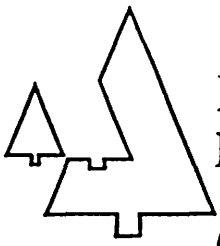
Evaluation of the Research and Development Projects Funded Under the Canada-Ontario Forest Management Subsidiary Agreement

September, 1985

Phase II of an evaluation for the Management Committee of the Canada-Ontario Forest Resource Development Agreement

Guy Smith

Forest Resource Development Agreement
Entente sur la mise en valeur de la ressource forestière
Canada
Ontario



Forest Resource Development Agreement
Entente sur la mise en valeur de la ressource forestière

Canada Ontario

September 13, 1985

Messrs. K.A. Armson and J.H. Cayford
Co-chairmen, Management Committee
Canada-Ontario Forest Resource
Development Agreement (COFRDA)

Dear Sirs:

Herewith is the final phase of my evaluation for your committee. This phase evaluates the 23 research and development projects which were conducted under the Canada-Ontario Forest Management Subsidiary Agreement.

Sincerely,

Guy Smith

Acknowledgements

Many people directly and indirectly contributed to this evaluation. I am very grateful to the many researchers and field staff who gave so much of their time and energy to providing me with the information and knowledge necessary to produce this report. I am also grateful to Ken Higgs, Bob Haig and Martin Walmsley for reviewing the report and providing valuable suggestions, and to Lillian Goodspeed for her assistance with typing.

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Tables and Figures

INTRODUCTION

This is an evaluation of the research and development projects funded under the Canada-Ontario Forest Management Subsidiary Agreement, COFMSA. The Agreement, in effect from 1978 to 1984, funded a variety of forest management activities, as indicated in figure 1. Under COFMSA's "Assessment Program" $4,336,286, or 5% of the Agreement's funds, were spent on the research and development projects evaluated in this report.

The 23 research and development projects were classified under COFMSA's "Assessment Program" as:

> Applied pilot research designed to establish field capability and to identify and rectify operational problems involving forest management techniques and equipment (Department of Regional Economic Expansion, 1982).

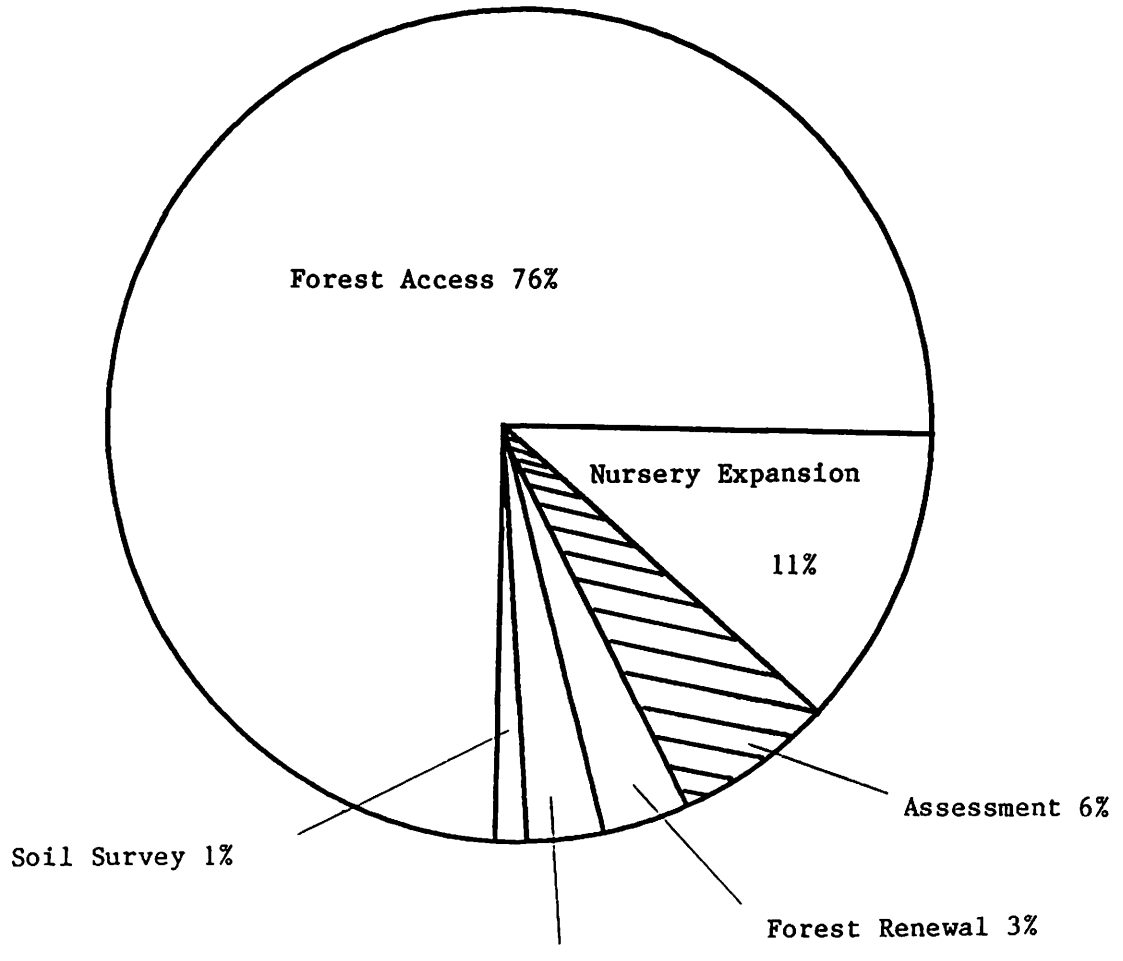
The report does not examine each of the 23 research and development projects in detail. Instead, the projects are compared and contrasted, recommendations made, and certain projects discussed as examples of key points.

The evaluation was conducted for the Management Committee of the Canada-Ontario Forest Resource Development Agreement, COFRDA. This Federal-Provincial Agreement, the successor to COFMSA, is worth $150 million, and is in effect until 1989. The evaluation is intended to assist the Management Committee in managing and evaluating research

and development projects under this latest Federal-Provincial Forestry Agreement. Other government programs may also benefit from the evaluation, hence recommendations are addressed to forestry research programs in general.

