

A COMPARATIVE STUDY OF FOREST RESEARCH  
ORGANIZATION AND POLICY

by

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## ABSTRACT

An attempt is made to evaluate the various concepts and to identify the orderly processes that allow of the efficient conduct of forestry research. Differing national research patterns are discussed.

Emphasis is on the organization of forestry research from the viewpoint of public and quasi-official bodies. The scope of forestry research is considered. It is stressed that forestry research to be purposeful must be reflected in the practice of forestry. Importance is attached to the maintenance of close relationships between research officers and forestry practitioners and consideration is given to the means by which this may be attained.

The need for specialist research officers with adequate supporting trained staff is emphasized and attention directed to the development of an organizational framework that is favourable to the conduct of research in forestry.

Although it is recognized that the difference between fundamental and applied research may, at times, be unclear, a distinction is drawn between the two. It is argued that because of the nature of forestry such differentiation is essential for the efficient conduct of research; different forms of organization, technique, staffing structure and qualities in the personnel being required in each case.

The link between research and education is examined, and, together with state, industrial, co-operative and privately sponsored research groups, attention is directed to organiza-

tional forms and the machinery of control. Research programming is considered, and the processes adopted by various agencies are reviewed, together with financial provision. The importance of inter-agency collaboration is emphasized.

Reference is made to personnel matters and to the conditions of service of research staff. Contrasting viewpoints on training for research are presented. Publication policy, and the dissemination of findings is dealt with in some detail and documentation processes reviewed.

There is some discussion of the functions and place of the experimental forest in forestry research.

Finally, international research activity is surveyed, and the work of regional groupings of various kinds reviewed. Stress is placed upon the contribution of the international agencies. The history and development of certain national programs is presented as an appendix.

An attempt has been made to present one philosophy concretely and consistently and, through consideration of the body of the literature, to explain this, while providing a framework that, it is hoped, may be helpful to others in the formulation of what must essentially be a personal philosophy.

Throughout, the universality of forestry experience is emphasized. A world view is taken and examples and views drawn from a number of countries in an attempt to obtain a synthesis of research thought.

"In research more important than  
planning, control, and costly buildings,  
is the correct atmosphere for the  
encouragement of the enthusiasm and  
the vision needed to lift research  
from analysis to creation."

Professor W. I. B. Beveridge.  
Fellow of Jesus College, Cambridge.

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## Foreword and acknowledgements

In this study the published writings have been scrutinized to determine research patterns.

I wish to make full acknowledgement of the debt owed to the many writers listed in the bibliography, both for background information and for material incorporated in the text.

Building upon this literature and on personal research experience, I have attempted to evaluate the various concepts and to identify the orderly processes that allow of the efficient conduct of forestry research.

This task of synthesis and interpretation would have been difficult without a background of experience, and the end product would have been the poorer but for those foresters of Great Britain, Europe, the Mediterranean Basin and the Middle East, and North America: colleagues, instructors, friends, who have shared, and enriched, these experiences. My ideas have been shaped to a considerable extent by these associations.

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J.V.T.

"You cannot plan discovery but you can plan the conditions which allow the discovery to be made."

Anon.

## INTRODUCTION

As Macdonald (154) and Laurie (147) have indicated, in forest research the possible subjects for investigation almost always tend to exceed the facilities available. It is essential that research activity be planned for the best use of financial and other resources. Among others, Wilm (223) has emphasized the importance of coordinated planning to provide for both the long-term investigation "which supplies great permanent values in land management investigations", and the short-term study of lower permanent value but with colorful momentary appeal, "the pot-boilers" which give a quick turnover of results". The concept of the research program, the problem analysis, and the experiment working plan, go far toward satisfying this requirement at the operational level, but the efforts of workers may be greatly facilitated, or retarded, by the organizational framework within which they work, and which in turn reflects the overall policy towards research and development. Clapp (52) ascribed many of the failures to make rapid or even reasonable progress in early American researching to poor supervision, poor organization, or a combination of the two.

At the Sixth British Commonwealth Forestry Conference, Canada, (29) A. H. Gosling stated,

"Unless research is properly planned, unless it is properly co-ordinated, the best results will not be achieved."

At the same meeting, J. D. B. Harrison said that the underlying objects of Canadian forest research policy were,

"to ensure the best use would be made of available personnel and facilities, to try to achieve coordination without regimentation, to preserve initiative and yet guide it."

The original and popular concept of research as the domain of the slightly eccentric and unworldly scientific recluse, Johnson's

"Hermit hoar in solemn cell  
Wearing out life's evening grey"

does not hold today. Most often present-day research is the function of comparatively large and complex organizations. Research may be the sole activity, or it may be only a minor interest. It will only rarely occur that the worker is free to follow his own inclinations; he has to come to terms with his environment. In compensation, he will almost certainly have greater facilities at his disposal and he will usually feel that his efforts are of some practical significance. Within this framework there is still much that may be done to facilitate the development of an atmosphere favorable to productive research. The difficulty lies in giving guidance without stifling initiative.

National traits clearly influence the approach. American procedures are, in essence, organizational. In Germany there are formalist patterns, in France, centralist tendencies. In Great Britain the structure which has evolved is opportunist, to a degree empirical, and with scope for improvisation.

In this study emphasis is on the organization of research from the viewpoint of public agencies or quasi-official bodies. These are most suited to the long-term effort necessary for the successful conclusion of much of forest investigation, for research today calls for sustained team-work, with a central, continuing administration and assured funds (69). In the development of the theme emphasis is on the utilization of varying levels of skills and experiences in the research team. Experience has shown these to be of great immediate importance to the practice of forestry.

It is only to be expected that there will be differences in opinion regarding the interpretations and conclusions presented. In part these may result from differences in terminology and nuances of meaning. Much depends on the background of experience. However an attempt has been made to present one philosophy concretely and consistently and, through consideration of the body of the literature, to explain this, while providing a framework that it is hoped may be helpful to others in the formulation of what must essentially be a personal philosophy. If all were agreed upon the conduct of man's activities such studies as this would be unnecessary.

In the United States the practice of periodic review and national project analysis has resulted in several major contributions to the literature (52,5,230,90). Recently Kaufert and Cummings (132) have completed a review of the status of current research.\* Research organization and policy was

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\* Duplication has been avoided and little direct reference is made to this report. It should be referred to for detailed accounts of more recent American activity and research thought.

considered by Francois (87), Chief of the Forest Policy Branch of the Forestry Division of the Food and Agriculture Organization, in his authoritative study on forest policy, law and administration and recommendations made for the positioning of the research organization within the administrative structure of Government. Considerable attention has also been given to research policy at the various British Commonwealth Forestry Conferences.

#### GENERAL RESEARCH ORGANIZATION AND METHOD

##### The orientation and scale of research

In general it is impossible to reach any definite conclusions as to a desirable scale of research effort. This can only be determined from direct consideration of local conditions, and especially of the stage of forestry development.

Details of most national research programs have been published (51,52,84). It is difficult to arrive at any realistic conclusions regarding their adequacy without personal knowledge of local conditions, or of the scale of the work described. Each country's research program must be adapted to its particular circumstances. Thus the proportionate forestry effort devoted to research in Canada, where,

"Silvicultural research has, up until the present been conducted in almost the complete absence of planned silviculture" (Bickerstaffe, in 29.)

but where there is extensive natural forest, has little relationship to the scale of research in South Africa where there is an intensive plantation forestry based on the use of exotics.

Nevertheless it is important that a balance be maintained and that the activity be commensurate with the total forestry effort. While the existence of an active and virile research group can do much to stimulate progressive thinking out of all proportion to its numbers, such a group should not absorb a disproportionate amount of the overall effort and resources. These resources may be of material, or perhaps of even greater importance, of men with a capacity for constructive thought.

Champion (29) drew attention to Troup's views, which, coming from a keen and experienced experimentalist, he felt should be given some weight. Troup was of the opinion that,

"... in the earlier stages of forest development the primary need is for efficient administration and executive work in the tasks of reservation, demarcation, protection, and survey, likely to keep all the staff which can be afforded fully occupied; that at this stage wholtime specialist and research officers may be a luxury which cannot be afforded..... the solution might be found in cooperative effort between neighboring territories with similar or common problems,"

In effect, the regional approach which is developing today.

Francois (87) holds an opposing view of priorities. He believes that research should be favored over administrative functions as the prerequisite to initial formulation of policy and the basis of rational administration.

It is obviously a matter of scale, and also possibly a matter of interpretation of the functions of that very diverse group of workers often included under the umbrella of 'research' for administrative reasons but engaged in a range of activities far removed from research sensu stricta. Laurie (147) declared,

"Forest research varies at the one extreme from fundamental scientific problems of tree physiology and ecology etc., through the practical problems of growing trees on particular sites, to matters that are doubtfully research at all, such as the collection of information for management purposes. One criterion that might be applied is whether the investigation is aimed at acquiring knowledge, or whether it is merely amassing data for a specific purpose."

In practice, such a definition is often not realistic. Laurie found it usually convenient to classify as 'research' all investigations that require a specialist staff to carry them out efficiently.

Experience both in the British Commonwealth and in the United States has amply demonstrated the weakness of depending on the general administrative cadre for the progress of investigational work.

"It takes a trained research worker to be constantly aware of the wide range of factors that play a part in producing any particular situation" (Champion, in 28).

Long experience has indicated that the specialized conduct of research in the field and the ordinary divisional officer duties cannot be mixed. While experiment maintenance can sometimes be left in the hands of the field officer, a specialist is required for the scientific details and maintenance of records (Ford Robinson in 29).

Chalk (45) discussed world developments towards specialist staffing in the immediate pre-war period. Since that time there has been very considerable expansion of specialized field research. Indeed, as has been well said in another regard, "Forestry, like other lines of business, runs to fads." (108) There is perhaps a present-day tendency for forest administrators to want 'research' in their departments regardless of the overall

picture, and perhaps on occasion, without any true knowledge of what it involves.

Irrespective of opinions as to the scale of desirable research effort, it is most important that enthusiasm be not allowed to over-extend a research program. It should develop progressively. Care must be taken to confine the investigational work to the limitations imposed by practical considerations of staff and facilities available. What is desirable will rarely coincide with what is possible.

One of the major problems has been the delimitation of areas of activity.

"Research programs are scarcely, if ever, planned from the start. They usually grow out of small beginnings according to the needs of the science or technology they serve, and, if not controlled severely, they can easily get out of hand. The possibilities of investigation are almost infinite and it is the general experience of anyone who tries to direct a research program that the field of investigation continually tends to expand, and become larger than the available research staff can cope with. This is inherent in any research conducted by workers with imagination and initiative. If it were not so, doubts should arise about the suitability of the research workers for their job." (147)

In departmental research the primary interest is usually, at least in the initial stages, the solution of current problems. The more "technological" the nature of these problems the less likelihood there is of obtaining the assistance of extra-departmental agencies. Such work will therefore quite naturally fall within the compass of in-service enquiry. When interest develops in research of a more fundamental nature, which is neither local in character nor confined to forestry, questions are apt to arise whether such research should not be left entirely to other institutions, whether it might not be

better to subsidize special researches elsewhere, or whether to employ a specialist within the forest service. The solution depends on the local circumstances.

Macdonald (154) emphasized that,

"..... any program of forest research must be closely related to the problems of the forest, and as the problems change in character so must the program of research vary in its scope, and in the parts on which emphasis must chiefly fall."

but he also warned,

"A Director of Research in forestry must be on his guard lest he be swayed too much by passing fashion. We all know how great a part fashion plays in forestry..... some of these enthusiasms have a very short life.... It is a bad thing when a program of research reflects too clearly the influence of these temporary changes in the current of thought in forestry circles."

He stressed the importance of long-term planning;

".... one must be careful..... lest the research program becomes solely a list of problems for which an immediate solution is sought. Research must look forward and the program must contain some items which are of little current importance but which will be of importance ten or even twenty years hence."

Although greatest attention is commonly directed to the biological and cultural aspects, the true needs of a forestry situation may require different research orientation. In present day North America it is commonly said that the greatest limitations to forestry advance are economic in nature. Under such conditions greatest benefits might well result from concentration on economic and managerial studies. The rapid development of interest and of activity in this general area in Northern European countries - in particular in Scandinavia and in Germany - in so-called "Work Studies", resulted from a realization of the importance to forestry of the solution of

the problems that resulted from the changed economic and social conditions after the second world war.

Clearly, as Clapp (52) wrote in regard to the United States,

"..... a broad understanding of the forest problem and how it must be solved constitutes the only satisfactory background for a critical analysis of the need for forest research, of its urgency, and of the character and size of a national program."

#### Fundamental research or applied investigation

Distinction between basic and applied research is often tenuous. Fundamental studies may result in information that has immediate and widespread application. Applied research will frequently produce fundamental information as a side issue. There have been many attempts at definition, recently by McQuilkin (157), E. C. Stone (197,198) and E. L. Stone (199). There is, of course no clear-cut distinction, but rather a gradation between two extremes. The difference is frequently one of initial approach and objective. Simplifying, basic research is often concerned with answering the questions 'what' and 'why', whereas in applied research interest is more frequently directed towards 'how'.

The situation is perhaps best summed up by E. L. Stone. After listing the whole range of terms; on the one hand, pure, basic, theoretical, fundamental, ivory tower, academic, impractical; and on the other, applied, non-basic, empirical, developmental, utilitarian, practical, he concluded,

"perhaps the test of good forest research should not be whether it is basic or non-basic, but, rather, is it relevant, is it well done, will it reduce the degree of empiricism in its area."

It is to be regretted that a tinge of apology is occasionally noted in the publications of certain organizations for concentration on applied investigation, suggesting that the authors consider their work to be somehow inferior on that account, for,

"ultimately the results of all research are judged by the improvement in efficiency and economy of operations." (147)

The approach should be dictated by the needs of the problem,

"When one (a director of research) has agreed to take a program up, one must decide whether it can be dealt with in the forest by experimental methods or whether it requires a more fundamental approach." (154)

In the Canadian Forestry Branch, research has been classified under three heads (Harrison, in 28). These are:-

Fact Finding Surveys, to evaluate and describe existing conditions as a basis for planning more detailed studies.

Fundamental Research, involving the study of the behaviour of factors influencing forest development and the adaptation of the methods and findings of the biological and other sciences to the solution of forest problems.

Applied Research, including the development of practical methods of influencing forest development, the improvement of operating and research techniques, and the testing of methods and equipment.

Often there are two irreconcilables, the need for immediate application, and the long time it takes for the accumulation of basic information. If a working solution, which will satisfy the needs of forest management, can be obtained through empirical investigation, it may be questioned whether

a public agency is justified in pursuing a more penetrating enquiry. Nevertheless, in a comprehensive national research effort, even if such activities fall outside the scope of in-service enquiry, there should be provision for the two lines of research, empirical and basic, for frequently the scientific foundation upon which to build is poorly developed. The division of responsibility will depend on local conditions. In settled countries there may be a basis of traditional knowledge, but this will rarely exist in the newer or less-developed nations. Harrison (29) looked for advice on this matter. In his discussion he indicated the effect of differences in the stage of national development on the orientation of research. He noted that, whereas,

"the European worker is living in a world of established forest practice and as one of his chief functions he is called in to find out why something goes wrong,"

In contrast the Canadian was endeavouring to conduct forest research in the absence of an established silviculture, and thus had a double responsibility to carry out investigations of the most useful character for the future and at the same time to try to stimulate the development of more intensive and better forest practice. He queried whether under such conditions fundamental studies might not be justified in in-service research. This situation obviously provides valid arguments for the adoption of a more fundamental viewpoint if considered in the light of comparisons between Canada and Europe alone. However there is also the circumstance that the more empirical approach has proved effective in the development of a rational

silviculture in situations where the total of scientific knowledge is but slight. Haig and his associates (105) have drawn American attention to the relatively simple information on which silvicultural practices have been based in tropical forestry, with very considerable success. The key to such empiricism lies in the provision of staff, both research and practitioner, of high calibre with a wide general background at the professional level.

Often, both investigational approaches are possible; the mass experimental attack, using less highly trained men and the evaluation of data from many field plots; or the study of basic principles by the individual, highly trained scientist. Field experiments can only give information of general application if a wide range of conditions is sampled, and may not explain causal mechanisms. The basic study, when completed, may still require a large experimental program to determine the necessary techniques. For example, in Canadian research,

"it has become clear that if the results of fundamental studies are to be put to practical use it will be necessary to arrange for a series of controlled cutting experiments." (35)

Although the Canadian Forestry Branch, as previously indicated, undertakes studies of a fundamental nature, it also recognizes that it cannot arrive at sound silvicultural practice through fundamental research into individual factors affecting the forest, while applied research will lead to sound practice in time (Harrison, in 29). The Forestry Branch feels unable to wait for a long period because of the pressing nature of the problems that face it, but it also realizes that

there is no substitute for applied research, for without it Canadian foresters "will never arrive at decent practice". This conflict, the Forestry Branch hopes to resolve through the conduct of fundamental studies that it trusts will help toward the earlier interpretation of the observed results of applied experiments - "if this is true then it is (considered) a complete justification for the fundamental research program."

Laurie (147) has discussed the two approaches in the following terms,

".... the ad hoc approach to finding what trees will grow best on a problem site is to lay down a series of pilot plots of different species and record their performance. The basic approach would be to study in detail the soils, the water relations, the available nutrients and other site factors on the one hand, and the physiology of different tree species, their tolerances and dislikes on the other, and gradually to build up a mass of knowledge on which to base the choice of species. The ad hoc approach is direct, quick and cheap. It depends upon making some inspired guesses to start with and results usually in a practical outcome that is useful. It contributes relatively nothing to fundamental knowledge.

The basic or fundamental approach is far more difficult. It becomes involved in elucidating a complex of factors and it may take a long time to produce practical results, and is usually costly in time and manpower. However, in the end, it will not only lead to a satisfactory solution to the problem at hand but may also add substantially to fundamental knowledge.

Both approaches are necessary in a well integrated research program as they supplement each other, the ad hoc experimental results often providing material for the fundamental researcher to work upon, and the findings of the latter providing inspiration for the ad hoc experimenter's guidance..... there is no hard and fast line between the two, each using the other's methods and approach to some extent. From the standpoint of research planning it is, however, convenient to make the distinction. The ad hoc experimenter works mainly in the field, carrying out experiments and recording the results. The fundamental worker, be he entomologist, plant physiologist, biochemist, pedologist, wood anatomist, mycologist or entomologist, requires laboratory facilities, expensive apparatus and more specialized scientific training."

Current American research philosophy appears to favor the more detailed or basic approach. Present United States Forest Service policy is directed towards extension of basic research in the national program. It is considered that the earlier more empirical methods have not proved entirely successful. The extension of basic studies in the American Pacific North West has been advocated, and formal graduate study towards higher academic degrees has been called for (61). In fact, this is being facilitated through suitable postings and assignments, and in other ways. Opinion has not been unanimous however. Previously Pearson (147) criticized "the western American neglect of experimentation through applied silviculture" for its inability "to provide a living demonstration of better silvicultural practice." He advocated field experimentation in place of "the conventional practice of working backward from visual effect to probable cause."

Without questioning the possible validity of the more recent conclusions it might be wise to recall the remarks (109) 154) quoted earlier on fashions in forestry, and, in any assessment of the success or otherwise of past American activity, to keep in mind the comparatively short time that work has been underway, and the difficulties encountered by the investigators, often working under very extensive conditions with limited supporting staff, and with little in the way of past experience to guide them.

The desire for more rapid advance is laudable but, by its nature, forestry is a long-term undertaking, and the bulk of forest research consists of the slow, routine, and painstaking

accumulation of facts, later to be interpreted in the light of experience. In the final outcome good forestry is dependent upon good field practice. No matter how competent its execution, research can have but little real effect in the absence of this.

The greatest advances in technique and real productivity in forestry research at the present day appear to be associated with those countries and organizations in which clear distinction is made between basic and applied research, whether this be formal or tacit. Different levels of investigation require different forms of organization, techniques, facilities, and not least, staffing structure and qualities in the personnel. When such differentiation is not clear, research may lose balance and, where major emphasis is placed on the fundamental aspects, lose contact with the practicing forester. This may be of small consequence in the case of the specialist working in fundamental enquiry, but it is unfortunate, and unsatisfactory, if the majority of forestry research officers cease to identify themselves with the practitioner. Macdonald (154) stated,

"... in my view it is most important that forest research officers should be at all times in close touch with their colleagues who are running the forests, it is a bad thing for the research worker to cut himself off from the general current of affairs."

In silvicultural research especially it is arguable that progress is most readily made when there is less concern with underlying causes, and silviculture is recognized as an empirical and inductive science, dependent in no small degree on personal skills, progressing from observation to observation,

and finally, by weight of evidence, to conclusions. Although the additional data which are obtained from detailed studies may be of great scientific interest, greater technological productivity is often to be obtained through less detailed and, possibly, more empirical approaches, with many more experiments on the ground, less comprehensive assessment, and the adoption of the strictly controlled crop approach. In applied field investigations the need is often for extensive methods of experimentation rather than the intensive methods of formal biology. This view does not lessen the ultimate value of fundamental enquiry, nor the importance of applying the results of such effort in practice, for applied research can progress satisfactorily only when based upon a sound foundation of fundamental knowledge. However, the need for vigilance in programming is underlined.

The varying concepts of forestry have undoubted influence. Where forestry is considered not so much a science complete in itself, as the synthesis and coordination of more specific sciences, and the interpretation and application of these to forest management, there appears to be less difficulty. In the British Commonwealth, with the possible exception of Canada, and in much of Europe, this concept is generally adopted and in-service research tends to concentrate on ad hoc investigation and the application of fundamental findings to technology. More profound investigation falls within the province of the man who has specialized in such problems, and who may be, but probably is not, a forester, either by initial training or subsequent experience. In North America lack of interest on

the part of pure scientists in the forest environment has led to the entry of the forester in these specialized fields. In India a similar lack of interest in the forest led to studies being undertaken by foresters that Champion (26) considered more truly fell within the province of the botanist. This state of affairs is, of course, not unique to forestry. A similar situation occurs and is often accepted in certain other professional fields. Nevertheless in forestry there are special considerations that arise from the comparatively small size and limited scope of the profession.

As noted earlier, it is not contested that forestry as an applied science cannot progress without fundamental research in such fields as plant physiology, ecology, soil science and the like. What is suggested here is that this work is better done when it is clearly recognized to belong properly in the appropriate discipline. The British view is that,

".....forestry will long need two types of specialists even if their fields will overlap to a varying extent, one whose work must by its nature be done in a forest environment and may be termed technological, and a second whose most effective environment is the research laboratory or workroom, with others working in the same speciality, but not necessarily in its forestry aspects. For the latter type the right training is a degree in the appropriate science..." (50)

Perhaps the lack of acceptance of these views in North America is a reflection of the lesser recognition of forestry as an area of truly professional endeavour and of the lesser development of scientific forestry as a discipline distinct from the underlying sciences.

Bailey and Spoehr (5), in their authoritative study of American forestry research needs, set forth the relation of

research, in the fundamental sciences, to forestry. They laid strong emphasis on the need for descriptive and empirical research,

"Even in those regions, e.g., Europe and Japan, where silviculture is most intensively practiced, it has developed almost entirely through an efficiently systemized empiricism. Thus the extension of silvicultural management over the earth's vast area of wild forest land must be preceded by a comprehensive descriptive survey and analysis of wildly fluctuating natural and economic variables, and by an intelligently formulated program of empirical experimentation." "Forestry cannot now wait for ultimate explanations of the extremely intricate biological phenomena of silviculture which must be supplied through exact and time consuming research in the basic experimental sciences."

These conclusions are of interest, for they are from outside the profession and from pure scientists, whom, it is to be assumed, might have been predisposed to favour a fundamental approach.

One explanation of the greater American emphasis on the need for fundamental studies in forestry, as compared to their British counterparts, may lie in the differing emphasis on pure research in the two countries. In Britain pure research, i.e., scholarly research undertaken for its own sake, amounts to 50 percent of the total national research effort. In the United States it forms 7 percent of the national total. According to Robert McKinney, (New York Times, Oct. 9, 1960) former Assistant Secretary of the Interior and first permanent United States representative at the International Atomic Energy Agency, only one-twelfth of present day United States ~~total~~ expenditure on research goes for fundamental research.

In terms of man-power, of about 300,000 full-time researchers engaged in research and development only 27,000 are in basic

research (218). Such bald comparisons are dangerous, but this particular circumstance may be a contributing factor in the emphasis on ad hoc enquiry that characterizes much of the applied research undertaken in Britain, both in forestry and in other fields, in that the work of the 'pure' scientist provides the necessary background (possibly of a cultural nature) to the efforts of the technological investigator, while in North America the researcher finds it necessary to develop this information himself.

Differentiation between the agencies engaged in various types of research activity varies in different countries. Where modern forestry was early established in the Germanic tradition this may have received little recognition. However, with the development of larger state research agencies, the older pattern is changing. At Zurich, for example, the Federal forest research agency is concerned very largely with the conduct of routine, applied enquiry, often of a long-term nature, while more fundamental studies are undertaken by the university (75). Weck and Kollman (220) have indicated an increasing realization of the desirability of such differentiation in German forestry research, and have described recent developments in the establishment of federal research institutions. In Britain there exists perhaps the clearest distinction. There, the overall national policy towards scientific research in general recognizes different types of activity. The duties of the Forestry Commissioners in respect to research have been largely determined by a report prepared in 1920 by the Agricultural Sub-Committee of a Cabinet Committee appointed to consider the co-ordination of

research work carried out by government departments. The Subcommittee recommended,

"for research work on other subjects (than timber utilization and other forest products, which is the responsibility of the Forest Products Research Laboratory of the Department of Scientific and Industrial Research and not of the Forest Authority) in connection with forestry problems and for any fundamental research other than that directed to an immediate economic result in relation to forestry, the Forestry Commission should refer in the first instance to the appropriate authority in whom is vested the control of research upon the subject under consideration."

The official policy of the Forestry Commissioners, which has developed from this, has been stated quite specifically in a Government White Paper (95), and reviewed subsequently (96). This policy is to leave the more fundamental aspects of forest research to the universities and other scientific institutions which specialize in particular disciplines, and are better equipped to deal with them. Where such enquiries are necessary for a practical outcome of some importance to the Forestry Commission's activities, the Commissioners' policy is for these to be carried out by individuals attached to these institutions. The cost of such research is usually met by grants from the Forestry Fund. If a study is not essential to operations, then responsibility for financing is not considered to rest with the Forest Authority. The staff of the Commission's own research organization is concerned mainly with the more technical aspects of forestry,

"with the more immediate practical experimentation and investigation, and with the practical problems arising", this is to provide a basis for the necessarily empirical methods of the executive staff.

## Research officers

"tackle and endeavour to provide a solution to problems as they arise in the course of large scale operations, and when failures occur, attempt to discover the causes and suggest remedies." (95)

Emphasis is on strictly controlled field experimentation, with concentration on crop observations and assessment. This arrangement has been found an efficient approach to research problems where specialist skills are available in universities or specialist institutes (147). It is recognized that in the absence of such facilities a forest authority may have to set up laboratories and recruit workers in the ancillary fields to supplement the ad hoc program.

Forestry has much to gain from the association of workers in related fields. Shirley (191) has emphasized the benefits to American forestry of such contributions from outside the profession. They bring fresh approaches. Viewpoints are uncoloured by forestry training, and new techniques enrich the research. It is noteworthy, and indicative of the wide range of talents which become available to forestry through a flexible research system, that selection of agencies for fundamental enquiry into forestry problems is not confined to the professional schools in Britain, but cover a wide range of scientific effort. In a recent Forestry Commission annual research report, in only three out of twelve basic studies reported upon, had the scientists concerned any professional forestry connection or background. Such investigations may extend over a period of years, with the development of close and highly fruitful associations between the research branch of the forest service and workers

in the basic disciplines. The worker may be at a university, at an independent research institution, or may belong to another government department. The arrangement is beneficial to all parties concerned. Individual researches are financed which would otherwise go unsupported, the Forestry Commission is able to call upon highly qualified specialists as required, and the researcher obtains assistance in the practical details of forestry and facilities, both material and personnel, that would otherwise be unavailable.

