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EXPERIMENTAL WATERSHED STUDY
YEAR ONE REPORT

PROJECT 93-2-07

EXPERIMENTAL WATERSHED PROJECT
RESULTS FROM 1993, YEAR I

A report prepared for the Manitoba Model Forest

by

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EXECUTIVE SUMMARY

The purpose of the Experimental Watershed Project is to examine the effect of timber harvest and reforestation within the Manitoba Model Forest on fish habitat. The focus of the study is on the physical changes in aquatic habitat associated with increased runoff, erosion, and sedimentation, which are deleterious to fish and their habitat. Sites will be monitored before, during and after timber harvest and reforestation to determine the effect of these activities. The study consists of two components: measurement of physical changes in water bodies affected by timber harvest; and measurement of erosion from logged sites and deposition in buffer zones.

The Experimental Watershed Project is situated along the Moose River to the south of Happy Lake in an area where Abitibi-Price Inc. will be harvesting in the next few years. In 1993, study was concentrated along the Moose River between Happy and Frenchman lakes, including a small creek flowing into the Moose River from the west. The small creek was included in the study because streams of this size are more vulnerable to the negative effects of timber harvest as a larger portion of their watershed is affected. Activities in 1993 had three general goals: 1) to survey the area for sites suitable for permanent sampling stations; 2) to initiate the collection of baseline data under natural conditions; and 3) to obtain information necessary to improve the design of future sampling programs.

The effect of timber harvest on water quality in the study area is being documented by measurements of suspended solids and conductivity (an indication of the amount of dissolved solids). Both of these parameters are affected by the amount of material entering the water from runoff. In addition, the amount of sediment deposited in aquatic areas often increases after logging. Sedimentation in the Moose River and adjoining creek is being monitored with sediment traps set at several locations.

In 1993, water samples were collected at several sites along the Moose River and adjoining creek as an indication of pre-logging conditions. As is typical of undisturbed streams and rivers in this area, both total suspended sediment and conductivity were low. Results from sediment traps will be available in the spring of 1994, when the traps are collected.

Continued monitoring of suspended solids, conductivity, and sedimentation as harvesting occurs will indicate if logging has a detectable effect on these parameters. The Moose River is probably too large to experience a detectable change in water quality due to logging but major

changes may occur in the small creek when a large portion of its watershed is harvested. In 1994, sampling of water quality may be extended to a second small creek to the east of the Moose River, if a large portion of its watershed will be harvested. The variability in water samples collected in 1993 indicated that both the number of replicates and the frequency of collection should be increased in future sampling programs.

Surveys were conducted in 1993 to identify areas suitable for the measurement of soil erosion and deposition in terrestrial areas. Of the three sites identified, two were located on hillsides with fine textured soils and the third was a relatively level hummocky area. In 1993, erosion pins were established at one of the hillside sites and at the hummocky site. Average changes in ground height at the erosion pins were similar at both sites, but variability at the hummocky site was greater. Changes in ground height were probably due to natural changes in the thickness of the organic layer though soil erosion or deposition were evident at some erosion pins.

Monitoring in 1994 will continue at sites identified in 1993 and be expanded to include areas as they are harvested. Post-harvest sites will be selected to include a variety of topographies and areas harvested by either conventional techniques or a new cut-to-length system to permit comparison of the amount of erosion associated with the two methods. Both the amount of soil lost from harvested areas and the distance to which it penetrates into buffer strips will be measured. Based on information gathered in 1993, the number of erosion pins installed at each site will be increased because of the large amount of small-scale variation. All terrestrial sites will be classified by the Forest Ecosystem Classification method to permit linkage between erosion information and forest type.

Changes in water quality and erosion following logging are closely related to annual precipitation. Therefore, to permit interpretation of observed effects within the context of long term, interannual differences in precipitation and runoff, permanent rainfall and hydrologic gauges were installed in the Moose River in 1993. Additional descriptive information, such as measurements of stream profiles and general habitat classification, is being collected on an on-going basis to provide a physical description of the area under consideration and the basis of comparison to other areas within the Model Forest.

Large natural interannual variations in fish populations preclude direct measurement of changes in fish populations as a result of timber harvest within the time frame of the Model

Forest program. A survey of adult fish in the area and drift of larval fish in spring, 1993, was conducted in the Moose River to provide a biological context within which to interpret results of the physical studies. Few adult fish were captured but included species typical of the area such as white sucker, walleye, northern pike, smallmouth bass, brook stickleback, and mud minnow. Spring sampling of larval fish drift showed that the Moose River is a spawning area for white sucker; there was no evidence of walleye spawning though sampling may have been initiated too late for this species.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

The effect of timber harvest on fish and their habitat has been documented in many areas. Though effects vary depending on local characteristics, logging typically affects fish through physical changes associated with increased stream flow, sometimes in association with increased sedimentation, increased water temperature, increased wood debris, altered water quality, changes in nutrient flow and other changes in habitat (Hartman and Scrivener 1990, Hetherington 1987). The majority of North American studies examining the effects of forestry practices on aquatic habitats have been conducted in mountainous regions (e.g. Hartman and Scrivener 1990, Newbold et al. 1980); boreal regions have received less study but effects are thought to be less because the ground is generally more level and hummocky, reducing the potential for runoff and erosion, rainfall is generally lower, and soils are different. In north-western Ontario, a comparison of water quality in unlogged watersheds to watersheds one and two years after harvesting showed a significant increase in several nutrients and sediment one year after logging, but, after two years, sites were indistinguishable from controls (Nicolson 1975). The observed increase was of a lesser magnitude and a shorter duration than seen in other areas, supporting the contention that results from other areas are not directly applicable to boreal regions.

Timber harvest and other forestry activities, such as reforestation, in the Model Forest are thought to not have a large impact on fish and their habitat, particularly in terms of sediment input, because the low and hummocky terrain reduces runoff and erosion. Gamefish populations and most recreational activity are concentrated on the larger water bodies. The major rivers and lakes are fed by an extensive network of small streams, lakes and wetlands. The importance to gamefish populations of small streams is not known, but these areas may provide habitat for forage fish and inputs from these small streams will affect water quality in larger water bodies. Present guidelines prescribe the maintenance of an uncut buffer strip along all water bodies in order to reduce or prevent sediment from entering streams, the width of the buffer strip varying depending on the type of water body (DNR 1990). Buffer zones have been demonstrated to reduce the impact of logging, particularly with respect to altered inputs (e.g. sediment) and habitat associated with streamside vegetation in other areas (Newbold et al. 1980). However, in the Model Forest area, the actual effect of timber harvest and reforestation on the physical environment within water bodies has never been examined. In addition, no information exists relating soil loss due to erosion and its subsequent deposition in buffer strips or entry into streams under different conditions (e.g. slope) in the terrestrial environment.