Figure 1

Allocation of Funds to COFMSA Programs



METHOD OF EVALUATION

The evaluation of COFMSA research and development projects was conducted during July and August, 1985. Preliminary investigations consisted of compiling and studying project documentation and reports. Subsequent investigation involved discussions with over 40 people, (listed in Appendix A), including project leaders, scientists, and people responsible for administering and evaluating research programs. Many discussions were held during field tours at locations across Ontario. Notes from these discussions were recorded on a standard interview sheet, (Appendix B). The evaluation focuses on issues arising from the discussions and the study of project documentation and reports. The recommendations in the report are intended to both affirm the value of certain current approaches to research and development and to pose some new ideas for research and development programs.

I. RESEARCH AND DEVELOPMENT: THE COFMSA PROJECTS

Research is a systematic investigation carried out by means of experiments, surveys or analyses, often requiring ingenuity in its methods. The general aim of research is to gain new knowledge and hence the outcome of research is uncertain until the research is complete. Under government programs, research is usually directed towards a specific aim and objective (Ministry of Natural Resources, 1983).

Development is systematic work drawing on existing knowledge gained from research and from practical experience. Development produces new technologies and techniques suited for operational use. Development uses experimentation to identify problems and improve technology and techniques (Ministry of Natural Resources 1983).

It is difficult to make a definitive classification of the 23 COFMSA projects. Some projects involved elements of both research and development. The classification of projects in tables 1 and 2 is a means of organizing the projects for analysis and discussion. The classification is based on dominant characteristics of each project.

Table 1

COFMSA Research Projects
and Agencies Responsible for Conducting them

Project Name	Agency Which Conducted Project
Aerial Seeding of Black Spruce	Canadian Forestry Service, Great Lakes Forest Research Centre, Sault Ste. Marie
Prescribed Fire Research	"
Mounding Experiment	"
Silvicultural Prescriptions for Containerized Planting Stock	"
Jack Pine Breeding	Ministry of Natural Resources, Ontario Forest Research Centre, Maple (now the Ontario Tree Improvement and Forest Biomass Institute)
Spruce Isozyme Study	"
Container Planting, Bud Development and Overwintering Damage	Ministry of Natural Resources Ontario Forest Research Centre, and Swastika Nursery
Forest Stand Structure and Dynamics	University of Toronto, Botany Department
Poplar and Willow Selection and Breeding	"
Tamarack Selection and Larch Breeding	"
Soil Nutrient Regime and Forest Growth	University of Toronto, Faculty of Forestry
White Pine Breeding	"
Nursery Stock Quality in Relation to Outplanting Performance	Lakehead University , Thunder Bay, School of Forestry
Forest Stand Growth and Yield Forecasting	"
Conditioning Containerized Seedlings for Summer Planting	University of Waterloo, Department of Biology

Table 2

COFMSA Development Projects
and Agencies Responsible for Conducting Them

Name of Project	Agency Which Conducted Project
Field Regeneration Assessments	Ministry of Natural Resources, Northern Region
Container Handling	"
Tree Improvement Through Vegetative Propagation	Ministry of Natural Resources, Northern Region, Orono and Swastika Nurseries
Purchase of Fluid Drilling Equipment and Dewa Block Machine	Ministry of Natural Resources
Accelerated Transplant Products	Ministry of Natural Resources, Provincial Nurseries Canadian Forestry Service, Great Lakes Forest Research Centre (advisory role)
Timberland Planting Machine	Ministry of Natural Resources Northeastern Region
Black Spruce Cone Harvester	Ministry of Natural Resources
Mechanical Development Assessment Crew	"

II. PROJECT OUTPUTS

Direct outputs of the COFMSA research and development projects include new findings presented in published and unpublished reports, new facilities and equipment, and employment and training of individuals.

1) Reports Written

Scientific reports describe the methods, results and conclusions of research projects and are sources of data and information for future reference and application. It is essential that all research and development projects produce a report, regardless of the project's findings. The report exhibits the scientific quality of the project. Quality of reports, not quantity, should be the measure of a project's success.

Published reports have been subjected to varying degrees of scientific review, depending upon the publication. Publication of reports is thus an indication of quality. Some unpublished reports have received little scientific review while others, especially student theses, receive rigorous review. The number of projects producing published and unpublished reports are given in table 3.

Table 3

Number of Projects Which Produced Published and Unpublished Reports

	Published	Unpublished
Research Projects	8	6
Development Projects	2	5
Total	10	11

(1 project produced no report)

It is noteworthy that university projects produced many unpublished reports. These are given in table 4.

Table 4

Unpublished Reports of University Research Projects

Project	Unpublished Reports
Forest Stand Structure and Dynamics	3 Master's Theses 1 Master's Thesis and 1 Ph.d. Thesis in progress 1 Synopsis of results from the above graduate studies
Soil Nutrient Regime and Forest Growth	3 annual progress reports 1 Ph.d. Thesis 1 Post-Doctoral Study
Nursery Stock Quality in Relation to Outplanting Performance	3 Annual progress reports 1 Final report expected in 1986
Poplar and Willow Selection and Breeding	5 unpublished reports 4 progress reports
Tamarack Selection, Larch Breeding	3 progress reports 1 report of summary and recommendations
Conditioning Containerized Seedlings for Summer Planting	2 Master's Theses

2) Facilities and Equipment

Table 5 indicates that all development projects produced some type of facility or equipment with COFMSA funds. Research projects were less productive in this respect. This is because most of the research projects made use of existing facilities and equipment purchased with funds outside of COFMSA.

Table 5

Facilities and Equipment Provided Through COFMSA
Research and Development Projects

Research Projects

Name of Project	Facilities and Equipment
Jack Pine Breeding	Electrophoresis laboratory
Silvicultural Prescriptions for Containerized Planting Stock	1 Greenhouse
Development Projects	
Field Regeneration Assessments	Computer Software
Container Handling	Prototype equipment for handling and transporting containerized seedlings
Tree Improvement Through Vegetative Propagation	3 greenhouses 1 header house
Purchase of Fluid Drilling Equipment and Dewa Block Machine	1 Fluid Drilling pregermination device and 1 Dewa block machine
Timberland Planting Machine	Modified hydraulic and electrical systems for Timberland planting machines
Black Spruce Cone Harvester	Cone harvesting machine
Mechanical Development Assessment Crew	Leno scarifier and ground herbicide sprayer

All of the projects in table 5 were conducted by the Canadian Forestry Service or the Ministry of Natural Resources. COFMSA provided no new equipment or facilities for universities.

