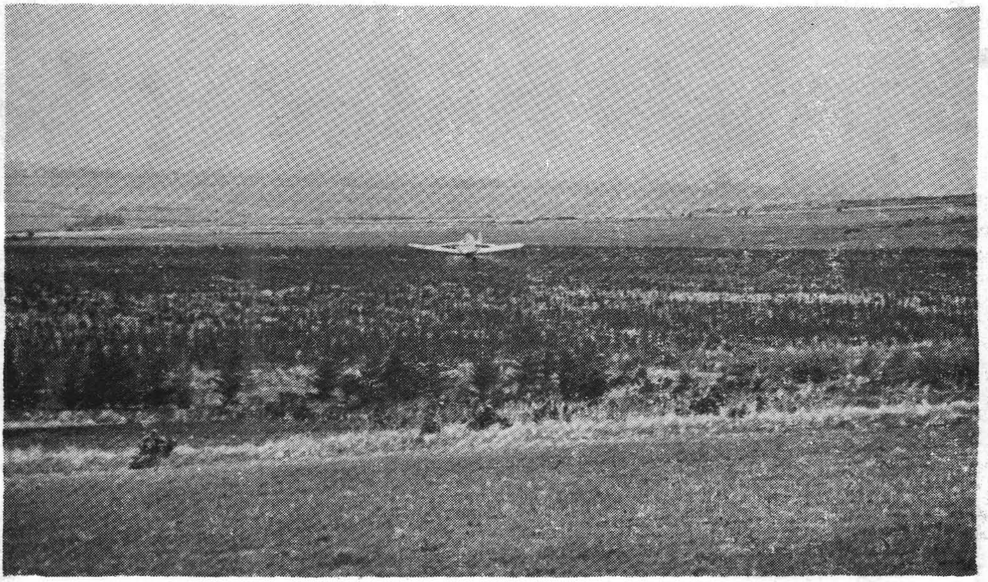


IRISH FORESTRY

Journal of the Society of Irish Foresters

Published Twice Yearly

Volume 25 No. 1 SPRING, 1968 10/-

IRISH FORESTRY

CONTENTS

(The views expressed in the articles and notes in this journal are not necessarily the views of the Editor or of the Society of Irish Foresters.)

Cover Photograph: Aerial fertilising of forest crops at Rossmore Forest, Co. Carlow, May 1968.

SOCIETY OF IRISH FORESTERS

President:

PROFESSOR T. CLEAR, Sheetrim, Monastry Road, Clondalkin, Co. Dublin.

Vice-President:

M. MCNAMARA, 41 Ballymun Avenue, Dublin 11.

Secretary:

C. KELLY, Jude's Acre, Bailey, Co. Dublin.

Treasurer:

T. MOLONEY, 1 Rosehall, Templeogue Road, Dublin, 6.

Editor:

M. H. SWAN, 17 Landscape Crescent, Dublin 14.

Business Editor:

J. DURAND, "Sequoia", 121 Arnold Park, Glenageary, Co. Dublin.

Hon. Auditor:

D. M. CRAIG, 85 Harcourt Street, Dublin, 2.

Grade I Councillors:

D. MCGUIRE, Columcille, Novara Road, Bray, Co. Wicklow.

D. O'SULLIVAN Ballydowling, Glenealy, Co. Wicklow.

D. MANGAN, 80 St. Aidan's Drive, Goatstown, Dublin 14.

B. WILSON, Pomeroy Forestry School, Dungannon, Co. Tyrone.

Grade II Councillors :

J. D'ARCY, Killygordan, Lifford, Co. Donegal.

J. J. PRIOR, c/o Mr. P. Cronin, Station Road, Portarlington, Co. Laois.

Associate Councillors :

S. GALVIN, Park Cottage, Wexford.

MISS E. FURLONG, "Silvern", 150 Clontarf Road, Dublin 3.

IRISH FORESTRY

Volume 25 SPRING 1968 Number 1

The Basis of Forest Planning

D. R. JOHNSTON, B.A.

Summary

The broad field of planning is subdivided into four main aspects — basic principles, basic considerations, planning procedures and the methods or tools of planning. Many of the difficulties of forest planning are due to imprecise or incompatible objectives and to inappropriate criteria of success. It is a basic principle that there should be one main objective with the subordinate objectives expressed as constraints. The most important considerations are that plans should be initiated at the right level of management and that they should be completely flexible. The logical planning procedure is to analyse the current expenditure in order to find where economies are most likely to be effective and then to investigate more closely whether the level and the nature of the investment is in accordance with the management objectives. There is a tendency to use simple drillbook planning guides at the lower levels of management and more sophisticated operational research techniques at the higher management levels.

INTRODUCTION

In a discussion on planning there is a serious risk of confusing relatively simple ideas merely because the words which are used to describe abstract concepts do not always mean quite the same thing to different people. It is, for example, almost impossible to define in a mutually exclusive way the meaning of the words *planning, management, administration* and *organisation.* Nevertheless it is possible to make a simple and commonsense differentiation between planning on the one hand and management, administration and organisation on the other. Planning may be thought of as the process of deciding what to do while management, administration and organisation are words used to describe various activities which are concerned with the implementation of plans.

It is even more difficult to differentiate between policy-making and planning. There is, for example, a tendency for the planning at one level of management to be regarded by subordinate levels as policy-making, and vice versa. But the difficulty may be overcome by considering instead the formulation of objectives which can conveniently be thought of as the end of policy-making or the beginning of planning at any particular level in an organisation.

As a matter of convenience in presenting this paper the broad field of planning is subdivided into four main subjects as follows:—

(a) Basic principles.
(b) Basic considerations.
(c) Planning procedures.
(d) Methods or tools of planning.

This series from (a) to (d) may be thought of as a progression from more abstract to more practical considerations or alternatively as a sort of chronological sequence which is followed consciously or unconsciously in a planning exercise. Thus the basic principles have to be considered first. The procedures of planning cannot be evolved until the basic considerations of planning have been clarified and at the final and most practical level the tools of management are used within an established planning procedure.

BASIC PRINCIPLES

Objectives and Constraints

Much has been said and written about the technical difficulties of planning a long-term enterprise like forestry but there is much to support the view that the greatest difficulties arise not from the vagaries of nature or from the uncertainties about future events but rather from uncertainties in the minds of the planners and managers about what they are really trying to achieve and how they should assess whether or not they are succeeding. Many of the purely practical or technical problems in forestry, or in many other activities for that matter, tend to disappear if the objectives are clearly defined and clearly stated.

It frequently happens that a forest enterprise has a number of different objectives not all of which may be compatible. For example, the objectives might be stated as follows:—

(a) To earn the highest profit.
(b) To provide employment in rural areas.
(c) To preserve the native fauna and flora.
(d) To preserve or improve the beauty of the countryside.

As a series of general aspirations there is nothing wrong with these statements but as a basis for planning they are of little value. It is extremely likely that any measures to achieve objectives (b), (c) or (d) will compromise the achievement of (a). Before planning can start therefore it is necessary to choose one main objective and to introduce all the other subordinate objectives as constraints. Thus in the example quoted above the objectives might be restated as follows.

To earn the highest profit subject to the following constraints.

(a) Employment is to be provided for x workers.
(b) X acres are to be set aside as a nature reserve.
(c) On y acres the main objective is to be the preservation of beauty rather than the attainment of profit.

Clearly, the constraints will tend to be expressed in qualitative terms at the highest level and in quantitative terms at the lower regional or forest levels where the dilemma of the local staff can only be resolved if they are given a well defined objective with the constraints clearly defined and, whenever possible, in quantitative terms.

The only valid basis for adopting a particular plan is that it will achieve the policy objective more effectively than any other course of action. It follows, therefore that the policy objective itself is fundamentally the criterion by which the effectiveness of a course of action should be judged. Policy objectives, however, are often expressed in somewhat vague terms such as "the attainment of the maximum profit". First of all the objective has to be restated in unequivocal terms. The expression "maximum profit" for example can mean a number of different things and it is necessary to specify precisely what is meant by profit before it is possible to plan logically for its achievement. It is most important that a particular investment criterion such as maximum net annual income, maximum financial yield or maximum net discounted revenue using a discount rate of 5 per cent should not be chosen until the full implications of adopting it have been considered. But even when the objective has been expressed in precise terms it still rmains an abstract concept which cannot be recognised in the forest. It is therefore necessary to find physical indices such as planting distance, thinning intensity or rotation age which are closely correlated with the abstract criterion and which can be recognised in the field. Failure to adopt a criterion which properly reflects the objectives and failure, in turn, to relate the criterion with closely correlated physical indices results in a great deal of misdirected effort. This may be illustrated by an example from a European country in which forestry is controlled by various official regulations which may be regarded as analogous with the physical indices mentioned above.

