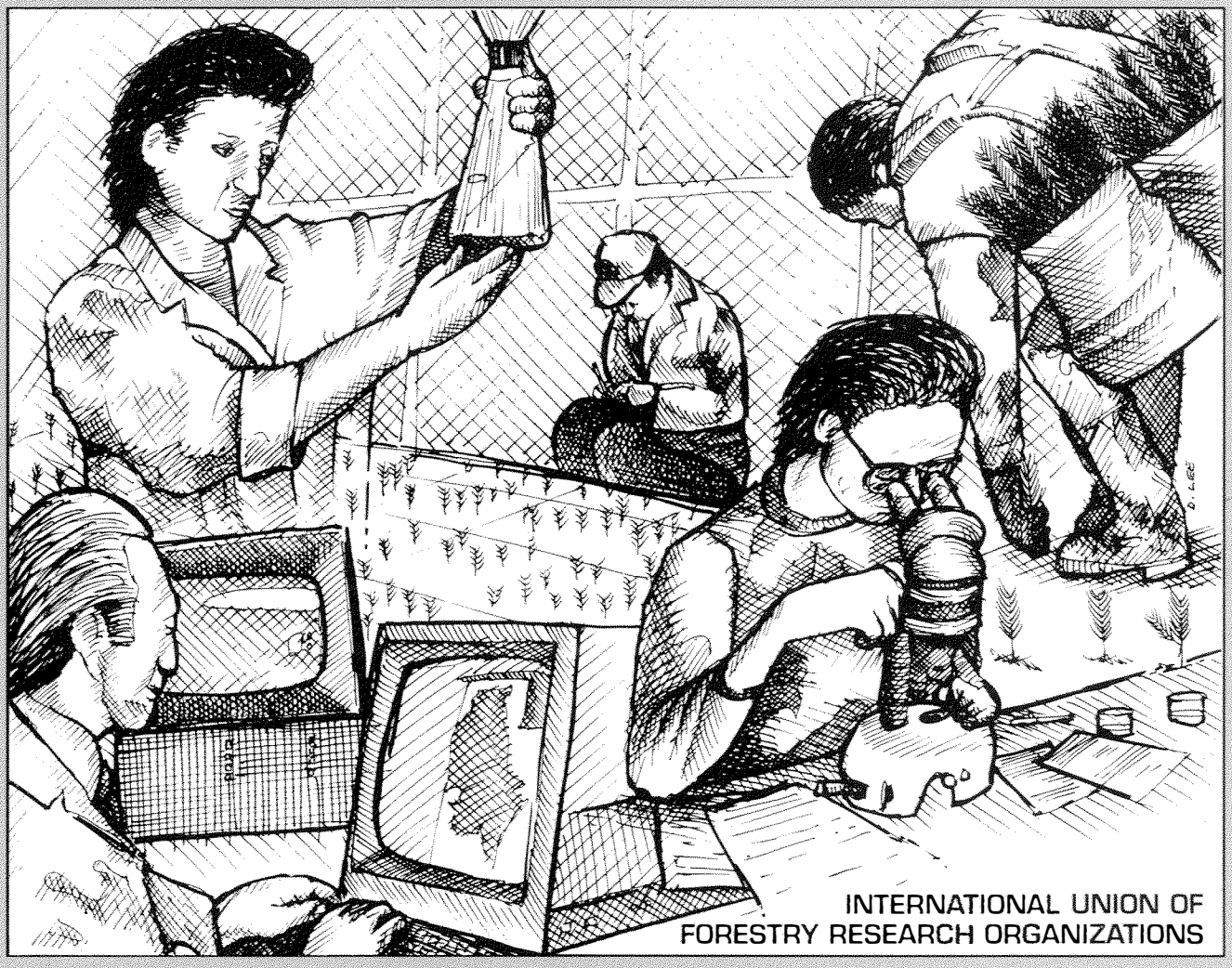
Research Management for the 1990s

A.D. Kiil, compiler



Forestry Canada Forêts Canada

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Forestry Canada's Northwest Region is responsible for fulfilling the federal role in forestry research, regional development, and technology transfer in Alberta, Saskatchewan, Manitoba, and the Northwest Territories. The main objectives are research and regional development in support of improved forest management for the economic, social, and environmental benefit of all Canadians. The Northwest Region also has responsibility for the implementation of federal–provincial forestry agreements within its three provinces and territory.

Regional activities are directed from the Northern Forestry Centre in Edmonton, Alberta, and there are district offices in Prince Albert, Saskatchewan, and Winnipeg, Manitoba. The Northwest Region is one of six regions and two national forestry institutes of Forestry Canada, which has its headquarters in Ottawa, Ontario.

Forêts Canada, région du Nord–Ouest, représente le gouvernement fédéral en Alberta, en Saskatchewan, au Manitoba et dans les Territoires du Nord–Ouest en ce qui a trait aux recherches forestières, à l'aménagement du territoire et au transfert de technologie. Cet organisme s'intéresse surtout à la recherche et à l'aménagement du territoire en vue d'améliorer l'aménagement forestier afin que tous les Canadiens puissent en profiter aux points de vue économique, social et environnemental. Le bureau de la région du Nord–Ouest est également responsable de la mise en oeuvre des ententes forestières fédérales–provinciales au sein de ces trois provinces et du territoire concerné.

Les activités régionales sont gérées à partir du Centre de foresterie du Nord dont le bureau est à Edmonton (Alberta); on trouve également des bureaux de district à Prince Albert (Saskatchewan) et à Winnipeg (Manitoba). La région du Nord–Ouest correspond à l'une des six régions de Forêts Canada, dont le bureau principal est à Ottawa (Ontario). Elle représente également deux des instituts nationaux de foresterie de ce Ministère.

RESEARCH MANAGEMENT FOR THE 1990s

Proceedings of the IUFRO Techncial Session Program: Subject Group S6.06 September 3, 1992 IUFRO Centennial Meeting Eberswalde-Berlin, Germany

A.D. Kiil, compiler

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ABSTRACT

A technical session dealing with management of forestry research was held on 3 September 1992, at the IUFRO Centennial Meeting at Eberswalde-Berlin, Germany. The technical session was attended by about 40 delegates from over 10 countries. Papers were presented on research roles and responsibilities for the 1990s, science reform and its impact on forestry research, the management of creativity in forestry research, and the diffusion of new research management philosophy.

RÉSUMÉ

Une séance spécialisée sur la gestion de la recherche forestière s'est déroulée le 3 septembre 1992 à l'occasion de la réunion du centennaire de l'IUFRO à Eberswalde-Berlin (Germany). Une quarantaine de déléguée de plus de 10 pays ont assisté à la séance spécialisée. Des exposés sur les rôles et les responsabilités des chercheurs pour les années 90, sur la réforme de la science et son impact sur la recherche forestière, sur la gestion de la créativité en recherche forestière et sur la diffusion d'une nouvelle philosophie de gestion de la recherche ont été présentés.

PROGRAM AGENDA

Research Management for the 1990s
Technical Session Program: Subject Group S6.06
Thursday, September 3, 1992
10:00 a.m. – 12:00 noon

PREFACE

At the 1990 IUFRO World Congress in Montreal, Denver Burns, Leader of Subject Group S6.06 "Management of Forestry Research", asked me to organize a technical session of the Group at the IUFRO Centennial Meeting in Eberswalde-Berlin in September, 1992. The theme chosen for the technical session at the Centennial Meeting was "Research Management for the 1990s". A preliminary announcement generated a strong response from about 20 potential participants or presenters, and resulted in the presentation of four excellent papers at the session. The technical session was attended by about 40 delegates from over 10 countries, and resulted in good interchange of ideas and establishment of new contacts.

