PAPERS

Organising forestry research to meet the challenges of the Information Age

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SUMMARY

This paper examines the needs for forest science for the 21st century and ways of organising research to meet them. The world of the 21st century will be one of knowledge-based societies and globalised economies. The need for global stewardship of the environmental and social values of forests is finally being accepted. Yet pressures for economic efficiency and competitiveness are reducing the resources available to state forest agencies. Many countries are transferring management of production forestry to the private sector. Emerging technologies are greatly enhancing our ability to assess and monitor forest attributes, to process and disseminate information as well as to grow trees faster and to more narrow industrial specifications. Such changes will affect how forest science is organised, creating new demands for, and new suppliers of, research. Funding responsibilities will be re-distributed between the private and public sectors. The private sector can take over conventional forestry research on productivity enhancement, but it is unclear who will fund research supporting the public values of forests at the local, national and global levels.

Keywords: information technology, public goods, research funding, sustainable forest management.

A KNOWLEDGE-BASED ECONOMY

'Recognising the pressures for change coming from low cost economies using new technologies, skilled people and mobile capital, the focus of the White Paper is on developing the knowledge skills and creativity that are distinctive assets of a knowledge-driven economy, rather than traditional factors such as land and natural resources. These are essential to creating high value products and services and improving business processes'.
From *'Our competitive future: building the knowledge-driven economy'*. A White Paper for industry prepared by UK Government, December 1998.

The changing context for forestry research

The world is moving rapidly towards a knowledge-based society. In the twenty-first century, access to reliable information will increasingly be crucial to success in most endeavours, including the conservation and management of forests. As argued in the quotation above, knowledge, rather than the endowment of natural resources, is becoming a primary determinant of the economic performance of nations. Countries which have invested heavily in education, science and technology generally make more rapid economic progress than those that have not. Economists now use science and technology investment figures as indicators of potential economic prosperity. Many industrialised countries invest up to 3% of their GNP in R&D whilst most developing countries invest very much less, often only a fraction of 1%. They are currently being urged to invest more and some countries such as Malaysia have targets to greatly increase R&D investments in coming years. In agriculture, the percentage of product value reinvested in R&D is often 2 to 3%. In forestry, it is much less than 1% (CIFOR 1993). Although the need for more and different forestry research has been recognised, conventional resources available for public sector research are stagnating or declining.

This is true at the national level but a further problem exists at the international level. The report (UNCSD 1997) of the Co-chairmen of the Intergovernmental Panel on Forests (IPF) recognised a shared global agenda for forest research. Its successor, the Intergovernmental Forum on Forests (IFF), revealed great scientific uncertainties still on global forest issues and as a result recognised significant forest steward-ship issues that require research and analysis at a global or multi-country scale. IPF-IV identified the need for a thorough review not only of the research that is required

but of the mechanisms that exist to execute that research and to generate resources to support it.[1] The forest research community has been slow to respond to the challenges and threats posed by significant changes in our economic and social environment.

In response, an inter-sessional meeting of the IFF was convened by the governments of Indonesia and Austria at Ort-Gmunden in Austria in September 1998. The results of this consultation (Government of Austria, forthcoming) provide a compelling case for radical measures to address an emerging 'shared global forest research agenda' but also stress the key role of strengthening national research capacity in order to improve the performance of broadly defined national forest programmes. It also concluded that international development assistance to forestry should focus less on delivering ready-made solutions to national forestry problems and more on supporting national researchers in developing their own solutions. Aid in the past has focused too much on technology and infrastructure improvement and not enough on human resource development The overall conclusions were that there should be a multilateral response to the need for a global forest research initiative and that any international legal instrument on forests that emerges from the IFF should be firmly based in science.

THE CHANGING EXPECTATIONS FROM FORESTRY RESEARCH

As well as improved science and more science, there is also a widely perceived need to change the culture of science as applied to forests.[2] In the past, most forestry research was carried out by public sector forest research institutes whose primary mandate was the national forest estate. The normal scale at which research was conducted was the management unit or forest stand. Foresters did not in general look outside the limits of the forest that was allocated to their state forest service. Much of research was concerned with improving productivity for timber - genetic improvement of trees, site management, silvicultural treatments, and inventory and monitoring of forest stands. If there is a world forest crisis, it is not so much a crisis of declining supply of industrial raw materials, as one of declining supplies of environmental services and of forest products essential to the still-marginalised populations of less developed countries.