Development of the Experimental Watershed Project began in the spring of 1993 with the objective of designing a study that would determine the effects of timber harvest on fish and their habitat by monitoring a watershed before, during, and after timber harvest and reforestation. The advantage of this type of experimental approach rather than comparison among natural and unlogged sites is that natural local variations often preclude detection of any forestry-related effects. An outline of the project development is presented in Appendix 1. During project development, it was decided that the time-scale and resources of the Model Forest were too limited to permit direct assessment of changes in fish populations (Appendix 1). Therefore, the study was limited to physical changes in the aquatic environment which are known to affect fish. Even detection of physical changes can be difficult due to both the small amount of change expected from logging and the large natural variability associated with these physical parameters. To alleviate these problems, the following elements were incorporated into the study design:

1. Variability in measurements due to causes other than forestry was minimized by establishing permanent sampling stations. Where possible, small-scale local processes, which are the most detectable, were measured.

2. Study sites encompassed a range of natural areas, including situations where the effect of timber harvest is expected to be maximum. Therefore, slopes with fine-textured soils, where erosion is expected to be maximum, were included among the sites where erosion will be measured. In addition, changes in water quality will be measured on a small creek, where a large portion of the watershed, possibly including the area normally left as a buffer strip, will be logged.

The Experimental Watershed Project is situated in an area along the Moose River to the south and east of Happy Lake where Abitibi-Price Inc. is planning to harvest in the next few years (Fig. 1). The area encompasses a range of topographies, including upland sites where more erosion is expected. At the moment, the area has not been affected by recent logging or fire, though a large fire occurred in the eastern portion of the Moose River drainage a decade ago. Harvesting will commence during the summer of 1994 to the south and east of Happy Lake; exact harvest plans are under development at the moment. Spring timber cruising surveys in 1993 found that much of the forest along the Moose River just south of Happy Lake had been killed by spruce budworm, reducing the amount of cutting that will be conducted in the area.

The purposes of the 1993 study were threefold: 1) to characterize the area and identify sites suitable for permanent sampling stations; 2) to initiate the collection of baseline data under natural conditions; and 3) to obtain information necessary to improve the design of future sampling programs.

Reconnaissance of the area in 1993 identified the Moose River between Frenchman and Happy lakes, including a tributary stream flowing into the Moose River from the west, as the best areas for intensive study. This was predicated on information from Abitibi-Price Inc. and DNR that the area to the west of the Moose River could be harvested in the near future. However, the 1994 harvest plan is under development and harvest in the near future may be limited to the east of the Moose River. Therefore, while activity in 1993 was concentrated along the Moose River between Happy and Frenchman lakes, the 1994 study may incorporate one of several small streams in the eastern portion of the area. Erosion measurements will be initiated on selected sites to the east of the Moose River as they are harvested.

2.0 METHODS

2.1 Measurements in the Aquatic Environment

The location of permanent aquatic measurement sites are indicated on Fig. 2. Samples were collected at five sites in 1993 including three on the Moose River (sites I to III) and two on Creek A (site IV, 0.3 km upstream of the mouth, and site V, at the mouth). Water conditions in the Moose River were assumed to be uniform before the commencement of logging so regular sampling was limited to Site I.

Water samples (for suspended sediment and conductivity) were collected as frequently as possible, with greater emphasis on the spring months when sediment concentrations from runoff were expected to be greatest. Care was taken not to include surface flotsam in the samples. Samples were analyzed by the Department of Fisheries and Oceans, Analytical Services Section.

Traps to collect sediment within the streams were set in June, 1993, at all the water collection sites as well as several points in between. Traps were 15" lengths of 1.5" diameter ABS pipe, for the 10:1 height to width ratio recommended by Bloesch and Burns (1980). Traps were set in groups of three cylinders, near the shore of areas where deposition was thought to be occurring, and were pushed into the sediment so that only 5 cm protruded. During the summer, several traps were lost due to muskrat activity. Traps will be emptied in spring, 1994, and samples weighed and analyzed for organic content and particle size.

An understanding of the hydrologic regime is necessary for the interpretation of physical measurements (e.g. total flow is required to calculate total suspended sediment movement). In 1993, a hydrologic gauge measuring stream flow and water temperature, and a tipping bucket gauge measuring rainfall were installed on the Moose River. Stage/discharge relationships will be calculated at regular intervals to provide calibration for the hydrologic gauge.

Additional descriptive information, such as measurements of stream profiles and general habitat classification, is also being collected to provide a physical description of the area under consideration and the basis of comparison to other areas within the Model Forest.

2.2 Measurement of Erosion and Deposition in the Terrestrial Environment

In June, 1993, the Moose River area was surveyed for stands of spruce that were of a sufficiently large spatial extent and occurred on relatively uniform topography to permit measurement of erosion. After consultation with Abitibi-Price to determine the suitability of these areas for timber harvest, three sites were chosen for erosion studies: two hillsides with fine-textured soils (sites A and C) and a relatively level, hummocky area (Site B) (Fig. 2).

Both slopes are quite similar: the initial 25 m are quite steep (20°), and then slope declines until the top of a ridge is reached 100 to 125 m from the river. Trees on the lower part of the slope are young spruce (diameter ranging from 3 to 9 cm) while larger, mature trees occur nearer the top of the ridge.

In June, grids of erosion pins were installed at sites A and B. Erosion pins are 0.5 inch diameter steel bar pounded into the ground. The ground surface is marked with a washer which fits snugly over the bar. Heights are measured from the top of the bar.

Erosion pins were placed at intervals of 25 m or less in transects perpendicular to the stream, extending from the streambank (in the buffer zone) into the area that will be logged. Several lines were established because erosion is often very localized, necessitating many measurement points.

The heights of pins were recorded at installation and were remeasured in November, 1993. Site conditions were documented with a photograph.

2.3 Biological Sampling

Biological sampling consisted of the following: monitoring larval drift at the rapids on the Moose River; periodic surveys of the fish fauna throughout the area; and collection of invertebrate drift samples and emergent insects in pan traps.