As Program Chairman of the S6.06 Subject Group meeting, I assumed responsibility for publishing the Proceedings on behalf of my employer, Forestry Canada. The Proceedings will be mailed to Subject Group members on our most recent mailing list; additional copies are available from the Northern Forestry Centre, Forestry Canada, 5320 – 122 Street, Edmonton, Alberta, Canada, T6H 3S5.

A.D. Kiil
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IUFRO Subject Group, S6.06
Management of Forestry Research

THE DIFFUSION OF A NEW RESEARCH MANAGEMENT PHILOSOPHY IN THE USDA FOREST SERVICE[1]

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INTRODUCTION

In the early 1980s, the United States Forest Service existed as an agency that did not foster entrepreneurship, innovation, or creativity. In the Research Branch, employees were bound by excessive administrative burdens, and scientists researched forestry issues in close-knit functional work groups. Communications outside of the traditional hierarchical boundaries of the organization did not adequately address emerging forestry issues.

The Chief of the Forest Service recognized that the agency must change in order to accommodate increased demands on its services in an era of declining budgets. He chartered six pilot test units, and challenged them to enhance their program-of-work at their given budget level. Leaders of these units empowered their employees to use their personal initiative to take action, make changes, and contribute ideas based on their knowledge, experience, and common sense.

The results obtained by the chartered research units has created a management philosophy that has diffused throughout most of the nine research stations. Characterized by changes in all aspects of program operations, this new work culture has brought about an increased practice of shared leadership, and an improved focus on the needs of the customer. Today, I want to share with you how this new management philosophy has taken hold at research stations in the USDA Forest Service.

BACKGROUND

By 1984, the Forest Service was strangling in its own red tape. Recommendations from a national study, and responses from a survey of Forest Service employees, suggested that management should "loosen up the system" and provide more opportunities for individuals to streamline administrative operations, reduce costs, and give emphasis to new technology. It was time for a change.

Pacific Southwest Experiment Station Selected as First Pilot Test Unit

Taking the lead, then Associate Chief F. Dale Robertson organized and chaired a National Steering Committee to oversee the design of a pilot test study where selected units would test the concept of maximum delegation and flexibility.

In 1985, three National Forests and one Forest Experiment Station were chosen as pilot test units. In the Research Branch, the Pacific Southwest Station (PSW) was designated as the first pilot test station. The Steering Committee selected PSW because it portrayed a mid-size unit with a stable management team.

Pacific Southwest Station's pilot program began in October 1985, and all Station employees were encouraged to submit ideas to improve Station operations. It is interesting to note that proposals submitted by lower grade employees focused on temporary employee issues and benefits, including child care, health benefits, and exercise centers; whereas middle to higher grade employees sought delegated authorities, alternatives to managing research programs, and incentives.

[1] Presented at the XX Congress of the International Union of Forestry Research Organizations, Section S6.06 Management of Forestry Research, Eberswalde-Berlin, Germany, August 31 – September 6, 1992.

Some of the most successful ideas implemented at PSW included: (1) an internal annual competitive grants program for Station scientists, (2) established "Senior Research Scientist" positions, (3) an awards program for the outstanding Station scientist and top support person, (4) the addition of nongovernment user specialists to evaluation panels for research positions, and (5) a career-pathing program targeted at preparing employees for professional positions.

By 1987, enthusiasm for the program began to decline. The program struggled with visibility, and most people did not connect pilot-inspired changes with the pilot program. In early 1988, an effort was made to renew the Station's commitment to pilot; however, as new priorities emerged at the Station, the focus turned elsewhere and the program declined.

The mechanics and complexities of administering a pilot program at a research station proved to be a difficult venture. One could draw the conclusion that the pilot test at PSW did not have much of an effect on the way the Forest Service functioned. Despite setbacks, Washington Office (WO) leaders viewed the experiment as a positive step toward improving the organization's efficiency and effectiveness. In early 1987, the Steering Committee decided to expand the pilot test to include another research station, along with an entire region of the National Forest System.

Northeastern Forest Experiment Station Becomes Second Pilot Test Unit

Representing a station with a proven record of risk taking and creativity, the Northeastern Station (NE) was designated to be the second research pilot in February 1987. The NE's accomplishments would serve as a barometer for determining the pilot's overall success. At the same time, the Eastern Region of the National Forest System was designated as a pilot test region.

Northeastern Station's program formally began March, 1987, under the name "GENESIS." The program fostered participative decision making and shared leadership opportunities for all employees in areas affecting research programs and Station operations. As the pilot spirit permeated throughout the Station, early champions and leaders emerged from the ranks who embraced the new working philosophy and communicated its benefits to others in and outside of the Station.

One of the most significant changes at NE resulted from several proposals that suggested the formation of multidisciplinary teams of scientists to address the most challenging scientific policy questions in forestry. In November, 1987, scientists in traditional functional work units also became team members involved in the development of a multidisciplinary land and resource management model. A second program was a research and applications program to manage the forests for the 21st Century in New England and northern New York. The focus of research in NE has changed from work units tailoring their research to accommodate the skills of its people, to providing solutions to forestry issues that meet customer needs.

Reaching outside Station boundaries, NE employees also have been instrumental in bringing about changes in administrative areas. Examples include:

1. Testing a direct hire and retention program designed to eliminate much of the traditional red tape associated with hiring.

2. Department-wide approval to carry over up to 24 hours of extra work time that employees can arbitrarily earn to supplement sick or annual leave.

3. Implementation of a Peer Recognition Program that has now been adopted by many units nationwide.

Although these ideas had departmental or government-wide impact, it is the net effect of hundreds of less comprehensive proposals that has changed the Forest Service culture.

The Diffusion of a New Research Management Philosophy Begins

Like tiny seeds, a new research management philosophy had taken hold at the Pacific Southwest and Northeastern Stations. The roots of a new work culture had formed, and Robertson recognized the organization was growing. He knew that for a cultural change of this magnitude to occur in an agency the size of the Forest Service, unwavering support must be generated from the top of the organization. Upon appointment as Chief of the Forest Service in February, 1987, Robertson's vision generated a momentum for change that flowed throughout the agency. The Chief informally encouraged each Regional Forester, Station Director, and the Area Director to learn about the experiences

of the national pilots and to adopt the pilot philosophy in their own style and within their own authorities.

Operations in pilot units were unstructured and in constant flux. Some notable interactions and events that nourished an internal understanding and acceptance of the pilot test philosophy, and furthered its emergence in the Research Branch follow.

The sharing of information, experiences, and accomplishments began early. Continual updates about successful applications in the test units were shared with employees throughout the Forest Service. The publication "What If We Could Start Over?" was distributed to all Forest Service employees in 1988, and provided a far-reaching, general orientation to the pilot program and its philosophy.

Also in 1988, test unit coordinators authored an important series of papers called "New Thinking for Managing in Government." These provocative papers dealt with several of the significant aspects of managing the bureaucracy based on the new direction and experience of the pilot test. The paper, "Promoting Innovation and Creativity in a Government Research Environment," was one of five papers circulated throughout the Research Branch, other government agencies, the private sector, and academia.

The "New Thinking" series was just one means where news of the pilot test philosophy was reaching external publics. Robertson, the NE Director, and other pilot leaders spoke frequently to audiences in the Forest Service, at other government agencies, and at various conferences and meetings nationwide about "how a new work culture can be cultivated and sustained in a research operation." Also, in several books, by well-known authors, the Forest Service has been recognized as a government agency where creativity and innovation have been cultivated through the pilot test.

The Diffusion Continues; Research Employees Experience Empowerment

In the spring of 1989, the Forest Service assembled 132 employees from all grade levels and disciplines to experience first-hand the synergy of the pilot test philosophy. At the national conference, participants learned about and discussed some of the new, emerging ideas; voiced concerns; and were encouraged to help develop recommendations for strategies to move the philosophy ahead service-wide. Perhaps the most important accomplishment at the meeting was the empowerment of people at all levels of the organization to be involved with agency operations.