3) Employment and Training

Table 6 gives the number of employment positions created with COFMSA funds for individuals and for firms. Full time contracts were awarded for positions ranging from research scientists and assistants to forestry specialists and technicians. Seasonal contracts were for summer field and laboratory assistants, usually students. Contracting firms were hired to make field assessments for applied research projects. Developmental research required contracting firms to make field assessments and to develop and test equipment.

Table 6

Number of Employment Positions Created With COFMSA Funds

Position	Research Projects	Development Projects
Contracts (full time)	7	4
Contracts (seasonal)	15	4
Contracting Firms	2	4
Total	24	12

It is important to note that numerous individuals who were not hired under COFMSA nonetheless received substantial experience and training through COFMSA projects. Regular and part-time staff hired by the Ministry of Natural Resources, the Canadian Forestry Service, or

by universities, were often directly involved with the work of COFMSA projects.

Research projects provided the most training and experience of individuals. The projects conducted by the Canadian Forestry Service are continuing to provide work for research scientists, technicians, and summer students.

The research projects conducted by universities provided funding for studies by professors and graduate students, and summer employment for undergraduates. At least 8 graduate theses have been produced from COFMSA research projects.

4) Other Outputs

Aside from the outputs already discussed, all projects produced other less obvious, yet nonetheless important outputs. Most projects established field plots for data collection. Some of these plots are particularly important as they were carefully selected on significant sites with well-documented forest management histories. Most projects gathered a large amount of field data. Some projects collected samples such as stem sections for stem analysis and seeds and cuttings for tree breeding. Several projects resulted in new techniques and all projects increased overall knowledge in their respective areas of forest management.

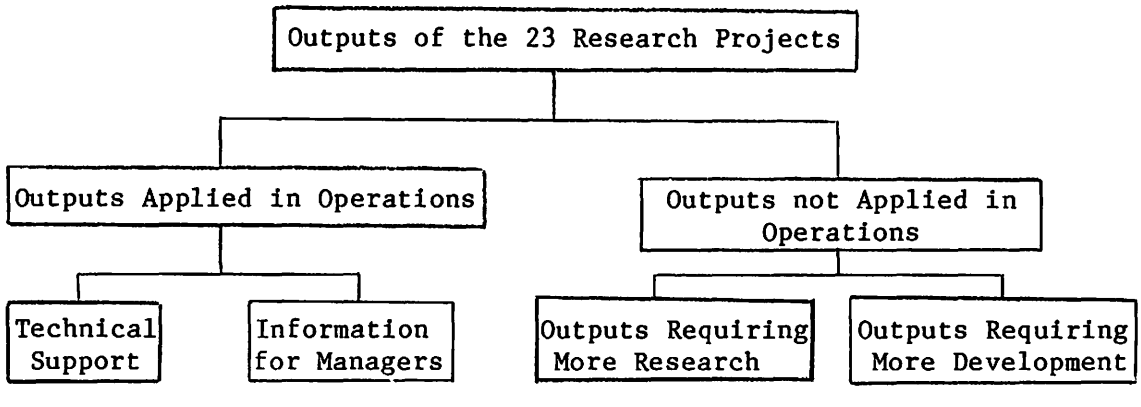
III. APPLICATION OF PROJECT OUTPUTS

An operation is a process, method, or series of actions, especially of a practical or mechanical nature (Collins' Dictionary). It involves regular, ongoing work which is necessary to meet established goals and objectives. Site preparation, stock production, planting, and forest inventory are just some of the many operations necessary to meet forest management objectives.

Figure 2 gives the various states of operational applications for the outputs of the 23 research projects.

Figure 2

States of Application of Project Outputs



1) Outputs Applied in Operations

Of the 23 projects, 12 produced outputs which are in use operationally. These uses fall into two main groups: technical support, which includes techniques, facilities and equipment, and information, which is useful to managers. These applications are summarized in Table 7.

Table 7

Operations Using Project Outputs

Research Projects

Project	Operational Use
Mounding Experiment	Scarification Operations: provided information on the effectiveness of the Bracke mounding equipment
Container Planting, Bud Development and Over-wintering Damage	Greenhouse Operations: provided techniques of extended greenhouse culture and frost hardiness testing to reduce the over-wintering losses in containerized seedling production. These techniques are in use at all of Ontario's containerized seedling greenhouses
Silvicultural Prescriptions for Containerized Planting Stock	Site Preparation and Tending Operations: Conducted trials to register Velpar herbicide for ground application, and Roundup herbicide for aerial application Planting Operations: Provided results of experiments on outplanting performance of various stock types on various site conditions
Poplar and Willow Selection and Breeding Tamarack Selection and Larch Breeding	Tree Improvement Operations: collected material for tree breeding (cuttings and seed). Provided information about the genetic variability of species which is useful in the selection process of tree improvement programs

Table 7 (Cont.)

Development Projects

Project	Operational Use
Container Handling	Tree Planting Operations: Developed equipment which is used for handling and transporting containerized seedlings in the Northern Region
Tree Improvement Through Vegetative Propagation	Tree Improvement Operations: provided 1 greenhouse at Swastika Nursery and 2 greenhouses at Orono Nursery for producing rooted cuttings for the Northern Region's tree improvement program. Also improved the technique of rooting cuttings and contributed to progeny testing and seed orchard establishment in the Northern Region
Purchase of Fluid Drilling Equipment and Dewa Block Machine	Nursery Operations: Trials indicated that the equipment was not suitable for accelerated transplant operations
Accelerated Transplant Products	Nursery Operations: Trials indicated improved techniques for accelerated transplant products, now used at several Ontario tree nurseries
Timberland Planting Machine	Planting Operations: trial indicated that the equipment was not suitable for planting operations
Black Spruce Cone Harvester	Seed Collection Operations: mechanical system for collecting black spruce seed. Used by MNR nurseries in the Northern and Northwest Regions
Mechanical Development Assessment Crew	Site Preparation and Tending Operations: acquired and tested the Leno scarifier and a ground herbicide sprayer. Equipment proven effective and now used operationally.