Larval drift was measured at a rapids site in the Moose River using four to six drift traps set for at least 18 hours at periodic intervals from May 20 to June 10. Drift traps were metal cones with a 25 cm mouth diameter attached to a funnel-shaped net ending in a collection vial with a 1 mm mesh. Samples were preserved in 5% formalin and transported to the laboratory where they were sorted, identified, and enumerated.

The composition of the fish fauna of the area was estimated by sampling with a variety of gears including gillnets, minnow traps, and a backpack electrofisher. Sampling was regularly conducted in the Moose River at sites I and II and in Creek A at sites IV and V. Other areas were occasionally sampled.

Samples of drifting and emergent insects were collected to permit their enumeration if this becomes desirable in the future. Drifting insects were collected simultaneously with the larval fish drift. Pan traps to collect emergent insects were set on the shore adjacent to water collection sites I, II, IV, and V (Fig. 2). Pan traps consisted of dish pans filled with antifreeze and a small amount of soap to reduce surface tension.

3.0 RESULTS AND DISCUSSION

3.1 Measurements in the Aquatic Environment

The Moose River originates near the Ontario-Manitoba border and flows through many small lakes before reaching the northern portion of Frenchman Lake. Total estimated drainage of the Moose River is 26,800 ha. The Moose River was not extensively examined upstream of Frenchman Lake. In this area it is a series of oxbows traversed by many beaver dams. Between Frenchman and Happy lakes, the Moose River is a series of oxbows with a relatively deep channel, 10 to 15 m wide, blocked by several beaver dams. Most of the bottom is composed of soft sediment but periodic bedrock outcrops and boulders occur within the river. Downstream of Frenchman Lake there are two distinct series of rapids, the upper one ending in a waterfall. The lower rapids were used as a sampling site for water and larval drift. These rapids occupy approximately 30 m of the river, river width at the narrowest point being 15 m. A cross section at the narrowest point showed highly variable depths (ranging from 0.10 to 0.57 m in early June) due to many large boulders. Water velocity in this rapids section was very variable: point estimates of velocity in the central area ranged between 0.31 and 0.56 m/s while large back eddies occurred at the downstream edge of the rapids.

Creek A drains an estimated 1650 ha. It is considerably shallower and narrower than the Moose River, width ranging from 2 m, 0.3 km upstream of the mouth to 7 m at the mouth. The channel is U-shaped with banks formed by marsh vegetation, and maximum depth ranging from 0.47 m in the upstream section to 0.70 m at the mouth. In June, velocities in the central portion of Creek A were 0.03 and 0.05 m/s at the upstream site and mouth, respectively. It is blocked by many beaver dams and in the spring of 1993, a dam which had created a large pond approximately 0.5 km upstream of the mouth began washing out.

Continuous flow monitoring of the Moose River was only initiated in November due to prolonged adverse weather conditions in late summer which prevented access to the site. Therefore, continuous discharge data will not be available until the spring of 1994. Discharge of the Moose River upstream of Creek A was measured as 0.23 m^3/s in mid-July. At this time, velocities in a narrow (2.5 m wide) section of the river peaked at 0.38 m/s, with mean velocity of 0.21 m/s.

Long term discharge records exist only for the larger rivers of the region, but these show considerable intra- and interannual fluctuations in discharge. For example, lowest average annual discharge in the Manigotagan River occurs in March, after which discharge increases approximately nine-fold to peak levels in May. Discharge declines for the remainder of the year. In July, discharge is approximately half that of May. The discharge peak in the Moose River probably also occurs in May; the difference between May and July discharge in the Moose River is expected to be at least as large as that of the Manigotagan River.

Substantial between year differences in flow, related to precipitation, also occur. In the Manigotagan River between 1960 and 1990, mean annual discharge varied eight-fold. Therefore, the results of studies dependent upon flow and runoff, and thus precipitation, must be considered within the context of local precipitation during the study. To measure local precipitation and thus provide a context for the interpretation of the erosion studies, a rain gauge was installed at the same site as the hydrologic gauge.

Water quality was monitored regularly during May and June and once in July and

November. Water temperature in late May was 11 to 13°C in the Moose River and slightly cooler in the upstream sections of Creek A, suggesting the presence of springs. By mid June water temperatures had risen to the low 20's. The warmest temperature recorded was in mid July. No sampling was conducted during August or fall, but water temperatures had dropped to 0°C by November.

The water of the Moose River in early November was slightly alkaline with a pH of 7.94. Both total suspended solids and conductivity of the Moose River were low, averaging 3.5 mg/L and 59 uS/cm, respectively, indicating that few suspended or dissolved substances were in the water (Table 1). Conductivity in Creek A was also low (average of 50 and 44 uS/cm upstream and at the mouth, respectively, but total suspended sediment concentrations were more variable (ranging between 6 to 9 mg/L, and 1 to 14 mg/L at the upstream and mouth sites, respectively) and some values were much higher than in the Moose River. The elevated and variable amounts of suspended sediment may have been related to erosion occurring as the result of reduced water levels after a large upstream beaver dam washed out in spring.

Too few samples were collected to assess the natural temporal changes in water quality, but highest conductivity in the Moose River was recorded in July. Conductivity generally shows a seasonal pattern, being lowest when flows are highest. Therefore, samples should be collected more frequently. Ideally, both conductivity and suspended sediment would be sampled continuously but necessary equipment is beyond the price range of this project. Measurements of conductivity varied little between duplicate samples, but measurements of sediment content differed by up to 4 mg/L in samples with a higher suspended sediment content, indicating the need for more replicate samples.

Low suspended and dissolved solids concentrations are typical of waters draining Precambrian Shield terrain. Little comparable information exits for nearby waters. In the Manigotagan River, total suspended solids averaged 4 mg/L (range 1 to 20 mg/L) (DNR 1991). An extensive study of the relation between forestry and fish habitat is currently being conducted in Catamaran Brook, New Brunswick (Cunjak et al. 1993). In Catamaran Brook during 1990, average suspended solid concentrations ranged from 1 to 4 mg/L during normal periods, but increased up to 25 mg/L for short periods in association with storm events. Increases of a similar magnitude may occur in association with storm events in the Moose River area.

Measures of sediment deposition in the Moose River will be obtained in the spring of 1994 when sediment traps are collected. A sediment sample collected in the river adjacent to Site A contained 26% silts and clays (i.e. particles finer than 0.063 mm) (Table 2). Comparison with soil samples collected from the adjacent area (Site A, lower) shows a much higher silt/clay fraction on the terrestrial site, suggesting that fine material in eroded soils is not deposited directly on the river bed but is carried downstream.