A larger National Pilot Symposium was held in 1990. Over 300 Forest Service employees attended, including personnel from almost every Research Station. Following discussions at the conference, employees were instrumental in introducing a new work culture at several stations.

Philosophy Chartered for Service-wide Implementation

On December 19, 1989, Robertson chartered "A Management Philosophy for the Forest Service" which, at last, gave all Forest Service units the freedom to incorporate the philosophy into their own operations.

Between 1989 and 1991, various programs, organizational structures, and working philosophies emerged nationwide. In Research, the North Central (NC), Rocky Mountain (RM), Southern (SO), and Pacific Northwest (PNW) Stations took steps to embrace the management philosophy.

At NC, the Station's new "Working Philosophy" was introduced in September 1990. North Central's cultural change was not portrayed as a structured program, but as an evolving process that would be absorbed within the Station's infrastructure. Implementation of many new ideas were accomplished by task groups set in motion by the Director and involved employees throughout all levels of the Station. Over time, employees began taking more initiative, and ideas were acted upon at lower levels of the organization. Research programs at NC have experienced a quick and dramatic change to integrating functions, which has generated a more cooperative environment between units and between other Research Stations.

Project "3E" was initiated at the RM Station in September 1990. An environment was created in which employees could be creative, innovative, and communicate their ideas from anywhere within the Station. In addition, decision making authority was driven down to the lowest informed and empowered levels.

Determination, Achievement, Responsibility, and Excellence characterize the SO Station's program "DARE". In June 1991, all employees were asked to share ideas that would increase the Station's

efficiency and support SO's mission. Barriers have begun to be broken down and employees now DARE to be different. An awareness has evolved that the people closest to the work, at all levels of the organization, have important ideas to contribute.

A different approach to institutionalizing the philosophy emerged at the PNW Station. In January 1991, PNW restructured and flattened the management of their organization into two levels: the Director with 3 Deputy Directors, and 11 Program or Project Managers. Numerous scientific and administrative teams were formed, each led by a team leader. This nontraditional work structure has increased communications throughout the Station, and has aligned decision making authority with responsibility and accountability.

Between 1985 and 1991, five of nine Research Stations had incorporated the philosophy into the management of their organization. At the NE Station, the Northeastern Area had linked with project "GENESIS," and research employees at the Washington Office were contributing ideas for change through project "EAGLES" established in January 1988. Nationally, various quality management and customer service programs were also implemented.

Research Works Together to Further the Philosophy

In 1992, the NE Station took the lead to further the diffusion of the new management philosophy in research service-wide. In cooperation with the NC, SO, and RM Stations, a working conference on "Empowerment in the Research Environment" offered participants from all Stations, the Forest Products Laboratory, and WO Research, the opportunity to learn about approaches that each has taken to implement the philosophy. Key principles of empowerment, leadership, teamwork, and accountability were discussed, and participants looked at ways to work together to further implement the philosophy.

Today, pilot unit leaders, management philosophy coordinators, management leaders, and committed employees throughout Forest Service research are working together cooperatively to build an agency-wide environment conducive to productive and quality work. Seven of nine Stations have linked together and are building comprehensive, widely supported proposals with potential for impact service-wide. In addition, they are coordinating the evaluation and implementation of many ideas that have been adopted at other Stations and Regions. A powerful network of "champions" connects Research Stations nationwide in the pursuit and diffusion of a new management philosophy.

CONCLUSION

After seven years, a culture of new thinking has unquestionably emerged and diffused throughout the USDA Forest Service. New national multidisciplinary programs such as New Perspectives, Global Change, and more loosely structured collaborative efforts and partnerships are representative of this change. The ability to go beyond traditional thinking, with a bias for creativity and innovation, has been clearly demonstrated by employees at all levels. The environment is one of shared leadership with a focus on the needs of the customer. In caring for the land and serving people, the organizational spirit and changing work culture in Forest Service research are thriving.

A comprehensive version of this paper will be available as a future Northeastern Station publication.

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SCIENCE REFORM IN NEW ZEALAND AND ITS IMPACT ON FORESTRY RESEARCH

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INTRODUCTION

Since 1990 New Zealand's science sector has undergone major reform, which has dramatically changed the organization and funding of science. The reforms aimed to improve the provision of policy advice, create a robust science funding system based on contestability, and improve the efficiency and effectiveness of operational science activities. The creation of a new Ministry of Research, Science and Technology to provide policy advice, a Foundation for Research, Science and Technology to allocate government funding for research, and ten research companies or Crown Research Institutes (CRIs) to do the research, were key elements of the reforms. The reforms in science were part of a much wider government restructuring and reform of New Zealand's economy and public sector, which began in the mid-1980s. Walker (1992) has outlined the science reforms in some detail.

Until the 30 June 1992 more than 85% of New Zealand's forestry and wood products research was carried out by the Forest Research Institute (FRI). The FRI was established in 1947 and had always been part of a government department; initially the New Zealand Forest Service and, since 1987, the Ministry of Forestry. Over the last two decades about 65–70% of FRI's total research program was concentrated on *Pinus radiata*, which forms the bulk of the country's 1.3 million hectares of softwood plantations. The R & D completed by FRI has contributed significantly to the rapid growth of the forestry sector and has helped enable radiata pine to provide for most of New Zealand's wood-based product requirements. Exported radiata pine logs and processed products also earn about $1.5 million/year for New Zealand. Over the next two decades it is expected that continuing rapid growth in the forestry sector will see a 2.5-fold increase in radiata pine wood production and possibly a 4-fold increase in export revenues from pine products (Ministry of Research, Science and Technology, 1991). Whether or not these expectations are realized or exceeded will partly depend on the continuation of a carefully planned and targeted research and development program.

REFORMS IN FORESTRY SCIENCE

On 1 July 1992, the FRI was transformed into two research companies or CRIs. In future, most of the R & D concerned with the growing, harvesting, processing, and marketing of radiata pine and other production species, will be carried out by the New Zealand Forest Research Institute (NZFRI) based in Rotorua. Those parts of FRI concerned with environmental protection and ecological forestry research have been transferred to another research company called "Landcare Research New Zealand" (LRNZ). Most of the research concerned with the protection and management of New Zealand's 6.2 million hectares of indigenous forests is now undertaken by this research company. The NZFRI will employ about 400 staff including about 300 science staff. LRNZ will also be about the same size in terms of staff numbers.

The CRIs were established under special legislation (Crown Research Institutes Act, 1992) and are set up as companies wholly owned by the government. They are to be run in a business-like manner and earn an adequate return on shareholders' funds. Compared to the old government department FRI, the new CRIs have more financial powers and are able to borrow, invest, and form joint ventures with other organizations and businesses to develop and commercialize new technologies. The CRIs are also free from many of the constraints and compliance costs associated with government department rules and regulations. The CRIs will pay tax on any profit they earn.

Until 1991 the government provided FRI with an annual bulk appropriation that had declined

from approximately $28 million (1990 dollars) in 1985 to about $19 million in 1990. To a large extent the institute with the aid of advice from the forest industry, determined where its research priorities lay and where the funds should be spent. Part of the science reform process involved the introduction of contestable government funding. The CRIs will submit research program bids to the new Foundation for RS & T for funding from a "Public Good Science Fund" totaling about $260 million. Funds will be allocated on the basis of a set of priorities set by the government. Research program funding will be allocated on a multiyear basis for some strategic research programs. Over the next 5 years the government has determined to make available more than $90 million for research on production plantation forestry and wood processing including pulp and paper processing. Although most of this funding is likely to go to the NZFRI (CRI), a proportion (10–15%) is expected to be allocated to other CRIs, universities, research associations, and the private sector.

