Not for publication

OPERATION OF THE SERVICE LABORATORY AT THE MANITOBA-SASKATCHEWAN REGION (1967 to 1970)

by

Y. P. Kalra and M. W. Ali

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DEPARTMENT OF FISHERIES AND FORESTRY
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OPERATION OF THE SERVICE LABORATORY AT THE MANITOBA-SASKATCHEWAN REGION (1967 to 1970)

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INTRODUCTION

The Service Laboratory was initiated in December 1966 to carry out analytical work for the various sections of the regional establishment. One senior technician was employed full time to analyse soil samples. A total of 3,600 determinations were to be carried out on 296 soil samples already submitted by research scientists. However, the Service Laboratory, between December 1966 and mid-September 1967, carried out only 140 determinations on 50 samples. During this period, plant samples were submitted to the Geology and Soil Science departments of the University of Manitoba owing to the inability of the staff of the Service Laboratory to carry out plant analysis.

The Laboratory was re-organized in September 1967 when the head of the Laboratory Services was employed. The services of the authors were procured in September and December 1967, respectively. Various techniques for soil analysis were standardized and modified for a variety of analyses. At this time, methods for the analysis of plant and water samples were also introduced. A report, "Procedure for taking soil samples", was put out as a departmental publication, Information Report MS-X-9, April 1968.

The present report describes the operation of the Laboratory from September 1967 to May 1970. The operation of the Service Laboratory

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at the new Prairies Region at Edmonton, formed by the amalgamation of the Manitoba-Saskatchewan and Alberta-Territories Regions, will be essentially the same as described in this report. The details of the different types of forms that have been prepared are found in Appendices I to XXX. The organization of the Laboratory, personnel, and number and types of analyses on samples submitted and the equipment in the Laboratory are given in Appendices XXXI to XL.

FUNCTIONS OF THE SERVICE LABORATORY

The following functions are performed in the Laboratory which is equipped to do soil, plant tissue, and water analysis:

1. Research in analytical work for the modification of techniques selected and for the development of new methods. This involves direct field sampling.
2. Analysis of samples submitted by different sections, with the use of routine, selected techniques, with or without modification. A standard set of procedures is used for analysing the submitted samples. However, different procedures are used if the research scientists so desire but this is done after the necessary technical discussion.
3. The performance of many kinds of specialized (i.e., non-routine) laboratory analyses.
4. Providing guidance and training in analytical methods and use of equipment.

ADVANTAGES OF A SERVICE LABORATORY

Several advantages of having a central Service Laboratory for the Forestry Branch became evident when the other options in use were considered. The latter consisted of using the services of the Manitoba

Provincial Soil Testing Laboratory or having individual researchers carry out their own analyses. As part of the program analysis, a comparison was made and the following points were considered:

A. Analysis by individual researchers in their own laboratories:

(i) Since for the same determinations different procedures were used, it was generally not possible to compare results of different scientists.

(ii) The same equipment was duplicated in different laboratories.

(iii) Most technicians were untrained in analytical procedures for soil, plant, and water analysis. Time-consuming training was necessary and a lot of time was spent in reading published work on analytical techniques, in trying to understand them and then carrying out the determinations in the laboratory for mastery of the selected techniques.

(iv) Several analyses could not be performed because of the lack of elaborate equipment and knowledge of basic principles of analytical techniques, and the necessity for a great deal of experimentation.

B. Analysis by the Provincial Soil Testing Laboratory:

(i) Only a limited variety of analyses were carried out by the Provincial Soil Testing Laboratory. These were: pH, conductivity, carbonates (qualitative), texture (by hand-texturing), NO_3-N (expressed as available N), $NaHCO_3$-P and exchangeable K. Therefore, it was not possible to get soils analysed for other characteristics of importance in forestry and nursery soils.

(ii) Problems in terminology also arose. Results received from the Provincial Soil Testing Laboratory would show, for example, available nitrogen as "x lbs/acre". However, this value, in general, would not hold true for forest soils where NH_4-N is important and must be determined before any quantities of available nitrogen are expressed.

(iii) For forestry research projects, where much time and money may have been spent in collecting samples, a high degree of accuracy is required and it is important that even slight differences be reported. The soil testing laboratories are oriented toward analysing samples for fertilizer recommendations on a large scale on a routine basis.

(iv) The Provincial Soil Testing Laboratory was not equipped for analysis of plant materials.

In the Service Laboratory, analysis can be performed most efficiently because the staff has the training and experience in analytical work with a variety of samples. Latest and most accurate techniques can be used. Expensive equipment can be purchased and properly maintained.

OPERATION

Estimation of Requirements of Different Scientists

Before the start of the field season, an estimate is obtained from Section Heads about the requirements of the researchers in their sections for analytical work. This consists of information on the expected number of samples and determinations, types of analyses required, and approximate dates when the results are needed. After this information has

been received, a final list giving tentative dates of completion of the analyses is prepared upon consultation with the Section Heads, if required, for approval of the Associate Regional Director. If the number of determinations required by a certain date exceeds the output of the Service Laboratory for that period, this fact is brought to the attention of the researchers concerned. It is then requested that either the number of determinations be reduced or arrangements be made later for research technicians or summer students to help in preparing and analysing extra samples.

