrate, occasional ledge - One SFGA electrofishing site (SFGA-8) - Redd count reach.
	14	Cedar Camp Brook confluence to headwaters including Cedar Camp Brook	- Riffles, runs, pools; gravel / rubble substrate, some ledge - No electrofishing sites.

Table 3. Upstream migrations of Atlantic salmon and brook trout through the McCully Station counting fence, Kennebecasis River, 1996 – 1998.

DATE		DATE FENCE REMOVED OR INSTALLED	SPECIES		
			1SW SALMON (grilse)	MSW LARGE SALMON (large salmon)	BROOK TROUT
1996	- May	Not operated	--	--	--
	- June	Installed June 3	0	0	691
	- July		10*	3*	893
	- August		6	3	116
	- September		26	6	42
	- October	Removed Oct. 28	40	33	50
	- November	Not operated	--	--	--
TOTAL			**82**	**45**	**1,793**
		* Fence did not operate from July 2-7 inclusive, 1996 due to high water			
1997	- May	Installed May 29	0	0	2
	- June		1*	1*	819
	- July		15*	1*	698
	- August		5	1	19
	- September		8	3	37
	- October		30	11	24
	- November	Removed Nov. 18	12	31	23
TOTAL			**71**	**48**	**1,620**
		* Fence did not operate June 26, 27 or July 4-7 inclusive due to high water			
1998	- May	Installed May 7	0	0	455
	- June		0	0	1,026
	- July		3	1	371
	- August		0	0	31
	- September		17	9	72
	- October	Removed Oct. 29	16*	6*	61
	- November		--	--	--
TOTAL			**36**	**16**	**2,016**
		* Fence did not operate from Oct. 30 – Nov. 8 inclusive due to high water. Fence could not be bypassed by fish on Oct. 2,3,11,12 and 16-19 inclusive due to high water conditions.			

Table 4. Salmonid population estimates for Kennebecasis River, 1981 – 2001.

STREAM	LOCATION	ECOREACH NO.	ELECTROFISHING STATION NO.	YEAR	BROOK TROUT per 100 m^2 AGE		ATLANTIC SALMON per 100 m^2 AGE		NO. REDDS PREVIOUS YEAR (Y-1)
					0+	1+	0+	1+	
Kennebecasis	Below Millstream	1	12 (SFGA)	1994	0.0	0.0	0.0	0.1	--
	Above Millstream - Below Smith Creek	2	No Stations						--
	Above Smith Creek - Below South Branch	3	No Stations						--
	Above South Branch - Below Calimingo Brook	4	15 (DFO)	1981			20.0	6.5	--
				1982			36.4	7.1	--
				1983			10.0	1.8	--
				1984			17.7	1.8	--
				1985			45.0	9.4	--
				1986			27.4	5.3	--
				1987			23.3	5.1	--
				1988			31.2	8.0	--
				1989			15.9	8.9	--
				1990			54.6	7.8	--
				1991			87.5	13.1	--
				1992			89.7	15.9	--
				1993			143.8	22.4	--
				1994			72.2	13.1	--
				1995			73.8	7.3	--
				1996			71.0	5.9	--
				1997			79.6	2.8	--
				1998			42.5	4.4	--
				1999			28.4	2.6	--
				2000			26.5	0.7	--
				2001			9.5	2.9	--

Table 4. Salmonid population estimates for Kennebecasis River, 1981 – 2001.

STREAM	LOCATION	ECOREACH NO.	ELECTROFISHING STATION NO.	YEAR	BROOK TROUT per 100 m^2 AGE		ATLANTIC SALMON per 100 m^2 AGE		NO. REDDS PREVIOUS YEAR (Y-1)
					0+	1+	0+	1+	
Kennebecasis – Cont'd	Above South Branch - Below Calimingo Brook	4	30 (UNB)	1996	10	20		0.0	--
				1997	37	5		0.0	--
				1998	10	20		0.0	--
	Above Calimingo Brook	5	8 (SFGA)	1994	6.0	21.0	8.0	10.0	--
			14 (DFO)	1981			0.0	27.3	--
				1982			5.8	19.3	--
				1983			0.0	6.5	--
				1984			0.0	0.0	--
				1985			0.0	0.2	--
				1986			13.2	3.3	--
				1987			0.0	5.4	--
				1988			0.0	0.1	--
				1989			0.0	18.6	--
				1990			0.0	0.8	--
				1991			0.6	15.0	--
				1992			7.3	32.1	--
				1993			0.2	6.8	--
				1994			6.5	47.0	--
				1995			0.0	0.0	--
				1996			0.2	16.8	--
				1997			0.0	31.9	--
				1998			0.0	0.7	--
				1999			0.2	1.3	--
				2000			0.0	14.6	--
				2001			14.4	4.8	--

Table 4. Salmonid population estimates for Kennebecasis River, 1981 – 2001.