Other Factors Influencing Forestry Research

In addition to the government reforms in science there have been some very significant changes within the forestry sector that have had an influence on forestry research priorities and funding.

- Approximately 550 000 hectares of State plantation forests were "corporatized" in 1987 and then put up for sale in 1989. To date about 450 000 hectares of mainly radiata pine forests have been sold to local and overseas buyers. The new forest owners, including Japanese, American, and southeast Asian companies, have increased the number and diversity of organizations requiring research services.

- The New Zealand forest industry is rapidly transforming from a dominantly domestically oriented to an export-oriented industry as the production of plantation-grown wood continues to increase. This change has been accompanied by the recognition of a need to shift some of the research emphasis from the forest growing area to the wood processing and marketing areas. The development of clean, efficient processing technologies and new high value wood-based products, is recognized as one of New Zealand's highest research priorities.

- The recent introduction of new resource management legislation (Resource Management Act, 1992), will place much greater demands on forest and wood processing companies to respect and protect the environment and develop operating techniques that are sustainable. The importance of environmental forestry research is expected to increase.

Impacts on Forestry and Wood Product Research

Many of the reforms described above have only recently been introduced thus precluding accurate quantitative assessment of the medium-term impacts of some of the reforms on research. Nevertheless, over the last 2 years the changes in the organization and funding of science and changes in the forestry sector have significantly affected forestry research.

Funding of forestry research. The introduction of contestable bidding for government funds for research halted the steady reductions in government funding for forestry and wood product research that had begun in 1985 and, in 1991–92, marginally increased the funding for research. In its first 2 years of operation, however, the bidding system has been costly in terms of scientists' time, but this is expected to become less of a problem in the future as multiyear allocations of funding for a large proportion of the research programs are introduced. Private sector funding for forestry research continues to increase slowly and currently totals about $11 million or 30% of the total funding available for forestry research. Overall, the new funding regime is expected to introduce more stability into the funding of forestry research.

Priorities for forestry and wood products research. Overall, there has been a shift in priorities from research concerned with forest growing to research concerned with wood processing to help improve New Zealand's competitiveness in overseas wood product markets. At a more detailed level, the new government research priority setting system has placed high priority on research concerned with protecting the health of forests, tree breeding and tree genetics, developing low impact, cost efficient forest harvesting systems, improving the efficiency and international focus of the sawmilling industry, and developing a range of "clean" processing technologies within the solid wood, pulp and paper, panel products, packaging, construction, and residues areas of the forest industry to create higher value, cost competitive products that will compete strongly in international markets.

Structural organization. The new CRIs will be efficiently structured and will have a higher science staff:support staff ratio than the old FRI, which should see more funding directed into research and less into administration and other support services.

Relationships with other organizations. It is the intention of government that the CRIs will work closely with industry, universities, and the business sector to ensure that the results of research and new technology developments are transferred to and used by industry and other potential end users. The old FRI had established a close and effective working relationship with the forest industry through the operation of the FRI/industry Forest and Forest Products Research Organization and its Research Cooperatives. The new NZFRI with its greater financial powers and ability to form commercial joint ventures with other organizations, should be able to strengthen its relationship with industry and universities and foster more collaboration and joint participation between NZFRI and industry/universities/businesses/local bodies in research and the commercialization of technology. Similarly, the LCNZ CRI is expected to strengthen its relationships with the forest and agricultural industries, local bodies, and the universities in research concerned with improving and developing new sustainable land use techniques.

These changes associated with the establishment of the CRIs provide expectations that the taxpayer will receive a better return on the tax dollars spent on forestry research than has been the case in the past.

THE FUTURE

The new science regime will provide more funding for forestry research, at least in the medium term, and will probably encourage an increasing number of participants in the funding and implementation of R & D. In particular, the forest industry and universities are likely to play an increasingly important role in forestry research. This will help in dealing with some of the major challenges facing New Zealand's research organizations. I will mention three of the challenges here.

In New Zealand there is a declining interest by school and university students in following careers in scientific research. Part of this trend appears to be related to the high cost of undertaking postgraduate studies in engineering and science and potentially more attractive and lucrative careers in areas such as commerce. Furthermore, over recent years there has been a serious "brain drain" as scientists and technologists seek greener pastures overseas, particularly in Australia and North America (Hyde 1991). The bulk of forestry and wood-product science staff are aged between 35 and 50 years (mean age of science staff at FRI in 1990 was 42), which suggests that peak retirement years for existing science staff will occur in the first decade of the next century. Maintaining a highly skilled workforce to undertake the research through the late 1990s and beyond will present a major challenge. The solution probably depends on the promotion of forestry and forestry research and the development of attractive career paths within these disciplines.

In New Zealand private sector investment in R & D is very low compared to many other OECD countries. One of the basic aims of the science reforms is to increase the level of investment in R & D by the private sector. Although private sector funding of forestry and wood-product research is higher than in many other areas of research, the investment pattern is uneven. Nearly 50% of the costs of pulp and paper research is met by industry whereas only about 20–25% of the costs of forest health and protection and agroforestry research are met from non-government sources. To help increase the private investment in forestry research, the benefits, costs and rates of return of R & D should be quantified where possible and promoted to forest companies and other organizations. Strengthening the relationships between research and industry as previously discussed, will also play an important part in lifting investment levels.

Managing intellectual property is becoming more complex and will present a big challenge for research managers in the 1990s. One of the particular problems that has confronted FRI over recent years and will undoubtedly remain an issue for CRIs, is the threat posed to the accessibility of research results by increasing "industrialization" of research. The management of intellectual property so that increasing needs for confidentiality do not prevent the publishing of research results, will be a difficult challenge to resolve.

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THE MANAGEMENT OF CREATIVITY IN FOREST RESEARCH

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The last few decades have seen a growing obsession with the management of research, together with a continuing and restless reorganization of research structures within forest departments and commissions. Concepts like value for money, customer--contractor relationships, and peer review are widely discussed and attempts made to implement these and many other ideas that have been borrowed from commerce, industry, or public administration.

This paper begins from the premise that the management of research is essentially the management of creativity and is not equated with the control of finance for equipment, facilities, and staff, important though such control may be. Indeed, many of the measures that are currently being adopted by forestry organizations in order to embed research within institutional structures are reducing the creativity of research scientists without necessarily making their research more relevant.

The paper presents ten precepts for the management of research, designed to enhance and encourage the creativity, which is the essential condition of progress in the difficult task of maintaining the sustainability of our forest resources in developed and developing countries alike.

INTRODUCTION

During the last two decades, there has been a marked shift towards the idea that scientific research needs to be managed, in sharp contrast to the earlier belief that the best management of research was the absence of all forms of management. Today, we see the introduction of customer–contractor relationships, peer review, cost-benefit analysis, management by objectives, etc. in attempts to manage scientific research and to direct that research towards perceived priorities and objectives.

In part, the shift towards greater control of research activities springs from the increased cost of research. When research could be done by individuals working with little or no equipment, it may well have been true that "the best research is done by a man and a boy in an old bicycle shed!" Today, research often seems to need teams of scientists from different disciplines working together in air-conditioned laboratories, using expensive equipment, and needing to attend numerous meetings in far-off countries. The cost of research makes it a natural target for demands that it should be more tightly controlled.

The insistence on tighter management of scientific research has usually been accompanied by successive reorganizations of the research institutions or divisions. In the absence of any clear model for how research scientists should be organized most effectively, new rearrangements of the structure and communication system of a research branch seem to arise every time a new research director is appointed. Some forestry research organizations now seem to be in a state of almost constant flux--a condition that I fear has been "caught" from Britain, where reorganization of research has become a recurrent "disease."