The projects in table 7 have three common characteristics which contributed to the successful application of project results.

(i) **The Projects Had an Obvious Operational Application**

In all cases, the projects in table 7 undertook work which was pertinent to an operational activity. Thus a user was identified for the particular innovation the project would produce. Timely delivery of research findings matched to the user's need is a key element of successful application (Marx, Moeller 1983).

In some cases, the project found a solution to an operational problem. An example of such a project is "Container Handling", which met the urgent need for a mechanized system of transporting and handling containerized seedlings in the Northern Region. When several Forest Management Agreements were signed in the Region, the demand for containerized planting stock rose from 4 million to 34 million seedlings annually. Good organization was necessary to coordinate the shipment of seedlings from 10 nurseries to 200 planting sites. Under the COFMSA Project, an engineering firm was hired to study the problem with input from regional forestry staff. A prototype piece of equipment was designed and proved to be effective. Further operational units were built with Ministry of Natural Resources' funds. The mechanized handling system is now used for tree planting operations in the Northern Region.

In other cases, projects made evaluations of management options. Most development projects fit this description. For example, in the late 1970's, nurserymen were interested in testing the operational effectiveness of pregermination equipment. The technique of pregermination, which separates germinated seed from ungerminated seed in a sucrose and water solution, has been used

operationally in vegetable production for some time. Under the project, a pregermination unit was purchased from Fluid Drilling Limited of England, and numerous operational trials were conducted with seed from black spruce, white spruce and jack pine. The trials indicated that the Fluid Drilling equipment was impractical for operational tree nursery work. Nonetheless, the project provided an answer for nurserymen, helping them decide among various management options.

Other projects provided techniques and expertise necessary to increase the size of operations. "Tree Improvement through Vegetative Propagation" was such a project. Under the project, two greenhouses were built at Orono Nursery and one at Swastika Nursery for rooting of cuttings. Large quantities of rooted cuttings were necessary for progeny tests in the Northern Region's Tree Improvement Program. Before the project, trials had been conducted in one greenhouse at Orono Nursery. The new greenhouse facilities funded by COFMSA permitted development of vegetative propagation techniques as well as large scale production of rooted cuttings. The project also paid the salary of a specialist in the Northern Region to coordinate the tree improvement work. Thus, COFMSA enabled substantial growth of tree improvement efforts in the Northern Region.

(ii) The Projects were Conducted in Close Association with Forestry Operations

The successfully applied projects were attuned to the needs of forestry operations and in many cases they were directly associated with the operations. A prime example is "Container Planting, Bud

Development and Overwintering Damage." Most of the research work for this project was conducted at Swastika Nursery near Kirkland Lake. Both the researcher and the nurserymen were interested in solving the problem of excessive overwintering losses in containerized planting stock. Effective communication and working ties were established between the research project and the nursery operation. The researcher was thereby clearly aware of the nurseryman's problem which the project was aiming to solve. This ensured that the output from the project was what the user really needed.

(iii) The Project Outputs were Introduced to the Operations in a Useable Form

If the project aims at solving a specific operational problem and works closely with the user it is serving, then the project will likely produce an output readily useable in the operation. All of the outputs from the projects in table 8 were directly used in operations, with no adaptive phase of development required.

2) Outputs Not Applied in Operations

There were 12 out of 23 projects which produced outputs that are not in use operationally. The outputs of these projects either require further research work or else they require an adaptive phase of development before they can be used in operations.

(i) Outputs Requiring Further Research

The projects requiring further research work are given in table 8. These projects represent preliminary phases to long term forestry research undertakings.

Table 8

Projects Requiring Further Research Work

Government Projects	University Projects
Aerial Seeding of Black Spruce	White Pine Breeding
Nursery Stock Quality in Relation to Outplanting Performance	Conditioning Containerized Seedlings for Summer Planting
Jack Pine Breeding	Forest Stand Growth and Yield Forecasting
Spruce Isozyme Study	

As with many forestry research projects, more than 5 years are required to yield reliable results. COFMSA initiated the research work in table 8, but the results of this work require more study before useable outputs are generated.

Two of the projects are still in progress. "Aerial Seeding of Black Spruce" is investigating the problem of successfully regenerating Black Spruce by direct seeding methods. It is a comprehensive project dealing with a slow growing species. Another four years of study are required before reliable final results are obtained. The project has received funding until 1989 under the Canada-Ontario Forest Resource Development Agreement.

"Nursery Stock Quality in Relation to Outplanting Performance" is also in progress. The project is working closely with operations at Thunder Bay Nursery. Final results are expected in 1986. The project studied the outplanting performance of seedlings produced by various nursery treatments. Nurserymen are interested in having more studies in this area to better understand the effectiveness of various nursery practices.

The other 6 projects are complete and produced results which will be beneficial in further research projects. The results include both scientific findings and laboratory equipment and procedures.

(ii) Outputs Requiring Further Development

Some project outputs are not immediately useful in operations. A period of adaptation is often necessary before project outputs match user's needs.

Two projects provided information to improve the "Forest Ecosystem Classification" (FEC), system for the Claybelt Region. "Forest Stand Structure and Dynamics" provided information on the ecology of forest stands from the post-logging disturbance stage to the mature stage. "Soil Nutrient Regime and Forest Growth" undertook an analysis of soil nutrients in the Claybelt Region. Both of these COFMSA projects provided valuable scientific results. These results require further development before they can be used operationally in the FEC system.

"Black Spruce Regeneration Assessments" provided an innovative system of recording field survey data in the Northern Region. Under the project, new techniques for making regeneration surveys were devised, and an interactive computer program was developed for inputting data from surveys. The computer program is compatible with the data processing system of the Ministry of Natural Resources Head Office in Toronto. Data may be entered at the local level onto computer diskettes and forwarded to Head Office for processing. Additional local data may also be stored on the computer. This

project was very innovative and the results have yet to be adopted by the Ministry of Natural Resources' operations. Regeneration assessment methods in the Northern Region must be modified to make use of this new system.