Nevertheless, it is important, when specialists are brought into association, that machinery be provided for close and personal relationships. Hollaway (in 16) has described how faulty liaison and lack of mutual understanding between botanists and foresters led to delay in researches into the natural forests of New Zealand,

"The botanists tended to supply blanket theories to "explain" all podocarp forests and all Nothofagus forests, while foresters, because these obviously were inapplicable to particular tracts, rejected these explanations and regarded the botanists as impractical theorists."

Formal and informal research, the observational method and the controlled experiment

Modern forestry practice has largely developed from empirical foundations. In the past much was achieved without specialized investigational approaches, e.g., the enormously enriched tree flora of Britain, which resulted from the skills of early arboriculturists, and which prepared the way for the extensive use of exotics in plantation. However, with progress, problems become less amenable to simple solution, and controlled and specialist enquiry becomes essential -

" the forests of many countries are littered with the remains of abortive experiments upon which much time, enthusiasm and money has been spent." (29)

Nevertheless, although formal investigation is now recognized as the major form of research activity, much valuable information and interest may result from small-scale trials and from observations. Shirley (191) has given a number of examples from America and Europe of advances only possible with the facilities and opportunities available to the practicing forester.

Lutz (151) stated,

"I would like to express my conviction that field foresters should never delegate all enquiry to professional investigators. Any forester who works in the woods can make useful contributions to knowledge if he has an enquiring mind and is a close observer. The long list of things we do not know about trees and forests includes many simple, but important, questions that can be answered without the benefit of either elaborate research equipment or highly specialized training."

There is a regrettable tendency, occasionally apparent in certain sections of present-day research, to discount the observational approach because of the admitted difficulty of producing statistically sound proof. Criticism, if any becomes necessary, should be directed towards the individual worker rather than as condemnation of the method. Correct evaluation is necessary and care must be taken to avoid selectivity in the fitting of natural phenomena to pre-existing hypotheses, or hasty conclusions on the basis of faulty interpretation of observed occurrences. But similar care is necessary in the use of the experimental method, when there is equal danger of the acceptance of results of limited experimentation as conclusive; in similar manner, responsibility rests with the interpreter.

In the words of Poulton (176), "one must beware of taking one feather from a goose and another from a leghorn." While formal, strictly controlled experimentation should provide the cornerstone of research activity,

"there is no more common error than to assume that, because prolonged and accurate mathematical calculations have been made, the application of the results to some fact of nature is absolutely certain." (A. N. Whitehead. ----)

Wilm (224) has discussed the desirable balance between "designed" experiment and "organized experience." He suggested that the research man is likely to place insufficient trust in the usefulness of training and experience, and to depend entirely on controlled experimentation; that a researcher should be able to develop a hypothesis on the basis of accumulated knowledge and observation which, if sufficiently strong, should be acceptable by itself, or, if some uncertainty is left, may be tested by experiment under controlled conditions. Conversely, he declared the practitioner to be impatient of the niceties of controlled research.

Bickerstaffe (15) has presented the views of the Canadian Federal Forestry Branch,

"The usual research methods employed in such fields as agriculture, biology, and the physical sciences can only be used in part for silvicultural research....., the long time element involved, the wide variations in forest conditions, and the difficulty in controlling or measuring various site factors for experimental purposes, often limit the application of the principles of experimental design and statistical methods. Although statistical methods are followed where applicable, much silvicultural research is undertaken with the full realization that the results are highly subjective and only as reliable as the judgement of the investigator."

This he considered a valid approach, for the demand was not primarily for information proved scientifically and statistically correct, but "rather for approximations to workable procedures which can be tested and refined under operating conditions." To provide this type of information, the Canadian Forestry Branch places emphasis on observational and applied research.

Support for the observational approach was very strongly given by Bailey and Spoehr (5). They constantly emphasized the value of the "extensive observational methods of the descriptive sciences" coupled with simple empirical experimentation, of so-called cumulative circumstantial evidence and, more especially, qualitative rather than quantitative data. Indeed, they questioned quite decisively whether the methods of the descriptive and the exact sciences could be combined successfully in the hands of a single investigator, considering that differing abilities, disciplines, and mental approaches were required. Few would subscribe to Bailey and Spoehr's views in their entirety today, but it is apparent from the literature that there is still a considerable body of support for their general conclusions. With recognition of the value of the statistical tools for experimentation that have been developed in recent years, there is also an awareness that the desirable qualities possessed by the gifted biologist and creative thinker are not necessarily linked with a mathematical facility. There are many roads to research contribution. "Guessers" and "accumulators", "speculative" and "systematic",

"intuitive" and "logical" are all terms used to describe the scientific mind, and all approaches have resulted in significant contributions (166). The greatest tool of research must always be the critical and enquiring human mind; inductive and deductive reasoning form a vital part of the research method. There should be no need to apologize for subjectivity.

#### RESEARCH AGENCIES

##### The relationship between forest research agencies and education

Investigational and educational functions are often closely related. There are two facets, the link between research and education within the organizational structure of a state forest service, and the more truly academic connection at university forestry schools.

Within a public agency the connection may be largely one of administrative convenience. Research, education, and, possibly, public relations divisions are formed of small groups of specialists. Individually these may be difficult to fit within an administrative structure primarily designed to meet the needs of territorial management. A typical arrangement occurs in the British Forestry Commission. There, a Directorate of Research and Education has equal standing with the major administrative divisions, the national Directorates of England, Scotland, and Wales. The Director is charged with the implementation of the Commissioners' policy in regard to research and education, the coordination of national activity in these fields, liaison with the universities and other research institutions, and foreign research agencies and international research organizations.

Within the directorate the two branches, research and education, are distinct, with standing equivalent to a territorial conservancy, the major executive formation. In British colonial forest departments, although on a smaller scale, there are often similar structures, with research and education divisions under a common administrative control.

A closer association may be found. In New Zealand the Forest Experiment Station was established during the immediate post-war years at the Rotorua Training Centre. In Malaya, there is a training establishment at the Forest Research Institute. In India, forest research, forest products research, and forestry education for officers and rangers are centralized at one institution, the Forest Research Institute and Colleges, Dehra Dun. This grouping was not so much a deliberate plan as a result of historical growth (178). The self-contained character is sustained by a township with hospital and school. The estate, comprising 11,000 acres, is under the management of the Central Silviculturist.

At in-service educational institutions the staff do not often engage in research, but there are exceptions. The Station des Recherches et Experiences Forestieres, the research agency of the French Forest Service, is an integral part of the French Forestry College at Nancy. The director of the school is also head of the research station and the professors take an active part in the research work. Nevertheless here also the trend has been towards increasing dependence on specialist, full-time, research staff, and the major, and long-term experimental and plot research of the French Forest Service is now done by such

personnel, while the academic contribution is largely confined to the basic and ancillary fields.

The circumstances of the Imperial Forestry Institute at the University of Oxford differ from those of most institutions. This Institute was expressly established with a dual function, as a centre for advanced forestry education, and also as a research centre. It was founded in 1924, consequent on recommendations of the First and Second British Empire Forestry Conferences,

"... to provide a central Commonwealth institution for advanced studies in forestry and to undertake research especially for those territories whose resources were not then adequate to deal efficiently with these matters." (47)

The institute is closely associated with the University School of Forestry, but is financed by various countries of the British Commonwealth. A common organizational structure has evolved in course of time and the two bodies are now completely amalgamated as the Forestry Department of the University, except for financial provision. There is also an advisory body to the Institute. In the Department the University School provides undergraduate instruction and the Institute is a graduate and specialist division, with special facilities to meet the needs of the serving officer or specialist, and carries on the research function. The staff is unified. Champion (47,50) reviewed the work of the Institute from 1924 in papers presented at the Sixth and Seventh Commonwealth Forestry Conferences. By its nature the Institute is not so well suited to undertake studies in the details of forest management as are the territorial Forestry Departments of the Commonwealth and its major research contribu-

tion has been in the basic and ancillary sciences, in major contributions to the literature, and in the facilities that it has been able to offer to forest research officers who require library and other facilities not readily available in their territories of service. Such men may work at the Imperial Forestry Institute for variable periods during the conduct of their researches. The library and documentation services are also made available to Commonwealth foresters on enquiry. Members of the staff may be called in by overseas territories as special advisors and to undertake investigations. An important aspect is the provision of a common meeting ground for foresters from the countries of the British Commonwealth. Comprehensive library facilities form the basis for 'Forestry Abstracts' published by the Commonwealth Forestry Bureau, a related but separate body, which is also housed at the Institute.

In Germany, many research institutes are associated with universities rather than with the forest services. These institutes differ in concept from those of the English-speaking world. They are small, frequently composed only of the specialist professor and his immediate assistants, are grouped at academic centres, and might better be considered as autonomous specialist sections of the larger institution. Kostler (146) and Weck and Kollman (220) have detailed the fields of interest. They cover the whole gamut of forestry activity with greater emphasis on fundamental enquiry. Criticisms have been advanced that, although academic atmosphere is provided by association with the teaching schools, and freedom of action results in research diversification, there is no over-all, comprehensive plan, and no

division between fundamental and applied investigation. The trend and nature of the research is largely at the discretion of the individual director, and reflects his personal inclinations. Incomplete coverage of important areas becomes possible. Further, there is no integration with the practitioner and dissemination of information is difficult. This is dependent on the many German forestry journals. To rectify these acknowledged weaknesses, other research stations have been established which appear to be more in line with those of other countries.

Older Scandinavian research structures reflect early German influence. The Norwegian Forest Research Institute, established in 1917, is at the Agricultural College at Aas. The staff consists of three professors, from the forestry division of the college, and four research officers. Work is done on biological and technical problems. In Sweden there is a similar pattern, the Forest Research Institute of Sweden, at the Royal Forestry College, is the central organization for state-subsidized research. Each division is managed by a professor with the cooperation of a research leader, assistants, and aides. The Institute is governed, together with the Royal College, by a joint board (83).

In Italy, a number of specialized agencies are associated with the university at Florence.

In Turkey, initial German influence is reflected in the joint research centre of the Research Division of the General Directorate of Forests and the Forestry Faculty of the University of Istanbul.

At Zurich, the Federal Polytechnic houses, in addition to the teaching school, the Federal Institute for Forest Research, the Federal Materials Testing and Research Laboratory, the Silvicultural Institute of the Forestry Branch of the Federal Polytechnic, and the Entomological Institute of the Federal Polytechnic. These are all concerned with aspects of forestry research and are state-financed, but also receive subsidies from various other funds (83).

Sponsored research institutes are commonly associated with academic institutions. Examples are the Forest Biology Centre in the Limburg Campine, Belgium, jointly sponsored by Province of Lunburg and the University of Louvain, and subsidized by the Institute for the Promotion of Scientific Research in Industry and Agriculture. This centre is concerned with research in the Campine forests. Specialists work under the supervision of University of Louvain professors (83). In South Africa, the Wattle Research Institute, at the University of Natal, Pietermaritzburg, operates under university auspices and is financed by commercial interests, the South African Wattle Growers Association. It is of interest that there is no other forestry connection at this University. In Canada, the Laval University Research Foundation is supported by the Canadian International Paper Company to promote scientific research and to develop post-graduate studies at the Faculty of Forest Engineering. There is close liaison with the Faculty and the School of Graduate Studies. Research is sponsored by the Faculty and primarily focussed on problems requiring immediate attention in the context of Quebec forestry; studies include both

fundamental and applied research.

In the United States, forest research institutes are an integral part of certain of the University schools of forestry. Perhaps most commonly associated with the state land-grant colleges, they follow the pattern of the Agricultural Experiment Stations, of which they may form a part. Although such institutes may have a separate director, it is often difficult to determine where the teaching school leaves off and the research institute begins. In some cases they appear to be primarily administrative devices aimed at the financing of professorial and graduate research and, through the provision of additional faculty, the reduction of excessive teaching loads, thus allowing additional time for research pursuit. Under such an arrangement there may be a specific allocation of the working time of a staff member between the research and education functions. There may also be full-time research staff, particularly where there is an experimental forest.

#### Other academic research

For much of forest research the resources of a state service or industrial organization are necessary. In the absence of the special facilities offered by associated research establishments, or special financing, university researching in forestry is at a disadvantage as compared with other interest fields because of the scale necessary for much investigational activity and the resulting heavy demands on staff, facilities, and time.

Nevertheless the unique facilities of the universities should be made available to forest science. It will be argued later that a research organization should be an integral part of

the forest administration. This does not imply that this agency should control all research. Especially in basic research the university contribution is of great significance. In general this rests upon the highly specialized and diverse skills of the faculty. These scientists are not confined to the professional forestry schools and it would be impractical to recruit full-time salaried staff of such diverse qualifications to a public research agency, even if the specialists concerned would consent to serve. The academic life has considerable attraction to such men. In addition these institutions have excellent libraries, unique and often expensive laboratory equipment and possibilities for consultation with outstanding scientists. All these provide the basis for developing strong programs in basic research.

The distinctive character of the university contribution to science requires special emphasis. It sets out to build up a body of knowledge rather than to solve particular problems. To a considerable extent financial and other support must be given to the individual rather than to the project, for major discoveries can be expected only through directing attention to goals that can be defined only in a very broad sense. Unless freedom is given, basic research cannot thrive. If it is subjected to too much administrative control and pressure for results, it can be stifled. The result is inevitably a program that masquerades under the name of fundamental research but which actually is a rather unimaginative extrapolation of known results.

A characteristic of the American literature is the acceptance of the desirability of maintaining pressure for research production. The intensity of this pressure may be subject to discussion, but the general concept is but rarely questioned. Although most evident in the writings on industrial research<sup>R</sup> it is also implicit in published statements of forestry agency policy. Some emphasis on results is to be expected in agency research, but the extent to which these pressures occur in the American academic world, and the processes by which they may be applied, are difficult for the European research worker, accustomed to academic freedom, or to a considerable freedom of action within in-service research, and to a less competitive atmosphere, to comprehend.

As research productivity is difficult to assess, recourse is often made in American research to output of publications. Such an index has obvious disadvantages, and is unsatisfactory as a criterion of research capacity and undesirable as a basis for research effort. Emphasis on publication can lead to emphasis on quick results and premature publication, and to fragmentation and unnecessarily detailed reporting. It can also lead to the submerging of significant work in a mass of trivia. The weaknesses inherent are generally recognized but, because of the highly competitive nature of American scientific activity, the title list retains its pre-eminent position for want of something better.

In organizations subject to direct fiscal control, some

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<sup>R</sup> e.g., Research Management, the journal of the Industrial Research Institute.

measure of administrative reporting is often unavoidable because of the difficulties of financial programming. Much time may be taken up in the preparation of detailed project outlines, progress, and terminal reports. In moderation this may be a healthy practice, but it is one that can well get out of hand and consume an inordinate amount of time and energy that might otherwise be available for productive research. It is particularly inappropriate in the conduct of basic research, the contribution that the universities are most suited to make. The problem is greatest perhaps in the context of those universities where the scientist, in addition to his academic connection, is also a member of an Agricultural Experiment Station, or where he has to seek individual financial support for his research projects. In the British system these intrusions on academic freedom have been avoided by the establishment of the Universities Grants Committee, composed of leading academicians, which allocates government funds to the various universities, and which Carmichael (44), an American commentator, considers has served admirably as a shield against public pressures on the universities. No detailed reporting back is necessary. In this way the administrative measures often necessitated by the needs of public accounting are avoided. Grants that are obtained directly also are not subject to the detailed control and reporting of American research, and in general the universities and faculty are very jealous of their independence and strongly resist any efforts at external control. On the other hand the funds available are often considerably less. Undoubtedly direction of research effort may result in greater

practical application of findings and its absence may result in much work being undertaken that makes no direct contribution to man's economic activities. In that sense it may be considered inefficient, but free enquiry in the tradition of the great universities of the world has provided industry with the basis for important technologies, and there would seem no valid reason why any greater measure of control should be needed in fundamental research in the sciences basic to forestry.

Hebb and Martin (110) have considered "free enquiry", as opposed to "controlled" or "directed" research, in the context of industrial and technological research. They defined free enquiry as the "pursuit of knowledge in which the investigator is at liberty to select his research projects in line with his fields of interest and to pursue his studies in accordance with his own judgement". A sponsored research program is usually motivated by the expectation of deriving eventual benefit. It is not to be expected, therefore, that it will extend far beyond the specified areas that show promise of yielding results of practical value. Freedom of enquiry is the first characteristic of basic research. Without this it cannot prosper. An equally important characteristic is the uncertainty of results, for the course of the exploration can rarely be predicted or results anticipated. Basic research often leads far from the initial objectives and opens up new avenues of advance. It is again stressed that the scientist must be free to explore the unexpected opportunities that his studies reveal. Attempts at control through the requirements of administrative programs and predetermined research outlines can only lead to constriction

and impoverishment through restrictive canalization.

The case for the close association of the applied forest research officer with the practitioner has been made earlier. The man in fundamental enquiry is in a different situation. Often such research scientists benefit from a certain isolation from current problems. As Hebb and Martin remarked "by drawing them into day-to-day activities you may benefit the present but sacrifice the future."

Organizational flexibility is desirable for free enquiry in research. It must be easy to set up new projects quickly, to carry out preliminary investigations, and then to concentrate activity where opportunities have been disclosed. Given the necessary resources, the universities are admirably suited for this.

The value of the academic approach and atmosphere in basic research is generally accepted. In applied or technological investigation the advantages are less certain, for it is easier to identify tangible goals. Consequently the course can be definitely set and freedom of enquiry may be circumscribed to some extent. Other considerations enter in. The applied researcher must remain 'close to the forest' in the figurative sense, for emphasis must remain on field activity since a woodland complex can be seldom reproduced in a laboratory. The desirable orientation may be obtained more easily in a rural environment than in either an academic or urban setting. There is also the need, previously stressed, to maintain close contact, and to be in sympathy with the practicing forester, "for the need for research arises out of the activities of the working

forester" (March, in 29). In this also the physical environment, and the intangibles of country living, play a major part.

"Forest research in general.....(is) apt to deviate into academic and somewhat fruitless channels unless continual inspiration from the forests is maintained" (Chaturvedi, in 29).

When the post-war expansion of British in-service research was planned, the new research centre might have been situated at a university centre. At Oxford, for example, there were the advantages of the academic environment, possibilities for close cooperation with the staff of the Imperial Forestry Institute and the Commonwealth Forestry Bureau, extensive library and documentation facilities and major research laboratories nearby. The other universities could also offer useful services and associated institutions and laboratories. It was, however decided to establish the headquarters of the expanded research branch in a rural setting. Subsequent development and expansion of this research organization and the contribution that it has made, during its comparatively short existence, to forestry practice and, through technological advance, to the implementation of the national forest policy, suggest the initial decision to have been soundly based in the circumstances of British research.

Dissociation of forest research from forest education was advised by Professor M. Näslund, acting for the Food and Agriculture Organization of the United Nations, in his recommendations to the Government of Burma on the formation of a Forest Research Institute (165). Although technical assistance reports

are to be interpreted within the context of local conditions, his views are representative on one body of opinion,

"An independent research institute must be completely separated from the University of Rangoon Forestry Faculty, because teaching takes so much time that the lecturers would be unable to fulfill their duties at the University and, at the same time, do comprehensive research."

His reasons for proposing the separation of research and educational functions were the importance of close and direct cooperation with practical forestry; the extensive nature of forest investigation; the frequency with which forest research necessitated the use of teams of specialists; and the need for these to be able to coordinate their scientific work freely.

It may be assumed that Naslund's views were conditioned by his background of experience of the Swedish forestry scene. On university research he wrote,

"The main object of the University consists in theoretical and practical education and all activities directly connected with it. University research work should be more or less restricted to short-term experiments which are not time-consuming."

Academic research was not to be bound to a particular research program. Research personnel were to be free of teaching commitments. Informal contact was envisaged, with faculty and students using the research institute for thesis work. It may be argued that such views lead to vocational-type training rather than to education in professional forestry, but in the assessment of the place of research in the educational structure much must depend on the nature of the research and the circumstances of the institution. Professionalism results rather from the outlook and background experience of the instructors, and out of the forest environment in which the student is trained,

than from the presence or absence of research in the educational scene. It can hardly be suggested that the Indian Forest Service Officer, or the colonial conservator of forests, is anything other than professional in outlook, despite the possible absence of a background of research in the educational process to which he was subjected. The situation is different when the emphasis is on the training of specialist scientists, when exposure to research processes is an essential portion of the training process.

Although research activity in the North American university schools of forestry was limited in the past there has been considerable attention given to this facet during the post-war period. Opinions as to the form that this should take range from the 'scholarly' to the 'comprehensive'. The more academic approach, and most akin to European thought, considers the colleges and universities as seats of learning, with the staff members providing instruction and doing scholarly fundamental research in their special fields, and with facilities for instruction and research by staff and students. Graves (90) considered contact with students a challenge to research workers, and has pointed out that it is through faculty research that individual schools often gain their special distinction and attract students in specific fields. He forecast the evolution of forestry schools as centres of productive research, as is the case in other disciplines. The scope of these undertakings would not usually be comparable to the specialized research agencies but equally significant contributions would be made in special fields, especially in basic knowledge. This approaches the

traditional concept of the university as a place where men have time to think.

A more dynamic role for the American university has been envisaged by Westveld (222). In his view, strengthening and expansion of state research (as distinct from federal activity) could be done most effectively and economically through the state educational institutions under the leadership of the various forestry schools. Increased state interest in post-war forest research he ascribed to academic leadership, and he indicated some of the advantages of working through the educational institutions. The advantages lay in personnel, equipment, ownership of forest land, and contact with specialists in other disciplines. He also indicated the greatest limiting factor to such investigational activity - lack of adequate financial support. To obtain this he advocated the direction of research effort to the solution of problems of local importance. In his discussion there is no indication that he recognized any differences between the necessary research structures and patterns for the conduct of fundamental and applied enquiry.

Emphasis on academic research indicates a virile academic cadre, but it is important that enthusiasm be not permitted to result in loss of perspective. Its extent must depend on the size of the faculty. While research is desirable and adds to the growth and scope of a school, it alone does not produce educated and well-rounded graduates. An active research program is essential for the advanced research student, but it is at least questionable whether emphasis on research is desirable at the first-degree level. Forestry differs from most scientific

disciplines in that most graduates are subsequently employed in the administration and technical management of a landed estate and in the direction of forestry operations, rather than in scientific activity. Over-emphasis on the research function, when a faculty is limited in numbers, may lead to the dissipation of faculty effort which should be directed to undergraduate instruction, where breadth, although not superficiality, is desirable, rather than narrow specialization. Although extensive graduate programs and faculty researches may be valuable they should not distract attention away from the undergraduate school. It is there that professional standards are set and philosophy developed. Although possibly outmoded, it might be salutatory to record the views of an eminent academician of an earlier period. To quote Sir Geoffrey Faber on Jowett, Master of Balliol, 1840-1893,

"He never concealed his own view that education, not research, was the first and final function of the tutor. Research, he seems to have thought, was more often a self-indulgence, an agreeable escape from more urgent, if more tedious, duties."

In Europe a considerable amount of fundamental research is done in academic centres. Many scientists are able to devote their major attention over long periods to researching. Students working for advanced degrees are able to devote all their time to research activity without the conflicts of prescribed courses and class-room activity. Although possibly working in fields ancillary to forestry and on problems with forestry connections, many of these workers are not foresters and may not be members of forestry faculties.

In America most forestry research of this nature is under-

taken by men trained initially as foresters and with subsequent specialized training in the appropriate disciplines. In recent years there has been considerable emphasis on formal advanced qualification through higher degrees. First degrees may have considerable vocational content, and of necessity formal teaching and course work has received considerable emphasis at the graduate level. Much time that would otherwise be available for faculty research or research direction is taken up with instruction and the close supervision of student study, both graduate and undergraduate, that is inherent in the American university system. It has been suggested that the part which the faculty should play in academic research is in the provision of leadership and encouragement of graduate students. This necessarily presupposes previous, or parallel, research contribution. Kaufert and Cummings (132) have indicated a close relationship between basic research and graduate training in American forest science,

"Take away the contributions to basic research through thesis study and contributions made as parts of applied studies, and little 'scientific capital', ..... would remain."

A characteristic weakness of research programs based upon graduate study is that this may lead to fragmentation of research and concentration on those areas which lend themselves to short-term study and to clearly delimited and straightforward solution, as contrasted with the very necessary, though less easily defined, integrating study of greater complexity.

Solutions to the problem of faculty research at the University of British Columbia were presented in a brief to the

Canadian Royal Commission on Forests and Forestry. Stress was placed on the desirability of undivided attention in the conduct of research of high quality. Three practical possibilities were the direction of research done by graduate students and assistants, the increase of teaching staff to allow the release of those particularly capable of researching for part of the academic year, and the provision of technicians to handle routine research processes (21).

The advantage of university research is the opportunity it offers for concentration of effort at various levels. Certain studies may be divided into areas capable of solution through a short period of concentrated work, and are well suited to graduate work. There is also the facility with which promising side issues may be followed at a relatively low cost.

Perhaps the most important quality for a university researcher is the ability to organize and co-ordinate the varied projects of his students, with all the uncertainties of student performance, into one major research scheme.

In general, the academic environment provides very favourable opportunities for fundamental research. There is also the stimulus of contact with colleagues, and students, and there should be an absence of pressures which seek to compel results within a specified time. Usually there are no restrictions other than those of finance and physical limitation. Nevertheless, there are recognizable weaknesses; projects are selected because of individual interest rather than importance or urgency, there is little programming, progress may be slow, the pressure of teaching may make research incidental. Conversely, excessive

preoccupation with research may lead to adverse effects on teaching, particularly in the lower levels.

In summation, the results of research at academic institutions are, in total, appreciable, and the distinctive character of the university contribution requires special emphasis, but a complementary and relatively more important contribution is often through the training of competent research workers and of professional foresters well qualified to apply the results in the field.

#### The development of state activity in forestry research

Forestry research, in the modern sense, did not exist until the latter part of the 19th Century. It had been early realized that observations, though useful, were insufficient, and that investigations were necessary to solve many problems, but the inherent difficulties, the scale of the material, and the lapse of time necessary before conclusions could be reached, mitigated against a successful outcome.

Gradually it became apparent that much of forestry research, to be successful, almost inevitably involved some form of organization which could assure continuity and conduct investigations on a sufficiently large scale. In 1861 Ebermayer advocated the formation of special research establishments. The first institute was founded in Germany in the 1870's. Others followed in countries where the forestry tradition was well established.

Toumey (210) described the formation of these 19th Century forest research institutes as "the final step in putting the foundations of silviculture on a firm scientific basis". Nevertheless overall progress remained slow and even in these countries

real expansion did not occur until after 1918.

The 19th Century European movement arose out of the dissatisfaction of the state administrations with the facilities and achievements of academic research of the period. In the United States the pattern was repeated. The evolution of 20th Century American governmental research was ascribed by Bailey and Sphoer (5) as an expression of dissatisfaction with the status, organization, and accomplishments of research in the universities, and particularly its subordination to teaching and administrative expediencies. Viewed in perspective there is the mitigating circumstance that, during this period, American forestry education, and indeed the profession of forestry itself, was still in the formative stages and striving for public recognition.

Although especially important where there is a lack of traditional knowledge of all aspects of national forestry development, research is the most difficult for which to obtain recognition and financial support. There may be little difference in the actual date of inception of research activity among the various major forested countries, but the significance of research was grasped more tardily in the less forestry-conscious nations, and in general outside of continental Europe research development has been slower. There are certain exceptions. Thus in the United States the Madison forest products laboratory was early in the forefront of its field, and in India there was forest research activity at an early date, the forest products laboratory and forestry research activity at Dehra Dun preceding similar institutions in the western world. However the overall picture shows

there was a general lack of appreciation of the potential value of research in the national economy.

This lack of recognition of research potential has often extended to the forest administration and to the practicing forester, and is not an index of the maturity of a country, for in many less-developed regions and colonial territories there was appreciation of research values a considerable time before these developed in more advanced countries. Although British foresters grasped the significance of research activity at an early stage in many of their overseas charges, the United Kingdom in its official policy was slow to implement large-scale research in the management of the developing home resource. In considerable part this was a side effect of strictly limited financial resources during the inter-war period. It may also be argued that, despite the relatively small size of the research establishment during this period, considerable research was in fact undertaken through sponsored university studies in the underlying fundamental problems, and actually in the day-to-day operations themselves, for these, to a very considerable extent, were essays into the unknown and therefore of an experimental or exploratory nature.