Almost all of the discussion on the management and organization of research seems to have been focused on the costs of staff, equipment, buildings, research materials, and on the need to direct research towards priorities that are perceived by the forest managers and administrators. The measures that are introduced are usually more concerned with the "furniture" of research than with the creativity of the research scientists themselves. What distinguishes research from every other activity, however, is essentially that creativity, and the management of research is therefore effectively the management of creativity. Techniques of management borrowed from industry, commerce, and administration are largely irrelevant because they do not address the issues of creativity and how that

creativity can be maintained in the research organization. If the creativity does not exist in the first place, there is no point in pretending that genuine research is taking place. Management practices that diminish or destroy creativity also destroy the whole purpose of the research activity. Sadly, we see such destruction taking place everywhere, in the name of management.

TEN PRECEPTS

This paper begins, therefore, from the premise that the management of research is the management of creativity, and is not to be equated with the control of finance for equipment, facilities, and staff, necessary though that control may be. It suggests, indeed, that many of the measures that are currently being adopted by forestry research organizations in order to embed research within institutional structures are actually reducing the creativity of the scientists they employ, without making their research either more relevant or more timely.

The paper presents ten precepts for the management of research, designed to enhance and encourage the creativity that is the essential condition for progress in the difficult task of ensuring the sustainability of forest resources, in developed and developing countries alike.

1. Research is not done by institutions: it is a creative activity of exceptionally gifted individuals.

The first requirement, therefore, for any organization that wishes to do research is to find, recruit, and keep creative scientists. Finding truly creative individuals is not difficult, but it does require a certain flexibility in methods of recruitment as such individuals often have unconventional educational backgrounds or past work experience. Indeed, they may not always appeal to interview boards and panels more accustomed to recruiting nonresearch staff, but it is important not to let a desire for conformity override the need for personalities and expertise that are capable of taking the research into new areas and directions. Creative research scientists are unlikely to want to transfer to other work, and therefore need a separate career structure in which advancement depends on the recognition of their peers rather than on any other criteria, for example the ability to manage a forest district.

The motivation for creative research scientists lies in their science and in their ability to anticipate and solve problems. Above all, it is important to recognize that good research scientists are not created by transferring men or women who have failed in administration or management to a post in the research organization. Round pegs in square holes do not fit holes of any other shape simply by transferring them out of the square holes, and scientific research is too important an activity for it to be conducted by unsuitable personnel.

2. Good research scientists represent a scarce resource that needs to be protected.

Anything that threatens the scarce resource represented by the creative scientists that a research organization has managed to recruit diminishes the creativity of the organization by reducing the initiative and originality of the individual scientists and their interaction with each other. A principal function of research management, therefore, must be to encourage and develop the individuals on which the organization depends for its effectiveness as a research institution.

In particular, the creativity of research scientists is easily damaged by insecurity, implied or actual, and by insensitive management. Creative scientists are unlikely to work standard hours or to conform readily to some corporate image. Their originality depends on their being able to devote as much time as possible to do what they most enjoy, their research, and on their being given the greatest possible freedom for their research activities within budgets and conditions that have been agreed with them in advance.

3. Research management should be recognized as being essentially the management of creativity.

Forms of management that may well be appropriate and acceptable for other activities (e.g., administration, sales, forest production, etc.) are not necessarily relevant to the management of research. Concepts such as value for money, market forces, and customer–contractor relationships have all been shown to have greatly reduced the creativity on which scientific progress depends. Good scientific research cannot be bought and sold like packs of panty hose or cans of baked beans. The value of any new idea in research depends more on how that idea will be combined with existing knowledge and then deployed in the future than on any contract to produce a solution to a problem that exists now. In particular, attempts to market scientific research focuses research attention on short-term objectives

at the expense of the longer-term thinking necessary for the development of new approaches and the anticipation of future problems. In retrospect, the last 20 years of British science, especially, will be seen to have been a mistaken attempt to apply market forces to research, unrelieved by apparent savings in research expenditure. Applied short-term research with objectives dictated by customers has quite simply eaten the seed corn of the fundamental research needed for the future, without encouraging or making allowance for the replacement of strategic and objective research.

A simple test of the appropriateness of any proposed management of administrative procedure is to ask, "Does this proposal help or hinder the creativity of the research scientist?" Most of the management procedures imposed on research today fail that simple test.

4. Administration and management in any research organization should have the sole purpose of enabling and enhancing the research activity.

While efficient accounting and administrative procedures are obviously necessary in research organizations, they should be maintained at the minimum consistent with maintaining accountability and good order. Wherever possible, the scientists themselves should be freed from administrative and executive chores by the appointment of a small number of executive assistants.

5. The head of any research organization should be a scientist with an acknowledged scientific expertise.

Science needs to be lead from the front. Research scientists respect other good scientists, and will follow leaders who can demonstrate their expertise in an appropriate field of research, especially if they have an international reputation in that field. Appointment of a nonscientist, or a scientist with a poor or nonexistent reputation for creative research, lowers the motivation of the research staff, and deprives them of an example and the leadership to which they can respond.

The head of the research organization should have the primary responsibility for devising the research strategy of that organization, and it is essential that the scientists who have to implement that strategy respect the judgment of their leader. Imposing a strategy from outside of an organization, for example by means of a steering committee of aging academics and administrators, or appointing a scientifically weak leader, undermines, and may totally destroy, the creativity of the research organization.

It goes without saying that the kind of leader who will maintain the respect of the research staff will also continue to play an active part in scientific research, and will refuse to be completely taken over by administrative responsibilities and meetings of various kinds. If the head of the organization is unable to schedule the necessary time for thinking and research, nobody else in that organization has any hope of doing so. Management by example is essential.

6. Research planning in forestry should have a time horizon of 10–15 years, and should provide continuity rather than constant revision and change.

It is too late to do research for today's problems. Such problems can, at best, be solved with the help of advice from appropriate experts. It is, rather, the role of the scientists in an organization to look forward some 10–15 years, and to try to anticipate the problems likely to confront the organization during that period. Appropriate research activities can then be defined and the necessary plans drawn up over the medium and long term. If that review and planning is done by the research scientists themselves, under the stimulus and guidance of an acknowledged leader, the motivation and creativity of the research is greatly enhanced.

Constant review and revision of research programs, especially by outside assessors, merely confuses the scientists and wastes money invested in staff, materials and equipment. Research programs should, therefore, evolve over relatively long time scales rather than be the product of short-term reviews. If a research organization loses its creativity and focus on long- or medium-term objectives, the failure is that of the head of the organization. He or she should be replaced, and the new head given time to establish effective leadership, rather than by attempting to manage the organization by committee.

7. Modern scientific research requires a high level of funding for capital equipment, and especially for instrumentation, computing, and communication.

The changes that have taken place in technology over the last 40–50 years have greatly altered the balance of research expenditure, giving much greater emphasis to capital equipment that also needs to be replaced regularly as it becomes obsolete. No organization can expect to keep first-class scientists if it does not provide them with the kinds of equipment that are necessary for them to keep up with the development of their expertise. Adequate and flexible funding, with due allowance for the rapid obsolescence of much of that equipment, must be a component part of any long-term research plan. Trying to do research on the cheap merely results in a waste of the money that has already been invested in good and creative staff.

8. Good secretarial and library services are essential for high research productivity.

Scientists should never be allowed to underestimate the value of well-trained secretaries and librarians in helping them to document and present their results. While many scientists now have access to electronic typewriters and word processors, few have the necessary skills to present written information in ways that are both attractive and effective. A well-trained secretary can greatly enhance the presentation of written information, in addition to relieving the scientist from a wide range of administrative and executive chores. Entry of data into computer files, annotating and archiving of research data, and making the necessary arrangements for meetings and workshops are further tasks that can be entrusted to a competent secretary, possibly working for a small group of scientists.