IV. TECHNOLOGY TRANSFER

Technology transfer is the means by which science and technology are diffused throughout human activity. Technology transfer is complete when the science or technology is incorporated in an operation (Walmsley 1982). During technology transfer, information flows between researchers and operations managers. The more effectively and accurately this information exchange occurs, the more successful will be the practical application of research findings.

This report has discussed the importance of bringing together the developers of new knowledge with those who need the new knowledge, and encouraging them to cooperate in solving problems. This type of working relationship is ideal, but not always possible.

1) Scientific and Professional Meetings

Scientific and Professional Meetings are important means of facilitating technology transfer. Besides providing presentation of research findings, these meetings open research projects to numerous individuals and encourage discussion and interaction.

The value of interpersonal contact was evident when the results of COFMSA's "Mounding experiment" were presented at the 1983 Jack Pine Symposium of the Canada-Ontario Joint Forest Research Advisory Committee (COJFRAC). The mounding scarification experiment was

conducted by the Canadian Forestry Service in cooperation with KBM Forestry Consultants. At the COJFRAC Symposium, the Management Forester for the Algoma Central Railway's Private forest lands learned about the mounding experiment. He is now cooperating with the Canadian Forestry Service to conduct trials of the mounding scarification method on the Railway's forest management areas.

Scientific meetings played an important role in technology transfer for the COFMSA research projects. Table 9 indicates that 10 projects presented findings at scientific meetings.

Table 9

Number of COFMSA Projects Which Presented Findings at Scientific Meetings

Meetings	Government Projects	University Projects
1) COJFRAC Symposiums:		
Jack Pine Symposium, 1983	1	-
Canadian Containerized Tree Seedling Symposium, 1981	1	1
Forest Fire Management Symposium, 1984	1	-
Forest Ecosystem Classification Symposium, 1985		1
2) OMNR Nurseryman's Meetings	2	-
3) Other Meetings (Non-Non-Government Sponsored)	3	-
TOTAL	8	2

Table 9 shows that only two university projects presented findings at meetings. Government projects tended to be featured at government sponsored meetings.

Three COFMSA research and development projects presented findings at non-government meetings sponsored by scientific societies and associations. No COFMSA research and development projects presented findings to meetings of the forest industry or the forestry profession. It is desirable for government projects to present findings at private-sector meetings. Such public-private sector interaction would help to dispell accusations that the government's projects only speak to the government itself.

2) Publications

Publications are another agent of technology transfer. Published reports are important because they provide detailed information and documentation of experimental work to a large number of people. Published reports are not in themselves technology transfer. The information presented in publications must be read and then used in an operation before technology transfer has occurred.

There are several types of publications available for reporting results of research projects:

i) Refereed Scientific Journals

Articles for these publications are selected through rigorous critical review by scientific authorities, thus assuring the scientific worth of the research work. Researchers and academics comprise the major audience for this type of publication.

ii) Information Reports

These reports are published by government agencies without a rigorous scientific review process. These reports summarize findings of research projects and draw conclusions aimed at practical applications. The audience for these reports include both scientists and operations managers.

iii) Research Notes

Published by government agencies, these are brief reports which outline the method, results and conclusions of experiments in a research project. These reports provide useful information for other research projects and for refining operational techniques.

iv) Newsletters and Bulletins

These publications are important because they have a wide audience of researchers, operations managers and people not directly associated with research and operations. Newsletters and bulletins are published by government agencies to briefly outline what research work is taking place.

The number of COFMSA projects which published reports in these various media is given in Table 10.

Table 10

Number of COFMSA Projects That Produced Published Reports

Type of Publication	Government Projects	University Projects
Refereed Scientific Journal	2	1 (4)*
Information Reports	4	0
Research Notes	3	0
Newsletters & Bulletins	1	0
TOTAL	10	1 (4)

* Number of reports expected in the near future is given within brackets.

Most published reports of the COFMSA research and development projects appeared in non-refereed government publications. The results of most of these projects were suitable for publication in scientific peer-reviewed journals. All research projects should be required to submit at least one report of findings to a peer-reviewed journal.

Government research projects have the benefit of a government system for publication and distribution of reports. The only published reports from university projects were in scientific journals. All university projects produced unpublished reports but none published findings in information reports, research notes or newsletters and bulletins. University and government projects should have equal access to government publishing and distribution services.

V. PROJECT MANAGEMENT

1) Principal Investigators and Scientific Authorities

To be effective, research programs must be well managed. Specific responsibilities should be delegated to the research program committee, scientific authorities and principal investigators. This division of responsibility is used by the Research, Development and Application Subprogram of the Canada-Ontario Forest Resource Development Agreement.

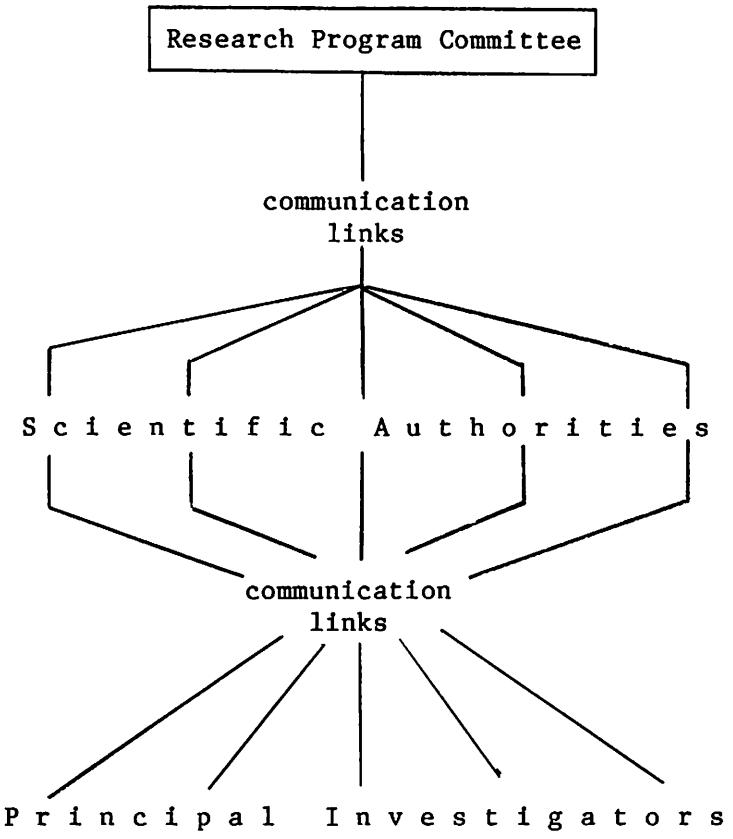
Scientific authorities are designated for each research project. The scientific authority is a liaison between the research program committee and the research or development project. He or she is responsible for ensuring that all conditions of the contract are met, for receiving and reviewing project progress reports, and for recommending payment of invoices. The most important role of the scientific authority is to ensure the scientific and technical integrity of the project.