Cameron (42) pointed out, in explanation of the relatively slow development of research in Canada, that scarcity, or the threat of scarcity, is a great stimulant to research. In Canada, with an historic surplus of forests, there was belated progress. Similarly in the United Kingdom, with its traditional role as the world's major timber-importing nation, and with a secure trading position, it took two world wars, with attendant wood

scarcity, to stimulate forest research on a large scale.

The years immediately after the first world war were favourable for research development but expansion, in most cases, had proceeded little beyond the planning stage, when financial depression halted development and, in many instances, resulted in retrenchment.

With improved economic conditions, activity recommenced in the late 1930's, only to be disrupted by financial and staffing restrictions during the second world war.

The greatest expansion in forest research, and acceptance of the need for self-contained specialized agencies, has come in recent years. Today there are few national forest agencies in which there is not some provision for specialized research activity.

Birch (16) considered the greatest lesson from the history of forestry in New Zealand was that little real progress is possible until sufficient staff is available to manage commercial forest intensively and, at the same time, to carry out, without interruption, a research program, properly designed to improve and extend such management. But world-wide evidence indicates that, in time of financial stringency, research is among the first activities to be curtailed in an administrative organization. This supports the view that,

"Administrative activities and research do not combine advantageously, research becomes incidental, investigators become handmen, the doers of odd jobs, and investigations inevitably suffer. Research can only be done effectively in executive organizations if it is separated entirely from administrative activities." (52)

Nevertheless, as Francois (87) has pointed out,

"..... research on forestry and forest products, if not organized within the administration itself, should at least be closely co-ordinated with its aims and interests, since the results will influence the development of forest policy and form the basis for the methods of applying it."

#### Some aspects of state research organization

Forest management research is characterized by a diversity of organizational patterns. In part a consequence of the difficulty of centralizing silvicultural enquiry, this is also a natural result of the way in which such research has developed, beginning with the first tendency of executive officers to specialize, and culminating in the grouping of specialists in a research branch organized to meet local requirements. In certain instances evolution has been taken a stage further with the establishment of autonomous research agencies. Each country has to evolve a system appropriate to its particular social and economic structure. As Edlin (69) indicated, in one the central forest authority may take the lead, as in Great Britain, in another the universities may play a major part, with or without government support, as instanced by much fundamental work in Germany; or again, associations like the Danish Health Society may pioneer afforestation projects that increase silvicultural knowledge.

To a considerable extent forest research has been set apart from other land-use investigation. It has been argued that the time-growth factor, and the management problems of growth and yield, have no parallel in other biological enquiry; also that concern with populations rather than with individuals makes forest research distinctive. There have been advocates of a wider approach. Bor (19) proposed the establishment of tropical

land-use institutes, with emphasis on systematic botany and basic ecology. In the Anglo-Egyptian Sudan research was separated from the executive work of the technical departments of Government and placed under a separate Director of Research (211). But it has usually been considered that research in forestry should be separately organized from other fields of research effort.

It is doubtful how far this separatist tendency, except where there is a large forest service or a large forest resource, is justified. In part it arises from the desire of the forest administration to retain control of research programming and direction, and in part from a fear that the claims of forestry will receive scant recognition if competing with the more immediate claims of agriculture for facilities. Champion (29) voiced reservations because of this possibility and it must be admitted that forestry has often fared badly when in association with agriculture, so much so that the separation of forest departments from agricultural agencies has become almost a tenet of faith to many foresters. The desire for separate establishments may, however, also stem from a narrow professionalism.

Forestry and agriculture are complementary occupations. Many of the biological problems involved in their practice are fundamentally the same. In the tropics, in particular, the problems and environmental questions in connection with many economic tree crops and shade trees are similar to those encountered by the silviculturist in his study of the forest situation.

There are certain advantages in an in-service approach to

strictly technological enquiry, but even at this level considerable economies may be effected by the pooling of libraries, laboratory facilities, and the supporting non-technical and secretarial staff. Clearly, where facilities are limited, much may be gained from joint institutions, provided there is a realistic apportionment of funds to the various research areas.

In some cases joint land-use research stations already exist. Among these are the Institute of Renewable Natural Resources in Mexico, established in 1952 (11), and the East African Agriculture and Forestry Research Organization at Maguaga, Kikuyu, Kenya (134, 68, 101). It may be expected that such ventures will increase.

Organizational problems occur where there are various levels of government, as in a federation. If undivided responsibility rests with one level, difficulties are often lessened. In West Germany the Land is the forest authority, and forest research is undertaken at Land-financed university research institutes. Where the Lander are without university forestry schools, forest experiment stations have been established. These are directly responsible to the forest administrations of the individual Land. Such stations tackle current problems of urgent and local interest. Supra-regional research is financed by the federal government and conducted by the Federal Institute of Forest and Wood Economy at Reinbek, in association with the research institutes of the University of Hamburg. This establishment conducts research in forestry and forest products and is the national centre for work on forest economics and the preparation of forest statistics. It is also the national centre for the

documentation of German and foreign literature and, in general, is responsible for foreign liaison.

The division of spheres of interest is not, however, clear-cut or absolute. By custom, German research workers are allowed to devote a proportion of their time to projects of their own choosing, and are provided with the necessary facilities. Some duplication of effort occurs, with resultant advantages and disadvantages. The multiplicity of agencies results in the fragmentation of limited research funds (220).

It is desirable that agreement, whether formal or tacit, be reached on the scope of activity at each level of government. There is a useful arrangement in Canada east of the Rockies. The provincial governments are responsible for the administration of the forest estate while the federal agencies have major responsibility for the research effort, operating territorially at the invitation of the provinces. In general, the federal effort has been directed to more basic studies, and the more limited research effort of the provincial services to technological enquiry.

An unusual feature of Canadian forest research is the division of federal activity between two major agencies. The Forestry Branch of the Department of Northern Affairs and Natural Resources is responsible for 'forestry' research while the Science Service of the Ministry of Agriculture has responsibility for 'forest biology' - research and field survey in pathology and entomology. This arrangement originated in the advisability of associating a small biological protection staff with the greater facilities of the agricultural services. Differen-

tiation between research spheres is sometimes indistinct and the desirability of retaining the arrangement has been questioned, most recently by the Standing Committee on Mines, Forest, and Waters of the Canadian House of Commons, during its consideration of the 1959-60 financial estimates.

For long the Province of British Columbia stood aside from the general scheme. The Federal Science Service engaged in entomological and pathological research, but until 1958 research in silviculture, management, fire protection, etc., was the concern solely of the provincial service. Despite the Province's great dependence on a forest economy, the resources at the disposal of the federal authority did not contribute to the advance of forestry research in British Columbia. The Provincial research division is equipped and staffed for applied research,

".... the application of known principles or procedures to local conditions in which specific reactions can only be determined by direct experimentation and observation." (R. H. Spilsbury, in 194)

The division has comparatively limited resources and although the size of the provincial research staff may be little different from those of Ontario and Quebec, the other provinces with major forest industries, in the absence of the federal contribution the total volume of research has been less than in those provinces. This situation gains added significance from the circumstance that, while to a considerable extent the other provinces have common problems, and research findings have a wide application, the forestry environment differs considerably in British Columbia. Thus experience elsewhere in Canada is of small value and separate enquiry is necessary. There are

indications of greater federal participation in British Columbia research in the future.

Although, more usually, research institutes embrace a range of interests, specialized bodies have been formed in areas where certain aspects of forestry are of special significance. Entomological and pathological laboratories are of long standing. In northern Europe there have been similar developments in work studies and in tree breeding. In other cases, special interests may require continuous or semi-continuous observations in a specific locality. To meet these needs, and depending on the scale of effort, out-stations or independent research centres have been established. Amongst the earliest were stations for hydrological research, as at Jonkershoek, South Africa, which was established in 1935.

A notable development has been the specialist centre for work on one species, usually of special economic significance and distinctive cultural characteristics. An example occurs in the Wattle Research Institute at Peitermaritzburg. In post-war forestry those specialist groups concerned with poplar culture are probably the best known, largely through the activities of the International Poplar Commission. Typical organizations are the Instituto di Sperimentazione per la Pioppicoltura, Casale Monferrata, Italy, and the Institut de Popiculture de l'Union Allumettiere S.A., Grammont, Belgium. Other institutions have been established in various countries for the study of other species of special local significance, e.g. the Estacao de Experimentacao Florestal de Sobreiro, Portugal, for work on the Cork Oak; the Centro di studio catagno, Florence, concerned with

sweet chestnut; and the Instituto Nacional do Pinho, Rio de Janeiro, which deals with problems of pine silviculture.

#### Forest Products Research

While products research falls outside the general scope of this study, its general relationship with forestry research may be considered because of the very conflicting viewpoints that have been advanced in recent times. A brief review follows.

The relation between the two branches of research were discussed in detail by the Standing Committee on Forest Products Research of the British Commonwealth Forestry Conference (30, 31). It was concluded that, while there was no question of the necessity for a close liaison between the two branches, it was also important that those engaged in forest research should keep in touch with the living forest, while those working in forest products research should be in close contact with consuming industries and markets. Although the possibility of duplication of effort could not be overlooked, it might be better for the two branches to work independently. The disadvantage of a common institute was through the potential restraint imposed upon research workers in attempting to bring them too closely into line with one another. In addition, the director might have difficulty in keeping up-to-date with developments in both branches. It was also suggested that the combination of forestry with forest products research might tend to make the latter unacceptable to industry.

Advocates of a closer connection have been motivated by an appreciation of the desirability of a biological approach to products research. This is not a recent development. In 1939

Chalk (45), a wood anatomist, forecast that the study of wood structure would serve as a link between forestry and wood technology by finding the anatomical features relating to timber properties, and relating these to growth conditions. He suggested that real progress in wood technology appeared to depend more on biological research than on attempts to solve isolated practical problems.

Birch (16) has described the particularly close integration which exists in New Zealand and has indicated the possibilities for quick application of new knowledge. There, expanded forest products research has been obtained through its inclusion in the Forest Research Institute at Rotorua. Reid (179) believed this association to be closer to the ideal than any alternative approach. Emphasis is on "moulding the living body" rather than "dissecting the dead carcass" and researchers from both sides work together during the crucial developmental stages of the forest crop. Long-term responsibilities are recognized as equal in importance to the immediate needs and problems of the wood-using industries. Intimate contact is maintained with the silviculturist, the tree breeder, the pathologist, the entomologist, and the forest systematist.

The explanation of this distinctive pattern is perhaps to be found in the history of forestry and forest utilization in New Zealand. Uncontrolled exploitation of very large, clean, quality timbers has been succeeded by dependence of fast-grown, knotty timber from extensive plantations. Birch has described how these were established over a short period in "an extraordinary wave of nation-wide enthusiasm" some thirty-five years

ago, but with scant silvicultural knowledge or background, and followed by neglect. By close cooperation and integration of research it is hoped that better use of the remaining native forest will be secured, including its closer utilization and sustention, and also the improvement and better utilization of the exotic plantations.

In a review of Reid's paper (152) an opposing view was advanced. In Australia it is found advantageous to have the Timber Division of the Commonwealth Scientific and Industrial Research Organization separate from the Forestry and Timber Bureau, with each state, and also industry, cooperating with both. The suggestion was that success comes not from the location of research, but from co-ordination and co-operation between researchers and those interested in the results. In New Zealand the Forest Service conducts all research into exotics, and most of that concerned with the indigenous timbers and forestry. It has a big stake in the utilization of exotic forests, and the great majority of the remaining timber resources are state-owned. Under such conditions there is much to be said for integration. When such conditions do not obtain the application of research findings may not always be readily acceptable if they come from the Forest Service's own laboratories, "for there is not always an easy relationship between a conserving service and an exploiting trade in indigenous forests."

Most often, distinct organizational separation results from an absence of common problems, at least at the time of separation. In the United Kingdom, forest products research was removed from the responsibility of the forest authority at an

early stage. The Forest Products Laboratory is an agency of the Department of Scientific and Industrial Research, a body responsible for a wide range of industrial research laboratories. The desirability of this separation resulted from the divergent interests of the two branches. The timber technologists were primarily concerned with the industrial utilization of a wide range of non-indigenous timbers, of interest to a timber industry largely geared to an import trade, and of importance to the developing forest economies of the colonial territories. Home-grown timbers attracted less attention. Conversely the Forestry Commission was charged solely with responsibility for United Kingdom forestry, and at that time the major preoccupation was with the establishment of new forests. Nevertheless there has been close co-operation. An experienced forester is head of an external relations section of the Forest Products Laboratory and is responsible for research and advisory work relating to forestry and, in particular, for cooperation with the Forestry Commission (111). For the Forestry Commission, a forest research officer, engaged in investigations into utilization of products from the home woodlands, is responsible for liaison with the Forest Products Laboratory and the home-grown timber trade. Further contact is maintained through the media of advisory bodies. The Director-General of the Forestry Commission sits on the Advisory Committee of the Forest Products Laboratory. The Director of the Forest Products Laboratory is a member of the Forestry Advisory Committee. In more recent years the requirements of the developing United Kingdom timber resource have led to greater attention to the

local product and a major change in products research orientation is now underway.

Aside from administrative questions, close co-operation may well depend most of all on the training of forest products research personnel. Often these have been primarily physicists, chemists, and engineers, rather than biologists. With this background there may be a tendency to accept wood as a variable material with inherent faults that have to be countered by technical means. With a biological background, the timber technologist is more likely to have a better appreciation of how such faults originate in the growing tree.

#### Research by industrial agencies

Industrial or company participation in research is difficult to evaluate. In the older countries the state has been the principle or major forest proprietor and, although there are co-operative movements of various kinds, government has usually been the sponsor best able to support long-term and sustained research effort. With the development of large integrated forest industries with considerable land holdings the situation has changed.

In general, although corporations (especially in North America, where large industrial holdings form a significant portion of the national forest estate) show a liberal approach to the provision of financial support for academic research and education, there has been a tendency to confine company research to the solution of immediate and pressing problems of economic significance. The volume of such effort, in integrated operations, reflecting the realities of the industrial scene, has

been very much less than that devoted to research in manufacturing and forest products. There are notable exceptions, as for example the Weyerhaeuser Forest Research Centre at Centralia, Washington. As forest properties advance towards more intensive management, there is certain evidence suggestive of the development of a more sustained research interest.

Informal investigations by industrial foresters engaged in pioneer and exploratory development cannot be disregarded in any assessment of the industrial contribution. Especially in the early stages such work may be of great significance.

Potentially, industrial interests are powerful research sponsors. But certain weaknesses inherent in industrial participation need recognition. The researcher may find the commercial atmosphere uncongenial to sustained research effort; the public relations aspect may predominate; the industrial environment may result in pressure for quick results and early, or even premature, application, and a tendency on that account to favour short-term enquiry and a superficial approach; project selection and continuance may be subject to the whims of higher authority; programs may be liable to fluctuating financial provision; and there may well be excessive concern with company secrecy in regard to results obtained. Much depends on the long-term prospects and security of tenure of the company, and on the policy of the administration.

#### Privately sponsored research

Research may be sponsored by individuals, foundations, industrial concerns, or by co-operative action.

Foundation support for the individual researcher may result

in notable contributions because of the independence of action that such support affords; however, for major sustained effort, a continuing organization is necessary. Here, distinct research benefits accrue from sponsorship. Long-term financial support provides security, while a semi-independent status permits greater freedom of action than may be possible in government-supported research. When associated with academic centres, stimulating contacts are enabled while providing for independence from purely academic and pedagogic control. A valuable facility in such an association is the possibility of exchange of teaching and research personnel for varying periods.

Privately supported research institutes are few. An interesting example is the forest research centre at Dartington Hall, Totnes, Devon, England. This is part of a private trust for the support of a number of very diverse rural activities (18). Facilities are available for research on an associated commercial forestry enterprise, with woodlands, sawmills, commercial nursery, and forestry contracting. Untrammelled by outside control during almost three decades, notable contributions have been made to the economics of plantation management. In particular, researches have been associated with the name of the forest economist, H. E. Hiley.

#### Researches supported by associations and cooperatives

Typically, co-operative research brings to mind Scandinavian forestry. However, it is not confined to these countries. Certain institutions have already received mention, other examples are the New England Pulpwood Research Centre at Gorham, New Hampshire; the Institut für forstlich Arbeitswissenschaft

(Institute of Forest Work Efficiency), at Reinbek, Germany; the Wissenschaftliches Institut des Deutschen Pappelvereins (Scientific Institute of the German Poplar Association), at Brüll, near Cologne; and the Pulp and Paper Research Institute of Canada, at Montreal.

The New Zealand Pulpwood Research Centre is sponsored by industry and serves the pulpwood industry in the northern New England States, New York, and Pennsylvania (174). The Reinbek institute is sponsored by industry for research in work studies, and especially into the effect of working conditions on the physical well-being and efficiency of the labour force (220). The Brüll poplar institute is supported by the pulp and paper industry as a measure to encourage the extension of poplar cultivation. The Pulp and Paper Research Institute of Canada is the fundamental research centre for Canada's pulp and paper industry, supplementing the research organizations of individual companies, and acting as a documentation and publication centre. It originated in a partnership by the Federal Government, the Canadian pulp and paper industry, and McGill University. The Research program includes investigations ranging from fundamental studies in wood chemistry and silviculture, to applied research and development in manufacturing processes (39).

In British Columbia a co-operative approach was advocated by Gibson (89). He envisaged a provincial forest research institute as a joint undertaking of the provincial forest service, the federal forest agencies, the forest industries, and the university; the participants retaining their own identities, and undertaking their own projects, but through a common

institute, achieving a greater degree of coordination.

Co-operation in research has found its greatest expression in Scandinavia. In Denmark a significant role has been played by long-established associations. The best known of these is the Danish Heath Society which dates from 1866. This is a classic example of a group founded to further a specific activity - its aim the afforestation of heath and other lands unfit for agriculture. Proprietor to 8900 hectares, the society has exercised great indirect influence; by 1950 it had been instrumental, through advice and investigation, in planting 80,000 hectares. Other societies that have contributed to the development of research are the Danish Forest Association, founded in 1880 to further the technical and economic interests of Danish silviculture, and the Association of Danish Forest Graduates formed in 1897 as a professional society with one of its objects to assert the practical value of scientific education and research (83).

In Norway, before the postwar reconstruction, forestry research was carried on in the east by a state agency at the University and in the west, by the Western Norway Forest Experiment Station at Bergen, sponsored by the Norwegian Forest Owners Federation. After the Liberation a voluntary co-operative organization of forest owners, industry, and forestry and forest products research organizations was formed.

"... to facilitate the extension of research activities by co-operation between the forestry and wood-processing industries,.... to establish these activities on the broadest possible basis, embracing the whole field from the conditions governing the growth of trees in the forests until the testing of the finished products turned out by the mills." (159)

There were three categories of corporate members, Trade, Advisory, and Research. The first of these were the trade associations representing the forest owners, the timber trade, and the various wood-processing industries. These provided the necessary financial support. The advisory group was formed of the professional societies. The research members were the research agencies, the Norwegian Forest Experimental Department, the Norwegian Pulp and Paper Research Institute, the Institute of Timber Engineering, and the Merchantile Research Institute. Under the auspices of this society, research activity has been greatly stimulated and facilities extended, through co-ordination of activity and increased availability of funds.

In the special case of tree-breeding in Scandinavia the results of co-operative endeavour are well-known.

In 1936 the Swedish Association for Forest Tree Improvement was formed on the initiative of Nilsson-Ehle. To obtain the early practical application of the theoretical knowledge of genetical principles, which was resulting from the work at its Ekbo nursery, Lindquist organized the Society for Practical Tree Breeding. Membership was drawn from central and north Swedish forestry interests in co-operation with the Gävleborg County Forestry Board. As this society as a whole was not ready to engage at once on a full program of seed-orchard production, it in turn gave rise to a subsidiary, the Gävleborg County Tree Breeding Group, which in effect became the "activist" arm of the movement (203, 83, 200).

In Denmark development followed a similar pattern. The state forest service established forest botanical gardens in

1799, 1838, and in 1936. The last of these, the arboretum at Horsholm, became the State Forest Tree Breeding Station. In 1941 the Krogerup Tree Breeding Station was opened for the practical application of the principles evolved in Horsholm. In 1951 private forest owners in Sealand organized a co-operative agency with a tree-breeding nursery to facilitate the application of the new techniques in their own forests (83). Throughout there has been close co-operation between state and private interests, and between research workers and practicing foresters. In such chains of technical development it is difficult to say where investigational work ceases and application begins.

The Scandinavian characteristic of support for research through co-operative associations shows an awareness of the long-term benefits, to industry as a whole, of advance on a wide front through research. It contrasts strongly with the excessive secrecy which too frequently characterizes industrial research. A special feature is the close collaboration which exists among Government, Industry, Research, and University. Each of these makes the contribution for which it is most suited. These features are especially evident in the movement for the rationalization of forest operations. The object in this is increased productivity leading to higher wage levels to combat a declining labour force. Interest is shown in mechanization of operations and the rationalization of working techniques, and extends to the study of hand tools and their improvement and to work studies. There is a link with woods schools to train young labour and to increase the efficiency and skills of

experienced woodsmen. Swedish developments are typical. A joint group from industry and state, the Job Study Department of the Forest Employers Association and the Swedish Forest Service, was formed in north Sweden in 1937. The following year the Society for Wörmlands Forest Work Studies, a similarly constituted group, was formed in central Sweden, and a few years later the Central and South Sweden Forest Work Studies Society completed the national coverage. In 1950 a Work Study Department was formed at the State Forest Research Institute.

Scandinavian research patterns are notable for their extreme flexibility. The Scandinavians believe their approach to be sound; the research effort handled by several independent organizations and supported by the various interested groups, including the state, rather than the major research effort concentrated in one government agency. A characteristic is the way in which individual organizations submerge their sectional interests for the common good.

#### PERSONNEL PROBLEMS

##### Co-operation in research

Collaboration is common between staff members of public agencies. Rarely is forest research in the happy position of having all the facilities available. More often, it is done under extensive conditions with limited finances, and much may be gained through inter-agency collaboration, through formal and informal committees, joint projects and working groups, and through personal contact. If other groups or organizations are better equipped to work in special fields, it is clearly wasteful and inefficient not to make use of these facilities.

Birch (16) has described the close liaison that exists in New Zealand between the Forest Experiment Station and other specialist agencies. There is collaboration with the Geological Survey, the Soil Bureau, and the Plant Diseases Botany Division, while the Biometrics Section of the Department of Scientific and Industrial Research advises on statistical methods. The specialized agencies participate in forestry research projects, and the Forest Research Station in turn provides assistance, in particular through observations and collections by the National Forest Survey field staff and through extension of the interest field of the Survey. In soil conservation research and river control there is a full-time liaison officer to represent forestry interests.

Canadian federal research agencies recognize the importance of close inter-agency liaison under extensive operating conditions. A study of past and present federal activity reported,

"Establishment of such experiments (regeneration fellings) must depend upon the co-operation and assistance of the forest industries,..... Increased co-operation with the university forest schools is also being sought in connection with the development of a more comprehensive program of fundamental research,.... Additional avenues for co-operation with other organizations... will be explored ... to provide for a satisfactory coverage of the whole forest research field. .... it is hoped that undesirable duplication of effort can be eliminated. Mutual assistance is particularly necessary.... research facilities available are small in relation to the magnitude of these problems." (62)

The Canadian Forest Insect and Disease Survey, which commands the voluntary participation of the Provinces and the large industrial operators, illustrates the benefits of co-operation. Without the active co-operation of these collaborators the coverage obtained by the federal agency would be impossible.

Coordinating machinery is desirable. In Austria this is provided by the Society for Timber Research, through its various sub-committees (83). In Canada the position varies in the different Provinces. Ontario is most advanced. It has a Government Agency Committee, for liaison between the Federal and Provincial forestry groups, and also a Forestry Advisory Committee of the Research Council of Ontario, formed of all interested bodies at the provincial level. These are the Federal Department of Agriculture, the Federal Forestry Branch, industry, the University, the Provincial Department of Lands and Forests, and the Provincial Department of Planning and Development, there are local co-ordinating committees in north-western and northern Ontario. Tangible benefits have accrued from this joint planning. Costs are shared in group research projects between public agencies and industry. There are arrangements whereby the provincial authority provides buildings and facilities for research establishments while the federal services furnish staff for entomological and pathological research.

Coordinating committees of a similar nature have been strongly advocated for British Columbia. Buckland (32) drew attention to the number of agencies operating within the province. He gave examples of neglect of important fields, lack of coordination, and general misdirected effort as a result of the absence of liaison machinery. Sloan (194) considered that a formally established coordinating committee might be advantageous. Ker and Smith (137) indicated the advantages which would accrue in the special field of mensuration merely through

organization and standardization of procedures. In evidence to the Parliamentary Committee on Estimates of the Forestry Branch, Ministry of Northern Affairs and National Resources, on July 15th 1958, Mahood called for a B.C. committee of experienced foresters, representing the two levels of government, industry, and the university, under the chairmanship of a qualified layman, to make a comprehensive study of research programs. In the following year a delegation from the B. C. Lumbermen's Association endorsed these views before the same committee.

In Britain, liaison is obtained through specialist sub-committees of the Advisory Committee on Forest Research. These consider special aspects of the state research program and may actively engage in research. Procedures are informal and, if desirable to further activities, additional members may be co-opted (153). Inter-agency committees, either formal or informal, are frequently formed. Such an informal joint committee of appropriate officers of the Forestry Commission Research Branch and the Nature Conservancy has facilitated a co-operative program of fundamental work on forest soils and the application of these studies to silvicultural management. A joint committee with the Forest Products Laboratory coordinates research into the properties of home-grown timbers. Intimate co-operation exists between the Forestry Research Branch and some staff of the Rothamstead Experiment Station, an independent institution. This has made possible the conduct of a long-term program of nursery nutrition research. Neither agency would have the necessary facilities or skills to undertake a study

on the scale that has been accomplished through joint effort.

Similar patterns have developed with other bodies, and on varying scales, thus there is co-operative research in biological control with the Earl Grey Institute of Field Ornithology. Here, the machinery for co-operation consists of a committee of foresters, entomologists, and ornithologists. Direction and planning is done by the ornithological institute, field work by local forestry staff, and detailed observations, on a voluntary basis, by local natural history societies (153).

A necessary prerequisite for the successful outcome of such programs of co-operative research is close collaboration at the personal level.

#### Governing bodies and machinery of control

It is essential to avoid organizational patterns that make more provision for administrative channels than for the conduct of research. If the initiative and activities of research workers are curtailed through excessively centralized direction and supervision, really able men cannot be secured or retained. It is essential that not only salary scales, facilities, and opportunities for advancement are satisfactory - the right administrative environment must be provided. Nevertheless, without sound planning and administration even the most profitable avenues of enquiry are likely to be less productive and wasteful of effort. Successful research management has been said to be attributable all the way from "the best research management is no management" to "research can be planned, costed, and directed exactly like any other phase of business" (66). The reality falls between these extremes. The aim should be to

provide the atmosphere and smooth-running organization necessary for fruitful effort, while at the same time allowing maximum freedom for the individual research worker. At all levels there should be provision for the exercise of a reasonable amount of discretion. Professional and specialist staff should in no wise be expected merely to carry out a series of directives.

Undoubtedly the best form of administration is that based purely on mutual understanding and co-operation, but it is rare that an organization is small enough for this to suffice, and a certain degree of formalism has necessarily to be introduced.

Francois (87) described various structural patterns for in-service research, in relation to the executive branch, and discussed their advantages and disadvantages. Although not mentioned by Francois one of the simplest structures is that of a separate research division with a divisional head who is directly responsible to higher authority within the administration. This is perhaps the most common arrangement where the research effort is an integral part of a state forest service. So, in New Zealand, the Officer-in-charge of the Rotorua Research Station is responsible to the Development Division of the Office of the Director of Forestry, and, in Britain, the Chief Research Officer works under the Director of Research and Education, who, in turn, is responsible directly to the Director-General, the chief technical officer of the Forestry Commission. Such officers, executive heads of research organizations, are responsible for over-all supervision of all research branch activities, project development, programing, preparation of annual reports, co-

ordination and co-operation between sections, preparation of budgets, and all matters essential to the conduct of the research program. Within specialist sections, the section head has similar functions. Individual project workers have independence of action within their own sphere, subject only to the general supervision of the section head. Given good will and mutual understanding, this simple structure works satisfactorily even in large institutions.