STREAM	LOCATION	ECOREACH NO.	ELECTROFISHING STATION NO.	YEAR	BROOK TROUT per 100 m^2 AGE		ATLANTIC SALMON per 100 m^2 AGE		NO. REDDS PREVIOUS YEAR (Y-1)
					0+	1+	0+	1+	
	McLeod Brook		19 (SFGA)	1994	--	--	--	--	--
				1995	0.4	0.2	0.6	41.4	--
				1996	69.5	27.8	0.7	0.7	--
				1997*	1.74	1.4	7.1	8.4	--
				1998*	1.74	1.4	7.1	8.4	--

* Data should be rechecked to determine whether 1998 data was collected.

Table 5. Juvenile salmonid population estimates for Millstream, 1994 – 2002.

STREAM	LOCATION	ECOREACH NO.	ELECTROFISHING STATION NO.	YEAR	BROOK TROUT per 100 m^2 AGE		ATLANTIC SALMON per 100 m^2 AGE		NO. REDDS PREVIOUS YEAR (Y-1)
					0+	1+	0+	1+	
Millstream	Below Beatty Brook	6	1 (SFGA)	1994	0.1	0.3	0.3	0.5	--
			2 (SFGA)	1994	0.0	0.3	16.2	16.4	--
	Above Beatty Brook	7	3 (SFGA)	1994	9.2	7.2	20.7	16.7	--
			13 (DFO)	1996	0.0	0.0	10.5	2.5	--
				1997	0.0	0.0	50.2	3.8	--
				1998	0.0	0.0	1.4	41.2	3*
				1999	-	--	--	--	--
				2000	--	--	--	--	--
				2001	--	--	--	--	34
									--

* Section 14 only (SFGA)

Table 6. Salmonid population estimates for Trout Creek, 1994 – 2001.

STREAM	LOCATION	ECOREACH NO.	ELECTROFISHING STATION NO.	YEAR	BROOK TROUT per 100 m^2 AGE 0+	BROOK TROUT per 100 m^2 AGE 1+	ATLANTIC SALMON per 100 m^2 AGE 0+	ATLANTIC SALMON per 100 m^2 AGE 1+	NO. REDDS PREVIOUS YEAR (Y-1)
Trout Creek	Below Parlee Brook (Wards Creek)	12	7 (SFGA) (Wards Creek)	1994	0.2	0.3	0.0	9.2	--
				1995	0.0	0.0	1.0	7.0	--
				1996	0.0	0.3	0.0	0.4	--
				1997	0.2	0.2	0.5	0.7	--
				1998	0.0	0.0	0.0	0.5	--
			6 (SFGA)	1994	0.0	0.7	9.3	2.5	--
				1995	0.0	0.0	2.4	0.8	--
				1996	1.4	2.4	0.4	6.5	--
				1997	0.0	0.0	24.9	4.6	--
				1998	0.0	0.0	6.5	15.8	103
				1999	--	--	--	--	--
				2000	--	--	--	--	13
				2001	--	--	--	--	103
			21 (SFGA) (Wards Creek)	1995	0.4	0.5	0.0	1.2	--
				1996	0.0	0.5	42.2	3.0	--
				1997	0.0	0.0	1.2	1.5	--
				1998	0.0	0.0	0.0	5.0	--
	Above Parlee Brook to Cedar Camp Brook and Trout Creek Falls	13	18	1995	0.5	0.2	0.2	15.3	--
				1996	1.5	1.5	5.7	6.9	--
				1997	--	--	--	--	--
				1998	--	--	--	--	--
				1999	--	--	--	--	--
				2000	--	--	--	--	43
				2001	--	--	--	--	14

Table 6. Salmonid population estimates for Trout Creek, 1994 – 2001.