3.2 Measurement of Erosion and Deposition in the Terrestrial Environment

The shoreline of the Moose River is exposed bedrock (in erosional areas) or beds of wetland vegetation composed of reeds, sedges, and, on drier areas, willows and other shrubs (Fig. 3). Cut banks are not common. The banks of the streams are generally lined by marsh vegetation, with occasional restrictions where bedrock outcrops occur. In early June, a dense mat of filamentous algae grew over rocky areas in the Moose River. Rooted vegetation also began to grow in soft-bottom areas at this time and by July had formed a solid mat over much of the river. Creek A, as is typical of small streams in the area, flows through a marshy area comprised of the same vegetation types as those along the Moose River. Neither bedrock nor marsh-dominated shorelines are very vulnerable to erosion due to increased water flow, so it appears unlikely that forestry activity would cause an increase in streambank erosion in the majority of the shoreline. As logging occurs, local sites where bank erosion might occur will be identified and monitored.

Terrestrial forested areas adjacent to the Moose River or Creek A vary between relatively flat, hummocky areas dominated by black spruce (*Picea mariana*) and slopes dominated by black and white spruce (*Picea glauca*) and varying numbers of deciduous trees with dry areas and ridges dominated by jack pine (*Pinus banksiana*). In the vicinity of Happy Lake, large numbers of black spruce have been killed by spruce budworm and deciduous trees form the major cover. Three sites with good stands of black spruce were selected for erosion studies: two relatively uniform slopes along the Moose River and one hummocky area along Creek A. Measurements in 1993 were only collected at one of the Moose River sites (Site A) and the Creek A site (Site B).

Soil samples were collected to provide an indication of soils in the area. Samples were collected at three locations: 100 m and 25 m from the Moose River at Site A and 50 m from the edge of the wetland at the Site B. All sites had a thick dark, organic horizon. This layer was smallest on the upper slopes of Site A (35 mm), intermediate at the same site near the river (80 mm), and thickest at Site B (120 mm). The A horizon was 70, 100, and 90 mm thick at the three sites, respectively. The results of the organic and granulometric analysis are presented in Table 2. Organic content ranged from 2 to 8%. The silt/clay fraction (<0.063 mm) in the soil from the upper slope of Site A was approximately a third that of this fraction on the lower portion of the same site or at Site B.

An erosion pin at the time of installation is shown in Fig. 3. A summary of the results from the erosion pins is presented in Table 3. At Site A (hillside), average change in ground height from June to November was -0.4 cm, with a range from -2.1 to 1.0 cm, indicating that ground height was both increasing and decreasing. Comparable results were obtained at Site B (hummocky area) though the range was greater: the average change was -0.5 cm with a range of -3.0 to 2.7 cm. Changes in the ground height can occur due to changes in the thickness of the organic layer, compaction or expansion of the soil, or erosion and deposition of soil. In addition, heaving of the erosion pins is a source of error, but there was no evidence that this had occurred during the short time period of the study. The majority of change in ground height is probably due to changes in the thickness of the organic layer. At several erosion pins at Site B, a small quantity of soil had been eroded or deposited. The presence of erosion at Site B, which is a low, hummocky area, was unexpected. Extreme flooding occurred during the latter part of the summer of 1993, so this may not be an annual phenomenon.

No clear relationship was observed between the magnitude of change in ground height and any noted local topography, slope or position. As expected, there is considerable small-scale variability, indicating the need for many sampling points.

The movement of soils from terrestrial sites into adjacent wetlands indicates that the latter areas may be important traps for soil, preventing it from entering waterways. In 1993, sediment traps identical to those used in the streams were installed in the area adjacent to Site B to determine the movement of sediment in this area. However, all traps were destroyed by bears, and in 1994 other designs potentially less vulnerable to bears will be tested.

Establishment of erosion pins at sites as they are logged will indicate if changes in soil height beyond those observed in the natural forest occur. In addition, future pins will be surveyed to correct for any heaving. In 1994, all terrestrial sites will be classified by the Forest Ecosystem Classification method to permit linkage between erosion information and forest type.

3.3 Biological sampling

Fish were intermittently sampled to provide an indication of the species composition and abundance in the area and provide context for the interpretation of other study results. Sampling was conducted regularly in the Moose River at Site I and at sites IV and V in Creek A. Few fish were captured in either the Moose River or Creek A. In the Moose River two smallmouth bass (*Micropterus dolomieui*) and one northern pike (*Esox lucius*) was captured. Several brook stickleback (*Culaea inconstans*) and one central mudminnow (*Umbra lima*) were captured in Creek A. In spring, large numbers of spawning white suckers (*Catostomus commersoni*) were observed in the rapids area (Site I) where later large numbers of eggs were observed. No fish were captured in the mouths and lower sections of either of the creeks flowing into Frenchman Lake during an electrofishing survey. Gillnets set in the Moose River upstream of Frenchman Lake caught no fish though three white sucker and one walleye were captured in Frenchman Lake itself.

Table 4 presents the species list of fish known to occur in the area as listed in the FHICS (DNR 1991). Little study has been done of Happy or Frenchman lakes or the Moose River, so nearby Manigotagan Lake is included to provide a more complete representation of the species present in the area.

Larval drift traps were set at weekly intervals in the Moose River from May 21 to June 11 to determine if this area was used by any spring spawning fish (primarily suckers and walleye). During this period temperatures ranged from 13 to 16°C. Drifting larval fish were collected from May 28 until June 4, when the largest number of larval fish were captured (Table 5). No drift was collected the following week. Of the 1973 fish collected, all but four were larval suckers (*Catostomus commersoni*). Three of the other fish were stickleback (probably brook stickleback, *Culea inconstans*) and the fourth was a yellow perch, *Perca flavescens*.

The Moose River is a potential walleye spawning area because it is the only major tributary of Happy Lake, which contains walleye, and walleye in post-spawning condition have been observed in its mouth. It is possible that the walleye in Happy Lake spawn in the lake itself or that drift of walleye occurred before larval drift sampling was initiated. Inspection of the river did not reveal any sites where spawning appeared probable downstream of the rapids area where the drift traps were located.

4.0 RECOMMENDATIONS AND FUTURE STUDY

The Moose River area between Frenchman and Happy lakes was chosen as a site suitable for the Experimental Watershed study because Abitibi-Price Inc. will be concentrating much of its activity in this area for the next few years. The spatial extent of logging will be somewhat restricted because of spruce budworm damage in part of the area. Many of the impacts caused by logging with respect to increased erosion and sediment input into streams will still be apparent, however, as these effects are more dependent on the movement of vehicles and road construction than actual tree removal. In addition, local studies of erosion will occur in groves of trees that are harvested.