Principal investigators undertake the projects funded by the research and development program. The Principal investigator is responsible for submitting progress reports and final reports, and for maintaining accurate accounts suitable for audit.

A basic management structure for a research and development program is given in figure 3.

Figure 3

Basic Management Structure For A Research and Development Program



Communication between the various levels of management is critical to the success of a research program. There were two problems with the COFRDA research and development program which impeded effective communication and project management.

Firstly, there were instances where the Scientific Authority and the Principal Investigator did not work closely enough. This was

often because the two individuals were separated geographically and could not afford to meet to discuss every problem that arose. These two individuals should work closely and meet frequently to discuss problems and project progress.

Secondly, two projects had different people who were responsible for the project at different times. When a new person took over responsibility, the project would be at a standstill until that person became acquainted with the project. This delayed the project's completion, and in some cases caused the project to be de-emphasized by the scientific authority who had other responsibilities occupying his time.

2) Flexibility of Project Progress

It is difficult to accurately predict the outcome of research projects. Research addresses problems for which there are questions, but few answers. Research projects frequently change direction as more is learned about a problem. For planning purposes it is necessary to outline a project's methods and objectives in a project proposal. This proposal is preliminary, not final. Research projects must be flexible so that, if necessary, methods and objectives can be revised to meet project deadlines. Research programs must recognize that proposed objectives may prove impossible for a project to achieve once it is underway.

"Forest Stand Growth and Yield Forecasting" was a COFMSA research project which aimed to develop growth and yield equations for managed plantations of jack pine and black spruce in Northern Ontario. These equations are necessary for estimating volume yields for management planning. The present estimations, made using Plonski's Normal Yield Equations, are inadequate because they are based on naturally occurring stands instead of managed plantations.

"Forest Stand Growth and Yield Forecasting" produced yield equations for stands under 20 years old. These equations, however, are not immediately useful for forest management in the Province. The study found great variability in growth and yield for managed plantations. Moreover, the greatest determinant of growth and yield was found to be the initial stocking level of the plantation. Further study and time are required to accurately identify the effects of silvicultural treatments on the growth and yield of managed plantations in Northern Ontario.

The project did not produce the immediately useful results that were hoped for when it was proposed. The project proved that accurate estimations of future growth and yield trends for managed plantations cannot be made yet.

A similar project was "Jack Pine Breeding", which established an electrophoresis laboratory for isozyme analysis. This analysis locates specific genes on chromosomes in the tissues of tree seeds. Initially, "Jack Pine Breeding" intended to use isozyme analysis to

determine the number and extent of Jack Pine breeding populations in the Province to support regional tree improvement programs. This was an ambitious pursuit in the area of forest genetics in which little research and development work had been done. After starting, it became necessary to scale down the project to focus on a preliminary study of jack pine breeding populations in the Chapleau and Blind River Districts of Ontario.

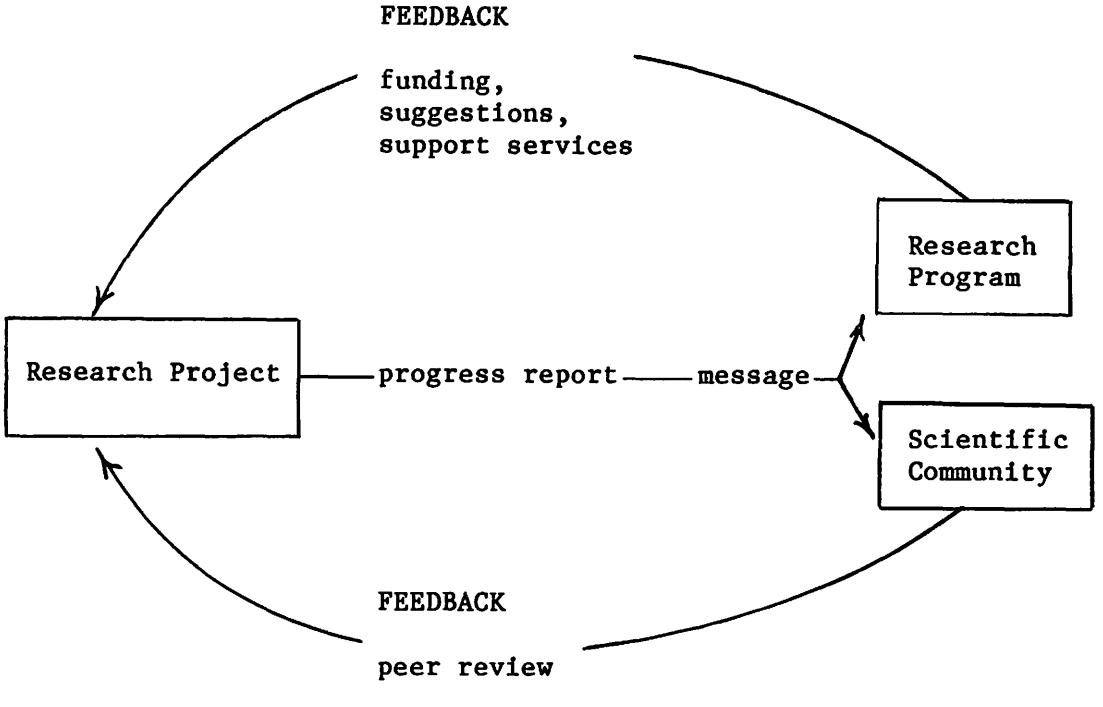
It is usually beneficial to change direction and narrow the focus of projects which would otherwise be too ambitious to complete under a short-term research program. With proper management, projects such as "Forest Stand Growth and Yield Forecasting" and "Jack Pine Breeding" can provide numerous benefits and spinoff applications, even if the projects do not meet all of the objectives first proposed. Research programs must be prepared to devote time and resources to assisting projects which investigate new areas of forestry research.