Where a public research agency is independent of control by the forest administration, supervision may frequently be exercised through a committee or board. In Sweden the State Forest Research Institute, together with the Royal College of Forestry, is so governed. Specialist divisions are managed by professors of the Royal College with the co-operation of a research leader, assistants, and aides.

Kallander (130) has described the administration of forest research in Oregon. There is a five-member Forest Protection and Conservation Committee, comprising three members of the State Board of Forestry, one member appointed for a term of four years by the Governor of the State and representing the public, and the Dean of Forestry at Oregon State College as ex-officio member. Among other duties this committee establishes policy, controls expenditure, and coordinates the activities of state agencies under the jurisdiction of the State Board of Forestry in regard to "research and experiment in the development of techniques for the protection, rehabilitation and management of forest lands". An Administrator is appointed, but

responsibility for the conduct of research rests with the Director of the Forest Lands Research Centre. The Director is appointed by the Committee, with authority to hire personnel, make expenditures, and "do or have done all things necessary for such research activities." There is a Forest Lands Advisory Committee of ten members representing state, education, research and industry, with the director of the research station as secretary. A similar pattern exists for the conduct of research in forest products.

In certain countries, especially where there are a number of interested factions, considerable importance is attached to the separation of research from the forest administration. From 1862 to 1900 Danish forestry research was conducted by a department of the forest service. In 1902 this group obtained separate identity as the State Forest Research Station within the Ministry of Agriculture. Full control rests with the Director, in collaboration with a Forest Research Commission, representative of state and private forestry and of higher forestry education (83). In Germany the research institutes are autonomous, with the Verband der Forstlichen Forschungsanstalten (Union of Forest Research Organizations) to negotiate with government (83).

The importance which some forest researchers attach to freedom from administrative control is exemplified by Näslund's (165) and Kollman's (139) recommendations. They advised separation of the proposed Burmese research establishment from the Forest Administration, with direct responsibility to the Ministry of Agriculture and Forests. As an interim measure, the

Chief Conservator of Forests was to be responsible for administration, but there was a specific reservation that the research program be "quite independent of control" by the administration. An initial program provided for a joint forestry and forest products research centre but eventually these also were to be separated. The ultimate achievement of complete independence was to ensure that research was "absolutely free and unfettered".

Though advantages may result when private forestry interests are of considerable importance, it is difficult to see very real advantages to a public research program in separation from intimate contact with the executive agency, when this is the major, or only, forest manager. The dangers of research isolation from the real problems of the forest are obvious. To quote Francois (87),

"Since research in forestry and forest products is absolutely necessary to any forest administration, the administration should be in a position to issue the necessary directives for the conduct of such research so that the attention of the research body is always focussed on the problems of greatest concern to the development of a sound forest policy and the efficient implementation of that policy. . . . . forest research has to obey such directives. Forest sciences, unlike pure sciences, have utilitarian objectives and must solve definite problems. . . . . specialized bodies for forestry research, or at least for the co-ordination of research results, must form an integral part of the administration."

It is to be stressed that the raison d'etre of forestry research lies in the practice of forestry. The function of the research worker, in the final analysis, is to serve the needs of the practicing forester. Temporary advantages may occur in separation from an unsympathetic administration, when more effective direction may result from autonomy, but is questionable

whether, in these unhappy circumstances, a research program will have any real impact. Positive advantages in recruitment and staff retention may occur, nevertheless, if separation facilitates the introduction of a staffing structure more suited to the needs of research and the provision of more satisfactory terms of service.

In co-operative or other independent research agencies, ultimate control is usually vested in a board representative of the supporting interests, often with the addition of independent members. In Canada, the Pulp and Paper Research Institute is administered by a board designated by the Crown, the Royal Institution for the Advancement of Learning, and the Canadian Pulp and Paper Association. There is also an advisory panel of leading members of the forestry and related professions. In Quebec, the Laval University Research Foundation is administered by a board of nine directors chosen from among the members of the Foundation. A Director of Research supervises all projects approved by the Board. The Foundation is formed of members who, by virtue of function, knowledge, or financial support, may help it to realize its objectives and pursue scientific investigations. The Dean of Forest Engineering is a member ex-officio of the Foundation, president of the Board of Administration, and serves as liaison between the Foundation, the Faculty, and the School of Graduate Study. The Woodland Manager of Canadian International Paper Company is vice-president. This company provides the major financial support. There is also a Board of Governors composed of leading industrial executives and eminent representatives in the fields

of education and research. This Board has an advisory function and the task of furthering knowledge and appreciation of the objectives of the Foundation amongst the general public.

The Norwegian Research Society of Forestry and Forest Industries, discussed earlier, is so constituted that each corporate member, in any of the three categories of research, advisory, and trade, forms a separate group, with its own group committee. These committees are responsible for activities within their own fields and for drawing up financial proposals. The Chairman and Vice-Chairman of the Society, together with the chairmen of the research groups, form the chief administrative body, the Research Board. This Board coordinates the detailed proposals of the individual groups and prepares the research program. Such a structure would seem admirably suited to the marshalling of financial resources and the coordination of activity among diversified interests.

Many research organizations make use of advisory or technical committees. Munns (163) described the State Forest Council of Poland. This had five or seven members, the Minister of Forestry, the Forestry Member of the Central Planning Board, the Chief of the Forestry Administration, representatives of the furniture and wood-using industries, and the head of one university forestry school. Among other duties it exercised an advisory function at the State Institute of Forest Research.

In the United States Forest Service, Forest Research Advisory Committees at the national and regional level date mainly since the early 1950's. These are formed of representatives of industry, wild-life and livestock interests, the forestry

profession, forestry education, and the public. They advise and assist in the formulation of research programs (141, 191).

In the United Kingdom there are two bodies to which the Research Branch may turn for advice. The first is the Technical Committee of the Forestry Commission, composed of senior officers who scrutinize the proposed programs in some detail. The second is the Advisory Committee on Forest Research. This is a committee of eminent scientists who meet periodically to discuss the research program, with specialist sub-committees. These sub-committees may undertake research programs themselves, or arrange for projects to be carried out. Some of these have extended over long periods, the procedures are very flexible. Through these two committees reference is made to the experience of practicing forest officers and to scientific opinion. They also assist in the difficult decision of deciding when to discontinue a research project (154).

For Burma, Naslund and Kollman proposed two special bodies, a Research Council, and an Advisory Board, to secure "regular, continuous and close co-operation" between the research institute and interested government agencies, the university, and the wood-consuming and exporting industries. The Research Council was to be composed of the Chief Conservator of Forests, the Chairman of the State Timber Board, i.e., the forest agency responsible for the control of exploitation, the Professors of Forestry and Engineering at the University of Rangoon, the Director of the Research Institute, and the two Deputy Directors of the Forestry and Forest Products Branches; the two first-named to hold the offices of Chairman and Vice-Chairman respec-

tively. This Council was to meet at least once a year to receive reports of the Institute's activities, discuss pending projects, and make suggestions for further research work. The Advisory Board was to comprise the Chief Conservator of Forests, and the Chairman of the State Timber Board, as Chairman and Vice-Chairman respectively, the representatives of the Ministries of Finance, Industry, Agriculture, and Forests, the Agricultural and Rural Development Corporation, the Agriculture Department, the National Housing Board, the Burma Railways Board, and the Timber Trade. This body was to meet near the end of the budget year to receive a report of research activity, in the interest of the body which they represented, in financial and other suitable ways.

Committees may be useful at the working level. Departmental project committees form automatically according to the needs of research; it is a matter of convenience whether these be formally constituted or not. The more formal programming conference may usefully be considered. Laurie (147) described United Kingdom procedure. There, the program conference extends over a number of days and is attended by all Research Officers. Every officer has a copy of the full program and the conference provides a valuable opportunity for ensuring that all research sections are kept informed of what other research sections are doing. At the discussion, notes are made regarding priorities, the possibility of carrying through difficult projects with the resources available, and the organization of work affecting more than one Research Officer, with clear allocation of responsibility. Every project is thoroughly discussed.

To provide for a longer-term review the work of either a whole or one or two of the smaller sections, or of a group of major projects, is subjected to a detailed review. The aim is to cover the whole field with these special reviews once every five years. The officers responsible prepare papers detailing the position reached in their work, and the lines on which future work is proposed. These papers are critically examined. After the conference the program is submitted to higher authority and to the Research Advisory Committee for scrutiny and comment. It is not formally sanctioned, though it is expected to be adhered to fairly closely, and in all Sections a certain degree of elasticity is preserved.

In India, Research is planned on a five-year basis, with a formally authorized Research Plan. A program is outlined and sanctioned as the Research Working Plan by a quinquennial Silvicultural Conference at the Forest Research Institute. This conference is attended by the Provincial Silviculturists and senior forestry officers from all India (178). Champion (46) described the procedures. Prior to the Conference, and after consultation with the territorial Conservators and Divisional Forestry Officers, a draft program is prepared in the Working Plans and Research Circle. The Central Silviculturist is given the opportunity to make any suggestions he may wish. Finally the draft is discussed and amended as found desirable by the Silvicultural Conference. At these conferences important matters of silvicultural policy are discussed and decisions taken on practices to be adopted. The record of past conferences shows detailed debate on basic silvicultural concepts and

systems of silvicultural working. In these deliberations the results of research, the corpus of existing knowledge, and the accumulated experience of the conference enter in. Decisions of the Silvicultural Conference have played a major part in the development of Indian Forestry. Although formalistic, these procedures have long provided for that synthesis which is desirable in a unified or federal administration operating on a continental scale.

However, investigational work, at whatever level it is undertaken, cannot be kept within strictly fixed boundaries. No matter how well-defined and specific the original scheme, fruitful research will tend to develop in directions that can rarely be predicted. On this account flexibility of organization and freedom of development are essential in a rational research program. Where the scale of the enterprise permits, there would seem to be advantages in the avoidance of formal, long-term programing.

The autonomous, yet more formalistic, status of some research groups, illustrated by Näslund and Kollman's writings, shows again in their concept of a collegium, composed of the senior members of the research institute, and meeting at the decision of the director, or at the request of at least one-third of the members. This collegium, as the governing body of the research institute, considers all research matters, both technical and administrative. It prepares the annual program and the budget, and is also responsible for personnel matters and the nomination of candidates for staff vacancies and promotions. If the director wishes to propose candidates he must

first consult the collegium. In this structure the director would seem to be rather a chairman among equals than an executive.

Programing procedures in the United States Forest Service have been detailed by Shaw (190). Proposals and plans are prepared by research officers and are subjected to the criticism of executive foresters. At least once a year, regional program review boards, representative of the regional administration of the national forests and of research, meet to consider programs and progress. The members are the heads of research and administrative units and the senior officers of both sides. It is a principle that all discussions are attended and not only those dealing with particular specialities. Opinions are formulated as to the relative attention to be given to different fields competitive in terms of men and money. Shaw remarks that this form of review ensures an air of reality to the research program and that "the retention of fascinating and costly forays into academic investigation" is unlikely if the chance of practical application cannot be substantiated, but that on the other hand the researcher knows that his findings are not likely to be disregarded.

Without criticizing this regional structure or questioning the desirability of bringing administrative personnel into close collaboration with research staff, it may perhaps be queried whether the situation suggested by Shaw's comment should ever arise in a research program with correct emphasis and a sound recruitment policy. "Fascinating and costly forays"..." or other unrealistic investigations or attitudes should not

arise in a properly oriented, applied research program in which the research officers identify themselves with, and have an understanding and appreciation of, the problems of the field staff. In such a program it is undesirable to employ men who, perhaps through exposure to basic research techniques during their educational experience, have adopted the viewpoint of the pure scientist.

If on the other hand, the program is specifically intended to embrace fundamental enquiry, then there must be freedom of enquiry and it may be questioned whether the administrative forester should sit in judgement, for the non-specialist will rarely have the background knowledge to evaluate. Men trained in the basic disciplines are required for such research and to a considerable extent there can only be confidence in the worker. If critical evaluation of the desirability of continuing a project is desired then this is better obtained through reference to a panel of independent, experienced scientists of standing, than to the judgement of an administrative branch the members of which will often be unqualified to assess the matter and who may tend to over-emphasis short-term objectives - Macdonald's "passing fashions and enthusiasms" and Hebb and Martin's "benefits to the present by sacrificing the future".

Shaw also ascribes another advantage to combined administrative/research conferences which may be questioned. These are said to give an urgency to research. Shaw says that there are always reasons why one more year of study seems essential to the researcher, reasons which are satisfactory to himself and to his vocational colleagues, but that administrators are "commonly

cold to such subjective wishes". Aside from the very questionable desirability of pressuring research (which should be unnecessary if staff of adequate calibre is recruited), this statement suggests a lack of accord between research and administration. Clearly there must be machinery for control. Macdonald (154) has indicated the importance of the Technical Committee of the Forestry Commission and the Advisory Committee on Forest Research in this regard in the context of British forest research. But such bodies should be advisory in nature. The final decision must rest with the director of research. Shaw's description may not give a true representation of the system in practice; behind the terminology there may be considerable flexibility. Nevertheless, it is noteworthy that the thinking basic to his views is the antithesis of that of the continental European research worker with his desire for independence from administrative pressures, as evidenced by Näsund's philosophies, the autonomous status of the Danish state research station, and the Union of Forest Research Organizations in Germany. Even if the extreme view is not held, the achievements of Continental forestry, often with very limited resources, suggest research benefits from the minimum of control by forest administrators. Especially in basic research there is much to be said for the advice of Leonard Engel (73) "Get a good scientist .... and let him alone".

#### The status and conditions of service of research staff

The need for high-calibre personnel and the frequent necessity of living under isolated and possibly primitive conditions are conflicting elements in research staffing. To the research

worker the absence of the intellectual stimulus to be derived from contact with other investigators may be of greater importance than the more material disadvantages.

Applied research, particularly, may necessitate permanent residence at remote field stations. Research workers will usually have strong professional orientation and men of the required calibre will often be prepared, and indeed desire, to devote themselves to field research. But it is important that dedication be encouraged by positive action.

"... official recognition,... should be on a par with that accorded to office jobs." (173)

"... all too often an individual is not adequately recognized until employment elsewhere is under consideration". (164)

This is not merely a question of financial remuneration but rather one of general recognition.

Difficulties which may be minimized by departmental action are concerned with questions of housing, living conditions, pay and promotion, provision of educational facilities for children, and working facilities. In remote regions they will often be concerned primarily with the well-being of the officer's family. It may seem unnecessary to stress these matters, but experience has shown these to be potent considerations in determining the efficiency of a research program, and which can be easily overlooked in the operation of an administrative machine.

It is most important that no man be directed to work in research, or remain in such work, against his wishes and inclinations. This applies equally to professional and to subordinate staff. The aim should be to make research sufficiently attrac-

tive to gain and to hold men of the required type, but without making it so attractive as to draw personnel purely because of material benefits.

Provision of adequate career prospects for specialists in a non-specialist service frequently causes difficulty. The question is how to recognize non-administrative scientific accomplishment. Francois (87) suggested it to be advisable, if all persons concerned have received the same basic training, to lay down the principle that all may be called upon to serve in any branch of the forest service. He recognizes, however, that some compromise will always be necessary, for a long period of specialization may make a man unsuitable for a position of corresponding responsibilities in another part of the service. The situation is made more difficult than in other biological fields because of the executive and administrative nature of much professional activity, and which results in promotion structures into which it may be difficult to fit senior specialist officers. Research is not alone in this difficulty, nevertheless within research groups possibilities for promotion are often more limited than in other, less specialized branches. Provision should be made so that competent men who wish to make the change do not suffer any disadvantage in eligibility for promotion to higher grades within the administration. It is desirable, of course, that a man is not necessarily obliged to abandon his research connection if he is to obtain advancement. There are obvious advantages in retaining outstanding men with long research experience within the research structure. Also, it does not follow that because a

research officer advances to research administration his positive contributions are ended. He may well enter upon a period of greater real productivity through the added facilities available to him.

But the qualities that merit recognition in a research officer are not necessarily those most suited for administrative duties. As Dinsmore (66) indicated in the context of industrial research, there are all degrees and gradations of scientific ability and a man who is an excellent research worker and can produce very valuable results as a creative individual may be unable to assume the responsibility for directing and coordinating the work of others.

In the past it has been suggested that a departmental research officer should have experience in administration before entering research. This concept is dying in the United States (164), but it is recognized that lack of such experience prevents a man transferring out of research, even when all concerned recognize the desirability of such a move from the research standpoint. One objection to the complete separation of research personnel from the executive is that it considerably reduces the possibility of a successful transition from research to administration. Movements in the opposite direction also become more difficult. When previous contact has been close, transfers are less difficult and may benefit both branches.

In many government agencies in the United States, "the difficulties in advancing or recognizing a research worker on the basis of his research contributions have been well-nigh insurmountable" (164). To advance a man it has been found

necessary to assign more and more administrative duties which cut into research time. Further, the number of administrative posts is often limited, and rarely sufficient to satisfy all requirements. The situation is similar in other countries.

Sometimes it has been possible to provide another path of advancement, the so-called parallel research ladder, where appointment is made to research positions of increasing independence, responsibility, prestige, and salary, with specific titles dissociated from those of the administration. Even when administrative functions are attached to a senior post, clear differentiation of title from the general administration is desirable. A first requirement is recognition that a scientist, working as a scientist, can make fully as great a contribution as is made by a supervisor (184). It may be remarked that in certain of the British dependencies the Chief Research Officer has received a larger remuneration than the administrative head of the service under whom he serves.

It is a frequent characteristic in research establishments that expansion, and hence recruitment, occurs spasmodically, resulting in the grouping of personnel of similar standing and seniority. While limitation of senior administrative posts in research is logical and determined by organizational needs, an arbitrary limitation of senior research appointments is artificial. The only real limitation to advancement in research appointments should be ability, seniority, and the general qualifications of the candidate.

Long incremental scales that allow of steady increase throughout a research life are another alternative. Leamer (149)

has presented a strong case for these in industrial research. If this procedure is followed the question of promotion or of title changes need not enter in although there may be the formality of an efficiency bar at a certain incremental level.

Another possibility is the award of special research allowances or, alternatively, lack of higher career prospects for specialists may be recognized and compensated to some extent by initial appointment to the middle grades, or by accelerated promotion during the early stages of a man's career, with tacit recognition that promotion to the higher echelon is unlikely within the research structure. Such solutions can only be worked out within the context of the individual service.

This matter is one of some importance if the more able men are to be attracted to a research career in societies where considerable social significance is attached to material rewards. In other situations, questions of prestige, professional recognition, and personal satisfaction may be of greater importance. But, notwithstanding the social environment, the research worker will wish for, "recognition, freedom, and security, and will expect to live on a par with other persons of equivalent education and training in the community." (135)

In small departments difficulties are intensified. In the British Overseas Civil Service this is recognized, and a separate, centralized research service has been formed. This is dissociated administratively from the territorial administrative and technical departments for which it provides services, and to which its members are often attached. Administration is by scientists and promotion is according to research capacity

rather than by standing within an administrative hierarchy. There is independence from local departmentalism and, in recognition of the fact that the research officer, unlike his administrative counterpart, may wish to undertake more limited engagements and seek other experiences, there is considerable flexibility in contractual agreements in regard to service, superannuation, and other terminal benefits. To provide for flexibility the officers are members of the federated superannuation scheme of the British universities and, in general, the conditions of service are more similar to those of the university than to the executive services. These arrangements are applicable to research officers in all technical departments of Government but have only proved partially successful, for they are unable to take account of variations in local conditions, such as may be recognized in a territorial service. Except where they are members of a large institute staffed by members of the research service, research officers have often preferred to remain in the general division, accepting the disabilities inherent in a staffing structure that is designed to meet the needs of general and technical administration, and on occasion perhaps administered by executives unsympathetic to, or without understanding of, the special characteristics of research activity.

Educational facilities for children often become critical just when the research worker is entering the most productive stage of his career. This difficulty is common to much of forestry effort but, while this can be partially overcome in regard to non-specialist staff by suitable arrangement of post-

ings, this is rarely possible with a limited research staff, largely composed of specialists. In the initial siting of experiment stations a compromise may be necessary and the 'scientifically desirable' situation discarded in favour of one more favourably situated in regard to amenities.

Although complete separation of applied research from practice is but rarely to be advised, the difficulty of reconciling the research and administrative minds must be recognized,

"The research management must recognize that non-conformity often accompanies creative ability, and must be willing to accept and work with the personnel problems that may arise as a result of non-conformity. The creative man continually challenges the interpretations of the rules of nature. The interpretations of man-made rules are even less acceptable without questioning."(115)

Above all, research should not be subject to excessive pressures. A certain volume of output of high quality is necessary but this will result from the recruitment of men of the right calibre. The research officer needs time for contemplation, for reading, for discussion. Freedom to browse, to generate new ideas, to explore new fields, and to evaluate old ones, is essential if a research program is to make the maximum contribution to forestry advance.

#### CONTRASTING VIEWPOINTS ON RESEARCH

##### American and British views on training for research

While there is general agreement with the principle that,

"Forestry research is a highly technical and specialized subject which should be carried out where-ever possible by specially trained research officers." (30)

there is not always an appreciation that the two levels of research activity, technological investigation and fundamental

enquiry, require different outlooks, distinct approaches, different methodology and, arising from these, different types of training. There is also the question whether research training should be based on in-service informal training through experience, or whether it should be of a formal academic nature.

In the sphere of basic research there are distinct differences between American and British views. The British concept is that basic research demands a knowledge of science rather than of forestry, and a command of scientific method rather than of silvicultural technique. For the worker in the ancillary or underlying sciences the right training is considered to be a degree in the appropriate science (50). In the American view the desirable background is most often provided by training in technical forestry followed by specialization through graduate study.

As opposed to more recent thought, Bailey and Spfoer (5) advanced a viewpoint in line with British ideas. They questioned whether researchers should receive their basic biological training in the forestry school and countered the suggestion that this was necessary to develop the 'forestry viewpoint' with the remark that it only substituted one type of undesirable specialization for another. They considered that basic research was best pursued in the broadest and most thorough manner.

"The American forester tends to be too exacting and too impatient for quick results in his demands upon the natural sciences, and to over-emphasize the value of a varied program of rather stereotyped, practical forestry courses in the training of investigators which culminates at times in attempts to give men, trained as practitioners in forestry, a top dressing of graduate instruction in

science..... fully as undesirable as to require a post-graduate, who has concentrated in some special field of science to take a complete course of practical instruction in forestry."

Much depends on the national situation. Perhaps the matter may be related to the way in which basic or ancillary research is organized. If the researchers are full members of a forestry organization then it is desirable that they have a basic forestry understanding, and an earlier opinion that a prerequisite for training men in forestry research, even in ancillary fields, should be a broad general training in forestry (52), has some weight. In general, only such training can give the background which is necessary for balance, so that minor interests do not become major objectives. On the other hand, if the worker in an ancillary field has advisory or consultant status, or is brought in to work on specific problems, then there is much to be gained from full identity with the basic discipline.

Contributing to the American view is the circumstance that the early use of men trained in the basic sciences in Forest Service research, often as experiment station directors, which received favourable comment from Chalk (45), did not work out particularly well (164). Munns attributed this more to lack of skill in their utilization than to lack of a forestry background, and considered that there was a real place for such men in the present-day American research structure.

Current American emphasis on basic or detailed studies of causal factors may be briefly discussed. Certain factors contribute to this accent. In part it results from a feeling of dissatisfaction with the results of past ad hoc researching,

in part from the current intense national consciousness of the need for research. But there are other contributory factors. There is the absence of a trained, distinct, subordinate cadre, making difficult the conduct of the large-scale extensive programs that are necessary for success in field experimentation. The pattern of forestry education may also contribute, often tending towards vocational emphasis at the undergraduate level with subsequent specialization in the underlying forest sciences at the post-graduate stage, from which most present-day American research foresters are drawn, and a lesser emphasis on silviculture throughout. Other contributory factors are the absence of a tradition of cultural forestry and of rural good husbandry, and hence a lesser appreciation of basic silvicultural practice as an integral part of forestry routine and part-and-parcel of day-to-day forestry. And, possibly, a climate of opinion that attaches greater prestige to fundamental enquiry than to applied research. There is also the circumstance of an extensive and highly developed research effort alongside a much lower level of practice and a greater isolation of research. The greater use of specialists in a 'line and staff' pattern of organization rather than the traditional 'generalist' professional forest officer line structure is also of significance.

It may be queried whether, in fact, a realistic program of applied field research can progress satisfactorily without the stimulus of urgent silvicultural problems arising in the course of day-to-day management, and of direct concern to the majority of the field staff or whether the results of ad hoc research

can be applied successfully in the absence of practitioners who are primarily silviculturists and with an intimate knowledge of local conditions. These last two requirements are necessary for the discerning application of applied findings. Perhaps the lack of opportunity for silvicultural practice has led the American forestry graduate with biologic potential to graduate study in the ancillary and underlying fields, thus resulting in the extension of the subject area and the development of distinct forestry connections in what are more accurately distinct disciplines.

The emphasis attached to formal post-graduate qualification in present-day American research, and its material rewards, doubtless contribute. The standing of research groups is often equated with the proportion of graduates of higher academic qualification. Kaufert and Cummings (132) used this criterion for the evaluation of agency research. Implicit is the suggestion that the higher the formal standing the better the research. While of substance in the assessment of a fundamental research program there is little evidence to suggest that the Ph.D. distinction makes significant contributions to applied research at the technological level if the initial degree training has been soundly based. Indeed, the deep penetration, usually implicit in doctoral study, may develop qualities and interests unsuited to research of this nature, especially if undertaken before experience in the field. Zivnuska, while accepting the value of post-graduate training, has spoken against "making a fetish of the Ph.D." and has suggested that a man with experience would benefit more from study planned solely in terms of his particular

interests "rather than the minimal accomplishment of the somewhat arbitrary requirements of a degree program."

However, Stone (198) believes that formal academic training cannot be automatically equated with motivation to basic research for all men with the same academic degree have not been exposed to the same educational experience. He considered that inclination towards basic or applied research is influenced rather by the school.

"It may be apparent at the bachelor, master, or doctoral level and reflects depth of training through study of a basic discipline as compared with breadth through study of silviculture or ecology."

In British forestry the recruitment even of some practitioners from the ranks of pure science has been advocated, such men to undergo a period of post-graduate training after recruitment. Until comparatively recent years this was practiced more especially in recruitment to Indian, and to a lesser extent, colonial forestry. There has been some division of opinion. Champion (49) saw considerable benefit to a forest service in recruiting a proportion of science graduates and providing facilities to take a forestry degree in a reduced period (consequent on the prior possession of the pre-forestry scientific qualifications),

"...this element has proved valuable as providing a field of posting to the technological specialist posts such as silviculturists, utilization officers, etc., and to the unforeseen odd tasks for which it is not justifiable or feasible to call in the high-power specialists and others, with whom they have more in common through their fuller training."

Weir (221) contested this view,

"... the forestry graduate is best qualified to undertake this type of work, provided emphasis is laid on the

necessity of including on a pure science standard the relative aspects of pure science as related to forestry, and not treating the pure science subjects as only needing a watered down science course good enough for forestry students."

While in basic research a knowledge of science will almost always be of greater importance than a knowledge of technical forestry, in applied research it is important that the investigator has a sound knowledge of forestry practice. Stoate (28) stressed that before specialization there must be a broad fundamental training in forestry which cannot be replaced by training in the basic sciences or in any other profession.

Of course much depends on what is considered to constitute adequate professional training. It is desirable that it include considerable emphasis on science as a foundation for subsequent instruction in forestry. Further essential requirements for research are training in field experiment techniques, including design and analysis of experiments, recording procedures, and a period of practical experience of research methods at a research establishment. The importance of ecology in the training of research officers has often been stressed, among others by Mooney, from India, and Egging, from Uganda (28). Egging said,

"Silviculture has been defined as applied ecology, and one of the mistakes which has been made in the past ..... has been to appoint to silviculturist posts men who have only the sketchiest ideas of ecology."

In this connection concern is not primarily in regard to the techniques of the professional ecologist, but in the approach to the study of the total environment. The importance of the ecological viewpoint cannot be overestimated.

"A great many problems, and indeed most of those involving the conservation of biological resources greatly over-reach the limits of any one field of specialization".... "It is only through synthesis that specialized studies acquire their true significance."(65)

Daubenmire's views (65) in regard to the training of ecologists are opposite to the training of silviculturists,

"... this role calls for broad training and experience, and an understanding of details without preoccupation with any one of them."