Over the years the more accessible forest in this region has been overcut and overgrazed and as a consequence it has degenerated into a relatively valueless coppice. But in the more remote, mountainous regions communications are poor and much of the forest had never been cut before 1946. As a result of relatively light cutting after the war the less inaccessible forests have tended to assume a two-storied structure with a light understorey of younger regeneration and a heavier over-storey of overmature trees. The stated intention of the forest enterprise is to practice fully commercial forestry but there is, or was, a regulation which restricted the cut to the current annual increment. An elaborate inventory has been undertaken with the principal objective of determining the current annual increment which thus determines the cut. Since most of the growing stock is very overmature it has an extremely low annual increment and it is suppressing the younger and potentially more vigorous regeneration. Clearly the cut should be far greater than the current annual increment for a period of several decades both to exploit the high capital value of the very slow-growing overmature trees and to encourage the younger regeneration which will have a much higher annual increment. The obsolete regulation has not only resulted in a form of management which is at variance with the stated management objectives but it has also resulted in a somewhat misguided inventory. There is little value in knowing the current annual increment of these forests. Interest should rather be centred on the volume of over-mature timber, the length of time it can be expected to remain healthy, the progress of regeneration and so on. Under the present circumstances the principal aspect of the inventory is of only academic interest. The same country provides another good example of a regulation which is incompatible with the management objectives. There is a surplus of beech in the mixed forests and much of it is of bad form. From an economic point of view therefore it is desirable to reduce the proportion of beech in the stands and to remove the genetically poor specimens. There is a regulation, however, that any tree which is felled must be harvested. Since the demand for firewood is diminishing and the average haul from stump to road is long the foresters have three choices open to them. These are first, to fell and extract the tree at a considerable loss, secondly to leave the tree standing to the detriment of future profitability or thirdly to fell the tree but not to extract it thereby risking a a substantial fine. Fortunately the illogicality of these regulations is being realised and steps are now being taken to repeal them.

A former British Colony provides another example of management rules which were incompatible with logical policy objectives. A few years ago this country was short of capital for development. In a particular region there is an area of natural but somewhat degraded forest. This type of forest can be considerably enriched by the simple process of clear-felling because the more valuable species regenerates more successfully than the other less valuable species in the forest. The local criterion of management success was that 1/70th of the forest area should be felled annually. This, it was estimated would ensure a permanent and consistent yield from the area on a rotation of 70 years. There were at the time two local sawmills but the planned yield was only sufficient to keep one sawmill going at about 60 per cent capacity. It was apparent that this country required a fully commercial forest policy and that the cut should have been increased sufficiently to keep both sawmills fully occupied whenever markets were available. The area would then have been cut over, and in the process greatly enriched, in about 20 years instead of 70. Even if there had been no further supplies of raw material for several decades the sawmills would have justified their establishment costs but there were in fact young plantation which were coming into production within about twenty years.

These practical examples show clearly that the physical indices such as spacing, thinning regimes or stand maturity which are used as practical applications of an economic criterion have to be chosen with care. Two factors have to be considered. These are technical efficienecy and convenience. Considering the familiar problem of crop maturity as an example, rotation age has several advantages over average tree girth as a practical index of economic maturity. In the first place it is much easier to read off a year on a calendar than to find the average girth of a stand of trees. A more important factor however is the extent to which the physical criterion and the management objective are correlated. Average tree girth is very much influenced by such factors as initial spacing and the thinning regime but girth is less closely correlated with profitability than is age. In other words an increase in thinning intensity or a change in the type of thinning may change the average girth by, say 20 per cent but the optimum rotation age by only, say 5 per cent. Finally, if maturity is specified as an age rather than as a girth the forecasting of future production is greatly facilitated.

BASIC CONSIDERATIONS

There appear to be two overriding considerations in forest planning. These are first, the level at which planning is carried out and secondly the flexibility of planning.

The level of planning

It is often easier to explain what should not be done rather than what should be done. It has been traditional in forestry to write forest working plans. These developed in the 19th century and their whole concept reflects the stability and assurance of 19th century Eurpoe. Transport in general and the transport of wood in particular was slow and cumbersome so that the management of an individual forest tended to be geared to the social and economic life in its immediate neighbourhood. Under these circumstances it was logical to consider a forest area in virtual isolation and to plan accordingly. Today forests are no longer isolated. Forest industries are large and transport is relatively easy. Therefore one forest may supply many industries and one industry may be supplied by many forests. Moreover technological development is rapid and Governments, in general, interfere more and more in the economic life of the country. Under these conditions it is clearly illogical for each forest manager to make his plans in isolation. This means that the forest working plan can no longer be regarded as the basic planning document.

The dominant forestry activities vary according to the circumstances of the forest enterprise. In a developing country they might be the construction of a harvesting and transport system and the establishment of forest industries. In a developed country the dominant activities may be harvesting or planting. The dominant constraints are nearly always the availability of capital and know-how. Almost all forestry activity ultimately stems from these dominant factors. Therefore planning must inevitably be initiated at the management level which controls them, and it must spread downwards through successive management levels to the forest.

In a large forest enterprise there are several levels of management each of which has a planning function. At each successively lower level the plans become less wide and more detailed.

At the highest level, for example, the planner considers all aspects of forestry including the numbers and types of staff required, their remuneration and conditions of service, the administrative organisation and so on. Lower levels of management are not responsible for many aspects of staffing nor for such matters as the level of forest investment and the marketing policy or for the relationship between forestry and other forms of land use. They are concerned rather with implementing an imposed programme within an imposed budget.

As one illustration let us consider the planning role of a conservancy in a country like Gt. Britain or Ireland. The conservator has little or no authority to make fundamental changes in the professional or technical staffing. He is likely to be allocated a planting and harvesting programme based upon the physical resources of his conservancy but determined also by the national forest needs.

There are, broadly speaking, two ways of dealing with this situation. One is to invite proposals from districts or forests and then to juggle with these until they add up to the conservancy requirement. This is time-consuming and inefficient and is rather like asking a number of builders to start work on a building without giving them a plan. The other is to consider the physical resources of the conservancy as a whole and to allocate the basic programmes — usually planting and production, to the various districts or forests. This provides a quantitative framework within which the subordinate manager can work. It is also necessary, however, to define a financial framework because there is a very large range in the level of management intensity which local managers may consider necessary for the implementation of the basic programme. The conservator has therefore to give guidance on such matters as cleaning, draining and protection.

It is a pure coincidence if the sum total of the plans initiated at one level of management happen to add up to a desirable plan for a higher level of management. It follows therefore that the preparation of forest working plans is likely to be a time consuming, frustrating and largely academic exercise unless they are preceded by a regional or conservancy plan which defines the broad qualitative quantitative and financial framework within which they have to fit. By the same token a number of regional plans are of limited value unless the place of the region within the national policy and the national targets has been clearly defined.

The Flexibility of planning

It is often said that the late 1940's and the 1950's was the age of planning and that planners have so frequently failed to forecast future trends that planning itself has become discredited. At the national level we have seen the development of various concepts of planning. At the one extreme some communist countries attempt, in effect, to determine economic development by laying down in advance exactly what is to happen for several years ahead. These are known as definitive plans. At the other extreme indicative national plans are no more than forecasts of future trends published with the idea of providing information for private industry and commerce. The F.A.O. timber trends studies are good examples of such indicative forecasts. There is no doubt that long-term forecasting is very uncertain; consequently there has to be an increasing interference with the natural economic processes if definitive plans are to be made to work. It follows therefore that the difficulties of long-term definitive planning are most likely to become apparent in countries with a mixed economy. In such countries the free market sector of the economy acts as a control against which the extent of the fiscal and economic measures necessary to ensure the implementation of the long-term plans may be measured.

Foresters have realised the purely technical difficulties of long-term planning for a very long time and their attempts to impose formal management patterns upon their forests have continually been frustrated by wind damage and regeneration difficulties. But more recently forestry, in common with other industries and other activities, finds itself increasingly involved in the complex economy of a modern society. Physical problems like wind damage and regeneration therefore no longer dominate forest management. The forester today is equally or perhaps more concerned with market developments, changing fiscal arrangements, social problems and a rapidly changing technology and unlike the powerful central government of a planned economy he has no power to make arbitrary adjustments to the economy in order to fulfil his long-term plans. It may therefore be concluded that, for a variety of reasons, longterm, detailed forestry planning is likely to be not only a waste of time but a positive hindrance to logical decision making.

On the other hand forestry by its very nature demands a long-term view. It is therefore something of a problem to reconcile a long-term view with the needs to adapt management to changing conditions. Almost every action that a forester takes will initiate a train of events that will take many years to complete. When a forester plants a tree, for example, he is, in effect, planning for sixty or more years ahead. Therefore the forester has to be clear about his long-term objectives although he must recognise that subsequent events may render them obsolete. In general, however, the basic objectives, if carefully defined, will change less rapidly than the methods used to implement them. Technology changes more rapidly than policy and the physical environment is always relatively unpredictable.

Fundamentally the solution to the planning problem in forestry is not difficult. It is simply to ensure that planning is completely flexible at all levels. That is to say that as soon as a situation has changed the plans should, if necessary, be changed accordingly. At first sight this may appear to be a somewhat irresponsible statement. It could be interpreted to mean that a longterm activity is to be subject to the whims of every successive planner or manager. It is clearly illogical however to persist with any plan after circumstances have altered sufficiently to change either the objectives or the optimum methods of achieving them.