The international focus is now for research which answers the questions posed by a much broader set of forest stakeholders. The major determinants of the extent and condition of forests are decisions that are taken entirely outside the forest sector – decisions with regard to infrastructure, agricultural and trade policies, resettlement of migrants, fiscal policies, etc. A whole new body of research is needed to enable us to understand the implications of extra-sectoral decision-making on forests. There is also a need to better understand the relationships between people and forests at the local community and household levels, and then the connections between these micro and macro studies (CIFOR 1996). These needs suggest that research relating to forests must embrace a new scientific culture which includes investigation of extra-sectoral influences and social interactions, as well as the traditional disciplines of forest science.

Some of the most interesting recent findings have been from research that has been intimately associated with projects dealing with local management of forests. This research had some characteristics of the so called 'third generation research' (Rousell *et al.* 1991).[3] It implies a new relationship of the researcher to the manager — research which is fully integrated into the day-to-day operations of the enterprise. This is the industrial equivalent of the 'action research' that is familiar to agronomists and foresters working with local people. The community-based research on forests of the 1980s was a form of third generation R&D and it was precisely this research which broke the most new ground at that time.

The research challenge that is emerging is to understand the relationships between interventions at different scales to take account of the interests of multiple stakeholders and of the need to be able to adapt management objectives to changes in stakeholder perceptions and requirements. The term 'ecosystem management' has been used to describe this system-level research which attempts to reconcile the interests of multiple stakeholders. The US Forest Service Ecosystem Management Program and the Canadian Model Forest Program both integrate research into management at the landscape level. This seems to be the form of third generation R&D which is likely to predominate in the forest sector in the early 21st century. It is the adaptive management advocated, for example, by Holling *et al.* (1996).

Research at all these scales can benefit greatly from the application of systems analysis to its conception and execution (Bossel 1998). The systems approach, coupled with much greater capacity to manipulate spatial data through

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[1] It also recognised the need for greater co-ordination and finding synergies between the work of organisations such as CIFOR, the International Centre for Research in Agroforestry (ICRAF), the European Forestry Institute (EFI), the International Boreal Forest Research Association (IBFRA), Food and Agriculture Organization (FAO), International Tropical Timber Organization (ITTO) and the International Union of Forestry Research Organizations (IUFRO).

[2] The issues concerned have been reviewed in CIFOR's initial medium-term plan (CIFOR 1993), the 'Bali Dialogue' (CIFOR 1995) and in CIFOR's strategy (CIFOR 1996).

[3] Rousell *et al.* portrayed industrial R&D as having evolved from first generation R&D where corporations recognised the value of research and established a research capacity in isolation from their day-to-day activities in the hope that it would yield benefits in the long term. The second generation was where corporations set tasks for their researchers to accomplish and provided funding against a requirement for specific outputs. This is the classic contract research which now dominates much work in forestry. Third generation R&D (characteristic of more advanced corporations) is where the researchers and the corporate directors work together so that there is intense feedback between the research community and corporate management.

geographic information systems, is transforming our ability to predict outcomes of different management interventions in forests at a number of scales. We are already witnessing a move from reductionist forest science – working at the level of components of forest systems – to a more eclectic science attempting to generate insights into the functioning of the systems themselves.

In the past, forest research has generally been poorly linked to research on social, economic and ecological issues relating to forests. This must change if we are to achieve a holistic understanding of the role of forests in society, as the basis for sustainable forest management. Many of the problems facing forest science can only be adequately understood and addressed by adopting an inter-disciplinary approach that combines methodologies from the social and biological sciences, including economics, geography, political science and sociology, in whatever combination each problem can be addressed most effectively.