Detailed consideration of the content of professional forestry training lies outside the scope of the present discussion. Nevertheless some reference is desirable. There is an obvious relationship with the initial training of research staff.

Primarily the applied researcher must be a sound forester. For forestry education to be of real value as training for research, it is essential that it does not consist merely of vocational and memory training. Emphasis is required on critical understanding rather than training for practice, and the course should not follow too narrow a vocational path. Obviously, it must be at the 'professional' rather than the 'technician' level. The aim, the inculcating of habits of reasoning from first principles rather than accumulation of factual knowledge.

Chalk's (45) comments are still topical,

"Forestry education appears to have reached a stage when two distinct trends are beginning to emerge. On the one hand there is a tendency to increase the amount of purely technical knowledge so that the forester shall be armed at all points with a ready made solution to every problem, while on the other there is a tendency to belittle the technical details as of comparatively little value except as a means to an end, the basic object being to teach men to draw reliable conclusions from their own observations. This seems to be the essential difference between technical training and education. It may be possible, perhaps, to combine the advantages of both methods, but only by conscious effort and a clear knowledge of the respective advantages and disadvantages.

The "technical" type of training has one big advantage, that it increases the chance of a forestry appointment at the end of the course. . . . . the selection of men for posts in the services is bound to be biased in favour of the man who can carry out his first job most efficiently, . . . . . and the "technical" type of training is purposely devoted to this end. The weakness . . . . only becomes evident in the later stages of a man's career, when he has to use his intelligence and draw on his scientific knowledge to solve the numerous problems that confront him. Whether a man has received a "technical" training or an education he still lacks experience and has much to learn after he has completed his courses, and it is very much easier for the man with the sound scientific background to pick up technical details during his service than for the man with the technical information to increase his knowledge of science. On the whole the "educational" type of training seems to be the most desirable."

Initially American forestry schools were closely modelled upon the pattern of European institutions, with concentration upon general biological training and the study of scientific forest management, but there was a gradual change of emphasis. Curricula were revised giving more and more attention to the administrative, economic, and industrial aspects, and a much lesser portion of the average student's time has been given to the biological sciences and silviculture. Bailey and Spoehr concluded that, while this vocational type curriculum might be indispensable to producing the type of practitioner most needed at that stage of forestry development, it was not adapted to the training of the investigators for forest experiment stations. that were then required (5). They proposed curricula

" . . . . . formulated, in the first place to enhance the powers of observation, of critically analyzing cumulative circumstantial evidence and of accurately interpreting statistical results, and in the second place, to give sound, well-rounded training in general science, a broad comprehension of forestry, and particularly of the biology of the forest, and an adequate reading knowledge of modern languages."

They advised against premature specialization, and recommended that concentration in special fields of science or forestry be deferred to the post-graduate phase, and then pursued where those subjects are most broadly and thoroughly developed.

These conclusions had great impact but little long-term effect. The trend in American education has been towards the maintenance of the technical or vocational nature of the first degree with a measure of specialization through the elective course system, and with emphasis on making up deficiencies in the sciences at the graduate stage. The reasons for this are too complex to enter into here. In part they may be due to lack of facilities for vocational training and hence a need for a broader basis of recruitment at the university level.

Currently there are indications of a re-evaluation of educational aims.

Fletcher and McDermott (76) have recently made a penetrating analysis of the current requirements of American forest research from the educational process. This study was supplemented by Neam (166). Emphasis is placed on the need for concentration on fundamental biological processes and relationships.

Although it may be assumed that an educational program develops to suit the particular requirements of time and place, and that the "technical" and the "scientific" types of training have evolved to satisfy national needs, the question is of some importance and Francois' (87) evaluation is given in detail,

"It should be born in mind that the applied sciences and techniques on which the treatment and administration of forests are based are numerous and varied and that they themselves are based on various pure sciences which are always in process of development and constantly being

specialized and subdivided. No attempt can be made to give a student a complete and detailed knowledge of each of these applied sciences and techniques, and still less of the basic pure sciences. ----- only two solutions are possible. Detailed specialized training may be given in the techniques concerned and their practical application without insisting on an understanding of the scientific principles and development on which they are founded..... Alternatively, basic training may be given which will enable a student to discover his problems, to define and to analyze them, and to develop techniques by logical reasoning from the scientific principles known to him. He will then be able during the course of his career to widen his knowledge in any desired direction. In this case, training will consist particularly of general instruction as a basis for future development. .... considering the increasing scientific technical requirements of forestry, the wide range of forestry activities, and the variety of physical and human factors that will be encountered during a forestry career, it seems that a general education might be preferable. Especially it will equip the forest officer for the wider aspects of his career in relation to the public welfare and to economic and industrial questions, which are steadily assuming greater importance in regard to forestry matters."

In Champion's view (49), extension of the length of training, either through extension of a first-degree course or through graduate training, is not the solution to the crowding of the syllabus with technical matters. He believed fragmentation through early specialization also to be undesirable. Where the problem existed, its root was the purely technical nature of the training given and the lack of educational value. In his opinion, to add a further year merely to enable a student to be filled with more technical data was worse than useless. Neither would the addition of a specialized year, graduate or undergraduate, fulfill requirements because it was primarily a broader (scientific) basis that was the real need.

Where there is excessive emphasis on 'technical' training, this has often resulted from attempts to "sell" the profession by providing the type of training considered necessary to meet

the short-term needs of industry.

Brasnett (20) summarized British thought on forestry education when he stated,

"the function of the universities is not to turn out men who 'know all the answers' .... but men who have learnt to observe and reason, so that they may evolve the theories and techniques of the future."

In the British view, for instruction in silviculture and forest management there can be no substitute for faculty members with extensive field experience,

".... the question of teaching staff instructing before it has practical experience..... for the practical aspects of forestry, the practical experience is of tremendous value in association with the academic training." (Champion, in 28).

Resolution VII of the 5th British Empire Forestry Conference included the clause:

"That forestry schools should be created and maintained only under conditions providing the full-time services of an adequate staff with field experience....."

There is also strong agreement with Francois' conclusion that in addition instructors should broaden their background through experience of their subject in foreign countries.

There is also the view that the research forester should have prior field experience. Champion (29) stated that it was essential, and he emphasized essential rather than merely important, that a research officer shall have established a reputation for himself as a man of practical ability.

".... in the more fundamental research work, it may well become unnecessary: but when dealing with the technological aspects, it is a point I think has a great deal of force."

Much may depend on the local situation. Harrison (29) remarked,

"While it may be desirable for the research man to have a reputation as a practitioner before he undertakes research work in countries where silviculture is highly developed this is rather difficult in Canada because there is so little of the practice of silviculture."

Nevertheless, March (29), of Jamaica, strongly advocated, from the viewpoint of the practicing forester, the inclusion in all research organizations of a nucleus of officers possessing a field background. The matter is not, as Harrison appeared to assume, primarily an emphasis on the value of practical silvicultural experience as an aid to research, but rather a question of rapprochement with the practicing forester.

In field research, in-service training is of considerable significance, especially for research officers who will work in isolation or in small units. Significant advantages will accrue from periods of secondment or detachment to established research organizations, for the observation of the practical details of research organization and procedure. Facilities for travel so that procedures, organization, and forestry techniques may be studied will also result in research benefits. Such tours may be of extended duration or of a comparatively limited nature for the study of specific problems. For greatest value an officer should have gained prior practical experience in his field, thus he travels as a specialist rather than as a trainee, and can relate what he sees to the conditions under which he will work on returning to duty.

Countries in regions distant from the European centres of classical forestry, and where forestry is practiced under very different conditions, as for example those of Australia, Africa, and Asia, attach considerable importance to European touring for

their forestry staffs, both administrative and research. It is perhaps arguable that considerable benefits might have accrued to North American forestry through the development of a similar tradition. In recent years tours organized through certain of the forestry schools, principally for foresters of standing, indicate an increasing awareness of the values of such experience. In like manner the increasing number of European foresters visiting North America indicates an appreciation of the value of study of the natural forest.

A useful innovation have been increased interest in international meetings. These are facilitated by increased ease of world transportation. Apart from the large international congresses, smaller specialist meetings and tours have positive values. For the greatest research benefits it is very desirable that national delegations to such meetings include practicing research officers and are not confined exclusively to more senior high ranking officers. The meetings of the various groups sponsored by the Food and Agriculture Organization and the International Union of Forest Research Organizations provide a valuable means of extending the experience of research staff. Such meetings as the Food and Agriculture Organization sponsored Research Workers Seminar in 1956 at Dehra Dun, India, the meetings of the specialized international commissions, and the Range Management Seminars of the American International Co-operation Administration, attended by land managers from Near East and South west Asian nations, have great benefits. The Dehra Dun meeting was attended by participants from nine countries. Attention was directed to research methods. Treatment was from the viewpoint of the practicing forest research worker and the methods discussed were chosen

specifically to meet the every day requirements of his work. Seminar leaders were research men drawn from a number of different countries.

So far, attention has been directed to the training of the specialized research officer. But of necessity, and desirably, a considerable body of investigational work, both formal and informal, must perforce continue to be done by the ordinary non-specialist practicing forester. All forest officers should be exposed to elementary instruction in research methods and record-keeping, to enable them to make simple experiments. This will reduce the possibility of erroneous conclusions, such as have occurred in the past, from well-meaning but poorly conducted experimentation. There has been much wasted endeavour and resources in attempted research by enthusiastic but untrained individuals that could be obviated by simple instruction during initial training.

#### The use of specialist personnel

The specialist has long been accepted in fields ancillary to silviculture and forest management. In technology there was slower recognition of the need for foresters specially qualified by training or experience for research.

Research was considered as part of the function of the practicing forester, and the earlier policy of the U.S. Forest Service of encouraging every forester to make his own experiments (45) was common to most administrative agencies. Such subjects as systematic botany, wood anatomy, timber testing, etc. demanded the services of a specialist, but in forestry sensu stricta the ordinary forest officer was considered to be the specialist. Those who advocated research by the executive

forester claimed that he could best formulate the problems, and that his experience and observations in the forest provided the best clues to their solution. Even in 1937 it was said (45) that in most parts of the British Commonwealth it was more usual for an administrator to direct research than for a scientist to undertake administration. In British Columbia first attempts at research took the form of spasmodic investigations by various officers attached to the staffs of district foresters (42). Pressure of routine duties and lack of direction mitigated against any very tangible results. During this period it was frequently not appreciated that,

"Forest research is a highly technical and specialized subject which should be carried out wherever possible by highly trained research officers." (30)

Only with the development of modern experimental techniques and increased complexity in methodology has there been more general recognition of the need for special research skills and reliance on the professional researcher. As Haig et al (105) have written in regard to tropical forestry,

"Advances have been the best and most satisfactory where good research agencies have been available; the poorest where such agencies do not exist or are not strong."

The full-time research appointment is now almost commonplace, but it is still not always appreciated that the needs of research, especially in a small department where the researcher is thrown on his own resources, cannot often be met merely by releasing a forester from other duties and gazetting him as a research officer. The award of a research title does not equip a man to undertake investigational work, nor does the possession

of aptitude alone.

Nevertheless it may be emphasized that although specialists are required for the satisfactory conduct of investigational work, this does not necessarily imply narrow specialization. Specialization enables a greater concentration on individual fields but there is a risk of an equal degree of isolation. In forestry the stage has rarely been reached which permits of the abandonment of the general view. Especially in the early stages of research, investigators of unusually broad vision are required in the pioneer task of developing sound and far-reaching programs.

#### Subordinate staff in the research structure

In most forest administrations there are, in principle, two trained cadres, termed by Francois (87) "superior" and "subordinate". North American forestry is almost unique in not making this distinction except for the limited use of a sub-professional ranger staff in certain forest services, more particularly in Canada. Where such men are employed, their role is largely restricted to protection and district administration. In the United States the pioneer forest ranger of earlier times has been replaced, not by a vocationally trained man but by the university graduate. In industry, the man with formal vocational training is almost unknown.

In all services, nevertheless, there are superior and subordinate staff. The former includes personnel in charge of research and those entrusted with the elaboration of forest policies at whatever level necessary. The subordinate staff has no responsibilities in regard to policy, but simply undertakes

routine administration and carries out prescribed operations on the ground in accordance with given instructions (87). Where there are two distinct cadres each receives a different type of training, the one at university level with emphasis on basic principles, and the other of a vocational nature with emphasis on field techniques. Francois reflects general opinion when he emphasizes that a clear distinction must be maintained between the assignments proper to each, and that one of the essential conditions for efficient forest administration is that superior staff will not be assigned work that can be done by subordinate staff, nor should their training be directed to acquiring the vocational skills necessary for the successful conduct of such work. It is generally accepted that each cadre should be trained for the level of work it will undertake and for no other. Where vocationally trained foresters form an essential part of the forestry structure it is recognized that these men are highly skilled, and have a distinctive professional function, and, as such, require a distinctive training which is not merely a watered-down version of the university program. The number of graduates from vocational schools greatly outnumber those from the universities. The status of the two types of schools and their graduates is clearly defined and accepted, giving stability and order to the relationships between professional and vocational forestry personnel.

In North America these principles have not yet been adopted and many tasks which elsewhere would be within the sphere of the vocationally trained forester are undertaken by

the university man, who thus combines the functions of both cadres.

With more intensive working the desirability of using vocationally trained men is receiving increased recognition. In recent times a number of papers have appeared in the American professional literature that are indicative of the changing viewpoint (60,6,107,67,65,196). These views agree very closely with practices outside North America, although in some instances it would seem that a technician is envisaged of rather lower responsibility than the vocational or working forester operating in other countries. Questions of professional recognition exercise considerable thought in present-day American forestry. To a considerable extent this also is related to the nature of the duties that fall to the lot of the university graduate.

It is to be anticipated that as North American forest management becomes more intensive and forestry more mature there will be increasing appreciation of these advantages and that the present wasteful use of graduate potential will give way to a structure more akin to that elsewhere.<sup>\*</sup> When this time comes many of the present day curricular difficulties of the university forestry schools will be resolved and also questions of professional recognition.

Canadian practice is perhaps a compromise between the two staffing patterns, traditional and American. But there is a

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<sup>\*</sup> Recently action has been taken within the United States Forest Service to provide for an establishment of three vocationally trained technicians to each university trained forester. (H. L. Shirley. Personal communication 1960).

notable difference between continuing departmental practice, with only minor use of vocationally trained men, and the support voiced by the Canadian and British Columbian delegates for the principle of dual-level staffing and education, when this has been discussed at various British Commonwealth Forestry Conferences. Doubtless, a factor in this apparent discrepancy is the constant difficulty of definition, terms may mean completely different things to men from different environments, thus a Canadian delegate may consider that such a situation is met by the very limited amount of sub-professional activity in Canadian government forestry.

Where the vocational principle has been fully developed, men, known variously as technicians, rangers, foresters, field assistants, etc., and trained in vocational schools, are frequently employed extensively in research. Such staff develop specialist skills and commonly have considerable responsibility. They staff field stations, have full charge of research nurseries or arboreta, or are employed as assistants to the research officers. Emphasis is on the team approach to investigation rather than on individualistic researching. This team concept is not one of a group of specialists at work on a common problem under a research leader, but rather of a research officer with an adequate supporting staff. Very large programs of field experimentation thus are possible, with a comparatively limited staff of university graduates. Forest investigations are dependent on the smooth working of a group of people, each with his own function, and trained to that level, and competent to undertake his part of the task, rather

than on the efforts of individual research officers.

In the United Kingdom considerable importance has been attached to this aspect and an official statement notes,

"It has been found that the progress and success of the work depend very considerably on the maintenance of a proper balance between the graduate staff planning and analyzing experiments and the research foresters responsible for their layout, supervision and assessment in the field. There is no doubt that the existence of this body of skilled foresters provides a vital link in forest research, which is lacking, or at any rate insufficient, in some forest research organizations, even in countries where more money is available." (231)

In British Columbia, although only limited use has been made of field assistance to the graduate research forester, and this by men without formal training, the employment of this element has been advocated,

"Field research, to a great extent, consists of routine procedures, such as experiment layout, treatments, assessments, recording, and compilation of material, all of which can be accomplished adequately by assistants and technicians under supervision." (Spilsbury, in 194)

Where there is an adequate supporting staff the professionally trained research officer is concerned with the planning and organization of investigations, the preparation of project analyses and experiment working plans, and with the interpretation of results, rather than with the actual conduct of the often time-consuming and routine work of experiment layout, maintenance, and assessment. Thus he can undertake a more extended program of research with a greater number of active projects at any one time. Among his functions is to use his specialist skills and experience to employ the more practical skills and training of his research foresters to the best advantage. Upon their capacity for detailed and accurate work

depends the value of the information derived. Much depends on the calibre of the staff recruited.

There is much to be said for a fairly frequent turn-over of staff at the non-specialist junior field-assistant level. Coming directly to research after completion of formal training, these men may be employed on such routine tasks as sample plot and nursery assessment and as assistants to the research foresters. Often these duties may involve a considerable amount of travelling and with extended periods away from the duty stations. After perhaps three years, unless they express a strong desire to remain, and are considered suitable for more specialized duties, these men are transferred to the territorial staff. In this way a man is not retained after his enthusiasm has begun to wane or he has become bored with the often routine duties of detailed assessment, and when family responsibilities may be of increasing importance. The short-term view might be that such men are lost to research at a stage when they are becoming of real value, and there might be a temptation to retain an experienced man rather than take a new and untrained recruit. Nevertheless in the long term, it is to the advantage of both the research branch and the service generally for this turn-over to take place. The service benefits from the further training which the man has obtained and from the habits of accuracy which have been inculcated, while the research branch gains from the understanding and cooperation of ex-research personnel in the field.

In field investigations the volume of work that can be directly controlled by one research officer is in direct

relationship to the number of assistants of sub-professional grade that he has working with him. It is generally overlooked that every permanent sample plot or experiment means a future demand on the time of staff, and every new area in which investigations are initiated means loss of time in travelling (Experimental Manual of the Indian Silvicultural Research Code, 1931). To a considerable extent the limiting factor in such research is the provision of subordinate staff for without such assistance the research officer cannot operate efficiently and the best use is not made of his time and skills. Without the provision of an adequate staff of field assistants the point is early reached when research has to be concentrated and often curtailed, with the cessation of the initiation of new investigations because of the demands of existing projects for routine work.

To be successful, field experimentation must be conducted on a sufficiently extensive scale. Where there has been failure to obtain satisfactory results from research of this nature it has often resulted from insufficient sampling of the range of conditions encountered. This, in turn, is dependent on the availability of staff. When there is inadequate provision of subordinate staff in the research structure, experience has shown that an extensive program of field experimentation can rarely succeed.

The provision of skilled assistance is of lesser importance in certain aspects of basic and observational research, though here also investigation may often be facilitated by a small team of trained assistants.

In district administration it is commonly accepted that a professional officer operates most efficiently when supervising the activities of between six and ten subordinate grades. Each of these will normally have a territorial charge with his own trained assistants and with full control of his own labor force.

In a small research group a similar ratio may apply, but in a larger organization the number of professionally trained men may increase relative to the vocationally trained staff, who may fall into two categories, those operating as direct assistants to the individual research officer and those stationed in the field and responsible for all activities within their area. To revert to the Research Branch of the British Forestry Commission, this has a staff of thirty-six graduate research officers, supported by 107 vocationally trained foresters (231). The staffing pattern is illustrated by the Mensuration Section. This has three graduate officers, and seven field parties each comprising three or four vocationally trained foresters (1955 establishment), additionally, there is a small group of foresters engaged in technical office work, assisted by female computer operators. The structure is flexible and men may be drawn from the field parties for work in the office for periods of varying duration, while the office staff may join the field parties.

Comparable figures for some Canadian research agencies are noted below.

"Professional" and "Sub-professional" Staff Employed  
by certain Canadian Research Agencies (41) in 1955

<u>Agency</u>	<u>"Professional"</u> <u>i.e. graduate</u> <u>staff</u>	<u>"Sub-professional"</u> <u>staff</u> (details of training not given)
Research Branch, Federal Forestry Branch	65	36
Forest Biology Service	149 (incl. 1 techni- cally trained)	83
Division of Forest Research. Dept. Lands and Forests, Ontario	17	4
Research Division, Forest Service, British Columbia	14	4 (in semi- technical work)
Canapcal Forest Research Station. Canadian International Paper Co., Quebec	3	1

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Additional seasonal staff may sometimes be engaged in substitution for a regular subordinate staff. This practice may appear particularly suited to conditions where climatic conditions dictate a distinct field season. Nevertheless special training and experience for research is as desirable at the lower level as at the upper and such personnel can rarely fully substitute for experienced permanent technicians in a sustained and continuing program of research. The temporary employment of students or others may have superficial attractiveness but this cannot replace the technical skills of the vocational forester; attempts to use such men necessitate a greater measure of supervision on the part of the professional staff and

the loss of the specialist skills of the working forester.

Where field experimentation is attempted under such conditions, examination clearly indicates the limited extent of the program which can be undertaken in relation to the number of research officers employed and the funds available. Characteristically, in the absence of vocational staff, upon whom the weight of experimentation normally falls, field studies take on a more intensive, though more limited, nature with the ever-present danger of the operation of the principle of diminishing returns in regard to information necessary for a practical outcome. Spilsbury (194) recognized these limitations,

"Assistants, when trained to carry out such routine duties, would relieve the present (British Columbia Forest Service research) staff of much (routine) work and enable (graduate) foresters both at head office and regionally to carry out more important duties and research programs."

When a subordinate research staff is employed, the codification of research methods and procedures and the use of standard record forms facilitates over-all control. Suitable methods have been developed by various agencies. The British Forestry Commission has a very workable system of silvicultural experiment records which lend themselves to modification for use under different conditions (206, 209) and its sample plot procedures and mensurational proformas have been published (118). Attention is also drawn to the methods described in the Indian Silvicultural Research Code. Such codification allows the use of less highly trained staff and tends to minimize the recording of superfluous data, while preventing the

neglect of necessary information. Given foresters with a sound vocational training in forestry practice, once they are experienced in the reading of an experiment working plan, and the use of standard record forms, then plot establishment and treatment, and the compilation of data becomes a matter of routine. The research officer is freed from the necessity of exercising close supervision, and is enabled to extend his program. Experience has demonstrated the practicability of such methods even in undeveloped countries with relatively uneducated subordinate staff.

In fundamental research there is, perhaps, less need for supporting staff. Nevertheless, in many countries the craft of laboratory technician is firmly established. In the institutes and universities of such countries most laboratories will have a laboratory steward and an adequate number of assistants. The steward is responsible under the head of the laboratory for routine laboratory administration and is often a personage of no small consequence to students and to junior members of the faculty. The technicians free the scientist from the conduct of the time-consuming laboratory work and the routine of preparation and disposal unseparable from student laboratory instruction. They may attain varying degrees of manual and technical skills in experimentation and in glass-blowing, etc. and may work as personal assistants to the scientific staff. A practical ability does not always accompany a capacity for creative research, and long and fruitful partnerships have occurred between highly skilled and experienced laboratory technicians and distinguished scientists. Entry to

the trade is often through a form of apprenticeship with nationally recognized qualifying examinations conducted by the technicians' own association.

Analysis of staffing at the Imperial Forestry Institute, Oxford indicates the level of assistance that may be attained when ancillary staff are available. There are sixteen academically trained teaching and research staff members. To assist, there are thirty technicians (50).

This skilled element is very largely absent from the North American university. To some extent it is replaced by graduate student assistants. Although this has a valuable training function, rarely can such short-term helpers fully replace the experienced laboratory technician.

#### The question of research publication

In the English-speaking world there is sharp contrast between North American and British Commonwealth thought on research publication. Canadian approaches have been influenced by United States practice. In the one case there is a tendency to over- and in the other to under-publication. There is also the question of audience. The proclivity of Canadian research foresters to write for other researchers has been commented upon by Place (175)

"Esteem of his co-workers is one of the chief incentives for the research worker, his prestige is not greatly enhanced by writing for non-specialists - thus he tends to write for other research men, his language is often technical and his papers assume a background knowledge few foresters have."

At the regional Experiment Stations of the United States Forest Service the Field Division Chiefs are responsible for

the output of publications within their divisions and it has been laid down that "productivity in this respect is an important consideration in judging the capabilities of these officers" (215). Clearly there is an atmosphere in North America that is conducive to considerable and detailed research publication. There is strong support for the view that "the earliest possible publication of research findings is an obligation assumed by public agencies engaged in research."

(132) There is also a strong feeling that full experimental details should be published. A wide choice of media exists. In the United States Forest Service these range from major departmental publications to short station releases, perhaps of one page only, and often in multilithed form and distinguished only by a distinctive letterhead. The latter serve as "outlets" for a considerable volume of material that for one reason or another is not suitable for printing." Material is also published in the professional and scientific journals. The United States Forest Service attaches considerable significance to the dissemination of research findings and devotes considerable effort to this facet. A tentative decision is made regarding the form of publication even at the problem analysis stage and as partial justification for the study, and before any investigational work is started. Other agencies have similar policies, but standards vary greatly. The situation is intensified by the significance attached to publication as an incentive factor in the conduct of research. Coupled with this is a feeling that there should be a policy of early publication to ensure recognition of contributions

and to encourage a creative atmosphere. On occasion it would almost seem that the purpose of investigation is publication. Characteristically, papers present the results of individual researches or experiments, and early publication, even of partial results, is encouraged. Work (225) has summarized the present situation as follows,

"When forestry was just getting a start in North America, Schlich had few competitors in our language. But now that forestry has come of age commercially in the past couple of decades, we find ourselves buried by publications of every form and type, so that one of the real problems is to discard the material not pertinent to our interest, and to keep track of what has been done."

In part, this situation has arisen out of a feeling of urgency in the development of forest science and the lack of a foundation of common knowledge, in part, possibly, from the large number of agencies engaged in forestry, and the continental scope of activities. It also arises from the circumstance that the research officer, unaided by vocationally trained staff and thrown much on his own resources, and with physical limitations to his operations, is obliged by circumstances to concentrate his attention on fewer problems at any one time. Thus he tends to give greater attention to the individual study, including the final publication of results. The importance attached to research publication as a criterion for the assessment of non-administrative capability within an agency also plays a part. The significance of this emphasis is difficult to assess, so must remain a matter of opinion, but it is clearly a contributing factor in many instances. Especially among the younger research workers there is much truth in the catch-phrase "Publish or Perish".

In contrast, there is much less emphasis on publication in the British scientific world. In forestry literature the British forester is accustomed to a form of publication in which problems or situations are discussed and lines of action outlined. The research officer is primarily concerned with investigation and the solution of problems and is but little interested in publication, often agreeing with the Preacher in Ecclesiastes that "of the making of many books there is no end and much learning is a weariness of the flesh." He does not identify himself with the scientist, but with his fellow foresters, so he feels no incentive to obtain scientific esteem. There is greater cohesiveness within the profession and fewer agencies; the natural result of a situation where the major professional activity is by Government, and the enlightened section of private ownership and practitioners are linked by national forestry societies. The lesser distances and greater possibilities for personal contact also play a part, as does the higher level of practice. As a result of this combination of factors the research officer publishes specific research papers more rarely, and his research findings appear in summary form in departmental annual and other reports, and often anonymously; much may remain unpublished, although influencing practice through departmental action. The more limited publication output is directed to the profession as a whole rather than to a limited circle of professional research workers, and detailed accounts of experimentation or of research procedures are rarely included. In general, the various society journals are professional rather than scientific. It

might be noted in passing that to a considerable extent a similar situation occurs in the universities, both in the forestry schools and the science faculties. In the educational process there is a considerably lesser emphasis on the study of individual research findings than on the corpus of established knowledge.

Indicative of the much lesser part that publication plays in professional life is the circumstance that during the period 1919 to 1949, the first thirty years of the existence of the modern state forestry agency, official publications of a technical nature composed only eighteen bulletins, three reports of national forestry inventory, twenty-seven leaflets, and five small booklets. Of these only a minor proportion dealt with research findings. This period covered the revival of scientific forestry in Britain and encompassed many important advances in nursery and afforestation technique. The lack of importance attached to publication is illustrated by the treatment of the important and significant developments in peatland afforestation. The first detailed account of this research program did not appear until 1954, when the bulletin "Experiments in Tree Planting on Peat" was published. This comprehensive account detailed the research activity that had gone into the development of these techniques, which had been a major activity over an extended period, had occupied many people, and had permitted the extension of tree planting onto a million acres of hitherto unplatable land during the previous thirty-five years, and is possibly one of the most significant advances in European forestry during this century. Almost nothing of research significance had been published

previously on this work.