Similarly, access to journals, books, and increasingly, electronically accessible abstracts, is greatly facilitated by the help of professionally trained librarians. Since the first stage of many research projects consists of a literature search, followed by careful documentation of the results of the search, it is foolish not to engage the services of someone who is professionally competent to advise on how both the search and the documentation can be done efficiently.

9. Scientists need continuous access to new ideas, preferably through attendance at meetings, symposia, conferences, and workshops.

Adequate provision for the attendance of research scientists at relevant meetings, symposia, conferences, and workshops is not a luxury, but an essential component of keeping in touch with developments in their field of research. Reading published scientific papers and books is important as a way of discovering who is working in a particular field of interest, but, if only because of the long delays in publication, new ideas are best communicated through informal discussions at such meetings. What may therefore seem to the non-scientist to be an expensive and time-consuming perk is in effect part of the essential fabric of scientific research. Because science is also international, many of the important meetings take place in countries far from the home ground of any individual scientist, thus adding to the cost of travel, and to the difficulty of convincing administrators of the need for support to attend the meeting. However, without access to the informal exchange of information, which is the lifeblood of creative science, research becomes ineffective.

10. Modern scientific research needs continuous access to statistical expertise, especially when experiments, surveys, or simulations are being designed or analyzed.

A great deal of time and effort is wasted by inefficient (and sometimes invalid) design of experiments, surveys and simulations, and by the incorrect analysis of the results of research. In forestry, in particular, research projects span over several, and perhaps many years, so that collection of data for badly planned experiments or surveys will be costly, as well as being impossible to analyze effectively. If at no other stage, the expertise of appropriately experienced statisticians should be available to research scientists when they are actually designing their experiments or surveys. Ideally, that expertise should be available from within the organization, but it may also be possible to obtain it from a local university, or from a sister research organization.

The existence of commercial computer packages for statistical analysis had lead some managers to believe that there is now less need for statistical advice than before. If fact, the reverse is true, in that the increasing complexity of modern research, and the greater dependence on instrumentation in both the field and the laboratory have increased rather than decreased the need for advice from competent statisticians. Computer packages for statistical analysis provide access to statistical methods but seldom explain either the basic assumptions in the use of those methods or the criteria for selecting between the methods.

IMPLICATIONS

These ten precepts have important implications for forestry organizations in both developed and developing countries. Original scientific research is not something that can be lightly and cheaply undertaken. The first, and most important, requirement is the recruiting and keeping of the genuinely creative individuals who will actually do the research. It is also necessary to find a leader for those scientists, preferably someone with an international reputation, who can develop with the scientists a research strategy and program that will anticipate the problems of the organization over the next five, ten, or fifteen years. That research program then needs the support of equipment, and of secretarial, library, and statistical services. The scientists must also have enough resources for communication with other scientists and for travel to conferences, symposia, and workshops.

Having created a research team, and made the resources available for it to work effectively, it is essential that it should be left to get on with its research without repeated reviews of its program or reorganization of the administrative structures, locations, and reporting arrangements. Temptations to disperse the valuable resources of creative scientists and leadership to other activities, including top-heavy administration, must be firmly resisted, and the research team left to get on with its primary task—that of finding solutions to the problems that the forest organization will have in the next decade.

The difficulties of initiating and maintaining effective research are especially acute for developing countries. Not only is it more difficult to identify genuinely creative individuals among the relatively few people who have been able to obtain a scientific education, but there will be an even stronger temptation to move those individuals to nonresearch posts in management or administration after only one or two years as research scientists. It is very difficult, perhaps impossible, to build a coherent research program around a series of temporary appointments, so that the result will usually be an accumulation of half-completed experiments, none of which have been satisfactorily analyzed and written up. Most developing countries will also have great difficulty in providing the scale of resources necessary for effective secretarial, statistical, and library services, or for laboratory and field equipment.

For developing countries, generally, perhaps the most feasible solution is to develop regional forest research organizations that can recruit a small number of high-caliber scientists from the countries in the regions, and support them at a convenient center. Foreign aid agencies would also perhaps find it easier to provide the necessary help in terms of expertise, money and materials if that help could be directed regionally. Clearly, however, such a solution raises many political, economic, and social problems.

CANADA'S FORESTRY S & T AGENDA: A NEW LOOK AT RESEARCH ROLES AND RESPONSIBILITIES FOR THE 1990S

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INTRODUCTION

The 1980s were a decade of change for forestry science and technology (S & T) in Canada, as in many other parts of the world. Many new technologies, in such fields as biological control, plant biotechnology, remote sensing, geographic information systems, and computer-based decision support systems, which were only just emerging ten years ago, are now high priority and mainstream parts of our forestry research activities. At the same time, an enormous shift has begun to take hold in forestry practices, towards more holistic forest management, the fuller recognition of environmental and other nonconsumptive values of the forest, and the implementation of sustainable development. These changes are having a major and pervasive effect on forestry research programs and priorities, and research managers and scientists are now focusing much of their attention on multidisciplinary issues like biodiversity and climate change rather than on the more traditional forestry disciplines.

Concurrent with these subject matter changes has been an evolution in agency roles and in the financing, organization, and management of Canada's forestry S & T activities. Funding has remained a significant constraint relative to overall forest sector needs, and there has been a major shift within that funding towards short-term (up to 5 years) allocations specifically tied to particular issues or topics, with a corresponding decrease in longer term (core) funding. Partly for this reason, and partly to respond to pressures on the forestry research program to become more relevant to immediate, applied R & D needs, there has been a shift in focus within most forestry research fields towards meeting shorter term R & D, technology transfer, and advisory service requirements. There has been an increasing emphasis on forestry S & T networks, alliances, and other forms of collaboration, both within Canada and internationally, stemming from a recognition that no one agency or country can, or should, meet all of the sector's research needs. And there has been a continuing focus on enhancing the involvement of client agencies with operational forestry responsibilities in the conduct of R & D and the transfer of technology that should flow from it. Advisory committees and other similar mechanisms have received increasing attention as ways to involve client agencies in the entire spectrum of forestry S & T.

Canada's forestry research organizations have and are continuing to respond to these changing circumstances, so as to ensure that the country's forestry program remains vital and of world class. In large part, however, their responses have been ad hoc and on an individual agency basis. While a broad consensus on future directions for Canada's forest sector has been achieved through two recent national forestry congresses (in 1987 and 1992), this has so far only found limited practical expression in terms of the country's forestry research programs and processes. As a consequence, it was felt timely to undertake a thorough assessment and reanalysis of the roles and responsibilities of Canada's forestry S & T performers and users and of the mechanisms, processes, and programs that are in place to permit the various agencies to deliver on those roles and collaborate effectively with one another.

APPROACH USED

A project to carry out just such a reassessment of current forestry S & T performance and to develop a "National Forestry S & T Agenda for Canada" was initiated by Forestry Canada in the latter part of 1991. The project is being undertaken by Forestry Canada in its capacity as the federal government's lead agency for forestry matters and as Canada's single largest forestry research

organization, but is addressing the entire Canadian forest sector and the roles of all major S & T players within it. The project has also been prompted by a recognition of the continuing preeminent place held by forestry within the Canadian economy, and by the key role of R & D in providing an underpinning for the continued health and vitality of the sector (see Table 1 for some basic statistics on forestry and forestry S & T in Canada).

In more specific terms, the objectives of the forestry S & T agenda project are to reexamine roles, responsibilities and interrelationships of the major forestry S & T agencies in Canada, and to recommend ways in which these might be clarified and enhanced. Factors that determine the success with which the various agencies are able to deliver on their particular roles and responsibilities are also being examined in considerable detail. These factors include: the adequacy of funding; the maintenance of a strong knowledge and expertise base; the effectiveness of working relationships with client and partner agencies; the suitability of organizational structures for and management of R & D; and effectiveness of technology transfer, communication and commercialization activities. Some of the key issues being considered within each of these factors are listed in Table 2.