THE CHANGING 'SUPPLY POTENTIAL' OF FORESTRY RESEARCH

In the future, much new information will be generated and it will be disseminated more quickly and more widely than has ever been possible in the past. As knowledge expands and societies' needs change, the requirements for new information and the technologies to obtain it will constantly evolve. The scientists of the twenty-first century will need to continue to acquire new skills and knowledge throughout their careers. Steady-state science is a thing of the past. Scientists and scientific institutions who do not move with the times will rapidly become obsolete and irrelevant. Forestry research, in many jurisdictions, has not been able to keep pace with the changing concepts and priorities of forestry in the 1980s and 1990s.

National governments will become less dominant in research; the generation of new knowledge will be important to individuals, communities, cities and regions and special interest groups at all levels from local to global. Some areas of research, where the protection of intellectual property can be effective, are likely to be dominated by the private corporate sector. Investing in private goods research can be very profitable. But public goods research will probably need to depend on foundations, associations (non-governmental organisations) and a variety of multi-national bodies, since the gains from such research cannot be captured commercially. Because research will become a key element of viability, competition for research funds is sure to intensify. The days of academic seclusion driven by scientific curiosity will end. Research capacity could become a traded commodity – resources going for the research which the 'purchaser' perceives as yielding the highest economic impact. Institutions whose research is most relevant and effective are likely to attract most finance and thus be able to offer the best conditions and materials to their staff. As the best scientists will seek to join these institutions, specialised centres of excellence will emerge. But given the dynamics of global societies, coupled with the element of luck that is an inevitable part of all research, excellence will continue to be ephemeral. The groups of people who produce the leading research of today will not necessarily be at the cutting edge a decade later.

The impact of information technology on research

Many forest problems have to be researched at a local or regional level. Yet very few libraries in the world have comprehensive collections of literature on forests. Most of the best libraries are in the developed world. Forest researchers throughout the tropics have great difficulty in accessing the literature that they require as a basis for their research. It would require a huge financial investment for a new research centre in a tropical developing country to accumulate quickly a critical mass of printed literature on forests. Fortunately, major revolutions are occurring in the possibilities for storing information in electronic form and in the technologies that allow it to be shared. The availability of information on CD-ROMs is rapidly increasing.[4]

Increasingly all this information is becoming available on the Internet and more developing country scientists are getting access to advanced information technology. We can be reasonably optimistic that electronic communications are going to enormously facilitate access to information for forest scientists of the next century. Perhaps one of the new challenges will be sorting out the *quality* information from a large volume of poor-quality or irrelevant material which may begin to clutter up cyberspace and slow down meaningful electronic communications. The problem of how to 'sort the wheat from the chaff' – deciding what is quality information and what is poor quality or irrelevant – can be resolved as the medium matures.[5]

CHANGING INSTITUTIONAL ARRANGEMENTS FOR FOREST RESEARCH

Progress in these new priorities – integrated socio-biophysical studies, management planning, forest policy and monitoring – and utilising new technologies will certainly require substantial changes in the organisation of research. The new forest science to study the wider role of 'forests in society'

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[4] The World Conservation Monitoring Centre has put forest maps of the world on a CD-ROM. CABI has for some years produced Tree-CD which contains citations and abstracts of mainstream forestry literature dating back to the 1930s. Numerous other abstracting services in Europe and North America are now dealing with natural resources and forestry material.

[5] Over centuries, systems have evolved in the print media – respected publishing houses are differentiated from pulp fiction and from self-published books; the peer-review system establishes the credibility of top scientific journals at one end of the spectrum, compared to popular mags, pamphlets and advocacy at the other; BBC documentaries are differentiated from 'info-mercials' on TV.

will have greater emphasis on identifying underlying processes, rather than applied research limited only to forest management and timber production.

Most research on forests has in the past been conducted by forest research institutes established within national (or State/Provincial) forest departments. In some countries universities have had a capacity to conduct research and much work on the biodiversity of forests has come from academic institutions and non-governmental organisations. The private sector has dealt with a relatively narrow subset of research issues mainly dealing with trees for industrial plantations and technologies for harvesting and processing wood. It has been suggested above that increased investments in forestry research will come from the private sector more than from the traditional public sector research institutes. However, the difficulty of obtaining intellectual property protection on much of the output of forest research and the increasing value attached to the environmental public goods nature of forests are likely to have an impact on who actually undertakes research in the future, and who pays for it.