A reasonable degree of continuity can usually be assured by ensuring that plans are initiated at the right levels of management. The greatest risk of confused and inconsistent management arises not from continual adaptation to changing circumstances but rather from the initiation of plans at the wrong level of management. Much of the confusion which arises from time to time in forest management occurs when subordinate levels of management introduce changes in policy when their function and perhaps their intention is merely to introduce changes in technique. It is obvious that this is more likely to occur when the objectives of the enterprise as a whole have not been stated clearly and unequivocally. The treatment of mixtures can provide an example of inconsistent management. In the absence of a clear objective one manager plants a hardwood crop with a conifer nurse. A succeeding manager with an amenity or sentimental objective removes a large proportion of the conifers, a third manager with an economic objective removes the hardwoods while a fourth with the object of realising capital in order to balance a budget clear-fells the crop prematurely. All these changes in management could have taken place without the basic management objectives of the enterprise having changed at all.

If forest planning is to be flexible it must be a continual process intimately bound up with the administrative and financial procedures of the enterprise. Some formal machinery is necessary but the traditional forest working plan has little place in the planning process. It has already been said that at successively lower levels of management planning becomes less concerned with formulating policy and more concerned with implementing it. It has also been said that policy changes less frequently than technology and practise. Therefore, in an age of rapid technological change there is little advantage and not a little danger in committing to paper detailed methods of working for more than a very short period ahead. Moreover methods will change not only because of technological developments but also because of new information and an increasing awareness of the economic implications of forest operations.

Stripped of all the inessentials the forest working plan thus consists of the basic management data on the forest estate; such as the growing stock, the labour force and the various types of equipment, all expressed in tabular form, a forecast of future work for, say, five years ahead, a budget for the current year and a budgetary control system which enables the forest manager to exercise an adequate control over the year's work. The planning and technological development which lie behind the forecasts and budgets are dynamic processes which are going on all the time. They should not be crystallised into formal documents.

It has already been said that planning should be a continual process. Nevertheless it is desirable, periodically, to make a thorough review of the plan for a management unit whether this is a forest, a district or a region and a major review of this nature provides a convenient basis for a discussion of the procedures of planning.

When undertaking such a review it is a useful preliminary exercise to summarise the total expenditure within the management unit in several ways. Expenditure outside the control of the management unit under consideration should normally be ignored.

One way is to summarise the total amount of money being spent on each of the basic resources of forest labour, foresters, office staff, professional staff, machinery, materials and buildings. This form of summary may be modified to give the total cost of overheads at each level of management. A quite different approach is to consider the total amount of money being spent on each of the forest operations such as planting, weeding, cleaning, estate work and so on.

Reviews of this type help to put the planning problem in perspective and to focus attention on the more important sectors. If, for example, fifty five percent of the toal budget is being spent on forest labour, thirty percent on local supervision and five percent on machinery, one wonders whether there is too much supervision and too little mechanisation. If in the forest operations account fifty percent of the total budget is going on weeding and only, say, eight per cent on planting it will very likely be more profitable to utilise work study, management and research resources in reducing the cost of weeding than in achieving economics in planting.

Although a preliminary review of this nature may show up inefficiencies and inconsistencies in the current use of resources it will not show whether the overall directions or intensity of the work is consistent with the objectives of the enterprise. It is therefore also necessary to investigate the posibilities of changing the level of the investment or the nature of the investment in forestry. It may be more profitable for example to switch part of the investment from new planting to the fertilising of pole stage crops or to reduce the intensity of investment by abandoning brashing, thinning, draining and roading.

In order to undertake this type of investigation, whether it is done with the aid of a paper and pencil or a computer the planner has to follow a logical procedure which may be summarised as follows.

(a) to define (or recognise) the objectives.

(b) to identify (or recognise) the constraints affecting his freedom of action.
(c) to adopt an appropriate criterion of success.
(d) to consider the possible courses of action.
(e) to assemble the relevant information on costs, prices, physical responses and so on.
(f) to test against the appropriate criterion the results of following different courses of action.
(g) to make the final decision.

In theory this appears to be a logical and straightforward procedure even if the calculations, may under some circumstances, be very complex. In practise, however, it is often difficult to define the objectives and constraints unequivocally. These must logically precede mechanics of planning but the investigations and calculations made in the course of planning may reveal that the objectives are unrealistic or the constraints impracticable or too expensive.

It is therefore possible to recognise a distinction between planning and decision making even if both functions are performed by the same person. Or looked at in another way the word *planning* may be understood to embrace both the testing of various courses of action against the appropriate criterion and also the final decision making. As well as requiring an opinion on uncertainty, decision making may also involve a reappraisal of the original objective and constraint. This is something which we all do every day often without realising it. For example, a man may set out with the object of buying a boxer dog with the constraint that it shall not cost more than £12. When he gets to the pet shop and finds that the cheapest boxer puppy is £20 he may relax his constraint and pay £20 or he may change his objective and buy an Alsatian puppy for £12 or he may decide to have a cat instead.

In practise it is the constraints rather than the objectives which are most likely to be uncertain. For example, in a depopulated region the objective may be to earn the highest profit subject to the constraint that employment is to be provided for, say, 200 men. If, however, it is found that the highest profit could be earned with a labour force of only 50 men this constraint might well be reconsidered.

In a large organisation considerable inconsistencies and inefficiencies can result when national or regional objectives and constraints are changed at subordinate levels of management. This often happens unwittingly when field practices are introduced locally, without a full realisation of their implications. This underlines the necessity for defining clearly and unequivocally the objectives, constraints and criteria. If this is done the execution of plans can safely and with advantage be decentralised as much possible.

It is sometimes said that planners should consider all the possible courses of action. In practise this is rarely possible although a large number of alternatives can be tested with the aid of the more sophisticated linear and other programming techniques if a computer is available. Most forestry planning, however, depends very much upon the experience and the imagination of the planner and the number of alternative courses of action which can be investigated is small. It is necessary, therefore, for planners to make a conscious effort to free themselves from prejudice and convention and to be prepared to consider courses of action which at first sight may appear to be unpromising or impracticable.

METHODS OR TECHNIQUES OF PLANNING

The basis of planning is commonsense and judgement but except in the most simple or familiar situations it is impossible for the human brain to see through the implications and interactions of the factors involved. Various aids are therefore required to help the planner.

But despite the rapid growth of analytical aids, or tools, in recent years their use cannot absolve the manager from using his judgement. There are two principal reasons for this. One is that it is difficult to collect all the relevant facts. The other is the difficulty of knowing how to handle those factors of the situation which are uncertain. this means that the manager is necessarily left with the task of making judgements about such matters as future economic conditions and their effects on the enterprise.

A plan attempts to mirror a real life situation but most day-to-day planning is based upon extremely simplified, rationalised and short term data. Highly sophisticated methods are required if a wider range of factors, a deeper consideration of interactions and a longer term view are to be taken into account.

It is possible to classify planning aids in order of increasing complexity or sophistication and Table I[1] sets out such a classification. The order from 1 to 5 can be associated with:

(a) a declining degree of compromise with and simplification of the situation;
(b) a use of increasingly complicated, yet more flexible tools;
(c) increasing realism and improvement of the overall result;
(d) a change from "ready-made" to "made-to-measure" solutions.

Drillbook guides

Leaving aside techniques which rely purely on habit and experience and which may be regarded as special types of drillbook solutions, it is probably true to say that most planning in forestry today depends upon the use of various tabular and graphical aids, reference charts and standard drills.

Volume Tables, Stand Tables and the Management Tables of the British Forestry Commission are good examples of drillbook guides which provide answers to problems without the need for any calculations on the part of the user.

Table 1. A Classification of Planning Techniques

Technique	Approach	Application in forestry	Examples
1. Past experience or habit. 2. "Drillbook" solutions from manuals, standing instructions, etc.	Conventional solutions, allowing little adjustment to the realities of the situation.	Widely used as the basis of most local management decisions.	Choice of species. Sowing densities, planting distances, layout of drains.
3. Ready reckoners.	Intermediate.	Becoming more widely used.	Setting of piece-work. Profitability calculation.
4. Operational research, that is broader analysis reviewing a number of courses of action and possible interactions within any one.	More flexible, recognising the realities of the situation but using a repeatable technique of analysis.	Used only for major problems, normally at higher levels of planning.	Allocation of national planting programme to regions. Cutting plans to meet mill requirements.
5. Comprehensive study of all feasible courses of action and foreseeable consequences.		Rarely used as yet, dependent on ability to exploit operational research techniques, applied at higher levels of planning.	

Ready Reckoners

A ready reckoner may be regarded as a more sophisticated version of a drillbook guide. Much of the information obtainable from a ready reckoner is derived from calculations built into the system but the user is required to make various assumptions and to undertake relatively simple calculations in order to find the answer to his particular problem. There is no clear-cut distinction between drillbook guides and ready reckoners. The difference is one of degree. Standard-time tables which are used for setting piece-work rates are a good example of a more highly developed drillbook guide or a simple ready reckoner. These tables give the standard minutes required for a particular job but they also enable the standard time to be adjusted in order to make allowance for local conditions. Ready reckoners are used by the British Forestry Commission for various types of profitability calculations.

