Detailed Study Plan
PLUARG Task C - Activity 2
Forested Watershed Surveys
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Study Objective

To determine the effect that various forest management practices may have on streamflow quality, quantity and timing; groundwater quality and fluctuations; snow pack distribution; and erosion rates.

Study Area

The Canadian Shield is an extensive area of Precambrian rocks covering approximately 50 percent of the total area of Canada and 60 percent of the surface of Ontario. Another important fact is that Shield areas contribute at least half of the water volume for the Great Lakes-St Lawrence system.

Near Kenora, Ontario, on the Canadian Shield is the Experimental Lakes Area established by the Freshwater Institute in 1967 for limnological studies of environmental problems. It has a modified continental climate with a January mean of -16°C (3°F) and a July mean of 19.5°C (67°F) with a 150 day growing season. Total annual precipitation ranges from 500-750 mm (20-29 inches) with about 65 percent falling during May through September. Annual snowfall ranges from 150 to 225 cm (60-90 inches), most of which falls from November through March.

Rock outcrop areas are extensive and the granite bedrock is strongly sheared, jointed and faulted, so that the rounded, convex rock masses are divided by deep narrow valleys which commonly join the lake basins. Relief does not usually exceed 80 meters (260 feet). Soils are coarse textured with some local lacustrine and beach deposits occurring as small discontinuous patches in a complex with water-washed till. Therefore, the soils are generally thin and subject to rapid leaching.

Jack pine dominates the area and on upland site black spruce, poplar, and white birch are the principal associated species. Red pine occurs infrequently and usually occupies well-drained glacial fluvial sand deposits. Black spruce generally dominates on well-drained deep glacial drift and in poorly drained "boggy" areas.

Thus, friable soils, rugged topography, and remarkably pure water production have resulted in the area being described as one of the most "fragile" of the Shield environments. The area has the climatic, edaphic and vegetation characteristics that would encourage elemental loss from the ecosystem if there is any impact due to forest harvesting. Clear-cutting and scarification are commonly used management practices in the area which allow evaluation of their impact on the environment.

... 2

Method of Investigation

In order to obtain some information on forest management impacts in a restricted time frame the traditional approach of paired catchments was avoided. Instead, a proposal to monitor catchments which had already been treated along with some untreated catchments and use a one-way analysis of variance to test the mean output from each catchment was adopted.

In 1972 twelve small catchments varying in size from 40 to 660 hectares (90 to 1600 acres) were selected. Conditions on these catchments consisted of uncut, one-year-old cuts, and about three-year-old cuts. In addition, records are available for six other uncut catchments from a contract study by the University of Manitoba. By 1975 all twelve of our catchments will be cut and the six reserve catchments will be used for baseline comparison.

Parameters Measured:

Nutrients: Ammonia Nitrogen, Nitrate Nitrogen, Total Dissolved Nitrogen, Suspended Nitrogen, Total Dissolved Phosphorus, Suspended Phosphorus.

Minerals: Chloride, Sulphate, Silicon, Sodium, Potassium, Magnesium, Calcium, Total Iron.

Physical: Turbidity, Conductivity, Temperature (present, weekly maximum and minimum), pH, streamflow,rainfall, spring snow pack.

Organic: Dissolved Organic Carbon, Suspended Carbon.

Status

At least weekly sampling has taken place on these catchments from early April until October for 1973, 1974 and 1975. Analysis of 1973 data is pretty well complete and work is continuing on the 1974 and 1975 data assimilation. Streamflow quantity and timing has not been analyzed as yet. The Study Progress Report gives more detail on the 1973 results.

STUDY PROGRESS REPORT

Study: Impact of Forest Management Practices on Forest Hydrologic Processes in Boreal Ecosystems

Study No.: GLC-12-088

Study Officer: John A. Nicolson, RS-1

Past Study Officer: N/A New Study - 1972

Other technical and professional CFS personnel with significant involvements: A.W. Johns, EG-ESS-4

INTRODUCTION

Forest management practices, such as clearcutting of large areas, controlled burning of slash, and scarification for regeneration purposes, have been subjected to adverse public criticism recently. Many claim that such management practices are detrimental to the environment by increasing soil erosion and accelerating eutrophication of surface water.

This study was originally proposed for two areas within the boreal forest; the Black Sturgeon Lake area near Lake Nipigon and the Experimental Lakes Area near Kenora; which differ in climate, vegetation, landform and soils. Lack of personnel and the distance between the areas dictated the necessity of concentrating on one area. The Fisheries Research Board Camp in the Experimental Lakes Area has extensive laboratory facilities so the study commenced there in the spring of 1972.