The project is being carried out through an extensive series of consultations, supported by a review of pertinent recent reports and publications. Consultations have been held at each one of Forestry Canada's establishments across the country, with separate sessions for research managers and for scientists and technicians. Senior staff in a wide range of other agencies involved in forestry and/or S & T in a more generic sense within Canada have also been consulted. The types of agencies involved include provincial government forestry or natural resource departments, provincial research councils, cooperative industrial research

Table 1. Some facts and figures on forestry and forestry S & T in Canada (all data are for 1989 unless otherwise noted)

Area of forest land	453.3 million ha	(49% of total land area of Canada and 10.5% of total world forest area)
Timber productive area	243.7 million ha	(54% of total forest land)
Gross merchantable wood volume (1986)	23.2 billion m^3	(of which, 77% is conifers and 23% is hardwoods)
Total area harvested	1.02 million ha	
Total value of forest products shipments	$50.4 billion	
Total export of forest products	$22.9 billion	(28% of world total)
Net export of forest products	$19.5 billion	(Canada's largest export earner; about as large as agricultural and fish products, energy, metals and minerals combined)
Total expenditure on forestry R & D	$356 million	(about 0.7% of total value of shipments)
Principal funding sources for forestry R & D		
Federal government		
Forestry Canada	$70 million	
Other	$22 million	
Provincial governments	$61 million	
Universities	$14 million	
Industries	$152 million	
Other organizations	$37 million	

Sources: Statistics Canada/Forestry Canada/Industrial Forestry Research Institutes.

Table 2. Key issues affecting the delivery of forestry R & D programs and responsibilities

Factor	Key issues
Adequacy of funding	• Total level of funding • Maintenance of funding stability • Dedicated program funding vs. core funding • Maintenance of critical mass of resources
Maintenance of knowledge and expertise base	• Peer review and evaluation processes • Supply of highly qualified personnel • Maintenance of science quality
Working relationships with client and partner agencies	• Adequacy/functioning of research advisory mechanisms • Promotion and effectiveness of networks, partnerships, and other collaborative mechanisms • Industry participation in R & D • Roles of "nontraditional" clients and partners • Removal of barriers between agencies
Organization and management of R & D	• Planning and priority-setting processes, and their link to budget allocations • Organizational structure for visibility and stability of R & D • Lead centres/Centers of excellence • Integration of regional (local), national, and international R & D roles
Technology transfer, communications, and commercialization	• Effectiveness of technology transfer mechanisms • Communicating the value of forestry R & D • Making industry more innovative • Developing a technology transfer and extension/service capability where it best fits

organizations, individual companies, university forestry faculties and other forestry-related departments or faculties, forestry research advisory bodies, industry associations, environmental and other nongovernment special interest groups, and federal government departments and agencies.

So far, over 40 separate agencies and more than 220 individuals have taken part in the consultations. In each case, opinions and experiences relevant to the series of issues outlined above have been canvassed from participants. All of the consultation sessions have been informal in nature, and stress has initially been laid upon getting individual participants' views and suggestions, rather than any "official" agency positions. It is also being emphasized that the project is not by definition a consensus-setting exercise; rather, its aim is to sample a complete range of agencies and individual viewpoints as "food for thought" in putting together a final report that will contain a complete, coherent, and objective set of recommendations on the best way ahead for Canadian forestry S & T.

To assist in the development of that final report, a small advisory group has been formed with membership from within Forestry Canada and from the provincial, university, and industrial forestry S & T community. This group, and all of the individuals and agencies consulted in the initial phases of the project, will be invited to review, and provide further input to the S & T agenda as it progresses through successive draft stages to its final form.

While the project is focused principally upon Canadian forestry S & T agencies, it will also

include some comparative information on the ways in which forestry S & T is handled in selected other countries. Of particular interest in this regard are countries that, like Canada, have a federal system of government, and also those countries that have had recent experience with more than one "model" for funding, organizing or managing forestry S & T. This phase of the project has only just started and will continue until spring 1993.

SOME INITIAL FINDINGS

The project is still under way, and a complete report will not be available until spring or early summer of 1993. It is therefore not possible to report any final or definitive results. Nevertheless, consultations have proceeded sufficiently far, and a sufficient degree of consensus has emerged in the views expressed by participants, that it is possible to give a preliminary indication of many of the themes that will feature prominently in the final report.

In considering this initial set of findings it is important to bear in mind that the first phase of the forestry S & T agenda project was deliberately focused on elucidating current problems and deficiencies. What follows is, therefore, largely a listing of ways in which Canadian forestry S & T falls short of an ideal that we believe it can and should attain. Despite this, it is also clear that Canadian forestry S & T programs remain strong and continue to be major players on the world scene. Recent initiatives to develop and strengthen research networks and partnerships, to enhance advisory groups through which clients can have a meaningful influence on forestry S & T priorities, and to put in place multiagency sustainable forestry research and operational programs, including a unique "Model Forests" initiative, are clear evidence that this is indeed the case. Most Canadian forestry S & T agencies recognize the need for the types of changes listed below, and are already beginning to tackle many of them. The willingness of Forestry Canada and the sector as a whole to undertake the "no holds barred" analysis implicit in the forestry S & T agenda project is also a clear indication of continued vitality and concern for future success within the Canadian forestry research community.

Some of the most important issues that will need to be addressed if Canadian forestry S & T is to continue to flourish are as follows:

1. The total level of resources allocated to forestry S & T in Canada is insufficient, both in terms of the needs and importance of the sector within the Canadian economy, and in comparison to many other developed countries with a significant forestry sector. This situation reflects the generally low level of investment in all types of S & T in Canada as a proportion of Gross Domestic Product, and the traditional reliance of the Canadian forest sector on large-volume, commodity products, which require relatively little research input. The structure of the Canadian forest industry is now beginning to change, however, and it is clear that this will need to be accompanied by a proportionately greater R & D effort if the industry is to remain competitive.

2. An increase in the overall level of support for forestry S & T should be a medium to longer term goal of the Canadian forest sector. In the short- to medium-term, however, making more efficient use of presently available S & T resources across the sector is at least as important, if not more important, than increasing the total effort.

3. The practice of forestry is becoming more holistic in nature, focusing more on issues such as sustainable development and the nonconsumptive values of forests, and drawing increasingly upon "nontraditional" expertise in fields such as biotechnology and the social sciences. This same trend is affecting forestry S & T in a significant and systematic way, resulting in the increasing involvement of nonforestry disciplines and agencies in forestry S & T programs. One example of this trend is provided by Canadian universities where about 40% of all university forestry-related research is now being performed outside of the forestry faculties. Clearly, our forestry S & T programs must respond in a dynamic way to these changes, both in terms of subject matter priorities and in terms of mechanisms appropriate to the wider and more diverse set of players now involved.

4. While considerable progress has been made in recent years, there is a continuing need to improve the level of collaboration between forestry S & T agencies in Canada. There are still too many barriers to communication and collaboration on an interregional and interagency basis, and a less than optimal level of collective effort on S & T priorities across the sector. Canada has suffered in this respect because of

its status as an intermediate size nation—too large to have been forced to confront the need for pooling of forestry S & T programs and resources between agencies, yet too small to be able to sustain viable wide-spectrum forestry S & T programs at several separate, and to some extent competitive, agencies. Funding constraints, and the increasing cost and complexity of forestry S & T, are now such that we must look at ways to increase collaboration and integration between major forestry S & T performers, as has already been done to good effect in many smaller nations (e.g., the Nordic countries).