In 1994, sampling will be conducted to include both harvested and natural areas. The 1993 sampling sites were chosen in consultation with Abitibi-Price Inc. and DNR, Fisheries Branch, with the expectation that these areas would be harvested in the near future. Due to wildlife considerations, harvest of this area may now be postponed, necessitating a change in 1994 sampling plans.

Assessment of the effect of harvest on water quality will depend on three comparisons as outlined by Green (1979): comparisons of water quality upstream and downstream of the affected area; comparisons of water quality between affected and unaffected streams; and pre-and post-impact comparisons within the same stream. Collection of water samples will continue at stations established in 1993 and may be expanded to another creek to the east of the Moose River if extensive harvest occurs in its drainage basin. Due to the variability between sampling times and duplicates, the frequency and number of replicates of water samples will be increased as much as funding permits.

Measurements of soil erosion and deposition in the terrestrial environment will continue at the sites established in 1993. Additional sites in 1994 will be established in accordance with harvest plans. At the moment, site types under investigation include both a steep hillside with fine-textured soils and a level hummocky area, which represent common environments in the area and would probably represent a high and low erosion situation, respectively. Additional site types will be included if they are identified as important. In an optimal situation, several sites, representative of each of the site types of interest will be identified and marked, and a portion of these will be harvested. Ideally, each harvested site would be split between the two harvest methods (conventional and cut-to-length) but this is dependent upon both the spatial extent of the site and practical considerations related to harvest. Measurements collected in 1993 indicated that there is a large amount of local variability, necessitating an increase in the number of erosion pins installed at each site.

Monitoring of established terrestrial and aquatic sites will continue beyond 1994 to measure the full effect of harvest, and if possible within the time frame of the Model Forest, reforestation. The present funding of this project does not permit the collection of any biological information. Depending on future developments, research plans related to biological measurements will be developed in relation to background information collected in 1993.

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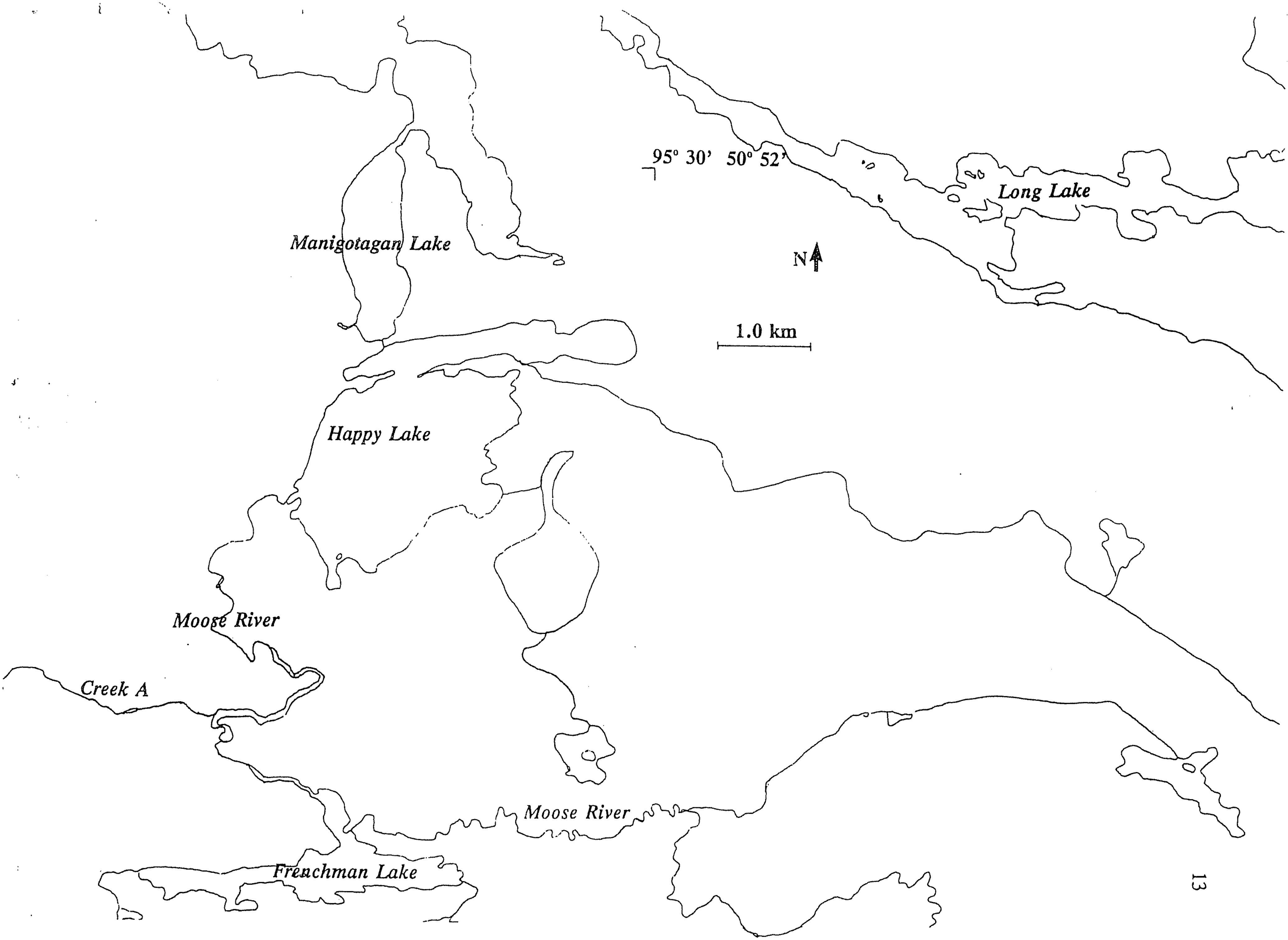

Fig. 1. The Experimental Watershed Project study area.