Classic mainstream research on **productivity enhancement**, notably on genetic improvement, micro-propagation and related issues to improve planting material for industrial timber estates seem likely to move almost entirely into the domain of the private sector. Fewer and fewer governments are attempting to manage plantation forests and some very large corporations (and some smaller ones) are already at the cutting edge of the technologies involved. Private sector investments in **biotechnology** are already running far ahead of those from the public sector. Our prediction is, therefore, that this area of research will be almost exclusively the domain of the private sector in the 21st century. The benefits of such research can be readily captured and privatised. Consortia of private sector researchers (e.g. tree-breeders in Australia and New Zealand) can achieve economies of scale, reducing any comparative advantages State-sponsored researchers may previously have held.

Processing and **harvesting** research and development may also move to the private sector. This is one area where intellectual property protection does allow private sector research to capture the value of its output through patenting. The sophisticated feller-bunchers now found in the forests of Scandinavia are an example of private sector R&D. As societies impose stricter conditions upon the environmental tolerances associated with forest harvesting, the need for sophisticated technologies to reduce impacts will increase (Sayer and Byron 1996). This should provide a major opportunity for the private sector. The role of the State is not to do the research, nor to specify which technologies must be used, but rather to specify the acceptable impacts and performance standards that society demands. Industry can best devise ways to achieve the specified limits. This represents a change from rule-based to performance-based systems.

There is a significant area of forest research whose products will be *national* public goods. This is research which deals with **environmental and social** issues of forestry - the needs for technologies, planting material and silvicultural methodologies, and institutional / tenure arrangements for small producers - areas where intellectual property protection is difficult. We would expect this to be the main focus for public sector forest research institutes in the future. These institutes will also have an important role in dealing with the increasingly complex issue of the silviculture of forests which are maintained primarily for amenity and environmental reasons but which are also managed for a wide variety of goods and services destined for consumption at the local level. Much of this research will be locality specific in nature and of a type where few products will be commercialised and intellectual property protection will be difficult. It will require major changes in those forest research institutes and particularly it will require them to mobilise more scientists from disciplines such as biology, the social sciences and economics.

There remains a significant area of research dealing with the *international* public goods provided by forests - global environmental services such as carbon sequestration and biodiversity conservation. As national governments become leaner and meaner, and if global governance and multinational corporations grow in importance, there are likely to be increasing research needs which will fall into the international public goods arena. Corporations are likely to re-locate to areas of comparative advantage for the production of forest products. Countries are likely to collaborate more and to recognise the significance of trans-boundary values of forests. This may lead to a whole new generation of research at levels of aggregation at which foresters have not worked in the past. If so, it will require the mobilisation of new types of science. Geographers, political scientists and economists may become much more important players in global forest research. International collaboration is necessary to develop research conclusions that are globally useful and acceptable and that can support local and national development goals.

Forestry research needs to be integrated at successive levels (CIFOR/IUFRO/FAO 1997):

(i) within each institution (Research Centre, University, NGO, etc.) among different forestry disciplines, but especially the biophysical and social sciences, to undertake inter-disciplinary research to the extent possible;
(ii) between forestry research groups and other scientific groupings within the same country, e.g. among forestry, agriculture, planning, policy, economics and other social sciences; and
(iii) among international institutions, e.g. IUFRO, CIFOR, FAO.

New research is necessary and appropriate because there is still so much to discover about the concept, not to mention the practice and evaluation, of sustainable forest management. The research institutions that produce this new holistic, strategic understanding of SFM may not be the traditional Forest Research Institutes that are often part of the structure of national forest services. They are likely to be research

institutions with a mandate beyond the conventional forestry goals of maximising sustainable timber production.