5. One of the prerequisites for more effective collaboration between forestry agencies is a clarification and, where necessary, rationalization of the principal S & T roles of each one of those agencies. Without such sector-wide rationalization there is a tendency for many of the agencies to attempt to address the same broad spectrum of needs and priorities, with a resultant diffusion of resources that does not achieve the best collective S & T output from the perspective of the sector as a whole. All of the current forestry S & T activities are addressing real needs and priorities, but because of the present division of labor many of those priorities are not being tackled as efficiently as might be possible. A lack of clarity and understanding of the principal roles and responsibilities of each major forestry S & T agency also leads to an unnecessary degree of competition between them and a tendency to defend perceived territory rather than to collaborate more openly.

6. A greater degree of cooperation between forestry S & T agencies would also aid in focusing the research effort on particular topics and issues that are the areas of greatest need and "natural advantage" for Canada's forest sector. At present, there is a tendency for resources to be spread too thinly over too many topics in many Canadian forestry S & T agencies, with the result that critical mass and high scientific stature are difficult to achieve or maintain. More effort needs to be focused on innovative mechanisms for creating "lead centers" or "centers of excellence". However, at the same time, research needs to be recognized as a dynamic process, and such centers need to be based on existing and developing research strengths and not be unnecessarily institutionalized or forced-fitted to any preconceived organizational structure.

7. A greater measure of long-term stability in forestry S & T funding needs to be achieved. Over the past decade the focus of much of Canada's forestry S & T effort has swung towards the short-term applied R & D and service needs of industry and provinces. Short-term research, technology transfer, and associated activities are a very necessary part of the forestry S & T spectrum, but not to the detriment of longer term, more strategic work that is the essential basis for future applications. Not all forestry agencies can take the shorter term view if the total sectoral effort is to remain in balance, and some S & T agencies, including Forestry Canada, should focus principally on more strategic and higher risk activities. Recent trends toward more short-term work have been exacerbated by a trend towards short-term dedicated funding ("soft money") for forestry S & T to the detriment of more stable core funding. The adverse effects of this funding situation need to be reversed or at least mitigated to better take into account the long-term nature of most forestry research.

8. Better links need to be established between S & T priority setting and strategic planning activities and budget allocation processes. In general, Canadian forestry S & T agencies have done a good job in identifying priorities but a much less effective one in channeling resources to these priorities in a well-focused manner. Research peer review and evaluation have also been a mixture of successes and failures. These activities need to be carried out in a more consistent manner to ensure that research quality is maintained and the research program well managed.

9. The past decade has seen an expansion of forestry research advisory committees and councils across Canada, at national, regional, and institutional levels. Now that we have some years experience of how these various bodies function, it is timely to consider ways to reinforce the more successful ones and to modify or "re-invent" those that have proven less effective. Many of these advisory bodies need to focus more of their attention on strategic/generic forestry S & T issues and need to reexamine their membership to ensure that there is adequate representation for agencies and views outside of the traditional production forestry area.

10. There needs to be a greater recognition of the international dimensions of Canada's forestry S & T program. Forestry science has always straddled international borders, but at the same time there has been an increasing tendency in Canada to compartmentalize the "national" and the "international" forestry S & T activities. In practice, such a distinction has always been largely without meaning, and is even more so today in the context of a global economy and environment. As one of the world's leading forestry nations, Canada needs to redouble the steps it is now beginning to take to carve out a stronger and more appropriate forestry S & T role at the international level.

11. There is an urgent need to improve the S & T performance of Canada's forest industry—as a performer of proprietary research, as a contributor to forestry S & T on a wider front through funding and "in-kind" support, and as a user of research results. The industry as a whole also needs to become more innovative and more market conscious, and should be generating a much greater demand pull for research results than is presently the case.

12. Despite considerably increased attention in recent years, the effectiveness of technology transfer within Canada's forest sector still leaves a lot to be desired. Many S & T agencies have increased their technology transfer and extension efforts, but few have succeeded in developing strong capabilities in the field. Part of the problem lies with the diffuse nature of the forestry S & T effort referred to earlier, and part with the lack of a large innovative receptor population among industry and the provinces. A solution is not simple, and will necessitate a different and more innovative philosophy on the part of user agencies as well as a strengthening of technology transfer links and structures among the research agencies. All forestry agencies need to be involved in one way or another with all facets of forestry S & T from basic research to operational trials, in order for technology transfer to be successful, but there is also a need for some agencies to assume a leadership role in technology transfer and extension activities. Such a role most logically belongs to the provinces, and several of them have indeed moved in that direction in the past few years through such mechanisms as Forestry Technology Development Units.

13. Finally, there is a need to improve the overall profile and understanding of S & T within Canada's forestry agencies and among the public at large. This will not be a quick or easy thing to achieve, but must be tackled, principally through the education system, if Canada's forest sector is to remain healthy and competitive over the long term. This need reflects a more general need throughout the country to foster a stronger "science culture" that is more attuned to, and supportive of science and innovation within society.

CONCLUDING REMARKS

A wide array of actions will be needed to properly address the issues outlined above. Some of the steps required may be quite small and incremental in nature, but many of them will be substantial and long term in nature, involving radical shifts in corporate and government philosophy. They will not be easy, and they will not be achieved by "tinkering at the margins", but clearly they must occur if Canada is to remain a major player on the world forestry S & T scene.

It is, of course, impossible at this juncture to guarantee that the needed changes within Canadian forestry S & T will indeed take place. It is clear, however, that many of the necessary circumstances and building blocks to make it all happen are beginning to come into place. There is now a much greater recognition of, and concern over the maintenance of international competitiveness on the part of the Canadian economy in general and the forest sector in particular. There is currently a major restructuring underway within the Canadian forest industry; this is a very painful process in many ways, but also one that can be expected to lead to a leaner, more competitive and more innovative forest sector that is more supportive of, and anxious to be involved in the business of forestry research. Over the past five years, two national forestry congresses and the national forest sector strategies that emerged from them have achieved a broad level of agreement among stakeholders regarding future directions for Canada's forest sector, and all major forestry agencies have "signed on" to the principles and policies that were established by this means. It now remains to fully implement these in practice. The national forestry S & T agenda is intended as a major first step in that direction as far as S & T issues are concerned, and I would hope to be able to report to you again in the not-too-distant future to the effect that the needed changes are well under way.

DEALING WITH TRANSITION OF A RESEARCH ORGANIZATION

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To survive, forestry research organizations must change in response to the environments in which they operate and the needs of the clients they serve. The Pacific Northwest (PNW) Research Station, one unit of the USDA Forest Service's research network, has responded to the forces of change through programmatic and organizational reorganization. Programmatic and organizational changes were formally put into effect in January, 1991.

Deciding what programs to undertake and how to go about its business has turned out to be the easy part of reorganization. The real challenge to managing such a change is to move the organization, its people, its clients, its existing culture, its cooperators, etc., through the initial impact of the change to full implementation of the change. In short, to facilitate transition from the "old" to the "new", while minimizing trauma to the organization and its people.

Preliminary study of major sources of employee resistance to internalizing change indicate that the following factors need to be addressed by management: perceived loss of "turf" (physical space, responsibilities, organizational power, etc.); working relationships/attachments; familiar work regimes; impact on careers; loss of control; and simple resistance to change. To fully implement organizational change, management must thoroughly analyze each of these factors and develop an action program to overcome them. At a minimum, such a program must include actions to: foster an understanding of why the change is needed; clear understanding of new ways of doing things; build solidarity; create communication channels; monitor progress/employee attitudes; and facilitate common understanding.

The PNW Station is now immersed in developing management actions to facilitate organizational transition to its new organization. Experience gained in this process should be of great value to other research organizations who are adapting to the future.