STREAM	LOCATION	ECOREACH NO.	ELECTROFISHING STATION NO.	YEAR	BROOK TROUT per 100 m^2 AGE		ATLANTIC SALMON per 100 m^2 AGE		NO. REDDS PREVIOUS YEAR (Y-1)
					0+	1+	0+	1+	
	Parlee Brook	13	5 (SFGA) (Parlee Brook)	1994	1.7	10.3	1.4	6.6	
				1995	3.2	6.3	1.6	5.2	
				1996	1.5	3.1	0.0	5.9	
				1997	2.8	7.4	0.0	0.9	
				1998	0.3	12.9	0.0	2.2	
				1999	--	--	--	--	0
				2000	--	--	--	--	0
			20 (SFGA) (Parlee Brook)	1995	0.6	0.9	0.5	2.9	
	Trout Creek Falls to Headwaters	14	4 (SFGA) (Cedar Camp Brook)	1994	15.4	26.2	0.0	0.4	
				1995	25.1	20.4	0.0	0.1	
				1996	9.0	11.1	0.0	0.0	
				1997	13.8	4.3	0.0	0.0	

Table 7. Salmonid population estimates for Smith Creek, 1981 – 2001.

STREAM	LOCATION	ECOREACH NO.	ELECTROFISHING STATION NO.	YEAR	BROOK TROUT per 100 m^2 AGE		ATLANTIC SALMON per 100 m^2 AGE		NO. REDDS PREVIOUS YEAR (Y-1)
					0+	1+	0+	1+	
Smith Creek	Below Windgap Brook	8	11 (SFGA)	1994	0.0	0.2	1.2	3.0	--
			17 (DFO)	1981			4.7	6.0	--
				1982			3.3	6.1	--
				1983			0.8	0.6	--
				1984			5.3	3.0	--
				1985			7.6	3.5	--
				1986			6.1	6.5	--
				1987			6.7	7.8	--
				1988			3.1	8.3	--
				1989			1.4	5.2	--
				1990			1.6	5.8	--
				1991			0.7	3.8	--
				1992			14.5	32.1	--
				1993			2.2	7.3	--
				1994			7.7	6.4	--
				1995			2.6	6.1	--
				1996			6.5	3.2	--
				1997			16.1	4.5	--
				1998			4.9	4.9	61
				1999			0.1	0.3	--
				2000			0.4	0.4	7
				2001			13.5	3.8	58
	Above Windgap Brook	9	10 (SFGA)	1994	0.0	0.6	3.3	3.2	

Table 8. Salmonid population estimates for South Branch, 1981 – 2001.

STREAM	LOCATION	ECOREACH NO.	ELECTROFISHING STATION NO.	YEAR	BROOK TROUT per 100 m^2 AGE		ATLANTIC SALMON per 100 m^2 AGE		NO. REDDS PREVIOUS YEAR (Y-1)
					0+	1+	0+	1+	
South Branch	Below Falls	10	9 (SFGA)	1994	7.0	22.6	0.0	6.8	--
	Above Falls	11	16 (DFO)	1981	0.0	0.0	0.0	5.3	--
				1982			5.8	2.5	--
				1983			0.0	10.5	--
				1984			0.0	1.4	--
				1985			0.0	21.6	--
				1986			13.2	2.3	--
				1987			0.0	4.0	--
				1988			0.0	1.4	--
				1989			0.0	4.5	--
				1990			0.0	2.6	--
				1991			0.6	0.2	--
				1992			7.3	2.8	--
				1993			0.0	1.0	--
				1994			6.5	9.4	--
				1995			0.0	14.1	--
				1996			0.2	5.5	--
				1997			0.0	0.0	--
				1998			0.0	0.1	--
				1999			0.2	0.0	--
				2000			0.0	3.5	--
				2001			0.0	0.6	--
		11	30 (UNB)	1996	12	28	0.0	< 5*	--
				1997	32	10	0.0	< 5*	--
				1998	10	22	0.0	< 5*	--

* Data available from Alan Curry, UNB

Table 9. Potential production of salmonids in Kennebecasis River basin streams or stream sections (ecoreaches) estimated from habitat assessments (1994) and default production values from northeast New Brunswick streams with similar habitat features.