Institutions and funding agencies will need to allocate resources for inter-disciplinary training, particularly in developing countries, so that personnel can develop the skills necessary to undertake such research. The constraints placed on formal study programmes may need to be changed to recognise the important role of broader scientific training. Although past professional and academic discrimination against those skilled in interdisciplinary research is fading, the IPF Kochi Workshop (IPF 1996) called for 'developing rewards and incentives for conducting applied, multi-disciplinary and participatory research.' This statement recognises the numerous constraints and impediments that still face forestry researchers in many developing countries. The tendency in a number of industrialised countries for university forestry faculties to be superseded by environment faculties is indicative of how forest research itself is evolving. Much ground-breaking work recently has come from forest research organisations with broader environmental mandates than old-style FRIs.

The strategy that we believe is most likely to succeed will be to encourage existing research groups and institutions to collaborate at both the national and international levels. However, there are three apparent weaknesses:

i) present research structures are designed to focus primarily on biological and local forest management practices, and thus are often inadequate for forest policy and socio-economic analysis and global-scale research;
ii) research generally aims only at finding immediate solutions to local problems; and
iii) incentives to collaborate are sometimes lacking. Existing forestry research organisations are usually committed to their present agendas. There are still relatively few willing, and with the resources, to work in the new research areas.

An analysis of the numbers of forest research institutions and universities throughout the world and their staffing levels clearly shows how few developing countries have even a minimal capacity in forest science (in terms of numbers of institutes, staff or budgets). The effectiveness of the few scientists working on forest issues in developing countries is frequently constrained by shortages of equipment and operating budgets, by limited access to knowledge of advances elsewhere (through literature, training and attendance at research meetings), and local institutional issues. Some research staff and administrators may be unconvinced that the returns to collaborative efforts are sufficiently rewarding, compared with pursuing a solitary and single-discipline project. Some institutional structures are inimical to cooperation, accidentally or deliberately discouraging contacts between disciplines, departments and ministries because of the administrative complexity which such collaboration can imply when different sources of public moneys are pooled. In certain countries, public sector research staff sometimes function effectively but informally in NGOs or with private sector support, outside the official systems. More recognition of the local validity of informal systems might also help make international partnerships more effective.

There are ways round almost all these obstacles, but the effort may not be recognised as worthwhile until there are enough well-known success stories to convince all relevant parties that cooperation is definitely worth pursuing. It is not desirable that 'sustainable forest management' research be centrally directed. This would be counter-productive, given its exploratory nature. However, coordinating or harmonising individual efforts, which are physically dispersed but on common themes, can achieve very great advances. Even if a coordinating group merely lists the key **inter-disciplinary** research questions and acts as a clearing house to bring researchers together to address these, it will serve a useful function.

Funding for forestry research and sustainable forest management

If the research effort that is required to address global forest problems is to be realised, it seems almost certain that it will not be entirely funded from the conventional OECD aid budgets. The World Bank predicts that within the next two decades, some of the world's most important tropical forest countries will be leading economic powers. The G7 of the year 2020 may include Brazil, China, India and Indonesia.[6] These countries already make major investments in research and if forestry research needs in the 21st century are to be met, these and other tropical countries will have to bear an increasing share of the burden. In the closing years of the 20th century, we may also witness the emergence of major multi-national corporations operating in forestry, and multi-national insurance funds investing in forests.[7] They will be concerned with the sustainability of the resource base of their industry and prepared to allocate resources to support not only research and development addressing their own production needs but also to support some public goods research.

The personal fortunes that have been made by the owners of major growth industries coupled with the unprecedented growth of securities values on the world's stock exchanges have led to the emergence of powerful new philanthropic actors. The major foundations, especially in the USA, now command resources which exceed those available to most of the world's sovereign states. These foundations are interested in the environment and are emerging as major supporters of forest stewardship and forest science.

[6] The GNP of China (7th in the world, even excluding Hong Kong) and Brazil (8th) are already greater than G7 member Canada (9th) while India is currently ranked 15th and Indonesia 22nd (World Bank 1998).

[7] For example the Victorian Plantations Corporation was sold by the State Government in November 1998 to a consortium of US investment company Hancock Timber Resources Group (60%) and 3 Australian/U.K. life insurance/superannuation companies (40%) for Aust $550 million (compared to its book value of $A 352 million).