Receiving and Preparation of Samples

The scientists are asked to complete a "Request for soil/plant analysis" or "Request for water analysis" (Appendices I and II). Upon receipt of the samples, laboratory numbers are given based on the fiscal year (April 1 to March 31) in which the samples are collected. The abbreviations LNS, LNP, and LNW are used for giving the laboratory numbers to soil, plant, and water samples, respectively. A complete record of the samples is maintained in a ledger showing name of the scientist, number of samples received, date received, description of the samples, and the corresponding laboratory numbers. One person is assigned to receive the samples and complete entries in the ledger.

Soil samples are air-dried in the drying room, ground, by a mechanical grinder in the grinding room, to pass through a 2-mm sieve, and stored in 2-pint ice-cream cartons in the storage room. For such analyses as total nitrogen, organic matter, and alkaline-earth carbonates, etc., the samples are further ground to 100-mesh size. Since several analyses have to be performed on fresh samples, they are either analysed immediately

after receipt or stored in the cold room. Plant samples are air-dried, oven-dried at 70 C, ground by a mechanical grinder, and stored in tightly capped glass jarsuntil they are analysed unless they have to be analysed while fresh. In order that metallic contamination be avoided in the determinations of Fe, Mn, Cu, and Zn, the soil and plant samples are ground with a pestle and mortar. Plant samples are stored at 34 F in the cold room, if necessary. Water samples are generally analysed immediately on arrival. However, when necessary, they are stored in plastic bottles.

Chemical Supplies

Depending upon the number of staff members and the type of analyses to be performed, chemicals and supplies are ordered well in advance. This is essential for completion of the work on schedule. One person is assigned to keep record of the supplies ordered and received.

Keeping a Record of the Analyses Performed

Certain administrative procedures have been developed for expedition of the laboratory work. Observations and results in the laboratory are recorded on the "Work Sheets" given in Appendices III - XXIII. Because only a few water samples have been submitted, no specific work sheets have been prepared for water analysis. A "Progress File" is maintained for each research scientist. All work sheets pertaining to his work are kept in this file. The results are transferred to the "Result Sheets". Details of these sheets are given in Appendices XXIV to XXX. Sheets bearing the results are placed in a file entitled "Analysis Checking

File". The results are checked for errors. The original copies of the result sheets are sent to the scientist concerned and the duplicates are retained by the Laboratory and filed in the "Analysis Completion File".

Techniques Developed for Economy of Operation

Time-saving devices have been incorporated. Some of the flasks and beakers have been numbered permanently in order to save time when they are used repeatedly. Wooden racks, each capable of holding ten samples at a time, are used when shaking soils with reagents in Erlenmeyer flasks. Special racks for filtration have been prepared. These enable the contents of ten flasks to be poured simultaneously into ten funnels because each rack can be manipulated as a single unit. The use of labor-saving devices has resulted in more expeditious handling of the samples without any loss in accuracy of the analyses.

Where possible, a set of beakers and flasks has been allotted for one specific determination. For example, the same volumetric flasks are used repeatedly for the colorimetric determination of phosphorus in soil. Again, for the determination of nitrate nitrogen by the phenoldisulphonic acid method, a set of 50-ml beakers is used exclusively for evaporating the filtrate. This arrangement ensures that the probability of contamination is effectively reduced.

In order that wastage of chemicals may be avoided, reagents such as sodium bicarbonate solution for extracting soil phosphorus are prepared only in quantities that can be used entirely before undesirable changes take place.

Although the usual procedure is to complete a set of samples for one scientist, it is sometimes more convenient to do, in one batch, only a

small number of determinations on a selected set of samples belonging to two or three scientists in order to save time. Moreover, the preparation of several extracts in advance enables a more efficient use of the atomic-absorption spectrophotometer.

For ease of analysis of a large number of samples, new instruments have been introduced (e.g., the atomic-absorption spectrophotometer) since the laboratory was set up. These have helped us attain a higher degree of accuracy, as well as speeded up several determinations.

Accuracy Checking and Training in Techniques and Use of Equipment

A stock of "standard" soil and plant samples is maintained. These are samples on which analyses have already been performed in triplicate. They are used by technicians from time to time to check techniques in use as well as the operation of the equipment. When a new technician or summer student joins the Laboratory, he is given these samples for analysis so that he can practice and gain confidence.

Arrangements are made with instrument suppliers (Fisher Scientific, Canadian Laboratories Supplies, etc.) for demonstration of new instruments to the staff.

Provision of Facilities for Other Sections

Help from technicians or summer students of other sections is solicited when relatively few determinations on a very large number of samples are required. Only then is it worth the time spent to train them and they get a chance to utilize the experience they have gained. If there are only a few (less than 40) samples to be analysed, help from other sections is not advisable. Moreover, it is strongly recommended

that a particular section send the same technician(s) for the analyses to be done for that section.