STREAM ECOREACH	TRIBUTARY	TOTAL HABITAT AREA (m^2)	COOL OR COLD WATER	ATLANTIC SALMON		BROOK TROUT			
				SMOLT PRODUCTION RANGE (Poor to Good)	ADULT RECRUITMENT FROM SMOLT RANGE (5 to 10%)	0+ AGE		YEARLING AND OLDER AGE	
						Per 100 m^2	Total (No.)	Per 100 m^2	Total (No.)
Main Stem Kennebecasis									
Ecoreach 1		574,858	Cool	800 – 6,310	40 – 631	1.3	7,707	0.28	1,632
	Moosehorn Creek	95,788	Cold ?	320 – 1,472	15 – 147	3.5	3,375	4.9	1,374
	Almshouse Brook	15,562	Cold	45 – 229	2 – 22	6.2	970	3.6	2,698
Ecoreach 2		226,132	Cool	492 – 2,906	24 - 290	1.7	3,928	1.27	1,429
	Musquash Brook	11,976	Cold	45 – 201	2 – 20	3.1	378	5.0	1,347
Ecoreach 3		303,214	Cool/Cold	704 – 4,025	35 – 402	2.6	7,842	1.45	4,401
	McLeod Brook	30,398	Cold	63 – 383	3 – 38	36.1	10,976	5.3	8,113
	Stone Brook	23,691	Cold	39 – 276	2 – 27	27.0	6,405	4.7	4,795
Ecoreach 4		200,444	Cold	603 – 2,946	30 – 294	9.7	19,624	6.2	12,496
Ecoreach 5		131,862	Cold	7 – 2,005	20 – 200	10.2	13,493	5.8	7,664
SUBTOTAL		**1,613,909**		**3,528 – 20,753**	**173 – 2,071**	**4.6**	**74,698**	**2.8**	**45,940**
Millstream									
Ecoreach 6		169,064	Cool	70 – 706	31 - 282	0.53	901	0.77	1,294
	Sharps Brook	18,943	Cold	34 – 227	2 -22	16.7	3,197	3.9	2,218
	McNair Brook	16,238	Cold	65 – 285	3 -28	9.9	1,617	4.2	5,936
	Mill Brook	26,946	Cool	108 – 436	5 – 46	2.9	794	1.2	1,063
Ecoreach 7		134,901	Cold	537 – 2,296	27 – 229	4.36	5,881	6.56	8,851
SUBTOTAL		**366,092**		**814 – 3,950**	**68 - 607**	**3.3**	**12,370**	**5.2**	**19,272**
Trout Creek									
Ecoreach 12		114,325	Cool	503 - 2,063	25 – 206	0.97	1,105	0.75	853
	Ward Creek	87,707	Cold	234 – 1,221	11 – 22	5.3	4,652	3.4	2,976
	Parsons Brook	5,125	Cold	14 – 72	1 – 7	4.0	207	2.0	100
	Mill Brook	12,147	Cold	21 – 143	1 – 14	5.8	703	2.6	311

Table 9. Potential production of salmonids in Kennebecasis River basin streams or stream sections (ecoreaches) estimated from habitat assessments (1994) and default production values from northeast New Brunswick streams with similar habitat features.

STREAM ECOREACH	TRIBUTARY	TOTAL HABITAT AREA (m^2)	COOL OR COLD WATER	ATLANTIC SALMON		BROOK TROUT			
				SMOLT PRODUCTION RANGE (Poor to Good)	ADULT RECRUITMENT FROM SMOLT RANGE (5 to 10%)	0+ AGE		YEARLING AND OLDER AGE	
						Per 100 m^2	Total (No.)	Per 100 m^2	Total (No.)
Trout Creek									
Ecoreach 13		37,891	Cold	187 – 746	9 – 74	3.1	1,179	1.6	619
	Parlee Brook	36,070	Cold	136 – 592	7 – 59	3.5	1,259	2.0	720
Ecoreach 14		27,775	Cold	205 – 752	10 – 75	4.7	1,315	10.0	779
	Cedar Camp Brook	52,604	Cold	175 – 817	9 – 81	4.7	2,497	4.1	2,161
SUBTOTAL		**373,643**		**1,475 – 6,406**	**75 - 538**	**3.4**	**12,917**	**2.2**	**8,519**
Smiths Creek									
Ecoreach 8		173,667	Cool	71 – 715	31 – 284	0.91	1,583	1.66	2,888
	McGregor Brook	10,275	Cold	43 – 181	2 – 18	10.6	1,092	21.2	2,178
Ecoreach 9		138,076	Cold	440 – 2,124	22 – 212	4.56	6,302	3.65	5,034
	Windgap Brook	25,814	Cold	71 – 362	3 – 36	5.5	1,410	2.2	583
	Sally Brook	20,919	Cold	56 – 279	2 – 29	30.0	6,293	22.2	5,276
SUBTOTAL		**368,751**		**681 – 3,661**	**60 - 579**	**4.5**	**16,680**	**4.3**	**15,959**
South Branch									
Ecoreach 10		43,877	Cold	163 – 737	8 - 73	5.3	2,334	12.7	5,788
Ecoreach 11		29,566	Cold	142 – 565	7 – 56	12.8	3,795	12.0	3,558
	Negro Brook	7,284	Cold	29 – 126	1 – 12	41.4	3,019	22.4	1,809
SUBTOTAL		**80,727**		**334 – 1 428**	**16 – 141**	**11.3**	**9,148**	**13.8**	**11,155**
BASIN TOTAL		**2,803,122**		**6,832 – 36,198**	**390 – 3,936**	**4.4**	**125,813**	**3.6**	**100,848**