In contrast to the sense of urgency which characterizes American policy the British view is that emphasis on early publication often results in hasty contributions of ephemeral value, and that presentation benefits from maturity and a longer period for the consolidation of ideas. It is considered a pity if what is considered a mistaken desire for early publication is permitted to obscure this advantage. Whether a delay of thirty years in the publication of an authoritative and detailed account of a major activity is justified is a question of opinion!

Even when allowance is made for the lesser variety of conditions, and the different scale of activities, it is clear that publication assumes a different place in the scheme of things in the United Kingdom Forestry Commission than in the U. S. Forest Service.

In the American practice there is danger that significant contributions may be lost sight of and the individual research worker, and more particularly the practicing forester, may have difficulty in maintaining contact with current development as a consequence of the sheer volume of publication. In the British there is little doubt that valuable information remains generally unknown outside the state service for long periods and especially on the international level. The British literature, apart from the brief selected accounts in the official annual research report, is no real guide to progress, or even of the present state of knowledge.

## PUTTING RESEARCH INTO PRACTICE

Relationships between research personnel and practicing foresters

Clapp's (52) view that there is objection to close contact between researcher and field staff, because this could result in more emphasis on immediate questions than is desirable, is rarely tenable. It does not hold for research in the main areas of forestry. The rational motivation for forestry research is the furtherance of the practice of forestry. Solutions may be sought through fundamental studies, or through technological investigation, dependent on the nature of the problem, but in most cases conclusions will eventually devolve upon work in the field. In the ancillary fields, isolation of research may be of little direct consequence, but it is essential that the applied research worker should have full and intimate contact with the practitioner.

In the report of the committee set up to consider research matters at the Sixth British Commonwealth Forestry Conference the desirability of close contact was clearly indicated,

"In some cases there appears to be a lack of interest in the potential value of research findings on the part of practicing foresters. In others, forest managers have rushed preliminary research findings into practice before the research man himself has been satisfied as to their validity. There is, therefore, need for closer cooperation and better understanding between practicing foresters and research workers."

Macdonald (154) has stated positive research values,

"..... a really good research officer will know what is going on in the forest and his experience may tell him that a problem which has arisen in one part of the country may have already been answered by a forester working on a private estate or in a state forest elsewhere who has stumbled on the solution, quite likely by accident."

There are also benefits in the dissemination of findings. Much depends on the nature of the research. There is little doubt that the research officer who is working on a program of field experimentation is better able to maintain closer contact with the practicing forester than is the man engaged in more fundamental enquiry, and is better able to ensure that the executive and research sides do not become isolated. Marsh (29) stated that "such an officer is far more likely to obtain the desired co-operation than is the pure scientist." In this regard it is important that those who are to apply research findings should be given the fullest consideration when developing research plans. Champion (29) emphasized the importance of having a program approved by those who "should be ultimately applying the results" and that to the maximum extent possible the practitioner should be drawn into the preparation of the program. This keeps the research effort

"focussed on the chief problems, those that cover the greatest area of forest, whose solution would be of the greatest economic advantage."

The very real advantages to the research effort that result from the local knowledge and willing co-operation of territorial staff also need emphasis. As Marsh pointed out, very often the practical experience of the working forester can short-circuit a very expensive research program. A certain degree of co-operation and mutual understanding may be achieved through formal measures, such as those provided by the regional program review boards of the United States Forest Service, but the final outcome depends on personal contact.

The onus for achieving the desired friendly relationship must rest with the research officer. Efforts to gain the confidence of field staff at all levels are amply repaid. In this regard, the absence of any executive position provides benefits.

The researcher should appreciate the difficulties of the practitioner, and the complexity of his duties. It is almost unnecessary to note that territorial officers should always be extended the courtesy of being informed of any work intended in their territorial charge, and their permission and co-operation obtained before action is taken to acquire experimental sites. Copies of experiment working plans should be forwarded for information, with additional copies for the local forester, and copies of any reports or conclusions. It is a wise precaution to clearly mark such research papers 'for information only', to avoid misunderstandings. It is easy for non-specialist personnel to misinterpret such documents and attempt to carry out experimental prescriptions.

However, although interest and active assistance should be welcomed, discretion should be exercised in requesting assistance with research projects. Research staff should remember that the territorial forester has a complex of responsibilities and has much to do.

It is important that research and executive functions do not overlap.

"It should be clearly recognized as a principle that the initiation of executive action, on the basis of results obtained in experimentation, is no part of the function of the research officer. The decision as to the

implementation of research findings, or the desirability of modifying current practices and standard techniques should remain the responsibility of the Director-General of Forests or executive officers nominated by him. The duty of the research officer is to give technical advice on the basis of his findings, implementation of this advice must rest with the executive who will have due regard to overall considerations of policy", (209)

The situation has been well expressed in the following statement of agricultural research policy.

"Progress in agriculture as in other fields of human endeavour depends ultimately on the practical man and on the tools (including new ideas) which he has at his disposal. The province of the research worker is to provide new tools, new techniques and new ideas which can be incorporated into practice. It is not for the research worker finally to judge whether the new techniques which his researches have produced are to be fitted into general practice. The worker in the field of applied research must, however, always have regard to practice and have an eye on the practical application of his results. If he does so he will find that his work creates interest among farmers; interest creates new thought and is a direct stimulant to change." (source unknown)

Except in special instances where the research officer is a specialist engaged rather in the development of a certain phase of forestry than in research proper, when circumstances may dictate otherwise, it is most desirable that he be not invested with executive powers that reduce his freedom of action, and possibly result in the intrusion of administrative details in the conduct of research.

It is to be desired that the research officer be enabled to undertake investigations at all stages by himself or through his own staff. Suggestions are frequently made for the conduct of research through territorial staff, especially in the early stages of in-service research development. In New Zealand the objective of the newly formed experiment station was the

supervision and coordination of forest service research (16). The territorial Conservancies were expected to make local investigations under the indirect supervision of the Experiment Station. With maturity most research groups become less dependent on outside assistance. As was stated in recommendations for the conduct of research in Iraq (209)

"No basic superiority of specialist personnel over the territorial forester is implied, and it is important for good relations that this concept is not fostered, but the specialist has a different type of training and experience, and.... is free from the routine commitments... of the territorial forester..... there should be the principle that ... no experiments will be laid down which cannot be controlled.... by research foresters. Only disappointment and wasted effort and funds will result if this is not so. If necessary the research program should be limited until men of the required calibre are available...."

Field experimentation can seldom be taken to a satisfactory conclusion if it is dependent on the general territorial staff.

#### The functions of the experimental forest

Typically, experimental forests are associated with North American forestry. In the absence of tracts under intensive management they have assumed great significance in Canada and the United States, both for research and demonstration. United States Forest Service experience has been that widely scattered plots, even in the national forests or other public lands, cannot be satisfactorily administered, protected, or utilized for long-term research (141). In consequence, the United States Forest Service has set up field experiment stations, i.e., experimental forests, in areas representative of the major ecological and management types in each region. These stations demonstrate the application of methods to local conditions and serve

as areas for extensive experimentation. In practice, all conditions are seldom represented within the field experiment stations and it has been necessary to go outside the boundaries in many instances. Rather, they serve as focal centres for regional research. Barr (8), when discussing the Blodgett Forest of the University of California in the Sierra Nevada, noted that experience had shown that the permanent research forest, if carefully selected and properly administered, and under a good plan of long-term study, provided the most effective basis for many types of field experimentation.

In Canada, although it is recognized that the experiment stations are representative of only a few of the important forest conditions, permanent research areas are considered necessary because of the superior physical facilities and assured tenure that they provide (15). The areas involved range from the seven-and-one-half square-mile mixed-hardwood experiment forest at Valcartier, in Quebec, to the 100-square-mile Petawawa Experiment Station in Ontario.

With the exception of Laval University, which maintains only a small tract, all the Canadian forestry schools have research forests. At the University of New Brunswick there is a 3,600-acre forest adjacent to the Campus, and another 35,000 acres of young growth fifteen miles away. The Faculty of Forestry of the University of Toronto has a 17,000-acre forest some 150 miles north of Toronto. The University of British Columbia has a 10,000-acre research forest at Haney, thirty-six miles from the campus. In the management of these areas the general aim is to maintain a well-managed, self-sustaining

forest area that will serve the needs of research, education, and demonstration. The U.B.C. Research Forest is illustrative of academic thinking in regard to such areas. The Forest is dedicated to forestry education, to forestry research, and to good forest management, in the interests of the Province and the people of British Columbia. Its declared purpose is to provide field training facilities for students in forestry and allied fields, to serve as a demonstration of forestry practices, and to provide a field laboratory for research (Allen, 1950). It is intended to develop the tract as a managed forest. Research is designed to guide management of the area itself, and to provide information of more widespread usefulness. The Forest is used for a summer training camp for students, and for a steadily developing research program under the supervision and coordination of a graduate forester assisted by a full-time graduate assistant. Another graduate forester is in charge of administration and the conduct of routine operations. Investigations are made by Faculty and students in forestry and allied disciplines. Direction is by a faculty Director and Associate Director. There is a Research Committee formed of Faculty members and also an Advisory Committee formed of leading government and industrial foresters (22).

During the period 1949-58 the forest provided facilities for fifty-nine research projects. These ranged from simple short-term studies completed in one season, to investigations continuing over a number of years. Twenty-six individual researchers, primarily faculty and graduate students in forestry

and the biological sciences, made use of the facilities available. These activities have expanded over the years and ever-increasing use is being made of the facilities provided by the tract. With the passage of time, management policies will clarify in long-term management and it is to be expected that the demonstration function of the tract as a well-managed unit will receive increasing public recognition. The award to the forest of the first British Columbia Tree Farm License is an indication that its potentiality in this regard is recognized.

Industrial management has taken up the idea of the experimental forest. Silversides (192) has described the operations of the Westvaco experimental forest of the West Virginia Pulp and Paper Company. Marples (156) discussed the operation of the Powell River Company experimental forest in British Columbia. In eastern Canada the Abitibi Power and Pulp Company operates a 40,000-acre woodlands laboratory. On this the company endeavours "to develop the art of forestry by manipulating forest factors on a practical basis within the limitations imposed by operating procedures."

The aim of the 7,000-acre Canapcal Forest Research Station of the Canadian International Pulp and Paper Company in Quebec is to "close the gap between forest research and its application to the business of forestry" and in furtherance it undertakes large-scale research into pulp-wood production. It is probably preferable to consider such areas as pilot forests rather than experimental areas. Their primary aim is the demonstration and adaption of known principles to the commercial management of industrial forests.

Evaluation of company research and experimental forests is difficult, for considerable public relations value attaches to sponsorship. Although the majority of corporations are sincere in their interest, a minority have little research substance to support their experimental or dedicated areas.

Outside North America, experimental forests have found more limited application. They are often confined to small areas of woodland controlled by university forestry departments, and are perhaps the exception rather than the rule. Their significance under American conditions, and absence from the European scene, was discussed in Unasylva (81). An exception is in Sweden where a total of 34,000 hectares of forest, in four units, has been set aside for experimentation. These units are to allow the use of careful inventory and stand description, and to permit forest-management measures to be studied and applied on a large scale (70).

In Burma, Näslund (165) recommended the formation of experimental forests in each of the natural regions, seven in all. He advised that field research should be concentrated on these areas, which would be exclusively at the disposal of the research institute. To facilitate research, permanent stations would be established. The research division should carry on rational forest management in those parts of the experimental forests not being used for testing purposes. Gradually a demonstration forest would evolve.

In North America the research forest is playing a useful role in bridging the gap between practice and theory. On such tracts it is possible to demonstrate on a practical scale not

only the application of research findings, but also the application of long-accepted forestry principles that cannot be observed elsewhere in the absence of managed forest. This was the aspect that was stressed by Chalk (45) when he discussed what he termed a wholly admirable feature of all the better American forestry schools. He attached importance to the student-training facilities, to the facilities for faculty research, to the potential value of such areas as examples of management where adequate records have been kept and especially to their importance as demonstration areas both for students and the public, in substitution for the managed forests which are available for inspection in Europe. He considered that the value of these areas would increase considerably with time. Illustrative of this is the Campus Forest at the University of New Brunswick where there is a complete aerial photographic record of the forest at five-year intervals over the past thirty years.

As Bickerstaff (15) has indicated, many questions that arise during the transition period between the era of uncontrolled exploitation and planned forest management cannot be answered on the basis of practical experience or of research in the strict sense of the word, and it is necessary to fill this gap in 'experience' knowledge through practical demonstration. Under such conditions 'research' and 'demonstration' cannot always be differentiated.

It is unfortunate that the name "Experimental" or 'Research forest' has been generally adopted for these tracts. In many cases 'Demonstration forest' would be better suited to the

long-term function. Considerable prestige has been attached to the term research, and possibly more significance given it than is justified. Less emphasis on this facet might well facilitate extension of the demonstrated practices into industrial management.

The desirability of demonstration in an experimental forest would seem to be the basic point at issue in the strong attack which was made by Pearson (173) on the administration of the forest experiment stations of the western United States. He criticized an alleged general failure to demonstrate in the experimental forests principles of management which had been established as a result of intensive research, and stated that after forty years of national forest administration there was yet to be produced a well-managed forest, even though for most of this period silvical research had been carried on at six experiment stations in the region. There was no lack of research studies but they were not integrated and applied in a balanced program of management. His view was that "clearly the function of research is to assume responsibility not only for bringing forth much needed information but also in applying it."

Of recent years there have been suggestions that the various functions of the experimental forest, viz., research, demonstration, and education, are not compatible.

When the Canadian Petawawa Forest Experiment Station was first established it was considered that its greatest use would be as a demonstration area on which the results of working-plan management could be shown to provincial author-

ities and industrial operators. As its use as a field laboratory expanded it became more and more difficult to harmonize the requirements of sustained-yield management and the provision of satisfactory areas for experimentation. It is now the policy to give priority to research projects. Forest resources are not exploited chiefly to obtain revenue or to satisfy local demand for raw materials, nor is any particular effort made to fell each year the yield according to the working plan (34).

Difficulties arise when it is necessary for research forests to be self-supporting, and also, as in the case of some university tracts, for the income to support a research program off the forest. It may then become necessary to maintain revenue, even at the expense of long-term research and demonstration benefits and of the improvements that would result from the more intensive management possible if forestry fund principles were followed. Where areas of second-growth forest have come into the possession of forestry schools lack of revenue from the immature stands may severely limit management possibilities.

Conflict of interest between research and the training and demonstration aspects has been suggested. At Blodgett Forest, California, a 2,731-acre tract, four elements of administrative policy were adopted when the area was taken under management. These are:-

1. The primary use of the forest should be to furnish facilities for research.
2. The forest should not be used for undergraduate instruction.
3. The Forest might be used for graduate instruction and research as opportunity developed.

4. Demonstrations of forest treatments should not be set up which might not be in keeping with the practical needs and limitations of the area, but should attempt to apply such improved practices as might be appropriate to local conditions (8).

There is room for differences of opinion regarding the fourth principle. In the management of a demonstration forest in a rapidly developing forest economy it may be wise to recall the words attributed to John Dewey - It does not pay to tether one's thoughts to the post of usefulness with too short a rope.

At Oregon State College the forest properties are managed under a different policy. Among the properties of the School of Forestry there are the 6,809-acre McDonald Forest, the adjacent 4,000-acre Adair Tract, and the 181-acre George W. Peavy Arboretum. These form one block of timber seven miles from the campus. Two other tracts are also within reasonable distance. These forests are used extensively for student instruction and a fleet of trucks takes classes to them daily for field instruction.

In general the greatest values in the university-type experimental forest appear to be in the provision of training facilities for students through the development of well-managed forest. There would seem to be no reason why this should be incompatible with the research function, not the employment of areas of forest for permanent demonstrations of more advanced practice or as natural reserves. Although in the intensively managed forests of Europe there might conceivably be a conflict of interest, this is most unlikely to occur at the present stage of North-American management. Greater difficulty arises

when the policy is followed of attempting to manage such tracts with these principles in mind, and at the same time attempting to demonstrate commercial management within the framework of current and, possibly, short-term economic conditions. This is particularly so in a rapidly changing forest economy such as obtains in much of North America.

A more valid argument is advanced against the experimental forest as a research unit. Ostram and Heiberg (170), while recognizing the value of such areas for combining biological and economic phases in a single trial, indicated the disadvantages that accrue. In general these arise from the additional demand on limited research resources through the need for attention to routine administration and forest management. A loss of research control was also suggested and the difficulty of interpreting results obtained in terms of other areas. The demonstrational and educational value of such areas was recognized - the extent to which the demonstration objective should influence a program of research depended on local needs and the policy of the research organization.

With the extension of control the importance of the experimental forest other than as a demonstration area will probably be much reduced. Kaufert and Cummings (132) referred to the 'more realistic' attitude of most American schools, and said that there was no longer the insistence that the ownership of forest lands was a prime prerequisite to silviculture and management research, in view of the increasing availability of government and industrial lands for academic research purposes. Forestry schools had wasted valuable research time and money

on the operation of extensive forests and many had become 'property poor' and 'operation poor' in the process. They considered that few could point to such operations as financially profitable unless they hid costs, something that they said was readily done. They concluded that the schools should leave to industry most of the task of demonstrating the profitability of forest land management and concern themselves instead with the important task of obtaining growth, reproduction, and other management information.

Possibly the question devolves into one of intensity of operation. Where forestry is practiced under extensive conditions a forest school may be able to manage a large forest estate with but little difficulty. With the evolution of more intensive practices this will be much less practicable without serious diversion of effort.

The true research value as distinct from the demonstration function will depend on local conditions. R. H. Spilsbury has stated (194) that the British Columbia Forest Service Research Division, from experience of two existing areas, has no intention of acquiring or developing more. Experimental stations were costly to maintain and generally of a somewhat restricted nature, they did not contain sufficient ranges in site, type, age groups, or other conditions to sustain a variety of studies. Instead, demonstration plots, covering the range of forest environments, were preferred. These could be situated on forest management license areas, public working circles, and on other crown lands.

Much may depend on the staff and resources available. In

recommendations for research development in Iraq (209) it was advised that separate experimental forests be not set up because their organization and administration would be too much of a strain on the young research division, necessitating duplication of staff, and diverting attention from urgently needed investigational work. Exceptions were special high-elevation experimental areas of limited extent outside the forest boundaries, and arboreta adjacent to the research institute.

In the final analysis, it may be preferable, if demonstration forests are established, that these be controlled by the research organization, but in this event additional staff should be provided, and the extension function clearly delimited.

#### Demonstration and the extension function

Forest research, to be purposeful, must facilitate, no matter how indirectly, the practice of forestry. Truly, "the results of research work in silviculture and management are valuable insofar as they become applied in practice" (Champion, in 29). But also the results of fundamental enquiry provide the necessary background for the activities of the technological investigator. His findings in turn, together with the fruits of accumulated experience, provide the basis for the craft of the practitioner. This information is only of value if it reaches the man who is to put it into practice.

There are various ways of bridging the gap between the discovery or development of new techniques and their field application. Demonstration and personal contact most commonly

have the greatest impact, but effects are localized and may be ephemeral. There may also be certain dangers. Champion remarked (29),

"Many research officers are almost afraid to open their mouths in conversation with their executive colleagues for fear that some suggestion emerging from preliminary results, but not yet established, will be extensively applied in current practice, with risks of undesirable results bringing the research work into disrepute."

For permanence and wide distribution, publication is usually necessary. Particularly in small, in-service groups, directly controlled by the administrative branch, there may be a conflict between "research" and "demonstration". The research officer may be called upon to demonstrate the suitability of predetermined practices and to establish "experiments", more truly demonstrations, or to "prove", for reasons of departmental policy, facts already well-established. Such activities intrude upon true research and on that account are often most unpopular. Under certain conditions however, an extension, or educational, function may be administered within a research structure with positive all-round gains, but efforts to give stature to departmental policies through the addition of a research cachet should be resisted. Demonstration should be clearly distinguished from research, and labelled as such.

The policy of the Canadian Forest Biology Service provides a useful model for the larger specialist research organization. Here the need is for "absolutely dependent and adequate surveys and thoroughly reliable research" (177). For this reason it has been laid down that although research workers should maintain close professional liaison with cooperating groups they should

not become so preoccupied with extension services that the continuation of research is impeded or prohibited.

To facilitate liaison it has been suggested (Prebble, in 194) that the provincial governments and each of the major forest companies should assign a man to cooperate with the Forest Insect and Disease Survey, to keep abreast of developments, to fill the gap between findings and application, and to assume organizational and directional responsibilities when large-scale control operations are necessary.

In recent years in India, a Publicity and Liaison Branch has been formed at the Central Research Institute to improve dissemination of research findings and for general forestry education. This was found necessary despite a large output of publications, aimed at both the profession and the general public, and also close liaison with forest departments and in the forest districts (178).

However, it is not always easy to distinguish between 'research' and 'non-research' activity, more so in the specialist fields. In these research and development may be combined. Poplar cultivation and tree breeding are examples of activities where the boundary between true research and the conduct of routine, though specialized, operational and extension duties is indistinct. The work of many commissions and working groups falls into this category.

#### FUNDS FOR RESEARCH

There is little need to justify expenditures for research, for as Wilm (23) has written,

"It has been shown repeatedly that well executed and adequately financed research pays dividends far beyond the necessary expenditures. If efficiently conducted, even large-scale and protracted investigations require only a fraction of the values that keep on being wasted for lack of knowledge."

Nevertheless, one must be realistic; it has to be recognized that,

"the real limitation of the scope of a research program is usually financial. Only a certain amount of money can be set aside for research, and how much that should be depends on a number of factors. In the case of the old, long-established forest department which has settled down to fairly stereotyped methods of working and has built up a tradition of management and silvicultural techniques, less expenditure would be called for than in a relatively young and developing department concerned with the creation of a forest estate under new conditions. The practical problems that arise in the latter case are more numerous and more urgent, and it is prima facie desirable to spend a larger proportion on research in relation to total expenditure. Other factors also come in such as the general financial situation in the country and the financial situation in the forestry department itself. It is an unfortunate paradox that in any industry, forestry included, the need for research is greatest when things are going badly and money can be least spared."

Attempts have been made at correlation with other spheres of activity. Kaufert and Cummings (132) used data from a range of industries to determine the desirable level of American research expenditures. The Canadian Lumberman's Association (24) have made comparisons with federal expenditure on agricultural research. It may be questioned whether such comparisons are valid for the research needs of one industry can have little bearing on the requirements of another.

An alternative approach has been to correlate research expenditure with present productivity but, unless forestry is to be considered only from the extremely narrow viewpoint of a short-term extractive enterprise it is difficult to see that

this index can give any indication of a desirable level of expenditure. There is, nevertheless, a significant disparity between expenditures in industry-sponsored research in forest products and in management research, even with due allowance for the possibly more costly nature of the former. The incentive of early financial return encourages greater investment.

Sloan (194) commented on the fact that in Canada and the United States about three times as much money is spent on products research than on research in forestry. He emphasized that:

"to compare the amount of money spent on products research in terms of percentage of net annual value of that product with the amount spent on forestry research in terms of net annual value of primary forest products, does not take into sufficient account the enormous future values that can be expected from intensive forest management of our capital asset. .... the capital value and potential production of our forests should be considered as well as the annual income value when assessing the adequacy of forest research programs."

Despite industry emphasis on products research it is salutatory to record that in 1955 one company was responsible for thirty percent of the total expenditure on forest management in British Columbia, and far exceeded Government's contribution (194). However it should be noted that the industrial contribution is apt to fluctuate widely with varying economic conditions. Government-sponsored research is less likely to be influenced by short-term trends.

Attempts at the development of an economic yardstick for determining the adequacy of research expenditures neglect the situation that timber production is but one facet of forestry, and that research is desirable in fields from which financial

returns, if any, will be of an indirect nature.

Clearly under such conditions an economic evaluation is impossible.

"In any research program the expenditure should not be limited arbitrarily to a certain percentage of total expenditure or to a certain fixed amount, but must be conditioned by the number, importance and urgency of the problems that have to be solved." (147)

In the present study an attempt was made to compare national research expenditures. This proved impossible in the absence of a common base. As Laurie also found, annual financial statements of forest services rarely prove very informative, for staff and other overhead expenditures are very often not clearly allocated. All that can be done is to describe individual situations. In British Columbia research expenditure during the ten-year period 1935-1945 was 0.94 percent of total forest revenue. In 1946-47 it was 0.47 percent and in 1956-57 it was 0.27 percent. In 1946-47, 1.06 percent of total government expenditure on forestry went to research. In 1955-1956, 0.62 was so devoted (194). In the United Kingdom, in 1956, the amount spent by the Forest Authority on forest research, including all salaries and overheads, and also grants to universities and other institutions for fundamental research, was 2.9 percent of the total state expenditure on forestry. In the United States, expenditure by all agencies on forestry research (excluding forest products) was given by Kaufert and Cummings as 0.06 percent of timber-products revenue.

As Laurie remarked, it is a matter of opinion whether or not any one level is correct.

Additional difficulties result from changing money values

with time and between countries. Direct comparisons between national expenditures can mean little. It is perhaps a valid criticism of Kaufert and Cummings' report that they relied to an undue extent on financial provision and academic standing for the evaluation of research effort. It is difficult to suggest any practical alternative as an exact yardstick; the question is whether quantitative definition is possible and has any real significance in such a highly personalized field of human endeavour. Kaufert and Cummings' attempt contrasts with the earlier studies when more philosophical and qualitative assessments were made. Perhaps the methods adopted in the various instances reflect the prevailing research philosophies of the time.

Recommended and actual expenditures on forest research in post-war Britain illustrate the difficulties of forecasting desirable financial provision. Including capital expenditure on the new research establishment, the Forestry Commission proposed an annual expenditure of £30,000 during the first post-war decade (95). An alternative program which was advocated by the national forestry societies called for annual expenditure rising to £150,000 at the end of the first ten years (98). In fact there was considerably greater research activity than was envisaged in either proposals, with a considerably enlarged staff, and a much extended range of interest, and actual research expenditure was £265,000 in 1956 (147). Expenditure has continued to increase, and in 1958 it was of the order of £300,000. The advantages of flexibility in programming, and of a certain opportunist approach, are obvious.

under such circumstances. This cannot be so readily obtained when long-term, formal, and detailed research programs are adopted.

Where the administration is not so favourably inclined towards research activity there are advantages in formal long-term assurance of adequate support. In British Columbia, Spilsbury (194) has said that the greatest need is for assurance of adequate provision for sustaining long-term comprehensive programs. Cuts in financial allocations destroyed all efforts at planning and encouraged day-to-day expediency, with emphasis on short-term studies, rather than on possibly more urgent long-term investigations. In America the McSweeney-McNary Act of 1928, authorizing ten-year appropriations, provided the assured support necessary for the development of the regional experiment stations which are the basis for present-day American federal research activity.

Most often, principle financial support is by Government, but it is desirable to obtain as wide a base as possible. Shirley (191) has evaluated the relative advantages and disadvantages of the various sources of support in the United States. Government funds, although a major source, often have limited flexibility. Support by industry has the advantage of provision for immediate urgency. That from the foundations and from university funds has greatest flexibility in the allocation of the resources available.

A common method of financial provision in in-service research is by direct allocation through a departmental budget. The reliability and extent of such provision depends upon the

value attached to the research function by higher authority. This obviously will be much influenced by the value of the research contribution to the furtherance of departmental practice. In this the applied research group has obvious advantages because of the more immediately apparent applicability of its findings.

Provision for research must reflect security of provision for forestry in general. Where the principle of the forestry fund has been adopted this has been greatly facilitated. To a considerable extent the facilities at the Dehra Dun institutions in India are attributable to the application of funding principles to forestry in India. The demands made upon Indian forest revenues by the states since independence has lessened the availability of funds for such purposes.