At all times, an effort is made to ensure that the incoming staff from other sections familiarize themselves with the safety procedures of the Service Laboratory so that accidents may be prevented.

Size of Batch Analysed

Samples are assigned to the technicians according to the priority dates for completion. The technicians analyse them in batches of 18 samples, two of them in duplicate. However, this number can vary if convenient for day's run or week's run etc. as based on past experience.

After the new technicians, summer students, and temporary staff from other sections have been trained in certain types of analyses, they are asked to handle, in the beginning, not more than 9 samples at a time, one of them in duplicate.

Post-Analysis Disposal of Samples

After the results have been sent to the scientists concerned, the soil and plant samples are returned to the "Storage Room" and placed on shelves marked "Work Completed". Sometimes, the scientists decide that the remnants of samples are needed after analysis for other investigations. This is indicated in the space provided on the "Request for soil/plant analysis" form (Appendix I). In such instances, the material remaining from the samples is returned to them. Otherwise, the soil and plant samples are stored until the end of the fiscal year. This is necessary because sometimes certain samples may have to be rechecked or samples with desirable characteristics may be selected for standardizations of some methods. Moreover, some scientists after receiving the results,

may wish to have the samples analysed for other characteristics. At the end of the fiscal year, the samples are discarded.

For water, the samples are returned to the researchers if this has been indicated on the "Request for Water Analysis" form (Appendix II), otherwise, they are discarded without further storage.

Necessary Collaboration

Discussions are held with scientists of other laboratories (Manitoba Soil Survey, Canada Department of Agriculture, Provincial Soil Testing Laboratory, University of Manitoba, Freshwater Institute etc.) for standardizing techniques and making arrangements for the use of equipment. This also involves exchange of visits. For better interpretation of results under field conditions, collaboration is maintained with the research scientists in the conduct of experiments.

Recently, the Pulp and Paper Research Institute of Canada distributed a standard-foliage sample (black spruce) to different laboratories across Canada to compare the results of forest fertilization experiments. The Service Laboratory received the sample and reported the results of analysis along with the techniques used. This collaboration provides a central basis for uniformity and accuracy of measurements for an inter-laboratory comparison.

The Working Group 3 of IUFRO, section 21 (International Union of Forest Research Organizations) is interested in an international comparison of methods for soil and plant analyses. At the moment, work is being limited strictly to leaf and needle analyses for an inventory and comparison of methods. This is being done through the results of analyses, determined by various participants,

of six plant samples. The Service Laboratory is participating in this project. In March, 1970, the following leaf and needle samples were received: Scots pine (rich), Douglas fir, Corsican pine, Scots pine (poor), Poplar, and Japanese larch. Results were sent to them in April. Dr. C. P. van Goor compiled the results available to him until July and published them as a preliminary report in August. Our results compare favorably with those who participated in this project from some 30 institutes. Final report on methods of analyses will be issued by IUFRO during the second half of 1970.

Suggestions for Increasing Output

(i) Laboratories operating by mass production manage to attain a higher output by having one person carry out, continuously, one or two determinations. However, this is not possible in the Service Laboratory owing to the size of staff and the variety of determinations requested. Nevertheless, an addition of three or four technicians would greatly increase the output of the Laboratory. This would be achieved because staff could then become more specialized. A stable, knowledgeable core of staff who can help to train temporary staff must be maintained. Because of the Laboratory's nature of service, a high turn-over of staff would be detrimental to the fulfilment of its purpose.

(ii) The desirability of having own equipment as opposed to borrowing is evident when one considers the scheduling of work by priority.

(iii) Although the existing equipment is sufficient for present needs, several accessories would be required for future requirements. The purchase of an atomic-absorption spectrophotometer has greatly

facilitated the determination of minor elements. An automatic sample-changer would greatly increase the output of the instrument.

(iv) Shortage of space is faced especially during summer months when seasonal help for the Service Laboratory and other sections is obtained. Additional work-bench area would be desirable in order to utilize more efficiently the services of temporary staff.

(v) Generally, there has been little loss of output from the break-down of equipment. However, on a few occasions, repairs have taken an unduly long time to complete owing to the unavailability of service personnel when called.