Table 10. Potential production (biomass) for salmonids in Kennebecasis River basin streams estimated from habitat assessment (1994) and default production values.

STREAM SUB-BASIN	TOTAL HABITAT AREA (m^2)	ATLANTIC SALMON PRODUCTION		BROOK TROUT			
		SMOLT PRODUCTION RANGE (Poor to Good)	ADULT RECRUITMENT FROM SMOLT RANGE (5 to 10%)	0+ AGE		YEARLING AND OLDER AGE	
				per 100 m^2	Total (No.)	per 100 m^2	Total (No.)
1. Main Stem Kennebecasis and Tributaries	1,613,909	3,528 –20,753	173 – 2,071	4.6	74,698	2.8	45,940
2. Millstream and Tributaries	366,092	814 – 3,950	68 - 207	3.3	12,370	5.2	19,272
3. Trout Creek and Tributaries	373,643	1,475 – 6,406	73 – 538	3.4	12,917	2.2	8,519
4. Smiths Creek and Tributaries	368,751	681 – 3,661	60 – 579	4.5	16,680	4.3	15,959
5. South Branch and and Tributaries	80,727	334 – 1,428	16 – 141	11.3	9,148	13.8	11,155
BASIN TOTAL	**2,803,122**	**6,832 – 36,198**	**390 – 3,936**	**4.4**	**125,813**	**3.6**	**100,845**

Table 11. Potential production (biomass) for salmonids in two Hammond River River basin streams located within Fundy Model Forest.

STREAM SUB-BASIN	TOTAL HABITAT AREA (m^2)	ATLANTIC SALMON SMOLT PRODUCTION RANGE (Poor to Good)	ATLANTIC SALMON ADULT RECRUITMENT FROM SMOLT RANGE (5 to 10%)	BROOK TROUT 0+ AGE per 100 m^2	BROOK TROUT 0+ AGE Total (No.)	BROOK TROUT YEARLING AND OLDER AGE per 100 m^2	BROOK TROUT YEARLING AND OLDER AGE Total (No.)
1. Main Stem Hammnond River Above Hillsdale	71,295	250 – 1,178	12 – 117	6.14	4,417	2.66	1,915
2. North Branch Hammond River	44,999	242 – 1,094	12 – 109	9.11	4,097	2.93	1,318
- Fowler Brook	3,255	3 – 18	0 – 8	0.31	10	2.85	20
SUBTOTAL	**48,254**	**245 – 1,112**	**12 – 117**	**8.51**	**4,107**	**2.77**	**1,338**
BASIN TOTAL	**120,179**	**495 – 2,290**	**24 - 234**	**8.3**	**8,524**	**2.7**	**3,253**

RECOMMENDATIONS

The establishment of the Kennebecasis interdisciplinary working group (Kennebecasis Watershed Restoration Committee or KWRC) represents a huge step forward in formalizing basin-wide ecological objectives especially with respect to reestablishment of riparian vegetation, the modification of land use practices, and monitoring background conditions and results. Future restoration activities require a stakeholder "blueprint", backed by specific funding, to focus coordinated operational input from all stakeholders, particularly those forestry and agricultural sectors who are the major users and beneficiaries of stream basin resources. Many of the riparian and stream ecosystems in the Kennebecasis basin have been degraded by "off channel" activities: grazing and croplands, usually in the lower to mid reaches of streams, and logging in headwater areas.