3) Project Progress Reports

Progress reports benefit research projects. A progress report is a message from the research project which generates feedback from the research program and the scientific community. The research program responds to the progress report by making necessary funding adjustments, giving suggestions on how to meet deadlines, and providing support services such as report publication. The scientific community provides scientific review of the project's methods and findings. The interactions initiated by a project progress report are shown in figure 4.

Figure 4

Interactions Initiated by a Project Progress Report



i) Progress Reports for the Research Program

The research program must maintain contact with all of its research projects to ensure that deadlines are met and that funds are effectively delivered and properly used. If a project requires increased funding, the research program must be notified in advance. Advance notice is also required for publishing project results, if that is the research program's responsibility.

Comprehensive progress reports are not necessary for the research program, but concise project outlines are crucial. All COFMSA projects submitted at least one synopsis of project progress to the

Assessment Program of the Agreement on a standard report form. One such progress report is given in Appendix C. These reports provided essential information, but would have been more effective if submitted more frequently. Several projects underwent changes which were not indicated in updated progress reports. The advantage of the standardized progress report form is that it allows all necessary information to be conveyed and updated. This information helps to document project progress and simplify future tasks of preparing annual reports and conducting evaluations and audits.

ii) Project Reports for the Scientific Community

A research program cannot scrutinize each of its research projects to ensure quality of scientific method and analysis. This task is best left to the scientific community.

Scientific peer review is an established system of evaluating the quality of research projects. Feedback from fellow researchers may provide new ideas and avoid duplication of effort. Research projects can benefit from this system by presenting comprehensive progress reports to the scientific community.

Comprehensive progress reports were provided by 12 out of 23 projects. Some of these reports were published or presented at meetings which increased the extent of scientific review from other researchers. Some COFMSA research projects conducted work in stages, with a report written after each complete stage. This allowed feedback on each stage of the project from the scientific community.

Ideally, researchers should become familiar with their peers' work, sharing knowledge, techniques and experiences. Unfortunately, this is the exception and not the rule.

VI. SUMMARY AND RECOMMENDATIONS

It is important to evaluate the outputs of research and development projects. These outputs may be difficult to quantify and attention must be given to quality of outputs, not just quantity. The major outputs from the COFMSA research and development projects were reports, equipment, facilities, employment, and training.

Recommendation 1

That research programs aim at evaluating the outputs of research projects in terms of published and unpublished reports written, facilities and equipment acquired, and employment and training.

The COFMSA development projects provided some important facilities and equipment which will benefit operations and research work for years to come. Equipment and facilities, however, were only provided for government-conducted projects.

Recommendation 2

That development projects acquire and develop equipment and facilities that are most necessary in forestry operations.

Recommendation 3

That government research programs provide new equipment and facilities for university projects as well as for government projects.

Research projects provided substantial training and experience for many individuals. University research projects provided important opportunities for young people to acquire knowledge and expertise through graduate studies.

Recommendation 4

That research programs recognize the value of student theses as measures of productivity. These theses indicate training of young people who will provide valuable expertise for future projects.

To be applied in operations, project outputs must have an obvious operational use. Of the 23 COFMSA research and development projects, 12 produced outputs which are applied operationally. These projects found solutions to operational problems, evaluated management options, or increased the size and productivity of operations.

It is important that research programs select research and development projects that meet the greatest needs of forestry operations. A wise choice of projects requires a prior identification of problem areas.

Recommendation 5

That the greatest needs of forestry operations be identified before research and development funds are allocated.

Recommendation 6

That the process of identifying operational problems be ongoing, and consider all forestry research and development activity in Ontario.

Recommendation 7

That forestry research programs rely on federal and provincial researchers and forest managers alike to identify major problem areas in forestry operations. The Ontario Forestry Council and the Canada-Ontario Joint Forest Research Advisory Committee comprise these individuals, and should therefore assist research programs in identifying problem areas.

Recommendation 8

That the Ontario Forestry Council and the Canada-Ontario Joint Forest Research Advisory Committee sponsor special workshops to analyze problems in specific areas of forest management. These sessions should receive input from both researchers and forest managers.

Special attention should be given to identifying problem areas for research and development under short-term Federal-Provincial Agreements.

Recommendation 9

That a research and development plan be prepared for each Federal-Provincial Forestry Agreement. The plan should be based upon a comprehensive problem analysis undertaken by forest managers and administrators of the Federal-Provincial Agreement. The plan should identify problem areas requiring research and development and should follow the general aim of the Federal-Provincial Agreement.

Many COFMSA research and development projects found prompt application of results because the projects had been undertaken in close association with forestry operations. Cooperation between principal investigators and operations managers permitted mutual understanding of problems and project methods.

Recommendation 10

That wherever feasible, research and development projects be undertaken in cooperation with forestry operations. Ideally, projects should share facilities and equipment with operations.

The outputs from 11 projects require more research or development before they can be used in forestry operations. These projects produced valuable outputs which contributed to long-term research and development efforts.

Recommendation 11

Problem areas requiring long-term research and development attention should not be neglected after a research project which investigated that problem area is finished. Research programs should ensure that work in such problem areas continues.

Scientific and professional meetings were important agents of technology transfer for 10 of the COFMSA projects. Only two university projects presented findings at meetings. No projects presented findings at meetings of the forest industry or the forestry profession.

Recommendation 12

That the Canada-Ontario Joint Forest Research Advisory Committee sponsor meetings in which all projects in Federal-Provincial research programs have an opportunity to present their findings. These meetings can be held while projects are in progress with interim results presented for each project.

Recommendation 13

That government-sponsored research projects be required to present findings to meetings of the private sector forestry associations.

The Research, Development and Application Subprogram of the Canada-Ontario Forest Resource Development Agreement has allocated $300,000, or 5% of its budget, to technology transfer initiatives such as scientific and professional meetings. This is a constructive step towards improving the effectiveness of applying project results.

The findings of 11 COFMSA research and development projects were published. Most of these were government projects which published findings in information reports, research notes, newsletters, or bulletins. Only three projects published findings in refereed scientific journals. It is unfortunate that more projects did not receive the scrutiny of peer review.