Operational Research

While drillbook solutions and, to a lesser extent, ready reckoners provide examples of ready made solutions of recurring problems, operational research is used to uncover the interrelations among a whole variety of factors. It may thus be regarded as a fully made-to-measure technique of planning and the term "operational research" is usually restricted to investigations which take account of a large number of variables and consider a wide range of possible courses of action.

A comparison of the various techniques

It is clear that each of these techniques has a place in forest planning and with a wider recognition of the need for planning from the top downwards operational research techniques must inevitably become more widely used.

The relative roles of drillbook guides and ready reckoners is less clear. Very many minor decisions are made in the forest but it is unlikely that the foresters and forest officers who make these decisions will have the time or opportunity or even the inclination to make use of a pencil, paper and a slide rule every time they are faced with a problem. Moreover, the use of a ready reckoner often involves the user in making assumptions and this may be difficult or uncertain. Basically, drillbook guides are used to ensure that all decisions are somewhere near the optimum whereas a ready reckoner is intended to assist the planner in approaching more closely to the optimum. It is probably better to ensure that most decisions are fairly good than that some decisions are very good. For this reason it seems that rather more effort can usefully be put into the preparation of drillbook guides than of ready reckoners.

An example of this is provided by the ready reckoner which was evolved by the British Forestry Commission for the calculation of optimum road density. In order to use this ready reckoner it was necessary to make several estimates including the unit cost of moving produce from stump to road and the factor representing the relationship between the road density and the average skidding distances. These two assumptions were often so unreliable that the answers obtained from the ready reckoner were often of little value. Therefore the ready reckoner has now been replaced by a drillbook guide. In order to use this guide one has only to decide on the proposed extraction technique, the soil conditions and the road cost per mile. The drillbook guide is more widely used than was the ready reckoner and the result has been to reduce the previously accepted roading densities by a considerable extent.

1. Johnston, D. R., Grayson, A. J. and Bradley, R. T., 1967, *Forest Planning*. Faber and Faber.

Potential and Actual Dry-Matter Production in Irish Forests

P. L. CURRAN, M.AGR.SC.

INTRODUCTION

It is of more than just theoretical interest to enquire about the upper limit to crop production in Ireland, because it is useful in defining objectives to know what the absolute potential in dry-matter production is. It is also useful to consider the factors which cause actual production to fall short of the theoretical, and to enquire about the distribution of dry-matter between the component parts of the total crop biomass.

Photosynthesis is responsible for the primary production of dry matter in higher plant ecosystems. For the present purpose, it is not essential that the detailed biochemical, biophysical or physiological mechanisms be considered, but, since energy capture and energy transfer is a fundamental part of photosynthesis, a consideration, in broad outline, of the nature of the energy aspect is desirable.

In processes involving change two properties, energy and mass, remain constant. Thus, changes in fresh weight or in dry weight of an organism must be balanced in terms of input and output components of mass and of energy.

Although energy is an abstraction, it is recognisable in its forms such as radiant energy. Radiant energy must be absorbed in order to be physiologically useful. The absorbing molecules are known as pigments. Higher plants possess chlorophyll *a*, and other accessory pigments such as chlorophyll *b* and the carotenoids. Radiant energy absorbed by chlorophyll *b* is transferred with an efficiency of almost 100% to the primary photosynthetic pigment, chlorophyll *a*. The transfer from the carotenoids is about 20% efficient. Of the total captured by the pigments, 90 to 95% is directed towards the reduction of an acceptor molecule under optimum conditions.

Radiant energy, or insolation, which is photosynthetically useful occurs almost entirely in the visible range (4000-7000A) and this latter represents 40-45% of the total radiation. The waves of light are said to be composed of discrete pulsating particles called photons (or quanta, for solar radiation in general). When absorption of light occurs one photon activates one pigment molecule. The quantity of photons absorbed by one mole (molecular weight in grams) of a pigment is a fixed quantity called one einstein and is equivalent to 6.06×10^{23} photons. The energy content per photon, and hence per einstein, is a function of wavelength. Some values per einstein are as follows: ultra-violet (2860A), 100 k. calories; violet

(4000A), 72 k. cal.; blue-green (5000A), 57 k. cal.; yellow (6000A), 48 k. cal.; red (7000A), 41 k. cal.

THE UPPER YIELD LIMIT

The utilisation of light in photosynthesis is a quantum process confined to the visible region of the spectrum. The mean daily input of total radiation on a horizontal surface at Valentia is approximately 394 g.cal/cm^2 in the April to September growing period and approximately 119 g.cal/cm^2 in the October to March period (Anonymous, 1961). The mean daily input averaged over the twelve months is thus 257 g.cal/cm^2. Loomis and Williams (1963) have used data from Brooks (1961) and Moon (1940) to convert total radiation data into a form which expresses its photosynthetic potential. Accepting their conversion factor (1 g.cal/cm^2 total radiation = 8.6 micro einsteins/cm^2 of photosynthetically useful radiation) a mean input of 257 x 8.6 or 2210 micro einsteins/cm^2/day is obtained for the twelve month period. If a value of 15% is given to the reflection coefficient (albedo loss for total insolation is generally given as 26% for grassland, 17.5% for oak woodland and 14% for pine forest) and 10% to absorption which is not potentially useful in photosynthesis, it follows that 25% must be deducted from 2210 micro einsteins/cm^2/day, giving 1657. The value of 15% given to albedo is probably excessive for photosynthetically useful light (Geiger, 1957).

The number of quanta required to reduce one CO_2 molecule in photosynthesis is generally taken as 10, although some experiments do not support this figure. Accepting this figure as the best available, 1657 micro einsteins/cm^2/day will produce 166 micro moles of CH_2O/cm^2/day of gross photosynthate.

Respiration losses in forests in temperate regions are often taken as 44% of gross photosynthesis (Boysen-Jensen, 1932; Becking, 1962). Loomis and Williams use a figure of 33%. An examination of the temperature response curves for photosynthesis and respiration (Fig. 1) suggest that for our climate the value selected by Loomis and Williams is closer to the truth. However, without more direct evidence of the extent of respiration loss a compromise value of 40% is chosen. On this basis the amount of net photosynthate produced per cm^2/day is approximately 100 μ moles of CH_2O. By confining our calculations, based on the same assumptions, to a six month growing season the potential productivity is approximately 150 micro moles of CH_2O/cm^2/day.

As our new forests are principally evergreen a calculation based on the twelve month period is probably best, as there is evidence of photosynthetic activity in evergreen trees in suitable weather during winter (Parker, 1953). One mole of CH_2O is equivalent to 30 grams, so that the conversion from 100 μ

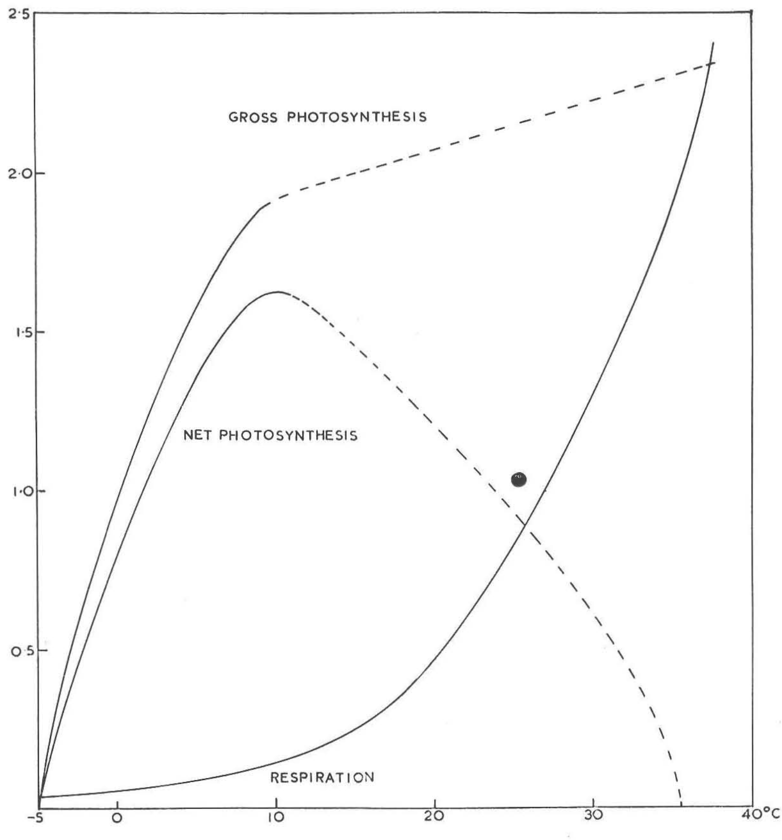


FIG. I PHOTOSYNTHESIS AND RESPIRATION OF PINUS CEMBRA IN RELATION TO TEMPERATURE. (TAKEN FROM TRANQUILLINI 1954).

moles /cm²/day yields 30 g/m²/day over the twelve months and is equivalent to approximately 292 lbs/photosynthate/acre/day, or 47 tons/acre/year. When the minerals absorbed from the soil are added the total dry-matter production potential is approximately 50 tons/acre/year. This represents the upper limit to yield assuming that chlorophyll is distributed in a uniform horizontal layer which intercepts light completely, and that no limiting factors operate to restrict photosynthesis. An examination of these two assumptions is necessary but is deferred until actual yields are compared to the theoretical.