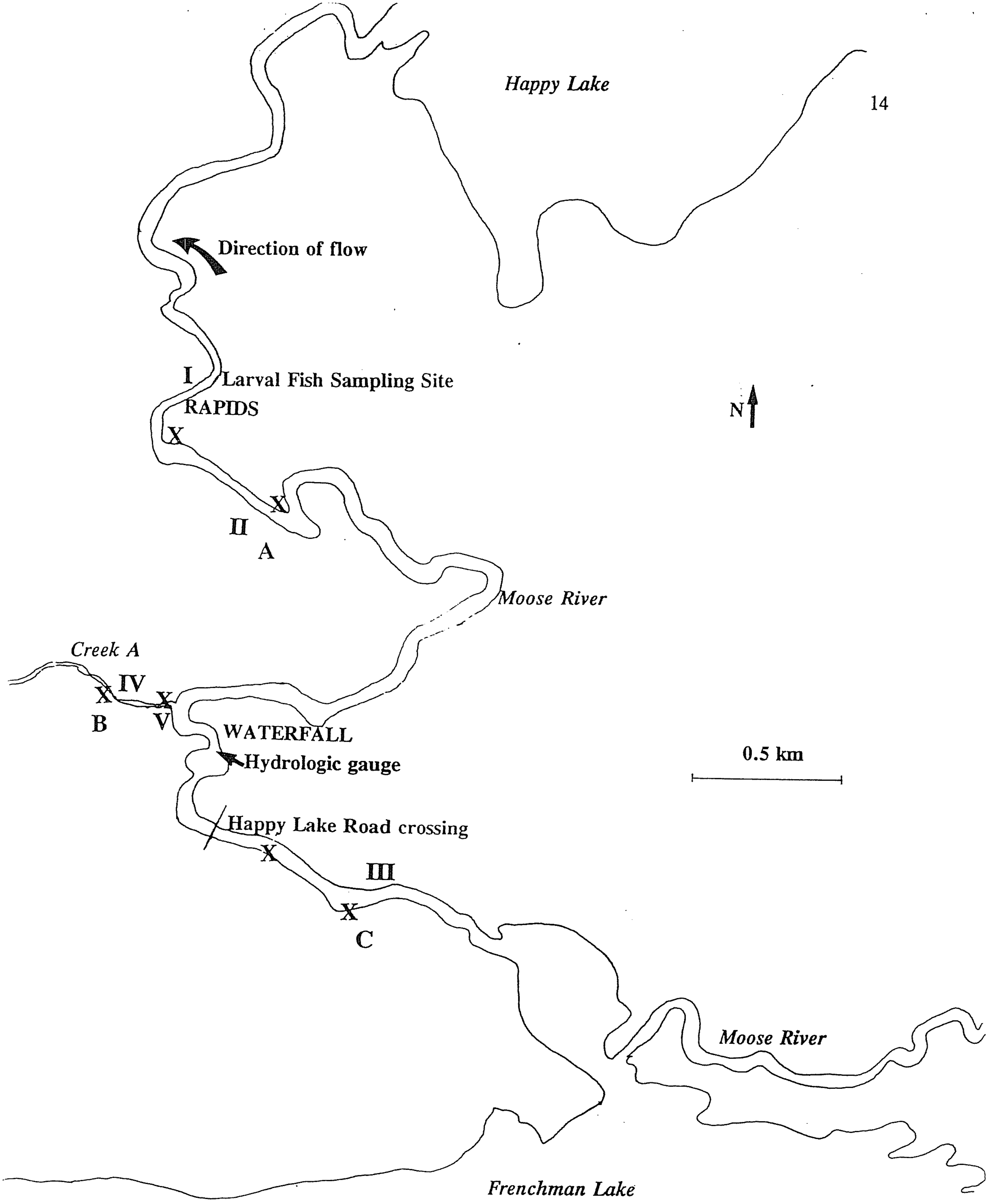

Fig. 2. Permanent sampling sites established during 1993. Water samples were collected at sites I to V, terrestrial erosion was measured at sites A and B (site C is also suitable for erosion measurements), and sediment traps were installed at all sites marked X. The location of the hydrologic gauge and larval fish sampling site are