Recommendation 14

That each project in a research program be required to submit at least one report to a scientific peer-reviewed journal for publication.

The Canadian Forestry Service has recently increased the standards for report publication and has implemented a system of scientific peer review. This will help to improve the quality of scientific work funded by the Canadian Forestry Service.

Government projects benefitted from a government system for publishing and distributing reports. University projects did not have this benefit.

Recommendation 15

That university projects and government projects funded under the same government research program be given the same access to government publication services.

Research programs require effective management structures. The research program committee, the scientific authorities, and the principal investigators should work closely and communicate effectively.

Some COFMSA research and development projects lacked close ties with scientific authorities. Some projects were delayed because the principal investigator was changed while the project was in progress.

Recommendation 16

That the scientific authority and the principal investigator meet together frequently to discuss the project.

Recommendation 17

That each project have one principal investigator responsible for the project until it is complete.

Project progress reports are essential for an effective research program. The research program requires concise, standardized progress reports. Ideally these reports should have input from the principal investigators, scientific authorities, managers, and other potential users of the project outputs.

Recommendation 18

All projects should submit concise progress reports to the research program on a standard report form. These progress reports should be submitted two times each year to maintain up-to-date records. Principal investigators, scientific authorities, and operations managers should collectively prepare the progress reports.

The scientific community provides a means of quality control, ensuring that projects are being conducted with sound scientific methods and analyses. Progress reports to the scientific community improve the quality of the research project and enhance the reputation of the research program.

Recommendation 19

That research programs require each project to write at least one comprehensive progress report for evaluation by peers in the scientific community. Ideally, these reports should be published or presented at meetings.

CONCLUSION

This report has presented one approach to evaluating government research and development programs in forestry, particularly programs under Federal-Provincial Agreements. It has focussed on project outputs, application of outputs, technology transfer, and project management. These areas of emphasis emerged through discussions with project participants and people associated with the administration of research programs.

There are several other means of evaluating research and development programs. One alternate approach is an economic analysis which aims to derive a value for project achievements and then compare this value with the cost of the project. Various approaches to evaluating research and development programs must be investigated. Evaluation is especially important in the 1980's as Canada and the Provinces face a future of Federal-Provincial Forestry Agreements.

APPENDIX A

People Interviewed for Project Analysis

Canadian Forestry Service,
Great Lakes Forest Research Centre

S. Anderson, Analyst, Forestry Development
A.J. Ballak, Implementation Officer
J.H. Cayford, Regional Director
R.L. Flemming, Researcher, Forest Production
R.A. Haig, Program Director, Forestry Development
D.W.J. McGowan, Chief Implementation Officer
D.J. McRae, Researcher, Forest Fire
L.F. Riley, Research Manager, Forest Resources
J.H. Smyth, Chief, Socio-Economic Analysis and Planning
C.R. Sullivan, Program Director, Research and Technical Services
T. Weldon, Technician, Reforestation Silviculture
J.E. Wood, Researcher, Reforestation Silviculture

Ontario Ministry of Natural Resources,
Head Office, Queen's Park, Toronto

R.P Alton, Special Projects Coordinator, Timber Sales Branch
K.A. Armson, Executive Coordinator, Forest Resources Group
A. Citro, Sivicultural Equipment Development Coordinator
K.G. Higgs, Administrator, Canada-Ontario Forest Resource Development Agreement
J. Hood, Tree Improvement Coordinator
Dr. J. Osborn, Supervisor, Forest Management Information Section
G. Pierpoint, Soil Scientist, Management Planning Section
R.M. Rauter, Supervisor, Tree Seed and Genetics
R. Reffle, Supervisor, Planting Stock Production

Ontario Ministry of Natural Resources,
Provincial Tree Nurseries

D. Bouford, Technician, Orono Nursery
L. Forcier, Superintendent, Swastika Forest Station
G. Levielle, Clonal Forestry Technician, Swastika Forest Station
G. Mcleod, Superintendent, Orono Nursery
B.J. Phillion, Assistant Superintendent, Thunder Bay Nursery
K.H. Reese, Superintendent, Midhurst Nursery

Ontario Ministry of Natural Resources,
Ontario Tree Improvement and Forest Biomass Institute

G. Buchert, Researcher, Forest Genetics
D.P. Drysdale, General Manager
C. Glerum,, Researcher, Planting Stock

Ontario Ministry of Natural Resources,
Regions and Districts

C. Cavalier, Forester, Kirkland Lake District
J. Gillham, Forester, Chapleau District
V. Wearn, Spruce Program Forester, Northern Forest Development Group

Ontario Ministry of Industry, Trade and Technology

Dr. M.F. Walmsley, Science Advisor and Coordinator

Universities

Dr. K.M. Brown, School of Forestry, Lakehead University
D.R. Cyr, Graduate Student, Department of Biology, University of Waterloo
T. MacLellan, Ph.D. Candidate, Department of Botany, University of Toronto
M. Tadesco, Undergraduate Student, School of Forestry, Lakehead University
Dr. V.R. Timmer, Faculty of Forestry, University of Toronto
Dr. L. Zsuffa, Faculty of Forestry, University of Toronto

The Northern Clonal Forestry Centre, Moonbeam, Ontario

J. deWitt, Manager

APPENDIX B

ANALYSIS OF COFMSA ASSESSMENT PROGRAM INTERVIEW SHEET

Project

Person Interviewed

Date

Location

A. Initial Project Proposal

Objective

Description

Expected Outputs

1) Describe the background to the project. Why was it proposed?

B. Post-Project Assessment

2) How would you classify the project? (e.g. was it basic research, development, an operational trial, etc.)

3) What were the outputs of the project? (tangible and intangible outputs).

4) How are the results of the project being applied in forestry operations?

C. Project Management and Execution

5) What are your complaints, if any, concerning the administration of the COFMSA Assessment program?

6) Where did you encounter problems in planning and coordinating the project?

7) Who provided cooperation and non-financial assistance in conducting the project?

D. Future Potential of the Project

8) What do you see as future applications of the project's results?

9) What further developments could be made on the project? Discuss any additional work that is required in the area covered by the project.

10) What work is being done to build upon the project's results?

E. Additional Comments on Reverse

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