Actual and Potential Dry Matter Yields

On the basis of the assumptions already stated, an annual crop, with an effective growing season of 140 days, will have a potential dry matter production of approximately 30 tons/acre. This production level, and that worked out for a perennial evergreen crop in the previous sections, represents about a 4.4% utilisation of total incident radiant energy or about a 10% utilisation of visible light. Each may be compared with actual records of highest level production (which include estimates of root producton) as follows: pine forest in Britain 14.0 tons/acre, 1.73% conversion of total radiation and 4.32% conversion of visible radiation; deciduous forest in Britan, 6.85 tons/acre, 1.4% and 2.85% converson levels; sugar beet in Holland, 6.45 tons/acre, 0.83% and 2.07% conversion levels; wheat in Holland, 5.50 tons/acre, 0.73% and 7.83% conversion levels (Odum, 1959). The data for forests do not include the early unproductive years. These production levels may be compared also with the performances of individual leaves under optimum conditions for short periods of time. Conversion levels of 5 to 7% for total radiation and 12 to 16% for visible light are generally recorded (Gaastra, 1962; Holliday, 1966).

It is evident therefore that the highest production levels actually recorded for field and forest crops represent some 18% to 28% of the theoretical maximum. Mean crop performance is of course lower still.

Factors Limiting Photosynthesis

In searching for the causes of the difference between actual and potential yields it is necessary to state that water is generally not a deficiency factor for crop growth in Ireland (Guerrini, 1953, 1957; Curran, 1964). Soil fertility levels are adjustable and this aspect is likewise eliminated from further discussion.

Two broad categories of modifying influence thus remain to be considered

(a) Factors affecting the component processes of photosynthesis, and

(a) the characteristics of the light intercepting surface.

(a) the components of photosynthesis

Photosynthesis is looked upon frequently as the reverse of respiration and as such it is conveniently summarised in the form

$$CO_2 \quad + \quad H_2O \quad \xrightarrow{+ \text{ light}} \quad (CH_2O) \quad + \quad O_2 \quad + \quad \text{energy}$$

Three components are recognisable immediately

(i) the supply of CO_2,

(ii) the fixation of light energy in chemical bonds, and

(iii) the synthesis of carbohydrate.

The influence of each component has been analysed by Gaastra (1962) and Monteith (1966). The position may be summarised in the following way.

Carbon dioxide has a mean concentration of 300 ppm in normal air. When other limitations are removed, leaves will respond to increasing CO_2 levels by increased photosynthesis up to a level of about 1300 ppm of CO_2. Therefore, under conditions of high light intensity and satisfactory temperature, photosynthesis is limited by CO_2 supply, and CO_2 is utilised by the chlorophyll units about as rapidly as it arrives at the chloroplast. Consequently, the path of flow of CO_2 from the surrounding air to the point of use is critical in determining photosynthetic rates. The concentration of CO_2 in air may increase with time, by virtue of man's industrial activites, to a level of 400 ppm. Otherwise, and except for the special case of glasshouse horticulture, the level is not subject to man's influence. The rate of flow is not only influenced by concentration differences but also by resistance to flow. A major source of fluctuation in resistance may be the surfaces of the sub-stomatal mesophyll cells of the leaf. A temporary dryness at this point may slow down diffusion considerably. While our crops generally do not suffer from a water deficit at the root, the rate of water entry from a cold soil may not keep pace with the rate of water loss to a drying atmosphere. In which case the plant may suffer physiological stress without displaying morphological symptoms of stress. This aspect also is not controllable. The mechanical disturbance caused by high wind speeds may cause temporary stomatal closure. All of these uncontrollable factors may increase resistance to CO_2 diffusion and thus reduce photosynthesis.

The next major component of photosynthesis is the fixation of light energy in chemical bonds. With factors controlling other components non-limiting, the photosynthetic response of *an individual leaf* to increasing light levels is linear at low light intensities until a level of approximately 6.5 cal/cm²/hr of total radiation or about 3 cal/cm²/hr of visible light is reached. Beyond that level the response is curvilinear, saturation being reached at about 33 cal/cm²/hr of total radiation or about 15 cal/cm²/hr of visible light.

The third component, involving enzyme systems, is responsive to temperature. Forage grasses are considered generally to grow at temperatures above 43°F or 6°C but appreciable growth rates are not reached until temperatures reach 50°F or 10°C. Evergreen conifers probably respond in somewhat similar fashion. Respiration rates climb rapidly at temperatures above 50°F. However, the net response varies widely from one population to another.

(b) The Characteristics of the Light Intercepting Surface.

The light intercepting surface is not a uniform layer of chlorophyll, but is a complicated mosaic of surfaces with reflection characteristics. During the establishment phase of the young forest the proportion of light which is usefully intercepted is rather small. The rate at which canopy development proceeds is a function of the vigour of individual plants and the number of such per unit area of ground. The nature of the control of these maters is determined by considerations of timber use and silviculture practices.

Once the closed canopy stage is reached, and indeed long before, the problem of mutual shading of leaves becomes critical. Mutual shading of one chloroplast by another occurs within the individual leaf, but there is some evidence of a regulatory mechanism in the form of protoplasmic movement and chloroplast orientation within the cell. The manner of leaf display is also a determining factor in degree of mutual shading and the regulatory effect of phyllotaxy and angle of leaf is especially evident in annual crop plants and in broadleaf seedling trees. Shape of leaf and angle of inclination of leaf are also important in closed canopies.

The penetrating power of light through foliage is related to its intensity. Although great fluctuations in intensity occur over brief periods of time, seasonal trends are also very pronounced (Anonymous, 1961, Table 2). This fluctuation, coupled with the rhythm of daylength change characteristic of our latitude, has important physiological consequences. The respratory process, which is essential in all living cells, continues in both light and in darkness at a rate determined by temperature. Photosynthesis proceeds in light at a rate determined by factors already discussed. The point at which organic matter production by photosynthesis balances organic matter destruction by respiration within the individual leaf is called the compensation point. It is the net effect of the physological activities of a myriad of individual cells. Theoretically at least, a compensation point for the crop or canopy is also conceivable. It is the net effect of the physiological activities of a myriad of indvidual leaves, all of whch are decomposers of organic matter in darkness, and some of which are net producers of organic matter in light. If light were a fixed quantity then it would be possible to arrive at an area of leaf (measuring one surface only) per unit area of ground such that the most deeply shaded leaves are at their compensation point. If the quantity of leaf increases beyond this amount, that is if the leaf area index increases, the lower leaves will be more deeply shaded and their respiratory activities will exceed their photosynthetic activities; they become net users of organic matter and in that condition are parasitic on the crop. If on the other hand the leaf area index remains unchanged but light quantity (intensity x time) decreases a similar physiological consequence ensues, the lower leaves become parasitic. Likewise if light quantity increases or leaf area index decreases the lower leaves become less shaded and become net producers of organic matter, but, if light intensity increases beyond the saturation level of lower leaves, light will reach the ground and efficiency of utilisation will drop. It will be apparent that light quantity for lower leaves is not a simple product of intensity and daylength because a certain threshold value of intensity must be exceeded before penetration through the upper foliage is possible. These leaves which are net consumers of organic matter can survive until they have lost more than 50% of their dry weight.

In field crops the optimum leaf area index for economic yield is a function of the variety used and the planting pattern and density used. Another density or planting pattern may result in a higher total biological yield, but in a reduced yield (or reduced quality) of economic product. For kale grown in rows, the optimum leaf area index is about 4, whereas for sugar beet it is about 6. The maximum, but not necessarily the optimum, leaf area index recorded for Scots Pine is 11, and for Spruce 28 (Ovington, 1958).

DISTRIBUTION OF ASSIMILATES WITHIN THE CROP

Total crop biomass is a useful measure of physiological efficiency, but may be of little concern to the practicing forester who is interested in yield of stem wood. Maximum dry-matter production per unit area of ground may not be compatible with maximum yield of timber. Ultimately the problem is one of distribution of assimilates to components of the crop. It has five aspects:

(1) the nature of the commercial requirement,
(2) the genetical characteristics of the individuals making up the population,
(3) the physiological characteristics of the stand at its several phases of growth,
(4) the ecological characteristics, which involve the morphological and physiological adaptations of the individuals, and soil changes, and
(5) economic considerations, which determine if certain silvicultural manipulations with biological consequences are justifiable in terms of net returns.

The third aspect has occupied our atention here. Available data suggests that the stem-wood share of total dry-matter produced is about 60% for a variety of mature forest types (Becking, 1962). This constancy may be more apparent than real, although Ovington (1958) found that 60% of the total dry weight of a

55 year *Pinus sylvestris* stand was in the form of bole. For field crops Brouwer (1962) has argued that changes in favour of the relative amount of the economic product generally are associated with a reduction in other organs and of the total product harvested. Holliday (1966) argues that an alteration in distribution of assimilates, such as has been achieved in wheat, is possible in other species without reduction in biological yield and with a consequent increase in economic yield. An intuitive judgement leads one to suspect that Holliday is right.