APPENDICES

SERVICE LABORATORY
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Appendix I

Form MS-1

Request Sheet -1: Request for soil/plant analysis

Research Scientist -

Project -

Please do not write in this space:

Lab No. (LNS/LNP) From _____ To _____
Analyses to be completed by (date) _____
Analyst _____

Have the samples been air-dried? Yes _____ No _____

Samples submitted to the Service Laboratory on (date) _____

Total number of samples submitted _____

Types of analyses required:

Total number of determinations _____

After the analyses are done, do you want the samples to be:

Returned to you _____ Discarded _____

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Appendix II

Form MS - 2

Request Sheet - 2: Request for water analysis

Research Scientists -

Project -

Please do not write in this space:

Lab No. (LNW) From _____ To _____
Analyses to be completed by (date) _____
Analyst _____

Samples submitted to the Service Laboratory on (date) _____

Total number of samples submitted _____

Types of analyses required:

Total number of determinations _____

After the analyses are done, do you want the samples to be:

Returned to you _____ Discarded _____

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Appendix III

Form MS-3

Work Sheet S-1: Qualitative test for carbonates

Name _____ Analysed by _____

Date _____

Lab no.	Sample	Carbonates	Lab no.	Sample	Carbonates

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Appendix IV

Form MS-4

Work Sheet S-2: pH

Name _____ Analysed by _____

Date _____

Lab no.	Sample	Beaker no.	Weight of soil (gm)	Volume of H_2O or 0.01M $CaCl_2$ solution (ml)	pH

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Appendix V

Form MS-5

Work Sheet S-3: Conductivity

Name _____ Analysed by _____

Date _____

Cell constant =
Temperature =

Lab no.	Sample	T.T. no.	Saturation extract or soil to water ratio	Resistance (ohms)	Conductivity (mmhos/cm)		Qualitative			
					at observed temperature	at 25°C	$SO_4^{=}$	Cl^{-}	Ca^{++}	Mg^{++}

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Appendix VI

Form MS-6

Work Sheet S-4: $CaCO_3$ equivalent (acid neutralization method)

Name _____ Analysed by _____

Date _____

Lab no.	Sample	Flask no.	Wt. of soil (gm)	0.25N NaOH used for back titration	meq HCl added	meq NaOH used for titration	meq HCl used to react with carbonates	$CaCO_3$ equiv. (%)

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Appendix VII

Form MS-7

Work Sheet S-5: Calcite and dolomite

Name _____ Analysed by _____

Date _____

BOTTLE No. LAB No. TIN No. SAMPLE WT. (gm)				
Time (min.)	Height of Hg (inches)			
	Used	Unused	Used	Unused
0				
0.5				
1.0				
1.5				
2.0				
3.0				
4.0				
5.0				
8.0				
11.0				
14.0				
24.0				
34.0				
44.0				
Final Reading (H_f)				
Inches of Hg Equivalent to $CaCO_3.MgCO_3$				
Inches of Hg equivalent to $CaCO_3$				
$CaCO_3$ equivalent in the sample (%)				
$CaCO_3.MgCO_3$ in the sample (%)				
$CaCO_3$ in the sample (%)				

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Appendix VIII

Form MS-8

Work Sheet S-6: Hygroscopic moisture and moisture factor (M.F.)

Name _____ Analysed by _____

Date _____

Lab no.	Sample	Crucible no.	Crucible + lid (gm.)	Crucible + lid + ovendry soil (gm.)	Ovendry soil (gm.)	Hygroscopic moisture (%)	M.F.

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Appendix IX

Form MS-9

Work Sheet S-7: Mechanical analysis

Name _____ Analysed by _____

Date _____

Lab no.	Sample	Container no.	Wt. of soil (gm.)	Container + sand (gm.)	Sand (gm.)	Observed hydrometer readings at		Correction at		Calculated Weight	Silt and Clay	Clay	Silt	%			Texture
						0 time, -°F	2 hrs., -°F	0 time	2 hrs.					Sand	Silt	Clay	

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Appendix X

Form MS-10

Work Sheet S-8: Sand fractionation

Name _____ Analysed by _____

Date _____

Lab no.	Sample	(gm.)						%				
		V.C.S.	C.S.	M.S.	F.S.	V.F.S.	Total sand	V.C.S.	C.S.	M.S.	F.S.	V.F.S.

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Appendix XI

Form MS-11

Work Sheet S-9: Organic matter

Name _____ Analysed by _____

Date _____

Standardization blank titration (B) = ml							
Lab no.	Sample	Flask no.	Wt. of soil (gm.)	Sample titration (S) ml.	S/B	1-S/B	O.M. %

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Appendix XII

Form MS-12

Work Sheet S-10: Nitrate nitrogen (colorimetric method)

Name ______________________________ Analysed by ____________________

Date ______________________________

Lab no.	Sample	Flask no.	%T	O.D.	NO_3-N (ppm) in	
					Solution	Soil

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Appendix XIII

Form MS-13

Work Sheet S-11: Easily extractable phosphorus

Name ______________________ Analysed by ______________________

Date ______________________

Lab. no.	Sample	Flask no.	%T	O.D.	P (ppm) in	
					Solution	Soil

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Appendix XIV

Form MS-14

Work Sheet S-12: Exchangeable potassium (flame photometric method)

Name ______________________ Analysed by ______________________

Date ______________________

Lab no.	Sample	Flask no.	Reading	K (ppm) in	
				Solution	Soil

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Appendix XV

Form MS-15

Work Sheet S-13: Exchangeable sodium (flame photometric method)