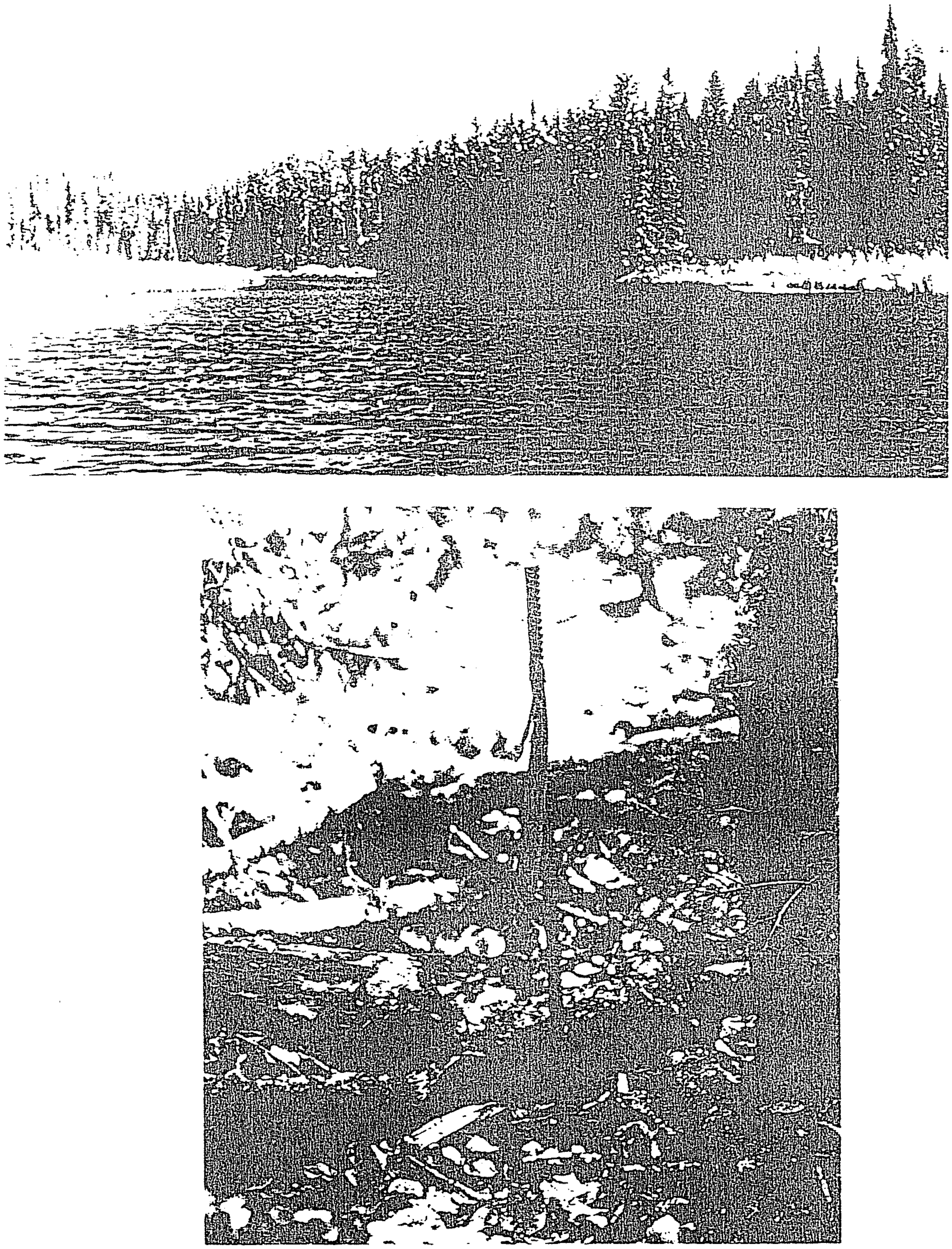

Figure 3. Shoreline along the Moose River showing areas of bedrock and marsh vegetation (top). At the far left, spruce growing on a level hummocky area are visible; the remainder of the trees are growing on a hillside. Erosion pin at Site B (bottom).

Table 1. Total suspended solids and conductivity for sites along the Moose River (I to III) and Creek A (IV and V).

Site	Sample size	Total Suspended Solids (mg/L)			Conductivity (μs)/cm		
		Mean	Min.	Max.	Mean	Min.	Max.
I	10	3.5	2	6	59	55	63
II	1	1			55		
III	1	3			53		
IV	4	7.3	6	9	50	42	60
V	7	4.6	1	14	44	37	55

Table 2. Organic and granulometric composition of soil samples collected in November, 1993.

	Organic	% Size Fractions of Ashed Weight						
	% Total	>2.00 (mm)	1.00-2.00 (mm)	0.450-1.00 (mm)	0.212-.450 (mm)	0.150-0.212 (mm)	0.063-0.150 (mm)	<0.063 (mm)
Site A-upper								
A Horizon	3	11	11	24	14	6	11	24
B Horizon	2	19	8	21	14	7	11	20
Site A-lower								
A Horizon	8	4	1	7	12	8	9	60
B Horizon	8	0	0	1	1	2	10	86
Site B								
A Horizon	7	0	0	1	1	1	20	77
B Horizon	6	0	0	2	1	2	23	72
Moose River								
Sediment	7	1	2	27	18	11	14	26

Table 3. Differences in ground height (cm) at erosion pins from June 9 to November 4, 1993 at sites A and B.

Site A

Position	Transect 1	Transect 2	Average
0	0.0	-0.9	-0.4
25	1.0	-0.5	0.2
50	-0.8	1.0	0.1
75	-1.2	-0.3	-0.7
100	-0.1	-0.6	-0.3
125	-2.1	0.2	-1.0
Average	-0.5	-0.2	-0.4

Site B

Position	Transect 1	Transect 2	Transect 3	Average
0	2.7	-0.9	no data	0.9
15	-1.3	-0.1	0.6	-0.3
20	-2.4	-1.4	0.7	-1.0
25	-1.3	0.3	-3.0	-1.3
50	-0.2	0.5	-0.8	-0.1
75	-0.5	-1.0	-0.9	-0.8
Average	-0.5	-0.4	-0.7	-0.5

Table 4. Fish species present in the Moose River and several nearby lakes according to the FHICS (DNR 1991). Known activities are indicated by "Y". Abundances are designated abundant (A), common (C), uncommon (U), rare (R), and unknown (X).

		Year Round	Spawn Elsewhere	Spawn and Hatch	Nursery	Migration Route	Over Winter	Presence
Moose River								
NORTHERN PIKE	*Esox lucius*	Y					Y	C
SMALLMOUTH BASS	*Micropterus dolomieui*	Y					Y	C
WALLEYE	*Stizostedion vitreum*	Y					Y	C
Frenchman Lake								
NORTHERN PIKE	*Esox lucius*	Y					Y	C
SMALLMOUTH BASS	*Micropterus dolomieui*	Y					Y	C
WALLEYE	*Stizostedion vitreum*	Y					Y	C
Happy Lake								
BURBOT	*Lota lota*						Y	X
CISCO	*Coregonus artedii*						Y	X
LAKE WHITEFISH	*Coregonus clupeaformis*	Y					Y	C
NORTHERN PIKE	*Esox lucius*	Y					Y	C
SMALLMOUTH BASS	*Micropterus dolomieui*	Y					Y	C
WALLEYE	*Stizostedion vitreum*	Y						C
WHITE SUCKER	*Catostomus commersoni*							X
YELLOW PERCH	*Perca flavescens*	Y						C
Manigotagan Lake								
BURBOT	*Lota lota*	Y		Y	Y		Y	U
CISCO	*Coregonus artedii*	Y		Y	Y		Y	A
COMMON SHINER	*Notropis cornutus*	Y					Y	X
JOHNNY DARTER	*Etheostoma nigrum*	Y					Y	X
LAKE WHITEFISH	*Coregonus clupeaformis*	Y		Y	Y		Y	C
LOGPERCH	*Percina caprodes*	Y					Y	X
LONGNOSE DACE	*Rhinichthys cataractae*	Y	Y	Y	Y	Y	Y	X
NORTHERN PIKE	*Esox lucius*	Y	Y	Y	Y	Y	Y	C
SMALLMOUTH BASS	*Micropterus dolomieui*	Y		Y	Y	Y	Y	X
SPOTTAIL SHINER	*Notropis hudsonius*	Y					Y	X
WALLEYE	*Stizostedion vitreum*	Y	Y	Y	Y	Y	Y	A
WHITE SUCKER	*Catostomus commersoni*	Y	Y	Y	Y	Y	Y	C
YELLOW PERCH	*Perca flavescens*	Y	Y	Y	Y	Y	Y	C

Table 5. Number of larval fish caught in larval drift traps in the Moose River, spring 1993.

Date	Hours trap set	Number of traps	Total catch	fish/trap/hr
May 21	16.5	4	0	0
May 28	16.2	4	85	1.3
June 3	19.0	6	274	2.4
June 4	22.5	6	1614	12.0
June 10	26.0	6	0	0
June 11	16.5	6	0	0

APPENDIX 1. DEVELOPMENT OF THE STUDY PLAN

The experimental approach, in which ecological characteristics of interest in an area are measured before, during and after some type of prescribed manipulation in order to determine the effects of the manipulation, has been applied to a wide variety of systems. The advantage of this method over comparison of previously disturbed and natural areas is that causes of observed differences can be more clearly determined. In Canada, the best known example of the experimental watershed approach is in Carnation Creek, British Columbia, where a fifteen year study revealed the biological and physical changes associated with a variety of logging practices (Hartman and Scrivener 1990).