The hydrologic cycle is a complex system which, because of the vital importance of water to the survival of lifeforms, is interlinked with almost every other cycle within the forest ecosystem. Quantity and timing of streamflow as well as the quality of the water produced are all affected by the type of land management practised and the site conditions on the watershed.

The variability of results shown by the study analysis literature review (Appendix I) is due to the complexity of the factors affecting the hydrologic cycle. This variability dictates the necessity of investigating representative areas within the geographic province of interest. To assess the impact of any disturbance, one must consider:

(1) quantity, quality and timing of surface runoff

(2) quality and flow fluctuations of groundwater when a catchment does not have a tight basement

(3) characteristics of the climate, such as rainfall amount, duration, and intensity,

and snowpack amount and distribution

(4) erosion of soil as influenced by alteration in soil physical properties, and

(5) changes in vegetative cover

The important point is to separate out forest management effects on the ecosystem and determine the severity and duration of those effects and, if necessary, develop alternative management procedures to minimize or eliminate the effect.

STUDY OBJECTIVES

1. To determine the effect that various forest management practices may have on streamflow quality, quantity and timing; groundwater quality and fluctuations; snowpack distribution; and erosion rates. Clearcutting, sometimes followed by scarification, is the major practice being investigated at present; however, clearcutting followed by a controlled regeneration burn is now being proposed for three catchments.

PROGRESS

Early in 1972 the hydrologic study analysis was drawn up and approved (Appendix I). The approach proposed for detecting possible gross effects of clearcutting was to sample a number of catchments which had already been clearcut along with some uncut ones and use a one-way analysis of variance to test the mean output from each group of catchments. With this technique in mind 12 small catchments varying in size from 40 to 1400 ha (90 to 3400 ac) were selected during the following summer and preliminary sampling for water quantity and quality was initiated (Figure 1, Table 1). These catchments, when selected, consisted of uncut, one-year-old cuts, and about three-year-old cuts. In addition to these 12 catchments there are records available for six other uncut catchments from a study by the University of Manitoba under contract with Environment Canada (Table 1).

Two natural disasters have affected some of these watersheds since the start of the study. On July 6, 1973 a severe windstorm (winds in excess of 70 mph) created extensive blowdown areas, in particular flattening most of the virgin timber in the East Subasin and most of the patches of timber left standing after 663 was clearcut. On June 26, 1974 wildfire covered half of the lake 239 basin including the entire East Subasin, half of the lake 240 basin, and a small portion of the upper part of the 663 catchment.

Streamflow, stream temperatures, samples for suspended sediment and for chemical analyses are collected weekly at the 18 sites from April to October. Water samples are analyzed in the camp laboratory by a contract technician and Freshwater Institute personnel for pH, conductivity, carbon dioxide content, dissolved organic carbon, total