Name ______________________________ Analysed by ______________________

Date ______________________________

Lab no.	Sample	Flask no.	Reading	Na (ppm) in	
				Solution	Soil

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Appendix XVI

Form MS-16

Work Sheet S-14: Exchangeable calcium and magnesium
(complexometric titration method)

Name _____ Analysed by _____

Date _____

Lab no.	Sample	Ca + Mg			Ca			Mg
		Volume of 0.01 N EDTA (ml)	Sample titration -blank titration (ml)	meq per 100 gm. soil	Volume of 0.01 N EDTA (ml)	Sample titration -blank titration (ml)	meq per 100 gm. soil	meq per 100 gm. soil

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Appendix XVII

Form MS-17

Work Sheet S-15: Exchangeable hydrogen

Name _____ Analysed by _____

Date _____

Lab no.	Sample	Flask no.	0.01N $NaOH/NH_4OH$ used (ml)	Sample titration - blank titration (ml)	Exchangeable hydrogen meq.H/ 100 gm. soil

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Appendix XVIII

Form MS-18

Work Sheet S-16: Cation exchange capacity

Name ______________________ Analysed by ______________________

Date ______________________

Lab no.	Sample	Flask no.	Volume of 0.1 N NaOH of (back titration)	Volume of 0.4N H_2SO_4 (ml.)		CEC meq/ 100 gm. soil
				Neutralized	Used to absorb NH_4	

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Appendix XIX

Form MS-19

Work Sheet S-17: Nitrogen determination by Kjeldahl method

Name _____ Analysed by _____

Date _____

Lab no.	Sample	Flask no.	Sample titration (ml.)	Sample titration minus blank (ml.)	NO_3-N (ppm)	NH_4-N (ppm)	Total N (%)

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Appendix XX

Form MS-20

Work Sheet S-18: Soil moisture tension

Name _____ Analysed by _____

Date _____

Lab no.	Sample	Ring no.	Tin no.	Wt. of tin (gm)	Wt. of tin + moist soil (gm)	Wt. of tin + oven-dry soil (gm)	Moisture (gm)	Oven-dry soil (gm)	Moisture (%) at.....atm.

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Appendix XXI

Form MS-21

Work Sheet P-1: Total nitrogen

Name _____ Analysed by _____

Date _____

Lab no.	Sample	Flask no.	Sample titration (ml.)	Sample titration minus blank (ml.)	Total N (%)

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Appendix XXII

Form MS-22

Work Sheet P-2: Total phosphorus

Name ______________________ Analysed by ______________________

Date ____________________

Lab no.	Sample	Flask no.	%T	O.D.	P(ppm) in		Total P (%)
					Solution	Sample	

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Appendix XXIII

Form MS-23

Work Sheet SPW-1: Determination of K/Na/Ca/Mg/Fe/Mn/Cu/Zn by atomic absorption spectrophotometry

Name _____ Analysed by _____

Date _____

Lab no.	Sample	%A	O.D.	Corrected O.D.	ppm in solution	ppm in sample

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Appendix XXIV

Form MS-24

Result Sheet S-1: Soil analysis

Name _____

Number of samples _____

Date _____

Lab. numbers _____ to _____

Lab no.	Sample	Fine earth (-2 mm) %	pH	Cond. mmhos per cm	Alkaline-earth carbonates %		Mechanical composition				Organic matter %	NO_3-N ppm	NH_4-N ppm	$NaHCO_3$ extr.P ppm	% 1/3 atm moisture	% 15 atm moisture	CEC meq per 100 gm	Total N %
							Particle-size analysis											
					Calcite	Dolomite	Sand %	Silt %	Clay %	Textural class								

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Appendix XXV

Form MS-25

Result Sheet S-2: Sand fractions, silt and clay

Name _____ Number of samples _____

Date _____ Lab numbers _____ to _____

Lab no.	Sample	V.C.S. (%)	C.S. (%)	M.S. (%)	F.S. (%)	V.F.S. (%)	Total sand (%)	Silt (%)	Clay (%)	Textural Class

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Appendix XXVI

Form MS-26

Result Sheet S-3: Cation exchange capacity and individual cations (meq/100 gm)

Name _____ No. of samples _____

Date _____ Lab numbers _____ to _____

Lab no.	Sample	(NH_4) Dist.	Ca	Mg	K	Na	H	CEC calculated

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Appendix XXVII

Form MS-27

Result Sheet S-4: Soluble salts

Name _____ No. of samples _____

Date _____ Lab numbers _____ to _____

Lab no.	Sample	(meq/100 gm)					
		Ca	Mg	Na	K	SO_4	Cl

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Appendix XXVIII

Form MS-28

Result Sheet S-5: Fusion analysis

Name _____ No. of samples _____

Date _____ Lab numbers _____ to _____

%													
Lab no.	Sample	Ca	Mg	K	Na	Si	Fe	Al	Ti	Mn	S	P	Total oxides

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Appendix XXIX

Form MS-29

Result Sheet P-1: Plant analysis

Name _____ No of Samples _____

Date _____ Lab numbers _____ to _____

		%						ppm	
Lab no.	Sample	N	P	K	Ca	Mg	Na	Fe	Mn

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CANADA DEPARTMENT OF
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Appendix XXX