DISCUSSION

The conversion of the light available in Ireland during an average year into net photosynthetic product has a theoretical maximum of 47 tons/organic matter/acre. The actual yield falls far short of the theoretical because of the limiting effects of CO_2, temperature and the nature of the intercepting surface. On taking these limiting factors into consideration and taking data from field crops for comparison it is suggested that the hghest production possible during the closed canopy phase in Irish forests is about 12 tons/dry matter/acre/year. On taking the establishment phase into consideration an upper limit of 9.5 tons/acre/year for a fifty year growth period is suggested, but actual performance data for the establishment phase are required to verify this. If the stem-wood component of the total crop biomass is taken as 60% the above production level yields 5.7 tons of stem-wood/acre/year, averaged over the full growth period of the forest. Complications of a physiological nature such as the relative performance of sun and shade leaves, changes in physiological efficiency of leaves with age, effect of variation in chlorophyll content and the relative efficiency of the chloroplasts from different species or different genotypes have not been considered because their overall significance in practice is highly conjectural.

References

Anonymous, 1961
Solar Observations at Valentia Observatory 1954-1959
Met. Services, Dept. of Transport and Power.

Becking, J. H. 1962
Potential and Actual Production of Stem Wood in Forestry Neth.J.Agric. Sci.10: 354-360.

Boysen-Jensen, P. 1932
Die Stoffproduktion der Pflanzen
Verlag G. Fischer, Jena

Brooks, F. A. 1961
Review of Specific Response to Solar Radiation in Agriculture
Sym.Rad.Comm., Int.Assoc.Met.Atmos.Phys., Vienna.

Curran, P. L. 1964
Water and Plant Growth
Agric.Record 22: 48-62.

Gaastra, P. 1962
Photosynthesis of Leaves of Field Crops
Neth.J.Agric.Sci. 10: 311-324.

Geiger, R. 1957
The Climate Near the Ground
Harvard University Press.

Guerrini, V. H. 1953
Evaporation and Transpiration in the Irish Climate
Technical Note No. 14, Met. Service, Dept. Transport and Power.

Guerrini, V. H. 1957
An Analysis of Evapotranspiration Observations at Valentia Observatory, August 1952-July 1956
Technical Note No. 25, Met. Services, Dept. Transport and Power.

Holliday, R. 1966
Solar Energy Consumption in Relation to Crop Yield
Agricultural Progress 41: 24-34.

Loomis, R. S. and W. A. Williams 1963
Maximum Crop Productivity: An Estimate. Crop Science 3: 67-71.

Monteith, J. L. 1966
Physical Limitations to Crop Growth. Agric. Progress 41: 9-23.

Moon, P. 1940
Proposed Standard solar radiation curves for engineering use
J. Frank. Inst. 230: 583-617.

Odum, E. P. 1959
Fundamentals of Ecology, Saunders, Philadelphia.

Ovington, J D. 1958
Some Biological Considerations of Forest Production, in W. B. Yapp and D. J. Watson *The Biological Productivity of Britain*, Inst. Biol. London.

Parker, J. 1953
Photosynthesis of *Picea excelsa* in winter
Ecol. 34: 605-609.

Tranquillini, W. 1954
Über den Einfluss von Ubertemperaturen der Blatter bei dauereinschluss in Küratten auf die ökologische CO_2-Assimilationmessung. Ber. Deut. Bot. Ges. 67: 191-204.

Why Forest Microbiology

J. GARDINER, M.AGR.SC., PH.D.

The efficient practice of forestry rests fundamentally on its biological side; upon a knowledge of the constitution of the associations of plants and animals which form the forests and of the interrelationships between the various members of them. Thus microbiology which is essentially a laboratory subject is studied as a means to an end, and not as an end in itself. Now, any laboratory requires extensive, expensive equipment if it is to deal effectively with the problems which arise and provide a useful service. Microbiology is only an exception insofar as parts of the equipment necessaary are specific to a microbiology laboratory. A very conservative estimate of the cost of equipping such a laboratory would be in the range of £1000. and this would only provide the absolute essentials for primitive research involving plate counting and nutritional studies. The question then must naturally arise: what is the position of microbiology in forestry and is it sufficiently important to warrant this expenditure on equipment and personnel ?

On the other hand forest management continues to become more intensive as a growing demand for timber necessitates both an increase in forest production per unit area and the afforestation of areas which at one time were regarded as unsuitable for commercial forestry. Clearly, forestry is becoming more agricultural in approach and with more intensive management, there must be a greater awareness of the need for precise information on the mineral requirements of forest crops, the possibilities of improving growth and the prevention of soil impoverishment by applying mineral fertilizers.

Although trees are basically similar to other plants in their nutritional requirements, greater consideration must be given to the natural nutrient cycle for woodlands than for agricultural land, because of certain distinctive features of forest communities. The most striking feature of a woodland community from the point of view of nutrient circulation is the regular annual return of nutrients to the soil in the litter falling from the vegetation cover. The amount and type of litter fall, varies not only with tree species but also with age and has been calculated experimentally to be of the order shown in Table 1.

TABLE 1

Species	*Age (yrs.)*	*Annual litter—lbs./acre dry wt.*
Beech	30-60	3028
Norway Spruce	(30-60 (60-90 (140	(3032 (2582 (1319
Scots Pine	(25-50 (50-100	(2629 (1479

Thus it has been estimated that the build up of organic matter after 55 years of afforestation with Scots pine on open heath in England results in the accumulation of:—

	In litter (lbs/acre)	In Wood (lbs/acre)	Cwts/acre (approx.)
Calcium	574	129	6
Nitrogen	948	289	11
Potassium	272	59	3
Phosphorus	77	17	1
Magnesium	127	29	1½
Sodium	46	10	½

Here then is a vast store of nutrients effectively locked-up from the tree crop and depending upon the ability of the microflora to decompose cellulose and lignin for its release. How then does the crop obtain its supply of essential mineral elements such as nitrogen? Is the soil being constantly drained of its supply of nitrogen while this extensive source builds up and lies useless on the soil surface. Certainly, soil fungi and bacteria degradate some of this organic matter with the resultant release of ammonia, carbon dioxide, amino acids, soluble carbohydrates and fats. Certainly plants can utilise such compounds to some degree, but it is equally certain, that some, such as ammonia, must be converted by micro-organisms into more available forms before they can be utilised by many plants. Are these organisms present in our forest soils? More important still, are they active in our forest soils? The high water holding capacity of many of our forest soils, which suggests at best microaerophilic conditions, at least for parts of the year, plus the acidic nature of humus deposits under coniferous plantations, indicate a great reduction in the activity of these organisms.

But still the question remains, of how the tree gets its supply of nitrogen. Is its supply inadequate? and if so, how inadequate? Recently many investigators have drawn attention to the fact that soil nitrogen balance sheets do not in fact balance. A large number of major reports on this subject show an unexplained increment in soils of about 30-50 pounds of nitrogen per acre, per year. So that not alone are the trees assimilating at least some nitrogen, but in some mysterious way nitrogen is being built up about them. Considerable justification exists therefore, for the entertainment of the idea of nitrogen fixation by non-nodulated plants. This is supplemented by the fact that the inevitable association between plant surfaces and bacteria is not always a random arrangement, but definite associations have been noticed particularly on seed surfaces and on leaves. Data have been produced showing that teeming microbial populations occupy the leaf surfaces of plants. Moreover these populations include various nitrogen fixing bacteria as prominent common components of the population. It is not difficult then to envisage, on the one hand, cuticular excretion of salts and metabolites, providing nutrients for epiphyllic nitrogen fixing micro-organisms, and on the other, uptake of fixed nitrogen by the forest plants, either by the leaf surfaces or via foliar drip, to the soil and then to the roots. However, despite this build-up of total nitrogen about forest trees it is more than likely that many of our forest crops, especially those on the poorer type, wet and heavy soils do suffer from deficiencies of this element.

As the number of flowering plant species is of the order of 250,000 and of the Eubacteriales about 1000, it does not belittle the literature on plant-bacterium symbiosis to say that not much is known about the subject. Even though the Romans in the time of Julius Caesar were aware of the fact that the presence of clover plants in a grass sward improved the fertility level, it is true to say that plant-bacterium symbiosis is largely an unexplored field. The results of plant influence in the rhizosphere are a differently composed, numerically more dense, metabolically more active microflora, compared to that of the surrounding soil. Many investigators claim instances of non-legume response to inoculation with rhizosphere organisms. This response is not ascribed to nitrogen fixation but to the beneficial effects of rhizosphere organisms on the availability of nutrients already present in the soil. Responses of about 10% due to such inoculations have been reported for agricultural crops. Again this is quite creditable for it is well-known that prominent rhizosphere organisms can release nutrients in much the same way as *Bacillus megaterium var phosphaticum* can release available phosphorus.