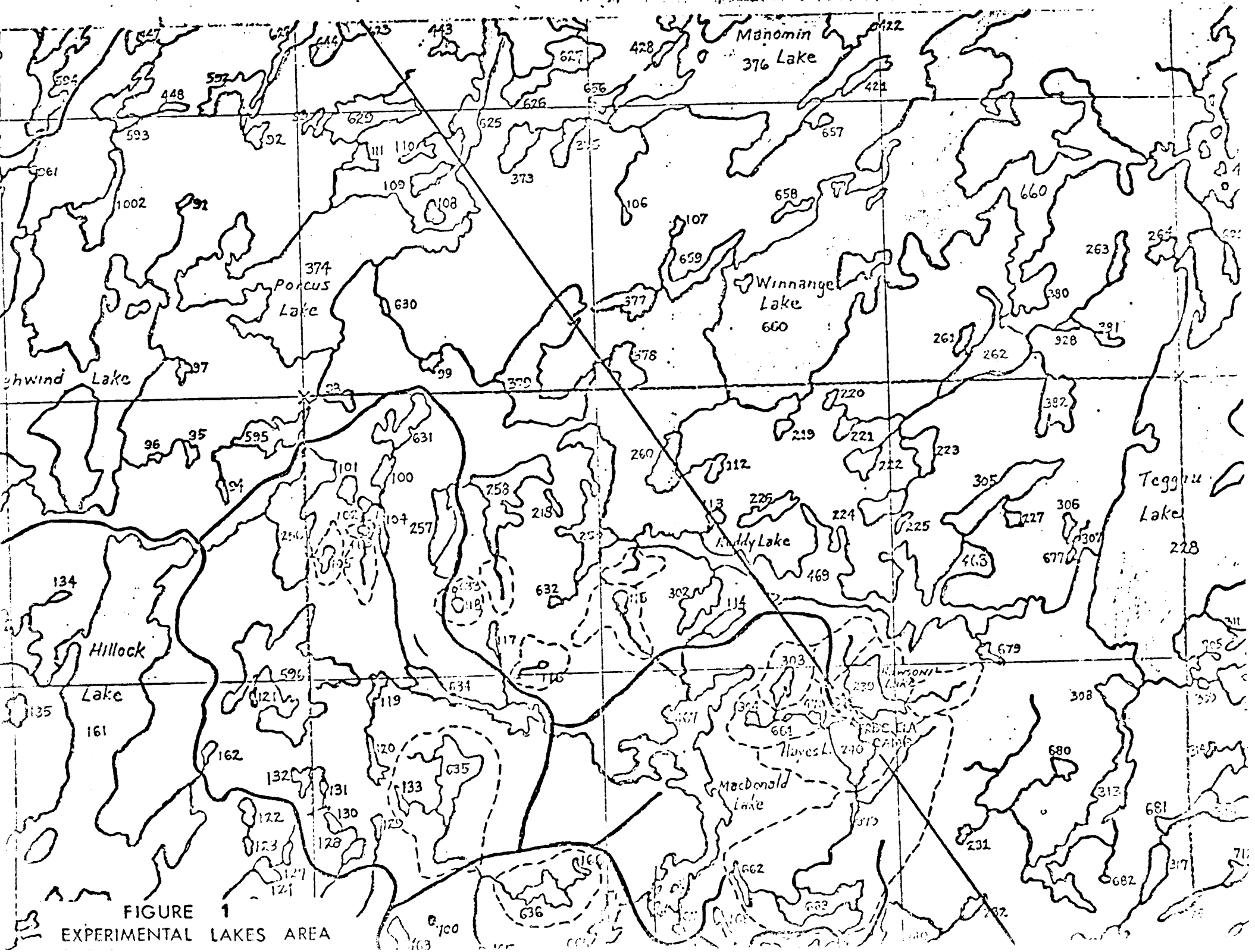

FIGURE 1
EXPERIMENTAL LAKES AREA

TABLE 1

EXPERIMENTAL LAKES AREA WATERSHED AREAS

	Hectares			Acres		
	Total	Water	Land	Total	Water	Land
GLFRC Watersheds						
103-1	35.6	-	35.6	88.0	-	88.0
103-0	48.9	2.8	46.1	120.8	6.8	114.0
105	43.4	6.5	36.9	107.2	16.0	91.2
115	167.5	7.1	160.4	414.0	17.6	396.4
116	65.6	1.1	64.5	162.0	2.8	159.2
118	50.3	2.3	48.0	124.4	5.6	118.8
258	104.1	0.5	103.6	257.2	1.2	256.0
468	44.2	-	44.2	109.2	-	109.2
635	441.1	41.0	400.1	1090.0	101.2	988.8
635-A	63.8	-	63.8	157.6	-	157.6
636	139.1	25.3	113.8	343.6	62.4	281.2
663	1392.9	150.8	1242.1	3441.9	372.7	3069.2
University of Manitoba Watersheds						
303	55.4	9.9	45.5	136.8	24.5	112.3
470	164.3	20.5	143.8	406.0	50.7	355.3
NW Subasin	61.8	-	61.8	152.7	-	152.7
East Subasin	171.0	-	171.0	422.6	-	422.6
239	400.2	56.1	344.1	988.9	138.6	850.3
240	727.8	120.7	607.1	1798.5	298.3	1500.2

dissolved phosphorus, and three forms of nitrogen (ammonium, nitrate and total dissolved nitrogen). The samples are then prepared and shipped to the Freshwater Institute in Winnipeg where determinations are conducted for suspended nitrogen, suspended phosphorus, suspended carbon, cations such as: calcium, magnesium, potassium, sodium, silicon, total iron, and manganese, and the anions: sulphate, bicarbonate and chloride.

A newtork of six recording raingauges is maintained for summer precipitation and a series of snowcourses are measured in the late winter for an estimate of spring runoff.