In North America basic research is often financed through trust funds or by grants-in-aid from public and private agencies, and most often the research worker has to seek financial support for the individual project. In other countries support comes most often from general funds, if at a university, or from government grants. When such support is provided by a forest administration, direction of funds towards projects of direct interest to the sponsoring body may be expected. Greater freedom obtains when government monies are channelled through public agencies charged with responsibility for the stimulus and support of fundamental research in general. Examples are the National Science Foundation of the United States and the Canadian Research Council. The aims of the American body are typical,

"..(the provision of) aid to any organization or individual in a position to make a significant contribution to scientific progress." (191).

Usually, however, the individual researcher still has to present an extremely detailed statement of his proposed research when applying for support. Much time may be spent on this facet.

The usual pattern of the European universities is for long-term support to be given to the laboratory or faculty rather than to the individual project and for this to be provided directly by the university. In the European state universities there is the ever-present possibility of government direction but the tradition of academic freedom is jealously guarded. In Britain the universities are independent foundations, although in modern times there has been increasing state subvention. Independence of action is provided through the University Grants Committee, which permits of government financing without government control or direction of expenditure. Funds are passed to the Committee for disposition to the universities as block grants at its discretion. The workings of the Committee, which is formed of representatives of the universities, has been discussed by Carmichael (43). In addition, specific studies may be undertaken at the request of government agencies. These are financed separately.

Earlier, reference was made to research sponsorship by non-governmental bodies, trade associations, cooperatives, foundations, trusts, private and industrial agencies, and through industrial participation. The degree of control that may be exercised by any of these is dependent on the interest that

the sponsoring body has in the application of the results obtained. Where there is disinterested sponsorship there may be little more than a check to ensure that funds are usefully spent, even this may be omitted.

Cooperative agreements between state and other interested parties provide research advantages. An example is the arrangement at Zurich where the research institutes attached to the Federal Polytechnic are financed by the State, but work is also supported by a 'Fund for promoting Forest Research and Wood Utilization' and by other sources (83).

The desirability of coordinated agency research has been discussed. Similar research benefits result from the pooling of financial resources, a much more difficult proceeding. The organization of the Research Society of the Forestry and Forest Industries of Norway has already been described. One of its most important functions was the marshalling of available finances so that the member institutes might be placed on the firm economic foundation that was necessary if they were to take the long view in their research. To facilitate this, all classes of members; industry, advisory bodies, and research institutes, pledged membership for an initial period of five years, automatically renewable for succeeding five-year periods. A voluntary levy was made on timber used, the forest owners contributed through their federation on the same basis as that obtaining for the collection of the state forest-improvement tax, while the trade members paid a levy on each ton of finished products and also one percent of the sales value of their output. These measures produced substantially more than had

hitherto been available for forest research and the sum was, moreover, assured for a period of years. Thus the annual research budget was provided for. Capital expenditure for new construction and the extension of facilities was obtained by application of a portion of the proceeds of an export tax levied on the wood-producing industries, twenty percent of which was reserved by government for purposes of common interest to the forestry and wood-processing industries.

In the United States the research and fire-control activities of the Oregon Forest Protection and Conservation Committee are supported through a privilege tax on the harvesting of forest products. This tax is levied on the produce of all forest lands containing merchantable stands, and from all forest lands protected from fire by official state agencies. The levy consists of four cents per 1,000 feet board measure of timber produced, excluding the first 25,000 feet. Monies for research financing are placed in a Forest Research and Experiment Account. This has a reserve base of \$400,000. If the resources in this account exceed the reserve base at the end of the financial year the tax is reduced by 50 percent during the following year. Similar arrangements have been made for monies allotted for fire protection. The Research Fund also receives any funds made available to the State of Oregon by any federal agency for forest research purposes, and any contributions or gifts by private persons or by public or private agencies (130). Despite this assured income the present situation of this research group, nevertheless, illustrates a danger that should be avoided, for while initial large capital expenditures permitted

the establishment of a large station and extensive permanent installations, current income is insufficient for the maintenance of the level of staffing necessary to make fullest use of the facilities available.

A characteristic of the American literature is the emphasis placed upon finance as the key to successful research. The example just noted may seem to substantiate the validity of this view, however the emphasis goes deeper than the provision of a minimum staff. Great and continuing stress is laid on a relationship between salary levels and research quality, and upon material rewards as a major force in the attraction of personnel to a career in research. This is much less in evidence in the early writings, for example Clapp (52) remarked that only relatively small subsidies were necessary to stimulate research activity. In contrast, Kaufert and Cummings (132) emphasized the important part that salary schedules play. Thus,

"those agencies and research areas with the best salary schedules appeared to have the highest percentage of imaginative and productive research personnel. Quality as well as quantity is purchasable . . . . Many outstanding forestry school graduates with research promise see more opportunity for advancement and for greater (financial) compensation in management and administration than in research."

This reflects the favourable employment situation that has been enjoyed by American foresters in recent years. Nevertheless, care should be taken in unduly weighting the pecuniary advantages as between research and administration or practice. Research is only a portion of the over-all forestry scheme. A healthy silviculture requires a virile research effort but it

also requires men with imagination and the capacity for constructive thought in management. Without these qualities there can be no truly professional practitioners. There is perhaps little real difference between the outstanding men in field research and in practice. Forestry would be ill-served if the inducements to research were such as to draw off all men of high calibre. Probably the situation is unlikely to arise! Nevertheless a balance is necessary. There can be too much emphasis on research and insufficient on sound management. Where the necessary balance is to be must depend on the circumstances of the forestry situation, but it is important that practice be not looked upon as the poor relation of research in the provision of staff of high attainment.

#### DISSEMINATION AND DOCUMENTATION

##### Publication policy and practice

Difficulties in dissemination may result from lack of distinction in aim. In general, papers should be directed to a specific audience.

Place (175) suggested that large research agencies should employ fluent staff writers for more popular accounts of research activity; in fact, publication or editorial branches are frequently organized within government forest agencies. They are perhaps less commonly concerned with research alone. The size of such establishments obviously must depend upon the size of the service. In the United States there is an editor at each Forest Experiment Station and also an editorial staff. In Great Britain, a Publications Officer is attached to the Research and Education Directorate and is responsible for

co-ordination of all Forestry Commission publications.

The machinery of publication varies. Research institutes may control their own publication policy and publish their own findings, or publication may be centralized through the forest service. Both practices may be followed within the same organization for different types of publication. Publication directly by the research station results in less delay, but it may lead to over-production. Much depends on the attitude of the research staff; there is considerable variation in this regard. In some cases workers or organizations attach considerable significance to research publications, in others there is but little interest.

The United States Forest Service procedure (215) is especially notable for its formalism and comprehensiveness. There are detailed and extremely specific instructions for each stage in the publication process. Little freedom is left to the researcher. Joint publication with other agencies is regulated and procedures are prescribed for the preparation of papers for publication in the scientific and professional journals. Responsibility for release through non-official outlets rests with the Director of the Forest Experiment Station. He is responsible for all research publication from his station and decides on types, scope, character and authorship within the limits laid down by the regulations. Important or controversial publications, or those dealing with policy matters, must be referred for approval to the Washington office.

In the standing instructions, responsibility for suggestion of topics, guiding authors, scheduling production,

controlling accuracy, etc., are delimited in great detail. Specifications are laid down for the technical production of manuscripts, including secretarial instructions in surprising detail. Conditions for the allotting of authorship credit are strictly prescribed. A timetable is laid down for each stage in the publication process.

Two types of official publication are recognized. These are termed Departmental publications and Station releases.

The Departmental publications must be approved by the Chief of the Bureau (i.e., the Forest Service) and reviewed by other interested government bureaux (departments), whose comments and suggestions must be considered and, if possible, harmonized.

Before preparation of the manuscript a prospectus is drawn up, endorsed by the Station Director and the Washington Division Chief, and approved by the Assistant Chief in Charge of Research. This officer is responsible for final approval of publications and for general policy and standards.

The chain of processing is complex. Copies of the manuscript pass through a large number of hands. A formal Board of Review, formed of senior officers, is responsible for technical review; in addition the manuscript is critically considered by each of a number of prescribed senior officers. A paper may be returned for revision to the parent station a number of times during processing. Finally it passes into the editorial hands and thence to printing. It may take several years from the initial submission of the completed manuscript before the final publication.

This procedure may be presumed to have evolved to meet the needs of an organization of the scale of the United States Forest Service, but in total it appears inordinately costly in man-power and subject to very considerably delays. It is a matter of opinion whether complete standardization in presentation and the elimination of individual style is desirable. It may moreover be questioned whether such a complex and formalized processing procedure is essential for a research staff of high quality, if there is a rational approach to research publication both in terms of quality and volume. Perhaps emphasis placed on the desirability of early and full publication has produced reaction in the need for detailed control of production.

To reduce delays, and for papers of lesser significance, the regional experiment stations of the United States Forest Service use station releases. There are technical, station, and research papers, all in numbered series and providing vehicles for different types of publication. There are also short station notes that give information on specific subjects and which report progress in investigations of limited scope. Their purpose is the presentation of timely research results and information on current investigations. Station releases are processed at the experiment station level. There are in-service procedures similar to those already described at the national level.

To maintain a high and uniform standard of publication the Experiment Stations conduct programs of continuing training in the techniques of writing and analysis for publication. The

ideal is uniformity and the elimination of individual characteristics or style.

In recent years increase in the number and size of research agencies has resulted in a greatly increased volume of publication. Partial solution is provided by the bibliographic agencies, but this is only a palliative for the numerous and ever-growing number of series and journals. One problem is the duplication of essentially the same results in different form.

It may be questioned whether the typically detailed research reporting, complete with literature review, is always necessary. A rational policy towards publication, and reliance on the standing of the organization concerned, should render superfluous a considerable proportion of the detailed accounts of methods and data analysis in routine experimentation, when well-tried techniques are employed or simple field trials are involved. It is of course desirable, in this regard, to distinguish between the presentation of findings from routine experimentation and the publication of new research techniques. An example of the value of the latter form of publication has been reported by Setten (187). This was the use in Malaya of principles initially described in a paper by J. W. Ker of the University of British Columbia.

The publication of large numbers of mimeographed station notes, reporting on individual experiments, extending over only a short period and of very varying significance, and often with only interim or provisional results, is consuming of research resources. A matter that has received little attention

in the literature is the demands that the preparation of this material makes on the time of the research officer, both in preparation and review. Kaufert and Cummings (132) remarked,

"Research notes are helpful in disseminating results in summary form, but usually they are available only locally to practicing foresters, and nationally only through the librarians of research agencies. Their sheer abundance makes their review by even research personnel difficult."

It may perhaps be questioned whether publication in this manner of the bald results of individual experiments is the most desirable method of presentation. While of interest to other research workers who may be working in the same area, and serving to keep them informed of progress and current activity, they do not supply the practitioner with the overall view that he requires to decide how his practice and techniques should be modified in the light of scientific advance. It is highly desirable that the specialist research officer interpret his findings in terms that are intelligible to the non-specialist, who will almost certainly not be able to keep in touch with all current activity through personal review of research publication, even supposing that he possesses the special knowledge to evaluate this information.

Individual research notes are difficult to conserve. The question is whether they serve any vital and irreplaceable function. If there is need for early publication of this class of material this may often be satisfied by a short note in the annual report of research activity, a most important publication. The short delay in publication is of but small consequence. If necessary this may be supplemented by an

occasional note in a current journal. Eventually the finalized and accumulated findings should appear in a comprehensive study.

To many foresters, time taken in the preparation of minor papers of ephemeral value, the desire for immediate publication, and the consequent impression of preoccupation with individual experiments, often of limited extent or minor nature, suggests a limited individual research program and an excessive desire for recognition. This assessment may be difficult for the American worker to understand but it is nevertheless so.

The English-language scientific journals Nature and Science provide a useful medium through their letter columns for miscellaneous observations and records in the basic sciences, the former, particularly, is used extensively for this purpose and is international in the scope of its contributions. It is to be regretted that more use is not made of similar facilities in the forestry journals for this class of material. Conservation would be greatly facilitated.

The need for synthesis has been indicated by several writers. Hignet (112) has commented on the fragmentation of study by which,

"for several decades the majority of scholars have preferred writing small studies.... of tiny areas.... of topics obscure and periferal.... those who look in from outside see no cathedral arising (but only haphazardly scattered heaps of bricks)"

In the preface to Baldwin's excellent synthesis Forest Tree Seed (6), it is said,

"Practicing foresters and nurserymen often do not have access to such (research) publications, or time for looking them up even if they hear of them. Such defects in our methods of scientific study must be remedied by an occasional synthesis and digestion of the scattered information, and concentration in a single publication."

Shirley (191) believes that,

"Studies that integrate results of specific research projects of limited scope into broad principles applicable over wide areas, and under a wide range of circumstances, are especially desirable."

Examples of such syntheses are the review articles in Forestry Abstracts and the Technical Communications of the Commonwealth Forestry Bureau. Academic theses also provide useful sources. It is to be regretted that funds do not permit of the publication of these. Much valuable material remains generally unavailable, and even unknown, to the majority of workers, within the covers of the many dissertations that are prepared each year. Periodic publication of summaries is useful. Microfilming techniques have also made a useful contribution.

Most normal requirements of government agencies may be met by a publication policy that makes provision on the following lines: The annual research report, the main research publication, summarizing the technical activities of the agency during the year under review, and reviewing and detailing the work undertaken and the results obtained. This should be the principle vehicle for the dissemination of research findings. Institute papers, a numbered series, published at irregular intervals and concerned with comprehensive accounts of specific subjects of lasting significance. Such a series is well reserved for major and authoritative contributions.

Leaflets, again a numbered series, containing material of lasting significance but of lesser magnitude.

Miscellaneous publications and single sheets, in unnumbered series, are best avoided. Such a publication policy is well fitted for the conservation of significant material while reducing the likelihood of its becoming lost in the dust of library stacks. Whether publications should be written for a professional or a scientific circle must depend on the circumstances but there should be clear appreciation that the present-day research publication is often of a nature that is suited to the latter rather than the former.

But unless a strong affirmative can be given to the query "If this contribution remains unpublished, in this form, will forestry and forest science be the poorer" then the question may be raised as to the desirability of publication.

Supplementing official publications, scientific and professional journals are valuable media for dissemination. Their choice depends much on the character of the contribution and the circle that it is desired to reach. The more penetrating study will usually merit publication in vehicles specifically serving specialist interests and possibly international in scope.

Finally, there should be facilities for the publication of observations by the practitioner. Whatever the importance of the research organization in a forest service or national forestry structure and howsoever it be organized, technical advance is not dependent only upon the professional researcher. Every forest officer frequently makes observations, experiments,

and trials for himself if he is worthy of professional standing. It may not be formalized but the mass of experience thus accumulated should not be lost. It may best be preserved through departmental, house, or society journals. In this way individual experience can be made accessible to a wider circle. There is perhaps much to be said for publications of the type of the now defunct Journal of the Forestry Commission in Britain. A technical publication, this had limited distribution and its circulation was mainly restricted to forest service personnel. Contributions were invited from all grades of the service. More usual, however, is the society journal. These have the advantage of a wider circulation. But, as in the case of official publications, there has been a tendency towards proliferation. The condition is general. An extreme example is provided by the German forestry literature. In all, fifteen German forestry periodicals were included in the most recent (1953) Forestry Abstracts check list (54). These cover a range of interests but with considerable overlapping. Jahrig (128) considered their number to be excessive and deprecated the situation; he maintained that three only would be sufficient and desirable; one for forest science and research; one for professional forestry and forest products; and one non-technical publication directed to the general public. In most national circumstances such an arrangement has much to commend it. Where regional interests are strong, or in a country as extensive as the United States, for example, it may, additionally, be desirable to provide vehicles for material of local interest, but it has been well said that writers should be

given a sabbatical year in which to be given time to read a rather larger fraction of what is already in print. Especially in the highly competitive atmosphere of American research it is highly desirable that attempts be made to overcome the vicious circle of over-publication.

#### Dissemination in industrial research

The freedom with which the Scandinavian forest industries co-operate in forestry research, and their rational approach to publication of results, is indicative of the maturity of the forestry effort in those countries. Company advantage may ensue from the withholding of information on industrial processes in the products field, but similar policies in the forest indicate a lack of appreciation of the nature of forestry endeavour. Much more may be gained through mutual advance than from the withholding of data. The extremes to which company secrecy may be taken is instanced by a case encountered by the writer during the preparation of this study. Permission to refer to a thesis prepared by a candidate for the British Columbia Registered Foresters qualification was refused by one of the largest integrated forest industries. The material in question comprised a short note describing the remuneration, organization and routine duties of a six-man silvicultural crew of field technicians. In that it substituted regular, year-long, for casual, seasonal, labour this was a new and promising departure in British Columbia forestry. However, this was considered to be confidential information of possible value to industrial competitors. Ker and Smith (137) discussed the difficulties in mensurational

activity that resulted from excessive industrial secrecy in British Columbia. They indicated the needless duplication that resulted and also the impossibility of undertaking satisfactory growth-and-yield studies on a company basis. They declared, "There should be no need to label as 'confidential' any research in forest mensuration." It is to be expected, or at least hoped, that with growing maturity and increased understanding of forestry the situation will change. Scandinavian industry provides a suitable model. Unless there is a change in thought it is difficult to see how there can be real advance in technology when the major activity is in the hands of industrial operators.

#### Documentation

"An important function of a research officer in a small department is to keep a watching brief on current developments abroad so that he might inform the executive of any development which has promise for his own department, or which may suggest a promising line of enquiry. He must keep in touch with current forestry thought and advance,"

To facilitate this,

"It is necessary that a researcher or specialist has access to a comprehensive and up-to-date library if he is to work properly ..... the value of the most important policy statement, investigation, survey or observation, rests entirely on its being known, it is therefore important that documentation and publication facilities keep pace with other development." (209)

Documentation is an essential concomitant to publication. Lack of knowledge of the existence of similar research or experience knowledge can lead to unnecessary duplication.

The Seventh Conference of the Food and Agriculture Organization urged Member Governments to establish centres for forestry bibliography to co-operate with agencies undertaking

documentation at the international level. The Director General of the Food and Agriculture Organization further suggested that national centres for forest bibliography should prepare title lists regularly.

In the larger agencies documentation centres are usually associated with library facilities. These provide for the classification of reprints, photostatic copies, clippings, publications and journals. To provide similar services for small groups, national and regional centres have come into being. Their pattern suits local needs. In Germany the documentation function is centered on Reinbek. In Canada, the Pulp and Paper Research Institute serves as a clearing house and distribution centre for technical information of importance to the pulp and paper industry. Here information from scattered sources is assembled and distributed in the form of monographs, bibliographies, translations, and critical reviews. In India the Silvicultural Section of the Central Research Institute has long functioned as a clearing house and documentation centre for Indian and world information, and an extremely detailed system of ledger files has been evolved. Similar services are provided by the East African Agriculture and Forestry Organization at Muguga, Kenya. For the British Commonwealth as a whole, collection and dissemination of information is undertaken by the Commonwealth Forestry Bureau, regular distribution is through Forestry Abstracts and Technical Communications. There are also facilities for the borrowing of literature. Any scientific worker or forester in a contributing country may correspond directly with the director of the bureau with

requests for information, or for bibliographies on any specific topic; these are prepared on request without charge to the individual or the service. The service is informal and there are no official channels of communication. These Agricultural Bureaux, of which the Forestry Bureau is one, are distributed at suitable centres in the British Commonwealth and are governed by an Executive Council on which each contributing country has a seat. The organization is dependent for financial support upon the contributions of the individual Commonwealth Governments.

For the best use of such facilities it is desirable that there be uniformity in classification of forest literature. The International Union of Forest Research Organizations—prior to 1929 called the International Association of Forest Research Institutes - put the question of forest bibliography on its program as early as 1903, with the object of creating a universal system of classification and an international bibliography. Subsequent developments have been described by Saari (185). After long and difficult preparation a complete system of classification of forest literature was presented to IUFRO by its Bibliographical Committee in 1933. This, the Forest Bibliography, became known widely as the Flury System, after Dr. Philipp Flury, a Swiss forester who did the greater part of the creative work on the new system. The System was so arranged as to be a sub-division of the Universal Decimal Classification (UDC). One of its main uses was to classify the title references in the International Forest Bibliography - this was a scheme organized by IUFRO for the regular exchange

of references to literature considered to be of international importance.

During the 1930's revision became necessary because of new developments in forest research. After the Second World War a completely revised system was submitted by the Commonwealth Forestry Bureau at Oxford.

This revision was based upon 10 year's experience gained in the course of day-to-day work in abstracting and classifying the world flow of forestry literature, and in consultation with the chief Research Station of the U. K. Forestry Commission at Alice Holt and the Forest Products Laboratory of the Department of Scientific and Industrial Research at Princes Risborough. The proposed new system was subjected to critical examination by a joint IUFRO/FAO committee over a period of four years, and at various stages of revision was circulated as widely as possible to members of IUFRO and to other research organizations throughout the forestry world.

The definitive text of what became known officially as the Oxford System of Decimal Classification for Forestry was adopted by the 1953 Congress of IUFRO when all its members were urged to adopt the new system because of the high importance to forestry science of using a single up-to-date system of classification. Subsequently, it was translated into French, German, and Spanish. Two months later the Conference of FAO, at its Seventh Session in Rome, commended the system for adoption by forestry libraries, institutes, and documentation centres in the member countries. Earlier, in 1952, the Committee on Forest Management, Silviculture, and Forest Protection of the 6th

British Commonwealth Forestry Conference recommended its use for indexing and classifying information. The joint FAO/IFURO Committee on Bibliography remains in being and is responsible for any further development of the System that may become necessary to meet the changing requirements of forestry documentation.

The System, thus officially endorsed at the governmental level by the member nations of the Food and Agriculture Organization and at the scientific level by the member institutes of the International Union of Forest Research Organizations, has received continuing favourable notice and review and is recognized as the most definitive method of documentation in forestry. It lends itself to the classification of book collections, pamphlet files, technical records, office files and even photographic collections and maps. Considerable manipulation and flexibility in use is possible without compromising the advantages of universality. It may be employed as a sub-division of either the UDC or Dewey Decimal Systems of Library Classification. On these accounts it has been adopted by most of the world's major documentation centres and libraries.

Although the internationally used Universal Decimal System was evolved from the American Dewey Decimal System of Classification, American library science has developed along different lines from elsewhere, principally in its use of "expandable-to-infinity" classifications in place of the "closed-catalogue" classifications that are more usual abroad. Forestry documentation has lagged somewhat. None of the major

classifications of the present day have been devised specifically for use in forestry and so have lacked precision. Because of these inadequacies, domestic systems of forestry documentation have been devised at most forestry libraries. These are of varying quality and although some have obtained wider distribution they lack the advantages of universality.

Frances Flick of the U. S. Department of Agriculture Library has discussed the American situation in detail (77, 78,79), describing early systems and the evolution of those in use at the present day. She analyzed the relative merits of the Oxford System from the American standpoint and has advocated its trial as a useful tool for classification in American forestry documentation. Its neglect she attributes to the reluctance of established forestry libraries to change traditional systems, the absence of new forestry collections, and the alarm with which American librarians and foresters (accustomed to simpler forestry concepts and not always informed on the greater complexity of world terminology), on looking over the System for the first time, view its size, detail, and comprehensiveness. This latter point, of course, is overcome by the facility with which it may be employed at any level of classification as need arises.

As Flick sees them, the advantages of the Oxford System are that it is up-to-date, expandable by its decimal nature, covers in detail the classic scope of forestry, and can be used in conjunction with shelf classification by another system. An additional facility is the link that it provides with the

literature citations from the world's forestry literature that appear in Forestry Abstracts and also with the lesser known Centralized Title Service, an unselected listing of abstracts indexed during the culling of the literature for Forestry Abstracts.

#### INTERNATIONAL RESEARCH ACTIVITY

There is increasing realization that forestry and forestry interests transcend national frontiers. In forestry research the time factor is of great significance. In field experiments, for example, intervals of a century or more may be required to bring an experiment to a conclusion in order to prove the results of research and technique. Under these conditions it is almost imperative that the forester be able to review a long span of experience. It is principally for this reason that the forests and forestry of the "old countries" constitutes such a unique and immense experimental field from which the world at large has been able to gain much practical knowledge and many theoretical concepts, that may be interpreted in the light of local conditions. In this regard it is important to realize that this "experience knowledge" is not confined only to applied forestry and research in the biological fields, but also related to the economic and social problems and the public policies designed to meet these. As the late C.E. Legat (28) said

"In a small world the narrow, insular or parochial point of view is to be avoided like the plague. Vital and dynamic forest policy is most likely to derive from forest control well informed on world current forest policy and in touch with the latest developments in forest science and practice."

American foresters have been subjected to the greatest criticism in this respect; recently by Edlin (69), Wood (226), and Hiley (114) among others, who see evidence of increasing insularity. Some of this criticism may be unjustified. However, published comments such as the brief note on initial American research development in Puerto Rico as late as 1942 (14) which even at that date demonstrated a complete lack of knowledge of the very considerable efforts of the foresters of many nations in tropical forestry, including much effort in the Caribbean region, and even claiming that no work had been done previously on tropical forestry; the problems of which were stated as though newly enunciated, do little to dispel the impression. It is notable that although Kaufert and Cummings (132) placed considerable emphasis on the importance of adequate dissemination of American research information, and discussed the adequacy of current media, they made no reference to the equal desirability for American research workers and foresters to have access to knowledge of developments elsewhere. The omission is in strong contrast to the importance attached to this facet in the earlier surveys, and especially in that of Bailey and Spoehr (5). These indeed went even further for they placed considerable importance on the need for foreign languages in the education of all foresters so that they might maintain contact with forestry advance and practice abroad.

Marcel LeLoup, until recently Director of the Forestry Division of the Food and Agriculture Organization of the United Nations, has written;

"International coordination of research is essential to the most effective use of limited manpower and funds if forestry investigations are to provide the necessary solutions to all forestry problems." (84)

Detailed consideration of international and regional activity lies outside the scope of this study, but for research to be fully effective there must be activity at the supra-national level. Without the efforts of agencies such as the Food and Agriculture Organization of the United Nations and its various specialized agencies and commissions (see p.174 for accompanying chart) (106, 228, 48, 12, 85), the International Union of Forest Research Organizations and its working sections (121, 122, 123, 124) and the provision of facilities such as those of the Commonwealth Forestry Bureau in the bibliographic field (Howard in 28, 56) national programs would be the poorer. It is unnecessary to detail the various activities-provenance trails, poplar, chestnut and eucalypt commissions, forest bibliography, seed exchange control and testing regulations, to name but a few - that illustrate the very real benefits that result.

Much of the stimulus for international activity has resulted from the activities of the Food and Agriculture Organization. Aside from its direct activities it has also performed a most important function as a stimulus to international thinking in forestry and as a coordinator. A major force in international forestry is the World Forestry Congresses, for which F.A.O. provides a Secretariate. There have been five Congresses, the first held in Rome in 1926, the second in Budapest in 1935, the third in Helsinki in 1949, the fourth in

Dehra Dun in 1954 and the fifth in Seattle in 1960. These gatherings are attended by foresters representative of all countries interested in forestry and the national delegations are usually representative of the various national forestry interests. The Congresses deal with technology and policy and promote interchange of information, personal contacts and wider knowledge of technique and development. Recommendations are made to F.A.O. and to the participating governments.

One of the encouraging developments of recent years has been the extension of the activities of the International Union of Forest Research Organizations, mainly confined to Europe in pre-war days, onto the world stage. This has resulted from the increasing realization of the research institutes of the non-European nations of the tangeable benefits that result from association. A very real advantage in its operations is its non-governmental nature. Truly an organization of scientists, the member institutes are representative only of themselves and not of their governments.

Excepting the notably close co-operation of working groups in specialist fields and most often sponsored by FAO or IUFRO, closest co-operation on a large and continuing scale has developed within the more restricted sphere of the British Commonwealth. The most important organ is the Commonwealth Forestry Conference which is held at five year intervals. This is attended by representatives of the Commonwealth forest services and of private forestry and the wood using industries. It has been responsible, through its deliberations, for the

various Commonwealth Forest institutions: the Imperial Forestry Institute; the Empire Forestry Association, a professional society of Commonwealth foresters that provides a valuable link through its quarterly Review; the Commonwealth Forestry Bureau. These bodies are inter-governmental and are entirely dependent for financial support on contributions from the member countries or, in the case of the Empire Forestry Association, from its Commonwealth membership. In addition to these formally constituted organizations there is considerable informal Commonwealth collaboration.