Form MS-30

Result Sheet W-1: Water analysis

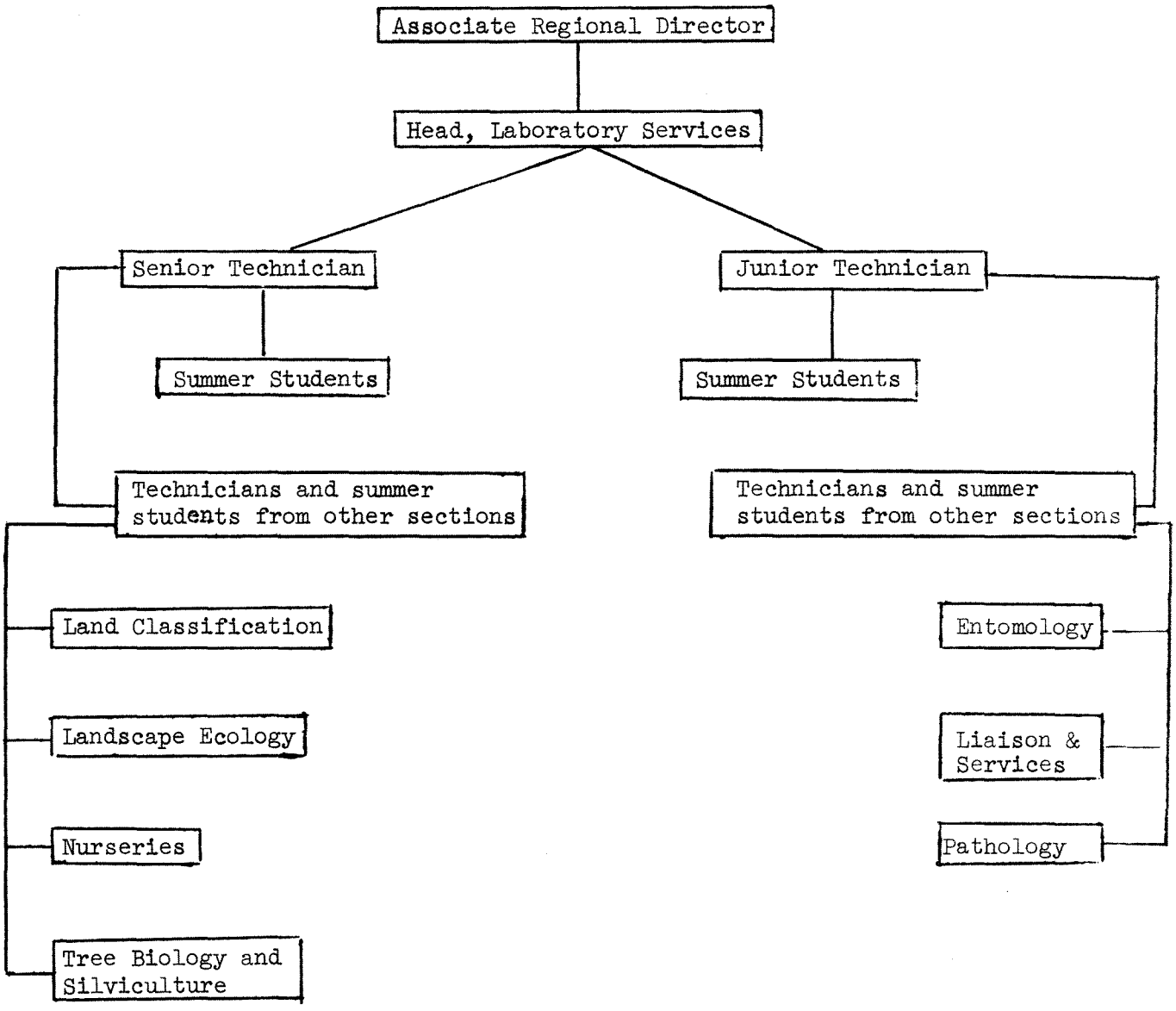
Name _____ No. of samples _____

Date _____ Lab numbers _____ to _____

Characteristics	LNW Sample:	LNW Sample:	LNW Sample:	LNW Sample:
Color				
Turbidity				
Odor:				
1. Qualitative				
2. Odor value				
pH				
Conductivity (mmhos/cm)				
Solids (ppm):				
1. Suspended				
2. Dissolved				
3. Total				
Ca				
Mg				
Na				
K (meq./litre)				
CO_3				
HCO_3				
SO_4				
Cl				
F				
NO_3				
NH_4-N (ppm)				
Soluble organic N (ug/litre)				
P (ppm)				
Fe (ppm)				
Mn (ppm)				
B (ppm)				
SiO_2 (ppm)				
SAR				
SSP				
Total Hardness as $CaCO_3$ (ppm)				

Appendix XXXI

Chart Showing Organization of the Service Laboratory



Appendix XXXII

Personnel

A. Staff of Service Laboratory

Year	Permanent	Summer student for a period of four months
1967 to 68	2	0
68 to 69	3	1
69 to 70	2.5	1

B. Staff from other laboratories who worked in Service Laboratory to help prepare samples and do analytical work (equivalent to one person, in weeks).