Forest scientists recognise the need to diversify their funding sources. Government forestry departments will not immediately be able to reallocate funding to complex, demanding new research directions. However, other funding agencies may be able to provide resources for the new SFM agenda. Greater diversity of funding will also lead to a more independent forest science which can simultaneously provide informed comment, even criticism, as well as guidance. If forest management in some countries is devolved to local communities and in others is increasingly in the hands of private companies, this will also affect the funding and organisation of research. In recognition of trends towards smaller government, and with the globalisation of forest industries, the nature and composition of funding for forest research will change, with limited government and NGO funds increasingly concentrated on social and environmental public goods while industries finance research with commercial applications.

The global trend to privatise forest research institutes, however much it may increase their cost-efficiency, would tend to lead institutions to re-organise their mandates and strategies to accommodate the interests of the new stakeholders.[8] But governments will still have to pay for much public goods research, and especially for international public goods, multi-lateral or inter-governmental funding will still be essential.

Already, much research in the new priority areas takes place outside conventional forest research centres, in other university departments, private non-profit research institutes and NGOs. As the influence of NGOs increases, which is probable if forest management becomes more decentralised, they may require more research support (perhaps from government research institutes), and are likely to undertake more research themselves. In India, for example, there are already extensive NGO networks monitoring and analysing forest regeneration and succession under the Joint Forest Management program. This constitutes a parallel, non-governmental research capacity, a widely-dispersed and loosely coordinated 'virtual FRI'. The research activities of commercial forestry organisations are also likely to expand, especially in countries where governments transfer ownership or devolve management of forests to the private sector.

An interesting analogy can be drawn with the Consultative Group on International Agricultural Research (CGIAR) which was established in the 1970s to address a shared international agricultural research agenda. It aimed to provide financial stability for long-term, high-technology, international public goods research. Most of its funding came from the major aid donors of the OECD. The difficulty that the CGIAR has experienced in maintaining its funding in recent years suggests that some caution should be exercised in advocating a similar mechanism for forests. Yet it is precisely this sort of long-term international funding that is needed for forestry because of the long pay-off periods involved and the public goods nature of most of the potential benefits.

Putting research results into practice

The results obtained from the type of research undertaken in the manner proposed here will lead to major advances in our understanding of the role of forests in society, and improved techniques for forest planning and management for an era of more sustainable development. However, the results must be put into practice, so they need to be communicated effectively to and forest managers. This is a vital element and emphasises the need to improve communication of research findings in the priority areas. The users of the information will vary from top policy makers to local forest dwellers and managers; intermediaries might include NGOs and university level researchers. At each level of dissemination, a different and innovative communication facility may be needed (Turnbull and Byron 1998). Where personnel to 'spread the word' are scarce, substantial resources may need to be directed towards training in communications.

Modern information technology is an effective communication tool. A partnership between policy makers and researchers is essential for improving in the techniques to deal with the pursuit of sustainable forest management. Researchers will need to recognise that government is not their only client. They will also have to service the different needs of civil society writ large and ensure that research results are communicated effectively to every type of client, especially those who are not on the 'information superhighway'.

CONCLUSIONS

Changes are occurring rapidly in how forests are managed, by whom and for what purposes. The new policy environment in which forest science now has to operate reflects a growing concern about environmental change, locally and globally, and the need to control this through more sustainable development.

The problem is to achieve a balance between the needs of all people; to recognise that changes in forest condition have multiple impacts on both local and global environments. Forests are a key part of the interface between humanity and the environment. They can no longer be studied as though they are simply 'outdoor factories to produce wood fibre', divorced from society and as if forest activities are only of local concern.

The international research agenda is broadening to include local and global environmental degradation concerns; a general decline is occurring in the finances available to support public goods research; and new opportunities are arising with the emergence of stronger national research systems in developing countries.

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[8] Because the recently privatised Forest Research Institute in New Zealand is financially dependent solely on commissioned research, its portfolio of research projects is almost exclusively private goods research – research which clients are willing to invest in, for commercial reasons.

To embrace these challenges, radical changes are imminent in the nature of forest science - the way it is organised, funded and undertaken in practice. The need for change is urgent.

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