In the Model Forest area, timber harvest is generally thought to have a limited impact on aquatic ecosystems. Regulations prescribe the maintenance of uncut buffer zones along most streams and regulate the construction of stream crossings. Two forestry issues that are of interest in the Model Forest are whether buffer zones are required to protect the aquatic environment in low relief areas and whether certain forestry practices cause more erosion than others. To date, the following have not been documented in this area: 1) physical changes in streams in response to timber harvest; 2) effects of these physical changes on the biota; and 3) differences among terrestrial sites in terms of harvest-related effects on adjoining aquatic areas. The Experimental Watershed Project was proposed to address these information gaps.

The detailed study plan was developed in three phases:

1. Initial meetings were held with project sponsors and proponents (Abitibi-Price Inc., Department of Natural Resources, Fisheries Branch) to clarify their concerns and a literature search was conducted to obtain relevant information;

2. A workshop was held at the Freshwater Institute involving all interested parties to obtain advice on study plan development and permit other partners to join the project; and

3. The study plan was modified in accordance with the recommendations of the workshop and subsequent meetings.

This study plan was presented to the Model Forest as a detailed proposal on May 18, 1993. Experience gained during the summer of 1993 in conjunction with modifications in the harvest plan of Abitibi-Price Inc. necessitated further technical modifications but no substantiative changes in content.

The following are the principal points discussed and conclusions reached during the planning phase:

1. Design of study.

The experimental approach, in which an area is monitored before, during, and after forestry activity, is a useful one. However, natural interannual variability necessitates the collection of a long period of pre-impact data and/or measurement at control sites (preferably just upstream of the impact). Smaller water bodies, in which a large proportion of the watershed is harvested, are the ones most likely to be adversely affected by logging.

From a practical perspective, it is of interest to identify the widths of buffer zones required to prevent sediment from entering streams under a variety of conditions (e.g. slope and soil type). In addition, a comparison of the amount of erosion produced by different forestry practices would be useful when, for example, two alternate harvesting methods are available.

2. Study site selection.

The Experimental Watershed study area had to include one or more small rivers and/or streams. One of the primary criteria for the selection of the study area was that it was a region that has not been recently affected by logging but would be harvested extensively in the next few years. In addition, the region had to include uplands, which are more prone to erosion than the extensive bogs occupying much of the western portion of the Model Forest. Several potential sites in the Model Forest were considered, but after consultation with Abitibi-Price Inc., it was apparent that only the area to the south of Happy Lake met all these criteria.

3. Water quality monitoring.

Parameters such as suspended sediment and conductivity indicate additions to the aquatic system from terrestrial areas. Although nutrient concentrations often change following logging, measurement of nutrients without the development of a general nutrient budget is not worthwhile. The development of a nutrient budget is beyond the scope of the project.

The level of change expected in water quality in the system as a whole is very small. Therefore, to detect any changes in water quality, samples would either have to be collected very near a point-source of runoff or a large proportion of the watershed would have to be affected.

4. Measurement of stream flow changes associated with logging.

Given the large natural interannual variability in stream flow and the relatively small change expected due to logging, detecting this effect is unlikely. Detection would require the following: 1) a relatively long (5 year) period of pre-logging data collection; 2) siting of the gauge at a hydrologicly sensitive site (i.e. bedrock exposure with a narrow channel; 3) no headwater lakes or marshes; and 4) a large proportion of the watershed would have to be logged.

A survey of the area did not reveal any small streams which met all these criteria. Therefore, the effects of logging on stream flow will not be included in the project. However, monitoring the hydrologic regime of an area is required for interpretation of other measurements, such as suspended sediment. In addition, physical changes following logging are closely linked to annual precipitation, which should be monitored to permit assessment of each year's results in context.

5. Detection of erosion and sedimentation in the aquatic and terrestrial environments.

Both erosion and sedimentation vary on a very small scale. Therefore, detection requires installation of large numbers of measuring devices over a large area rather than detailed measurements at a few sites. Ideal devices, therefore, are cheap to build, install and maintain.

In the terrestrial environment, erosion pins, which are simple metal stakes driven into the ground are useful because a large number can be installed. In contrast, gerlach troughs, which collect all material in runoff at selected points along a streambank, are prone to effects induced by local variations in topography.

Critical to the success of local erosion studies is the selection of suitable sites. The following criteria must be met: the site has to be relatively uniform and over a sufficient spatial extent that an effect could be reasonably detected; the topography (i.e. sloped, level) and location (i.e. proximity to stream or river) of the site has to be suitable; and 3) the area must contain merchantable timber. Selection of specific sites was somewhat limited because spruce budworm has killed large numbers of trees along the Moose River in the vicinity of Happy Lake. The terrain along creeks flowing into Frenchman Lake was also investigated but these were not suitable for harvest because of access difficulties or absence of suitable timber.

6. Detection of changes in fish/invertebrate populations associated with logging.

Natural variability of fish and invertebrate populations is very high. Therefore, a relatively long (5 year) period of pre-logging data would be required to adequately describe natural variability. In addition, a similar, unimpacted control site would be required as comparison in case of unusual events. Given the small change associated with logging expected in this area, intensive sampling would be required to detect an effect related to logging.

Given the limited budget and period of time of the project, it was felt that the project should focus on detection of local, physical effects which could reasonably be expected to be observed. Therefore the study plan incorporated the following:

1. The study area included both a large river and a small stream. To maximize the effect of harvesting, it would be useful if harvesting around the small stream could be without a buffer strip. Local sampling should be arranged to permit detection of differences between harvest techniques.

2. Water quality measurements were limited to suspended sediment and conductivity (a measure of total dissolved solids). Samples would be collected in both natural and logged areas.

3. Hydrologic measurements were only collected to provide context for other variables. A small watershed that was suitable for hydrologic gauging and forestry was not identified in the area.

4. Local measurement of erosion using erosion pins on a variety of sites was emphasized.

5. No attempt was made to measure changes in fish and invertebrate populations in response to logging. Rather, surveys were conducted to determine the fish species composition of the area to provide context for the study. Drift of larval fish in spring was monitored to determine whether spring-spawning fish were using the Moose River.