Section	Sept. 1967 to March 1968		April 1968 to March 1969		April 1969 to May 1970	
	Technician	Summer student	Technician	Summer student	Technician	Summer student
Entomology	-	-	1.8	-	-	-
Land Classification	-	-	-	-	33	-
Landscape Ecology	-	-	52	16	52	32
Liaison and Services	4	-	-	-	-	-
Pathology	-	-	1	-	-	-
Tree Biology and Silviculture	7	-	8.4	-	-	5.5
TOTAL	11	-	63.2	16	85	37.5

Appendix XXXIII

Details of samples and analyses (1967 to 1968)

Section	Number of samples* (submitted during Sept. 1967 to March 1968)			Number of determinations (analysed during Sept. 1967 to July 1968)		
	Soil	Plant	Water	Soil	Plant	Water
Entomology	-	-	-	-	-	-
Land Classification	48	-	-	780	-	-
Landscape Ecology	-	-	-	-	-	-
Liaison and Services	21	3	-	147	9	-
Nurseries	-	-	-	-	-	-
Pathology	19	8	-	180	8	-
Service Lab	23	4	-	198	12	-
Tree Biology and Silviculture	255	-	-	2255	-	-
TOTAL	366	15	-	3560	29	-

* This list includes 70 soil and 15 plant samples collected in the fiscal year 1967 to 1968 and 296 backlog soil samples from 1964 to 1967.

Appendix XXXIV

Details of samples and analyses (1968 to 1969)

Section	Number of samples* (submitted during April 1968 to March 1969)			Number of determinations (analysed during Aug. 1968 to Sept. 1969)		
	Soil	Plant	Water	Soil	Plant	Water
Entomology	136	-	-	376	-	-
Land Classification	151	35	5	1416	219	30
Landscape Ecology	540	402	-	1458	2412	-
Liaison and Services	24	16	-	66	48	-
Nurseries	48	-	-	500	-	-
Pathology	99	29	3	561	127	18
Service Lab*	17	1	10	225	12	38
Tree Biology and Silviculture	237	98	-	1041	714	-
TOTAL	1252	581	18	5643	3532	86

* In addition, 25 soil and 29 plant samples were collected on which 375 analyses were carried out for standardizing procedures and developing new procedures. Some analyses were carried out by new technicians and summer students on samples already analysed in order to familiarize them with the techniques.

Appendix XXXV

Details of samples and analyses (1969 to 1970)

Section	Number of samples* (submitted during April 1969 to March 1970)			Number of determinations (analysed during Oct. 1969 to May 1970)		
	Soil	Plant	Water	Soil	Plant	Water
Entomology	-	-	-	-	-	-
Land Classification	854	22	3	2553	176	20
Landscape Ecology	130	750	-	809	1956	-
Liaison and Services	30	30	-	109	132	-
Nurseries	3	-	-	9	-	-
Pathology	36	12	-	365	144	-
Service Lab*	8	35	10	192	151	23
Tree Biology & Silviculture	360	9	-	96	72	-
TOTAL	1421	858	13	4133	2631	43

* In addition, 53 soil, 35 plant, and 13 water samples were collected on which 879 analyses were carried out for standardizing procedures and developing new procedures. Some analyses were also carried out by new technicians and summer students on samples already analysed in order to familiarize them with new techniques.

Appendix XXXVI

Samples received and analysed during the last three years (1967 to 1970)

Section	Number of samples submitted in fiscal year				Number of determinations completed on samples submitted			
	1967 to 1968	1968 to 1969	1969 to 1970	Total	Sept. 1967 to July 1968	Aug. 1968 to Sept. 1969	Oct. 1969 to May 1970	Total
Entomology	-	136	-	136	-	376	-	376
Land Classification	48	191	879	1,118	780	1,665	2,749	5,194
Landscape Ecology	-	942	880	1,822	-	3,870	2,765	6,635
Liaison and Services	24	40	60	124	156	114	241	511
Nurseries	-	48	3	51	-	500	9	509
Pathology	27	131	48	206	188	706	509	1,403
Service Laboratory	27	28	53	108	210	275	366	851
Tree Biology and Silviculture	255	335	369	959	2,255	1,755	168	4,178
TOTAL	381	1,851	2,292	4,524	3,589	9,261	6,807	19,657

Appendix XXXVII

Types of analyses performed on soil samples (1967 to 1970)