The 1972 survey results were reported in a Forest Research Newsletter progress report (Ellis, Nicolson, Mattice and Bourgeois, 1973). Clearcutting alone appeared to effect a small increase in the concentration of some elements dissolved in the stream (see Table 1 in Appendix II) but after three to five years these differences seemed to disappear. This suggests that the impact of clearcutting on water quality, at least in this area, may be less than expected.

In February 1973 six V-notch weirs, one flume and one natural control were installed and equipped with stilling wells and recorders. A great deal of extra work was involved to get these installations operational, which severely cut into the sampling season. Subsequent work that summer (1973) involved the regular weekly chemical sampling as well as intensive metering of streams in order that rating tables could be compiled for each of the control sections.

The 1972 survey results were also reported in a seminar at the Freshwater Institute in Winnipeg in December 1973 (Appendix II). These data indicated that commercial clearcutting apparently increased the concentrations of most materials in streamwater; however, only dissolved organic carbon, chloride, sodium, potassium and magnesium had statistically significant increases when an analysis of variance was applied. Moreover, preliminary analyses using incomplete 1973 data showed ammonium, total dissolved nitrogen, and total dissolved phosphorus concentrations to be statistically higher from fresh cut as related to uncut areas. Also, concentrations from two-year-old cuts were still higher than, but not statistically significant from, the uncut catchments.

Summarization of the background and approach to the water and soil aspects of the Impact Project is contained in a paper presented at the Lakehead University Forestry Association Sixth Annual Symposium in February 1974 (Nicolson and Bourgeois, 1974). The text is included as Appendix III because to this author's knowledge the paper has not yet been published. An outline of the study was also presented in a talk to an Ontario Forest Industries Association Press Tour in October 1974, and some of the initial results of 1973 data were included in a presentation in Toronto in January 1975 by Mr. W.R. Grinnell of the Ontario Ministry of Natural Resources to the Pollution from Land Use Activity Reference Group (PLUARG) of the International Joint Commission.

The 1973 data were compiled and 25 variables graphed by computer. Comparing uncut catchments to those cut one year, two years and three or more years the graphs indicate:

(1) 12 variables show no appreciable change

(2) total dissolved nitrogen, suspended

carbon, and chloride initially doubled in concentration

(3) ammonium, total dissolved phosphorus, and dissolved organic carbon concentrations initially tripled in value

(4) potassium, iron and colour are four or more times higher

(5) bicarbonate shows a seven-fold decrease

(6) pH indicates a more acidic condition after cutting, and

(7) potassium, iron, colour, and dissolved organic carbon are still higher in concentration on the three-year-old cuts than on the uncut areas.

At this time the analysis of variance for the 1973 data has just been completed and a paper has been prepared for presentation at the National Hydrology Symposium (August, 1975) in Winnipeg (Nicolson, 1975, Appendix IV). The concentrations of materials during the 1973 growing season are reported for eight catchments (three were uncut, two were one-year-old cuts and three were two-year-old cuts). Concentrations of ammonium, phosphorus, and sulphate were higher the year after cutting but subsided to near precut levels in the second year. Acidity, as indicated by pH, followed the same trend. Suspended sediment did not exceed 2.4 mg/l (ppm). Total dissolved nitrogen, carbon, potassium and chloride concentrations were higher for a longer period but appear to be returning to precut levels. Calcium was lowered slightly. With some elements differences are persisting for longer periods. Maximum water temperatures were higher on cuts than in uncut areas, while minimum water temperatures were essentially unchanged. The differences do not appear to be of major significance, for example, total dissolved nitrogen, although it appears to double in concentration after cutting and does not return to the precut level until through the third year, was only increased from 0.3 to 0.6 mg/l (ppm). Relatively speaking, high quality water flows from these catchments and even a two- or threefold increase in ionic concentrations would not impair water quality. However, further study is needed to determine if these differences in concentration could have a lasting effect on the total nutrient status of the ecosystem. The 1974 data are just now complete and the analysis of variance will be applied in the near future.

Sampling will continue at 16 sites through 1975. Three catchments (103-I, 103-0 and 105) were cut in the winter of 1974-1975 and a prescribed burn for regeneration has been proposed for August, 1975 so monitoring will be necessary in 1976 to assess the impact of this management practice.

Soil moisture investigations are being conducted and some transects with a refraction seismograph may be possible to investigate the underlying layers in some of the study watersheds.

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