The New Brunswick Department of the Environment and Local Government (DOE) does not enforce its Clean Water Act requirement that riparian zones within 5 meters of a stream cannot be impacted by agricultural practices. By default, watershed groups in the Kennebecasis and Hammond stream basins have on a limited, piece-meal basis, initiated fencing projects to keep cattle from grazing within the 5 meter riparian zone. There are minor initiatives that, along with various in-stream channel projects, focus on symptoms, not causes of watershed degradation within the Kennebecasis and Hammond basins. Watershed groups should formalize with their stakeholders basin-wide ecological objectives and strategies with respect to "wholesale" reestablishment of riparian vegetation and preservation of healthy resources within a two to five year time frame. The DOE requirement should be strictly enforced, or challenged in court. The New Brunswick Departments of Agriculture, Environment and Natural Resources should allocate financial resources and regional staff to work directly with the watershed coalition group to: (1) develop common goals (2) avoid special interest projects, isolated manipulations of individual elements, and (3) ensure operations are dedicated to restoring natural ecological processes in the basin.

Watershed managers, working directly with a formal, multi-government committee should consider how current landscape conditions compare with historical conditions of the Kennebecasis and Hammond basins before habitat degradation, then:

- identify/document processes leading to the decline (grazing, logging, rural development, etc.)
- establish realistic goals, for example (1) the necessity to fence all riparian areas subject to grazing or siltation; (2) plan to plant riparian species necessary throughout the basin; (3) preserve habitat in key salmonid production streams: McLeod, Stone, Sharp, McNair, McGregor and Sally; focus DOE and UNB to study causes for low water in South Branch and Kennebecasis headwaters by examining peak flows, low flows, rapid fluctuations and land use practices; and (4) protect the healthiest portions of the basin first, then rehabilitate the rest.
- Develop/ apply methods and techniques to reverse/mitigate aquatic habitat decline
- develop simple, observable measures of success (monitoring program, adaptive management)
- document and communicate restoration techniques to others.

The immediate challenge to Hammond and Kennebecasis watershed agencies and stakeholders will be to focus and coordinate funding and regional manager priorities. A strategic watershed plan, conceived and accepted by stakeholders, will ensure basin-wide operations that are co-managed by permanent, professional staff with supporting infrastructure to achieve conservation and restoration objectives, and actions everyone supports. Ecological restoration will come at a high cost, but has to be regarded as an investment in the natural capital and environmental wealth of the basins, New Brunswick and Canada. Eventually, basin stakeholders and future generations will reap the self-maintaining benefits in perpetuity.

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APPENDIX A

Habitat Assessment Reports
for Kennebecasis Stream Sub-basins and Tributaries

Mainstream Kennebecasis
Almshouse Creek
Moosehorn Creek
Musquash Brook
McLeod Brook
Stone Brook

Millstream
Sharp Brook
McNair Brook
Mill Brook

Trout Creek
Wards Creek
Parsons Creek
Mill Creek
Parlee Brook
Cedar Camp Brook

Smith's Creek
McGregor Brook
Windgap Brook
Sally Brook

South Branch
Negro Brook

APPENDIX B

Habitat Assessment Reports
for Hammond River Streams
within the Fundy Model Forest

Mainstream Hammond River (above Hillsdale)

North Branch Hammond River
Fowler Brook

APPENDIX C

Atlantic Salmon Redd Counts
For Stream Sections
Within the Kennebecasis River Basin

APPENDIX D

Salmonid Production Potentials by Ecoreach
for Kennebecasis Stream Sub-basins and Tributaries

Mainstream Kennebecasis - Below Millstream
Moosehorn Creek
Almshouse Brook
Mainstream Kennebecasis - Millstream to Smith Creek
Musquash Brook
Mainstream Kennebecasis - Smith Creek to South Branch
McLeod Brook
Mainstream Kennebecasis - South Branch to Calimingo Brook
Stone Brook
Mainstream Kennebecasis - Calimingo Brook to Headwaters

Millstream - Below Beatty Brook
Sharp Brook
McNair Brook
Mill Brook
Millstream - Above Beatty Brook

Trout Creek - Below Parlee Brook
Wards Creek
Parsons Brook
Mill Creek
Trout Creek – Parlee Brook to Trout Creek Falls
Parlee Brook
Trout Creek – Trout Creek Falls to Headwaters
Cedar Camp Brook

Smiths Creek - Below Windgap Brook
McGregor Brook
Smiths Creek - Above Windgap Brook
Windgap Brook
Sally Brook

South Branch - Below Falls
South Branch -Above Falls
Negro Brook

APPENDIX E

Salmonid Production Potential
for Hammond River Streams within the Fundy Model Forest

Mainstream Hammond River: above Hillsdale

North Branch Hammond River: Headwaters to Forks (above Hillsdale)
Fowler Brook