CH_2 . OR
1 1
CH . OR
1 OH
CH_2 . OPO (CH) + $3H_2O$
O $(CH_2)_2$ 3 + Decithinase
OH

Lecithin (A phospholipid)

CH_2OH
1
CH OH
1 OH 1 (CH)
CH_2 OPO + ROH + R OH + $(CH_2)_2$ OH : N
OH OH

Glycerophosphoric Acid Fatty Acids Choline

Microorganisms often live together because certain bacteria and fungi produce substances that render the existence of other organisms possible. A similar connection exists between the higher autotrophic plants of the forests and microorganisms of forest soils. The microorganisms are dependent to a large extent on organic substances of the litter produced by the autotrophic plants and they in turn promote the autotrophic plants by making the mineral substances of the litter available to them. This however, is not regarded as true symbiosis, nor is the case of epiphytes, where organisms live on or in close proximity to the roots; the concept symbiosis is restricted to the living together of two organisms in immediate contact. There are however, innumerable cases in which the plants and organisms not only come into contact, but in which at least one of the symbionts lives partly on the tissues of the other; e.g. nodule bacteria, mycorhizal fungi or actinomycetes, which live in the roots of their host plants. This is a specialized form of living together in which the contact is close and there is a reciprocal influence on metabolism. It is possible and in fact probable, that the nodulation of *Myrica* and *Alnus* fall into this category, as do root nodules which are known to occur on some conifers and are considered to contain a microsymbiont. One is unable however, to conclude the identity of the latter organism since opinion is divided between fungi and bacteria.

In some cases such close mutual dependence has developed, that under natural conditions, neither of the partners is entirely capable of independent existence; e.g. several mycorhizal fungi form their fruiting bodies only in symbiosis with forest trees and the failure to afforest certain areas of prairie and peatland has frequently been attributed to the lack of mycorrhizal fungi. To what extent then should we, as foresters, worry about these mycorhizal fungi?; after all Ireland has always been a land of forests. How do these fungi get onto our trees? or to what extent are these, all too frequently generalised about mycorhizae present on our trees?

Dealing with these questions in rotation, it is not difficult to find reasons why we should be concerned about these fungi for it has been shown experimentally that pines with mycorhizae can absorb 234% more phosphorus, 86% more nitrogen and 75% more potassium than pines devoid of mycorhizae. Because of the absence of root hairs in the mycorhiza and because the fungal sheath covers those parts of the roots capable of absorption of nutrient salts and water the latter have no other course to the plants than through the fungal associate. Beyond this, the hyphae spreading into the surroundings from the fungal sheath contribute in a high degree to the enlargement of the absorbing surface. The mycorhizae actually represent absorptive organs of the trees and hyphae going forth from the fungal sheath into the substrate act in an analogous manner to root hairs in respect of salt absorption. Moreover pine and spruce grown in pure culture do not assimilate complex organic nitrogen compounds to any great degree, but mycorhizae can be shown to facilitate the absorption of ammonia and organically combined nitrogen and to be of special importance in those acid and poor soils in which nitrogen is combined in organic humus substances. They also make the plants more competitive for nitrogen with other fungi and this fact is borne out by the sparce development of mycorhizae in richer soil types. It has also been shown repeatedly under normal conditions that tree species devoid of mycorhizae on difficult sites become stunted and die. This is reported frequently on freshly drained peat bogs, on which pine and spruce seedlings are at first stunted. The mycorhizal fungi which spread rapidly after drainage then stimulate their growth. Furthermore, it has long been known that orchid seeds depend on mycorhizal fungi for successful germination and the same may very well hold true for the germination of many other seeds. For instance, acorns inoculated with an appropriate fungus, yield about 34% more plants than acorns without mycorhizae, while addition of mycorhizal soil increases the height of uninoculated seedlings by about 52%. Other functions frequently attributed to mycorhizae include the protection against pathogenic fungi, while the fixation of atmospheric nitrogen by mycorhizae has been mentioned over and over again. Because of these important considerations therefore, not only should foresters be conscious of these organisms but because of their great practical significance forestry should provide the requisite impetus for their intensive study.

As to the method of formation of these mycorhizae, there is every indication that primary infection is of the endotrophic nature. This primary infection seems to mobilise the defence forces of the host plant, which digest the intracellular mycelia and which push the fungus into an intercellular position, in which case an ectotrophic association is formed. If however, the fungus is able to resist digestion by the enzymes of the cortical cells it may remain in an intracellular position. The mycorhizal fungus, therefore, attacks the host primarily in the same way as a parasite. The volume of the infected cells often increases or the cells may be stretched in a radial direction. On the other hand the growth in length of the roots is often arrested. In this way the stocky form of the root arises, which is characteristic of many mycorhizae. Plants thus allow mycorhizae to penetrate only to a certain distance. On penetrating a certain distance hyphae of the fungus may be digested by the plant and on the basis of the degree of digestion different types of mycorhizae are now recognised. Thus a gradation from ectotrophic to endotrophic is now generally recognised.

In the absence of experimental evidence to prove otherwise, the only logical explanation for the relative success of many of our Irish forest crops on extremely difficult sites, is the presence on the roots of mycorhizae. Much of our blanket peat is otherwise, too acidic in nature, too high in moisture content to allow vigorous microbial activity and too impoverished in mineral nutrients to support tree growth. It seems to be also that the requisite fungi are not present in these bogs themselves but are carried on transplants at planting time.

Whatever section of forestry activities one takes the importance of microbiology is equally striking but none more so than the field of plant pathology. For instance, in a recent report on the pathology of forest trees in New Zealand, 93 fungal, 3 bacterial and 1 algae pathogen are recorded, together with one mycorhizal deficiency disease. However, apart from the undetermined damage caused by heart rots, few diseases have caused serious loss in either native or exotic plantations in Ireland. Two important reasons for this are, our geographical isolation from sources of infection and the wide generic differences between our exotics and our native trees, which has meant that few native pests or diseases have attacked our exotics. Nevertheless the danger cannot be overemphasised, for almost the whole of our forest industry is based upon a few exotic species. In such a situation an economic catastrophe may result from the introduction of a single primary pest or disease. It is becoming increasingly obvious that more fundamental information on the biology of the many forest organisms, both beneficial and pathogenic, is needed before field experiments or any control measures can be satisfactorily attempted. Recent developments in the biological control of *Fomes annosus* have emphasised this point for now the value of creosote as a protectant can be looked upon as a 'passive' measure and seriously questioned. The inoculation of the fresh stumps either naturally or artificially by fast cellulose decomposers such as *Trichoderma viride* or *Peniophora gigantea* and the alteration of stump tissues by chemical means have now been proven to be preferable methods. More recently still, at least two actinomycetes have been discovered producing antibiotics which inhibit the growth of Fomes. It is not stretching the imagination to extremes, to foresee the synthesising of these antibiotics and the injection of valuable trees or stands of trees with them, to prevent further damage to the timber. Investigations have also shown that fumigation of the soil with carbon disulphide may also lead to biological control of *Armillaria mellea.* After fumigation *Trichoderma viride,* a harmless fungus grows much faster than other fungi because of its tolerance to carbon disulphide and produces two antifungal antibiotics, Gliotoxin and Viridin which are antagonistic to Armillaria. Furthermore the living bark of European Larch may be expected to carry a microflora which contains both fungi and bacteria and frequently *Dasyscypha.* The necrotic areas which constitute a canker can be shown to carry a similar microflora, but *Dasyscypha* is not necessarily the most abundant or dominant organism nor is its presence necessary for the development of canker. What then is the importance of the fungus in these areas? or is it a harmless saprophyte. Again the microbiological examination of 250 Sitka Spruce seeds which had failed to germinate showed that 80% of them were infected with microorganisms.

69	carried	Bacteria
55	,,	Psychrophilic seed fungus.
43	,,	*Penicillia*
7	,,	*Cylindrocarbon*
5	,,	*Rhizoctania solani*
4	,,	*Verticillium*
3	,,	*Ceratobasidium*
2	,,	*Mucor*
1	,,	*Gliocladium roseum*
13	,,	Unidentified fungi

There are moreover numerous reports of up to 50% failure of Sitka Spruce seeds to germinate even though laboratory viability tests seldom show this failure rate. This discrepancy has frequently been attributed to the infection of weak and damaged seeds by microorganisms, some of which cause decay of radicles. However, no microbial infection of seeds can be found on cones direct from the tree; only slight seed infection on cones opening on the tree and 50-100% infection on seeds when the cones are stored in bins or storehouses. Furthermore fungal growth is noted on seeds stored at temperatures below freezing point and Table II will provide further evidence of the influence of the seedcoat microflora upon seed germination.

Effect of storing at 10°C. on germination at 20°C.