Determinations	Number of determinations completed			
	Sept. 1967 to July 1968	Aug. 1968 to Sept. 1969	Oct. 1969 to May 1970	Total
pH	326	474	246	1,046
Conductivity	219	239	132	590
Soluble sulfates	5	-	-	5
Soluble chlorides	5	-	-	5
Particle-size analysis	167	352	197	716
Calcite and dolomite	18	229	201	448
Organic matter	197	295	219	711
NO_3-N	233	281	561	1,075
NH_4-N	84	227	189	500
Total-N	82	254	447	783
$NaHCO_3$-P	276	384	188	848
Exch. calcium	219	361	208	788
Exch. magnesium	219	361	238	818
Exch. potassium	259	410	250	919
Exch. sodium	219	315	215	749
Exch. hydrogen	96	287	127	510
Cation exchange capacity	138	160	43	341
Total exchangeable bases	69	74	38	181
Permanent wilting point	45	81	11	137
Field capacity	49	81	11	141
1/10 bar moisture	50	-	-	50
Extractable-Fe	92	111	116	319
Extractable-Zn	-	-	32	32
HNO_3 extractable P	80	97	-	177
K	80	97	-	177
Ca	80	97	-	177
Mg	80	97	-	177
Pyrophosphate soluble material	-	-	14	14
$CaCO_3$ equivalent	113	6	-	119
Extractable -Mn	50	90	104	244
Bulk density	-	183	-	183
Extractable -Cu	-	-	30	30
Unrubbed fibre	-	-	17	17
Ash	10	-	14	24
Miscellaneous	-	-	305	305
TOTAL	3,560	5,643	4,153	13,356

Appendix XXXVIII

Types of analyses performed on plant samples (1967 to 1970)

Determinations	Number of determinations completed			
	Sept. 1967 to July 1968	Aug. 1968 to Sept. 1969	Oct. 1969 to May 1970	Total
N	15	571	87	673
P	7	571	94	672
K	7	571	75	653
Ca	-	555	66	621
Mg	-	555	81	636
Na	-	97	427	524
Fe	-	106	498	604
Mn	-	73	498	571
Cu	-	20	85	105
Zn	-	11	85	96
Miscellaneous	-	402	635	1,037
TOTAL	29	3,532	2,631	6,192

Appendix XXXIX

Types of analyses performed on water samples (1967 to 1970)

Determinations	Number of determinations completed			
	Sept. 1967 to July 1968	Aug. 1968 to Sept. 1969	Oct. 1969 to May 1970	Total
pH	-	7	7	14
Conductivity	-	2	1	3
Fe	-	9	1	10
Mn	-	2	-	2
Na	-	5	1	6
Ca	-	5	-	5
Mg	-	5	-	5
Alkalinity	-	13	3	16
Chlorides	-	2	7	9
PO_4	-	7	-	7
NO_3	-	5	2	7
K	-	3	-	3
SO_4	-	7	-	7
HCO_3	-	3	-	3
Turbidity	-	8	-	8
Color	-	3	1	4
TOTAL	-	86	23	109

Appendix XL

Equipment in the Laboratory

1. Muffle Furnace (Gallenkamp)
2. Atomic Absorption Spectrophotometer (Perkin-Elmer 303)
3. Colorimeter Bausch and Lomb (Spectronic 20)
4. Spectrophotometer (Beckman DU)
5. 15 Bar Ceramic Plate Extractor (Soil Moisture Equipment Co.)
6. Heavy-Duty Lindberg Hot Plates
7. Spex Mixer Mill (Spex Industries)
8. Mechanical Grinder for plant samples
9. Centrifuge (International Equipment Co.)
10. Suction Pump (Cenco)
11. Sieving Machine (American Instrument Corporation)
12. Water Bath (Lab Line Instrument Incorporation)
13. Soil Grinder (Ruhuka)
14. Balances - 1. P 1200 Mettler
    2. P 120 Mettler
    3. Sartorius
    4. Trip Balance (OHAUS)
15. Shakers (Eberbach) - variable speed
16. Milk Shake Mixer
17. Conductivity Bridge (Industrial Instruments)
18. pH Radiometer (Bach Simpson)
19. Automatic Titrator (Bach Simpson)
20. Macro Kjeldahl Digestion and Distillation units (Labconco.)
21. Glassware Cart (Labconco)
22. Kjeldahl Flask Cart (Labconco)
23. Ovens (Precision Scientific)
24. Wrist Action Shaker (Burrell)
25. General Purpose Illuminator
26. Barnstead Hose Type Cartridge Demineralizer

Glassware

Beakers, flasks, burettes, pipettes, separatory funnels, glass rods, glass tubes, medicine droppers, etc. (normally used in analytical laboratories).

Miscellaneous

1. Spade, trowel, sampling auger and tube for sampling
2. Spoons, spatulas, filter paper
3. Wooden racks, shakers, filteration racks
4. Burners
5. Plastic bottles for water samples
6. Airtight plastic containers for plant analyses
7. Ice-cream cartons for storing soil samples
8. Polyethylene bags for sample collection
9. Spot plates (white porcelain and clear glass)
10. Vials
11. Silica and porcelain crucibles