At the regional level co-operation has usually developed out of a realization of common problems. Such collaboration may take any of several forms. There may be collaboration between national agencies on a specific project. Examples are the co-operative program on rodenticides of the British Columbia Forest Service and certain American agencies, and the co-operative Douglas Fir provenance study coordinated by the Oregon Forest Lands Research Centre in the north western United States and in British Columbia. It may take the form of special services, as in the provision of facilities at the Forest Products Institute of the Union of South Africa for public and private concerns throughout Africa (219) or it may be on a formal level, as in the various regional commissions and research centres sponsored by the Food and Agriculture Organization (discussed in detail in 85).

In the Caribbean the formation of a Commission was advocated

"to obtain full coordination of research, to prevent overlapping and duplication of research on common problems,

to render unnecessary the constitution of a number of uneconomic and individual research stations, to meet the needs of units which could not afford a research station" (43)

The validity of such arguments are generally recognized. Nevertheless, despite unanimity among the delegates and considerable activity in the preparation of a detailed problem analysis and progress report on work then current, at least in regard to its forestry activities, this Commission, representing the United Kingdom, the United States, France, and the Netherlands did not achieve its early promise and now appears to be either defunct or moribund. Its lack of success is perhaps an indication of the important part that can be played in such groupings by an international agency. Such intervention can supply the coordination that is necessary when there are no close political or other links. Subsequently a West Indies Regional Research Centre, confined to the British territories, and established at the Imperial College of Tropical Agriculture, Trinidad, has proved successful in the same region. In this case there were no international interests to confuse the situation.

The advantages of the regional approach have received increasing recognition in recent years. A regional rather than a territorial approach to research activity in the British Dependencies was recommended by the United Kingdom Colonial Research Committee (93) when considering post-war organization.

The Committee on Forest Management, Silviculture and Forest Protection of the 6th British Commonwealth Forestry Conference (30), held in Canada, considered the matter. Its

ORGANIZATION

CHART

(Dates in brackets are dates of formation)

ECONOMIC COMMISSION  
FOR EUROPE  
Timber Committee (1947)  
(ECE/FAO Timber Division, Geneva)

JOINT COMMITTEE: Forest Working  
Techniques and Training of  
Forest Workers  
JOINT WORKING PARTY: Forestry  
Statistics

EUROPEAN FORESTRY  
COMMISSION (1948)  
(FAO HEADQUARTERS: Rome)  
WORKING PARTIES:  
Afforestation and Reforestation  
Torrent Control and Avalanches

NEAR EAST FORESTRY  
COMMISSION (1955)  
FAO REGIONAL OFFICE: Cairo)  
WORKING PARTY: Forest Range  
Management  
COMMITTEE: Research

JOINT SUBCOMMISSION  
ON MEDITERRANEAN  
FORESTRY PROBLEMS  
  
Silva Mediterranea  
(1948)  
(FAO HEADQUARTERS:  
Rome)  
WORKING PARTIES:  
Cork-Oak  
Eucalyptus  
Planting Techniques

ASIA-PACIFIC FORESTRY  
COMMISSION (1950)  
(FAO REGIONAL OFFICE:  
Bangkok)  
SUBCOMMISSION: Teak  
WORKING PARTIES:  
Grading and Standard-  
ization  
Public Education in  
Forestry Watershed  
Management  
COMMITTEES:  
Silvicultural and  
Forest Management  
Research  
Forest Products  
Research

LATIN AMERICAN  
FORESTRY COMMISSION  
(1949)  
(FAO REGIONAL OFFICE:  
Santiago)  
WORKING PARTIES:  
Forestry Development  
Afforestation and Re-  
forestation  
COMMITTEE: Research

F A O  
FORESTRY DIVISION  
(1946)  
(HEADQUARTERS: Rome)

TECHNICAL COMMISSIONS  
International Poplar Commission  
(1947)  
International Chestnut Commission  
(1952)

TECHNICAL COMMITTEE  
Joint FAO/IUFRO Committee  
on Bibliography (1949)

TECHNICAL PANELS  
Mechanical Wood Technol-  
ogy (1947)  
Wood Chemistry (1947)  
Forest Range Management  
(1954)  
Forestry Equipment (1954)  
Forestry Education (1955)

views on the scope of regional activity are reproduced.

"It is essential that research workers, particularly those engaged in silvicultural investigations in the forest, should be able to obtain information relevant to the work on which they are engaged, get expert advice, obtain information on research techniques and standardized methods, and learn who are the workers in the same field.

It is ..... of the utmost importance that regional research organizations should be set up, with the following functions:

- a. to be a storehouse of up-to-date information on all silvicultural and other forestry matters within the scope of the research field of the region. This information to be indexed and classified, -----,
- b. to advise research officers and all others carrying out investigations and experiments, and to examine and comment on all project plans for experiments before field work is initiated;
- c. to circulate information on work going on within the region;
- d. to maintain liaison with similar research centres in other regions;
- e. to standardize research methods and codify them;
- f. to organize co-operative experiments in subjects of common interest in the territories within the region;
- g. to organize, where necessary, the training of research officers."

The Committee drew attention to the fact that such a regional organization had existed since 1906 in India in the Silvicultural Branch of the Forest Research Institute at Dehra Dun, with highly productive results, and considered that the creation of the forestry section of the East African Agriculture and Forestry Research Organization at Muguaga in Kenya, was a significant step in this direction. The Committee considered that such organizations should be developed in certain regions, such as West Africa, the Caribbean region, and South

East Asia (including Malaya, British North Borneo, Sarawak, Hong Kong, and possibly Fiji and the Solomon Islands) and it drew attention of the Dominions to the advantages of such regional research centres.

The activities of the Dehra Dun centre are well known and documented. Those of the East African Agriculture and Forestry Research Organization are less well known. Problems common to all the East African Territories - Kenya, Tanganyika, Uganda, and Zanzibar - are investigated and particular attention is given to coordination. In this region most problems are inter-territorial (101). A regional documentation centre has been established within EAAFRO and standardized research procedures adopted for the territorial groups.

Where common ties do not exist less formal arrangements may be more effective. Griffiths (103) has discussed the forestry aspects of the International Committee for Technical Cooperation in Africa, south of the Sahara, and the Second Inter-African Forestry Conference held at Point Noire, in the Moyen Congo of French Equatorial Africa, and has indicated the benefits that have resulted in the following terms:

"..... in general we are far too parochial in our outlook and it is of the greatest value to meet our technical neighbours and to get to know them and their problems, and what they are doing about them."

Greatest success may perhaps be obtained when such meetings are specialist in nature. The annual African "Miombo Conference", a meeting of specialists on Miombo savanna (169) that has resulted from the Inter-African Forestry Conference is such a case.

That such international bodies can be successful when there are common interests is shown by the Northern Forest Union, formed in 1946, of the leading forest research institutes and organizations in the Scandinavian countries to promote inter-Scandinavian collaboration. A congress is held at four year intervals and management of the Union's affairs devolves in turn on the four countries concerned.

In the Pacific Northwest of North America a very high level of regional co-operation has developed in recent years between British Columbia and the American Pacific Coast states. Ritchie (180) listed eighteen committees which have come about spontaneously to gather information on a wide range of problems. Almost invariably these committees have been formed to gather facts needed by management, to exchange ideas, to define problems, and to indicate needed avenues for research. They include representatives of government, industry, research, and the universities.

Typical is the Forest Soils Committee which was formed in 1948 as a result of a meeting of a group of foresters to discuss ways and means of promoting the development of information on forest soils. This committee has been the nucleus for soils work, and has served in an organizational, educational and publicity capacity, and as an agent for the distribution of information. In conjunction with the universities it has organized short courses. It was instrumental in promoting research and teaching in forest soils at the university level in the Pacific Northwest with the establishment of a forest soils department at Oregon State College.

These committees have stimulated interest in research by bringing into focus the needs and the opportunity for public and private organizations to contribute.

Not least of the values of regional and international activity is the opportunity it provides for overcoming the disadvantages of isolation, and of facilitating contact with current development elsewhere and, hence, stimulating research activity.

The values that lie in the exchange of information and personnel between world regions has been emphasized by Haig et al (105), in their discussion of the lessons that American foresters can learn from tropical forestry

"Tropical forestry has undoubtedly profited immensely by the presence of colonial foresters trained under quite different conditions, often interchanged between regions and periodically brought together, as at the Indian Silvicultural, British Commonwealth and, more recently, at the Inter-African Forestry Congresses. More formal contact and interchange of information on a regional and world basis is needed in the tropics. Temperate zone silviculturists could probably profit by following this pattern."

#### FINIS

Viewpoints are greatly influenced by changing social and economic conditions, and by the increased enlightenment that results from developing experience. New problems arise and their solution gives rise to more efficient methods of working. In turn, new organizational concepts evolve that meet the needs of the new situation.

Nevertheless, care should be taken before disregarding the methods of the past, for it is upon these foundations that the future must be built, and from a critical evaluation of the

corpus of knowledge that true advance is obtained. There must be understanding and recognition of the universality of forest experience. This is applicable to policy and organization as it is to technology.

In the circumstance of the modern world, it is impossible for any nation or group of people to exist in isolation. It is in the interest of all that the peoples of the world should learn to live together, to work together and to develop their resources together for the mutual benefit of all.

It is hoped that this study may contribute to this better understanding.

"Yes, I think you'd better leave  
off", said the Gryphon, and Alice  
was only too glad to do so.

## APPENDIX 1

The development of some national programs

France - In France the period from the end of the 17th to the beginning of the 19th Centuries was rich in research effort. There is a history of early experimenters, such were Duhamel du Monceau (1700-1782), Varenne de Fenille (1700-1793) and most important of all, Phillipe Andre de Vilmorin (1821-1862). However French research properly dates from the founding of the Station de recherches et experiences forestieres in 1882 as an annexe to the Ecole nationale des Eaux et Forets. This station had modest beginnings with one or two forest officers and until 1914 there was only slender financial provision. The field of action was, of necessity, confined to the forests in the vicinity of Nancy and directly under the control of the school. The professors participated very largely. Research was limited exclusively to forestry questions or to questions directly bearing on the forest, notably forest meteorology. According to Rol (183) there is mention of research on the effect of thinnings.

As early as 1866 Mathiew, Professor of Natural Sciences at the School, had established a series of meteorological posts and undertaken research on influence of the forest on climate, this work was continued and extended by the research station, eventually the results were published and are now universally accepted.

During the first world war the greater part of the station's records were lost. In the subsequent reorganization

the organizational patterns of the present day were introduced, though subsequently extended. The station was organized in branches each under the direction of the professors in charge of instruction in the various specialist fields. The Director of the School remained Director of the Research Station. A separate branch for the management of the school forests and for the conduct of general forest research was formed under a specialist officer. His principle task was the systematic study of growth and development with sample plots throughout France, a chain of Meteorological stations, and also with responsibility for special major projects. In subsequent reorganization this post has advanced in standing until today it is of conservateur rank. Gradually also provision has been made for co-operation with other research agencies, the Central Timber Testing Laboratory in Paris, the Central Station of Applied Hydrobiology, and with geographers and others on questions such as mountain landuse and protection forestry. Concurrently field sub-stations have been developed.

Germany - In Germany there is a similar story of gradually unfolding research activity. Here, however, in the absence of a unified forest service, research was not exposed to centralizing influences such as moulded French forestry. Groups of small, specialized and autonomous research institutes were formed at the various university schools. Although individually small these institutes have made notable contributions to forestry. They have been strongly influenced by the individuals who worked in them, so, to the present day the silvicultural tradition of the University of Munich, which since 1878 has

been linked with the names of such persons as Carl Gayer, Heinrich Mayer and Ludwig Fabricius, moulds the work of the Institute of Silviculture while at the University of Göttingen the Faculty of Forestry at Hamm-Munden maintain those of the experimental areas of Eberwalde, the former Prussian Forest Research Institute, which are in the Federal Republic. Some of these plots have been the subject of accurate observation for over 70 years. In Lander without forestry schools research stations were established with responsibility directly to the Lander forest administration. In more recent times the need for more comprehensive establishments with greater facilities has led to the establishment of a national research agency - the Federal Institute of Forest and Wood Economy at Reinbek near Hamburg (220).

Scandinavia - Initially the Scandinavian countries were influenced by German research thought but gradually a distinctly Scandinavian approach evolved. In Denmark, with the longest tradition of scientific forestry, a research department of the state service was formed in 1852. In Sweden a research station was founded at the Royal College of Forestry in 1902. In Norway the national forest research institute was established at the Agricultural College at Aas in 1917. Swedish developments have been described by Eklund (70) and Streyffert (200). After 100 years of extensive exploitation of over-mature virgin forests, previously conserved for centuries, the need was realized for serious attention to re-forestation and better forestry practices. There was little or no national experience.

Guidance was sought abroad, and particularly in Germany.

Higher forestry education was started in 1828, and on the German pattern some experimental work was undertaken but without any solid footing in the natural sciences and mostly of the "trial and error" type. This formed the investigational front up to the end of the 19th Century. In 1902 the institution which was eventually to become known as the Statens skogsforskningsinstitut (Forest Research Institute) was founded as the Swedish Institute of Experimental Forestry. Originally on modest lines it was soon recognized that requirements had been underestimated. In subsequent years there have been several reorganizations with increases in staff and material resources.

During the 1930's other traditions began to emerge. In each of the Scandinavian countries the co-operative movement got underway and groups of industries, forest owners, with sometimes the state, joined together in associations to advance various aspects of forestry, notably tree improvement, and rationalization of work methods. To further their aims these associations set up research establishments such as have been described in the main text.

Canada - Experimental work dates from early experiments in tree planting in Manitoba in 1905, and research proper from the period 1910 to 1920. Federal activity started in a small way with the Commission of Conservation, which undertook fact-finding surveys and the gathering of information generally, the first serious attempt to obtain information regarding the forest resources of the country. The first provincial inven-

tory was conducted for the Government of Nova Scotia in 1909-1910 under the direction of Dr. B. E. Fernow of the Faculty of Forestry, University of Toronto, and published by the Commission in 1912. In 1914-1916 an inventory was conducted in British Columbia. The report was published in 1918. During 1918-1921 the Commission carried out certain experimental work in Eastern Canada. In 1917 a division of silvicultural experimentation and research was formed in the Forestry Branch of the then Department of the Interior. Staff was extremely limited. Various small scale silvicultural experiments were made in the western provinces and at the Petawawa Forest Experiment Station which was established in 1918. When the Commission of Conservation was abolished in 1918 the Forestry Branch took over its research staff and several of its projects, and a small research team of five foresters was established in Ottawa. The research program at Petawawa developed at a moderate rate, a number of experiments were established outside the station in co-operation with various commercial companies. In 1930, after the transfer of the natural resources of the western provinces to the provincial governments, research became the chief function of the Forest Branch and progress became more rapid, although adversely affected by economic conditions. At the time of Chalk's visit to Petawawa in 1937 he noted that while the experimental station had had the use of plenty of relief labour and was well off for roads and buildings, the money available for research seemed less adequate, and the research officer in charge of the station had many

administrative duties in connection with the running of the forest. The original policy, later superceded, was to maintain the Petawawa Station as a demonstration forest as well as a research unit. A gradual expansion of activity took place and regional research offices and other experimental forests were established. Especially since the second world war larger appropriations have allowed considerable expansion, and in all five district offices have been set up, with eight experimental forests or research areas. By 1952 there were 48 professional foresters engaged exclusively in silvicultural and management research. Bickerstaff estimated that an approximately equal number of men were employed on silvicultural work by the various provinces and industrial organizations.

A notable feature of Canadian forest research is the separation of entomological and pathological enquiry from the rest of forest investigation. The original agents were the Forest Insect Investigations Unit of the Entomology Division and the Forest Pathology Section of the Division of Botany and Plant Pathology, in 1951, the two groups were brought together to form the Division of Forest Biology in the Science Service of the Department of Agriculture. The insect and disease surveys which form a major part of this agency's activity originated from a survey made in 1936 to determine the extent and severity of the European Spruce Sawfly infestation of Eastern Canada. Recognition of the value of this survey led to its gradual extension to all provinces and the inclusion of all types of insects, and, after merging with pathology in 1951, disease. A series of laboratories and stations has been

developed across Canada and in addition specialist laboratories and sections operated, notably in co-operation with the provincial government in Ontario. In 1955 technical staff consisted of 193 scientific and 144 technical grades. In addition the Department of Agriculture makes extra-mural research grants.

Since 1923 the National Research Council has also interested itself in forest research, concerning itself largely with the support of the more fundamental enquiry.

Certain limited phases of silvicultural research have been under provincial and industrial auspices. The most consistent effort has been by the provincial forest service in British Columbia. After early sporadic efforts in the districts sustained effort started with the initiation of some growth studies in 1920 by a forester attached to the headquarters staff. Organized research has continued uninterrupted since that date. A small research division of five professional foresters was organized in 1927. Two field experiment stations were established. The staff was increased to eight. Economic conditions resulted in setback and by 1936 the research staff was reduced to three. In 1939 research was merged with forest surveys to form the Mensuration, Silviculture and Soils Sections of an Economics Division. After the war the Division once more took on a separate existence. In 1955 it had a staff of 15 professional foresters and four technical assistants.

In Ontario the provincial forestry branch initiated growth and yield studies on a small scale in 1920, these were carried on sporadically until 1930. Activity ceased during the depression and was not resumed until 1941. In 1944 a Research

Division of the Department of Lands and Forests was formed and subsequent development has been rapid. In 1955 the staff consisted of 89 of whom 35 were professionally trained, plus a seasonal recruitment of some 40 to 50 persons. The only other province to engage in research activity has been Quebec, here, provincial forest service research staff, although few in number, have done certain work especially on site classification, and the Bureau of Entomology of the Department of Lands and Forests has done work on forest protection, the only provincial agency in any of the Provinces to have made any serious effort at active entomological work in the field (42) (15) (63).

New Zealand - The initial recommendations of the first Director of Forestry of the newly formed forest service in 1920 included the statement that the formation of a strong research division was absolutely necessary if they were to make any advance in the forestry problems of New Zealand. Action on the recommendation was deferred. Birch (16) has described subsequent development against a background of world depression and financial stringencies. In these conditions, with a few marked exceptions, forest research was sporadic in the extreme. Research undertaken was the work of individuals; a notable contribution was that of Dr. Leonard Cockayne on the botany and ecology of the indigenous forests, and of the Forest Service generally, involving many experimental plots of diverse character in exotic and indigenous forests. In more recent years more fundamental research was undertaken on seed-

crops, seed viability and growth cycles of commercial species. In 1939/40 increases in staff made it possible to plan forest service development on a specialist divisional basis in place of the previous territorial organization. War intervened. In 1946 the planned reorganization took place and research was included in a Development Division. A Forest Experiment Station was established at Rotorua in 1947. By 1949 research personnel were engaged in initiating and co-ordinating short term research projects and in developing a long term policy. The initial staff consisted of nine professional officers, with provision for about thirty divided between four sections - Botany and Silviculture, Management, Pathology and Forest Products. The National Forest Survey, commenced in 1946 was absorbed within the research structure.

Great Britain - Forestry in Britain has a long history. Evelyn's 'Silva' was published in the time of the Stuarts, but there was a gap in the middle of the nineteenth century, and forest research in the modern sense started only with the organization of the Forestry Commission in 1919 and then to a limited extent. With its traditional role as the world's greatest timber producer it took two world wars with attendant wood stringency to stimulate forest research on a large scale. Review of subsequent development is facilitated by the Government White Paper on the Forestry Commissioners' Proposals for Post-War Forest Policy (95) and the Forestry Commissioners' comprehensive report on their first thirty years activity (96).

When large scale activity started in 1919 the new Authority was faced with a lack of technical information. Forestry

education was directed towards the needs of overseas, and largely Indian forestry. Hitherto home forestry had been mainly practiced on private estates or in the limited areas of Crown Forest. Knowledge was localized and personal and the few textbooks available were mostly translations of German books and of doubtful applicability. Much of the knowledge accumulated in the past was of slight application to the conditions under which the Commission had to operate. With few exceptions experience was confined to the better soils and where poor sites had been planted the knowledge had been lost. In addition there was a difference in scale. Formal research, such as that of Augustine Henry, had largely been concerned with systematics and dendrology and the botanical aspects of growth. Practical work, apart from more recent effort such as Sir John Stirling Maxwell's moorland spruce planting at Corroul, which set the pattern for future development, had been confined to the introduction of exotics and production of some hybrids, emphasis had been on arboriculture. Such was the setting in 1919.

The Forestry Act of 1919 empowered the Commission to "Make, or aid in making such enquiries, experiments and research, and collect or aid in collecting such information as they may think important for the purpose of promoting forestry, and the teaching of forestry, and to publish or otherwise take steps to make known the results of such enquiries, experiments or research, and to disseminate such information." The duties of the Commissioners in respect to research on a) timber and other forest products, and (b) "the deeper underlying reactions which

trees have in common with other organisms", were largely determined by the reports of two Sub-Committees dealing with research by government departments. In 1920 the Agricultural Sub-Committee of a Cabinet Committee appointed to consider co-ordination of government research recommended that a Research Institution be set up under the Forestry Commission to "deal with problems connected with the growing crop" but that for research work on other subjects in connection with forestry problems and for any fundamental research other than that directed to an immediate economic result reference should be made in the first instance to the appropriate authority "in whom was vested control of research upon the subject under discussion."

A small research branch was set up in 1919 and executive officers encouraged to make their own experiments on local problems. The proposal to set up a research institute was not implemented, mainly owing to lack of funds and because in the circumstances, the Commissioners considered it better to make the fullest use of existing centres of forestry training and research. The second recommendation led to certain difficulties in practice and in 1929 the policy towards forest research was reviewed by the Research Co-ordination Sub-committee of the Committee on Civil Research, which recommended the appointment of an Advisory Committee on Forest Research, and the provision of sufficient funds to enable the Commissioners to finance research of the nature envisaged by the 1920 Committee. The Advisory Committee was appointed but no effect was given to the recommendation for increase of funds. Nevertheless from time

to time research of a purely scientific character was financed where this was considered necessary to solve problems of practical significance. Over the greater part of the first twenty-five years the staffing level of the Research Branch remained stationary with a Chief Research Officer stationed at London headquarters, a Research Officer for England and Wales, stationed at the Imperial Forestry Institute, Oxford, a Research Officer for Scotland, stationed in Edinburgh and a Sample Plot Officer who covered the whole country. A Mycologist and an Entomologist were appointed to the staff of the Forestry Institute at Oxford, nominally employed by the Institute but engaged full time on problems for the Forestry Commission. The two research officers were responsible for silvicultural research, each with a small staff of research foresters and foreman stationed in those areas where nursery and plantation investigations were mainly concentrated. The remaining researches during this period were grant-aided. They covered a wide range of subjects, for example, vole disease, mycorrhiza research, forest soils, and the investigation of certain fungus diseases. A detailed account of the major fields of activity to 1939 is given in the White Paper.

In postwar development research activity was much extended, the policy of confining the research branch activity to work mainly involving field studies was continued but specialist recruitment extended interest fields beyond silviculture into the related forest sciences, and more recently into economics. There were considerable increases in staff. The weakness of maintaining a scattered and fragmented research group was recognized

and a central research station founded in the State Forest of Alice Holt, Farnham, Hants, which had been under a management plan for some 35 years. A small research group was established in Scotland. Grant aided research was extended and continued. A high degree of co-operation was developed with other research bodies and with private forestry interests. Development followed and surpassed the program of the White Paper. In the immediate prewar years research expenditure averaged £15,900 per annum. The estimated cost of the program envisaged in the White Paper was £300,000 for the first postwar decade, including the capital expenditure on the research station. In 1952 active annual research expenditure was £148,000, by 1956 it had reached £265,000 (146). The White Paper proposed a professional staff of nine or ten officers. In 1957 the research staff consisted of 23 professional officers plus supporting technical grades. By 1960 there had been a further increase to 36 officers. The research accommodation has proved inadequate and recently a large new research institute has been opened.

United States - An account of the historical development of forest research is incomplete without reference to the United States. To quote Harper (108) "Federal Forest Research started with the appointment of one man in 1876, his job was to find out about timber consumption, timber for import and export, the probable supply for the future, the best ways of preserving and renewing the forests, and to report on the same within one year." The level of research activity is indicated by the overall national expenditure (1953) of \$45,400,000 for all agencies and a staff of approximately 1100 technically trained

personnel in the federal agency (132). A general review of the development of U.S. Forest Service researching was published by Kotok (141) and the development of research in academic institutions and agricultural experiment stations by Westveld (222). For a comprehensive account of American research development, attention is directed to the report by Kaufert and Cummings (132).

India - Of the eastern nations research activity first developed in India. Progress has been traced by Champion (46) and Ranganathan (178). The first silvicultural contribution to the 'Indian Forester' was published in 1891. The present Forest Research Institutes and Colleges at Dehra Dun are outgrowths of a ranger school established in 1878 by the then Government of the N. W. Provinces. In 1900 the first research post, that of Forest Entomologist, was instituted. In 1906 the Central Research Institute was founded with branches for Silviculture, Botany, Entomology, Chemistry and Economics. This was the second of a series of central Indian Government research agencies, and was preceded only by the Indian Agricultural Research Institute, formed in 1901. For the first two years the post of Central Silviculturist was held by the Principal of the College but in 1908 a separate appointment was made. In 1916 a separate Silviculturist for Burma was appointed and soon after development became more rapid with acquisitions of staff, and also decentralization through the appointment of provincial silviculturists from 1918 onward. In 1921-22 the Economics Branch was expanded to form a branch of wood technology and forest products. In subsequent years this branch expanded and

came almost to make up an institute within an institute. The Central Research Institute tended more to serve as a co-ordinating and documentation centre for decentralized provincial activity, and as a training ground in research techniques.

Since the second world war and the partition of India further reorganization and expansion has taken place. War experience indicated the value of the Institute to the country, and highlighted its deficiencies in equipment and personnel; there was a large reorganization scheme aiming at extensive modernization of equipment and buildings.

The branches dealing with forest research proper, the administrative offices, herbarium, museums, library, Convocation Hall, and Indian Forest College, are now all housed in one large and imposing building. Laboratories, workshops, and pilot plants connected with forest products research occupy a number of separate buildings scattered over the site. There is a demonstration forest, an extensive arboretum, and a botanical garden.

The Herbarium contains a quarter million leaves, including 1200 type or co-type sheets and dating back to 1816. The Reference Collection of insects contains over 17,000 authenticated identified species. An important feature is a large photographic collection covering all aspects of Indian forestry. Copies of all official photographs are sent to Dehra Dun. Another feature of the collections are card indexes and ledger files which have been carefully maintained in all branches.

Burma - Burma was administered by the Government of India until 1935. An Indian Forest Service forest research officer

was appointed in 1913. Early activity had been largely confined to botanical research and empirical advance, with Brandis and Grimble in the forefront and active at the end of the 19th Century. In 1920 a Research and Working Plans Circle was formed but economic depression prevented the realization of plans for a research institute. As a compromise, a Working Plans Circle with an additional post of Silviculturist was formed and a separate utilization circle was established. No further advance was made until after World War II when the supply of munitions timber brought out the fact that other species than teak had a range of utility not realized before. After the war economic research was undertaken by the Utilization circle at Rangoon, biological and statistical research at Maymyo. In 1956 Forest research was still linked with that of India to some extent for the Burmese Government still contributed to the cost of the Indian Forest Research Institute. In that year assistance was obtained from the Food and Agricultural Organization of the United Nations in drawing up plans for a Forest Research Institute and Forest Products Laboratory (165) (139).

Malaya and the East Indies - In other non-European countries initial development was slower, but by the 1930's research groups were coming into being. In Java the Boschbouwproefstation at Buitenzorg served the Dutch East Indies and was mainly devoted to the biological aspects of forestry. In the British Dependencies Malaya was the only country to have achieved a local forest research institute although others had specialist

officers and research groups. Again progress was delayed by economic depression. The decision to establish a station at Kepong was made in 1926. By 1929 the establishment was ready. Original intentions to provide a comprehensive research service went unrealized due to retrenchments. With the return of more prosperous times expansion was just beginning when the outbreak of the second world war again delayed matters (145).

## APPENDIX 2

Authorities to whom reference is made in the text

<u>Name</u>	<u>Title and Affiliation</u>
Allen, G. S.	Dean, Faculty of Forestry, University of British Columbia.
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