Days at 10°C.	*% Germination*	*% Ungerminated seeds yielding Bacteria*	*Penicillia*	*P.S. Fungus +*	*Other Fungi*
0	82	30	50	5	5
3	72	15	35	20	30
5	68	20	25	20	40
7	65	0	60	20	35
17	63	15	5	45	10
32	40	0	10	50	15

+ Psychrophilic seed fungus

Thus far I have confined myself to pointing out some of the microbiological problems of forestry, but with more intensive management of our forests, how are we to harness these useful micro-organisms and control the harmful ones? For instance is it possible to control the build up of organic material on the forest floor and gradually return to useful circulation this vast store of nutrients locked-up from the trees? Is it possible to utilise more efficiently those sites heretofore regarded as unfit for commercial forestry or will the tourists of future years looking upon our poor stunted effort to re-afforest our peatlands, re-echo the words of an eminent visitor, looking upon these same barren peatlands in the 17th century and say, (quote), 'that it is due to the wretchedness of the Irish, who took no care to tend or cultivate them'. (unquote). Well may this comment be true, for all of the available evidence suggests that high yielding Sitka Spruce can be grown even on the most difficult peats provided, (1) that additional nitrogen is provided: (2) that the pH is rectified to some degree, and (3) that some drainage is carried out. Under these circumstances, if Sitka spruce were given a few nitrogen top-dressings, sufficient nitrogen would be injected into the nutrient cycle to keep trees growing especially if the trees could by this time utilise the nitrogen reserves of the peat through increased microbiological action in breaking down the organic matter.

Again a comparison of the total annual litter fall under different thinning grades and the weight of the forest floor, illustrates the important influence of this silvicultural operation on the rate of decomposition of organic material, through its effect upon the micro-climate at the soil surface.

Monthly litter fall under different thinning grades (N. Spruce)
Dry Wt. lbs./acre.

Thinning grade	B	C	D	L.C.
Oct.	480	412	295	393
Nov.	478	379	334	318
Dec.	278	211	231	180
Jan.	355	304	281	263
Feb.	489	296	304	249
Mar.	683	420	342	557
Totals	2763	2022	1877	1960

Wt. of forest floor under different thinning grades.
Dry Wt. lbs./acre

Thinning grade	B	C	D	L.C.
	44,000	23,500	14,900	26,300

The greater litter fall and unfavourable microclimate under the heavy shade of the B grade thinning results in twice the weight of organic material accumulating compared with C and L.C. grades, and three times that under D grade. The large difference in the weights of the forest floor between C and D grades whose annual litter fall is similar, confirms that this is due to differences in the rate of decomposition and not merely to differences in litter fall. Perhaps this is a factor which ought to be borne in mind in laying-out future thinning experiments or perhaps we might take a lead from the agriculturalists, who have for long treated build-up of organic material in permanent pasture by disc-harrowing and rotovation, which practise is not foreign to many European foresters in dealing with the same problem. The true value of microbiology in the field of pathology has, despite recent advances, probably yet to be realised, in the biological control of the diseases which threaten our forests.

Agriculturalists do not have to contend, to the same extent in any case, with the build-up of organic matter; they are not so concerned with those fungi which play such an important role in feeding our forest crops; they do not, in Ireland in any case, sow pure crops in blocks of hundreds of acres, as the forester does. Therefore, microbiology is not as great a concern for them as it must be for the forester. Insofar as it is of concern they have not been slow to recognise its significance; e.g. the nitrification and nitrogen fixing processes in soil are probably the most researched aspects of the whole subject. Because of its great practical significance in forestry, then, the intensive study of microbial-microbial and microbial-plant symbiosis must be carried out by foresters, for forestry. I at least, have no doubt, but that forest microbiology is a vital link in the chain that is slowly but surely changing this Emerald Isle of bogs, (to quote another eminent visitor), into the Emerald Isle of woodlands, it undoubtedly once was.

GENERAL DISCUSSION

1. The question of the nitrogen supply to plants in the afforestation of peatlands continues to be of concern. It is generally conceded that the nitrogen supply from the peat itself is inadequate to meet the demands of a growing crop. The question automatically arises as to which form of fertilizer is most efficient in supplying the necessary nitrogen?

The general opinion at the moment seems to be that plants growing on peat can utilise all three forms of nitrogen. Most plants can readily utilise nitrate as a nitrogen source but the advisability of applying nitrate nitrogen to peat is questionable, since the nitrate ion is very mobile and is readily leached. Furthermore acid peats in general show a very strong denitrifying power. Application of nitrate therefore, would of necessity, have to be in the form of frequent light dressings, which over large areas would for economic reasons be unfeasible. Ammonia has been shown to be absorbed very rapidly by mycorhizae but addition of ammonium salts and nitrates diminish the intensity of root infection with symbiotic fungi. The ready availability of ammonia to plants, therefore, depends upon the presence of mycorhizae, and it is known that the microflora necessary for the conversion of ammonia to the nitrate form is either completely lacking or completely inactive in virgin peats. Organic nitrogen compounds, such as, glumatic and asportic acids, amino acids, urea, nucleic acids and protein hydrolysates are therefore more likely to be better sources of nitrogen than the ammonium or nitrate forms, but again the presence of mycorhizae must be assumed.

A question of practical significance now arises, for plants which are normally mycorhizal can be raised successfully as uninfected seedlings and can make very good growth in a short time under heavily manured conditions. But the relative poverty of available mineral salts determines the prevalence of mycorhizae on seedlings. Is it more important to the forester to grow large nursery stock although it is uninfected or to ensure that the seedlings become mycorhizal in the nursery at the expense of the degree of growth. Where exotics which are not habitually grown are being raised, it seems to be good policy to raise infected seedlings by suitable inoculation and treatment to ensure a source of inoculum in forest conditions. This is borne out by the fact that self-seeded pine and spruce seedlings on recently drained peat-bogs develop poorly and show signs of nutrient deficiency, such as are associated with nitrogen starvation.

The specificity of mycorhizal fungi and the possibility of the presence of these organisms in peat was queried. It was rather discouragingly admitted that it was unlikely that these fungi were present in peat. In fact, examination of the surface layers of Irish peats by some of our leading mycologists has shown that many fungi are present on or near the surface but that these are mainly Penicilli, Aspergilli, and Mucor sp. Although some unidentified fungi are recorded in these reports there is not even one mention of a mycorhizal fungus. As far as specificity is concerned most host species seem capable of forming mycorhizae with several fungi, and on any given root system, more than one type of mycorhiza may be observed, i.e. a single host may associate with members of several fungal species at one time. The most unspecific of all the mycorhizal fungi seems to be *Cenococcum grandiforme*, which has been found on on the root systems of species of *Pinus, Picea, Abies, Pseudotsuga, Tsuga, Tilia, Larix, Quercus, Fagus, Betula, Corylus, Corya; Populus, Salix* and *Alnus*. The greatest degree of specificity is shown by *Boletus elegans*, which is only known to associate with *Larix* sp. Between these two extremes there are many fungi from amongst the Phycomycetes, Ascomycetes and Basidiomycetes of intermediate host range.

The question of the role of phosphorus in plant nutrition was raised and it was observed that phosphorus is mainly present as a structural component of the nucleic acids, ribosenucleic acid (RNA) and deoxyribosenucleic acid (DNA). It is also present in the phospholipids, which are believed to play an essential role in the structure of the membrane. A deficiency of phosphorus is thus very serious for the cell, preventing the formation of new genetic material in nucleus and cytoplasm. Phosphorus is critically involved also in all energy transfer steps in the cell, since compounds such as adenosine diphosphate (ADP) and adenosine triphosphate (ATP) contain two and three phosphates.

enterprise and then, while still retaining enough flexibility to deal with changing circumstances, to control the work done against the objectives. They give a brief resume of some of the various planning tools which are now being used in industry, such as mathematical programming, game theory, etc., but the treatment is so sketchy that the reader will be forced to other texts to obtain an understanding of the full power and limitations of these techniques. Considerable attention has been paid to rational planning with selection of best alternatives through various criteria, in particular, investment criteria and not only are various financial measures described but there is also an interesting section on the choice of discount rate. A discussion on costs and prices is dealt with in more detail than foresters frequently have considered this topic and with particular reference to changes over time. Attention has also been paid in this section to the assessment of such things as recreational values. It should, perhaps, have been emphasised that while forestry is certainly a capital intensive industry the capital is largely accumulated by the use of local labour which has exteremely important social implications. The chapter on risk and uncertainty is in the reviewer's opinion the best in the book.

Most of this part of the book is concerned with rather more detailed discussion by forest operation headings, e.g., plant supply, crop establishment, crop treatment, silvicultural practices, effects of thinning on growth, economics of thinning, the felling decision, concepts of normality, forecasting, regulating and controlling yield, logging and loading, and marketing. Foresters will feel rather more at home when reading this section but may well consider that too much basic forestry knowledge, such as the definition of a 2 + 1 plant, has been given in a book primarily devoted to planning principles and procedures. Some of this is, of course, needed to provide a readable framework. Your reviewer would very strongly disagree with the suggestion that it is safer on a given site to choose a low production species likely to have a relatively high yield class rather than a high production species likely to have a similar yield class which would, of course, be low for that species as this latter species has obviously the greatest potential for improvement through site amelioration works, etc. It is certainly time that Foresters looked at many of their practices, such as plant spacing, weeding, brashing, fencing, etc., in the way in which Messrs. Johnston, Grayson and Bradley suggest they be looked at and as we move into a period where greater consideration is being given to crop treatments to increase these treatments must be assessed sensibly, e.g., by comparing growth benefits against costs etc.

Many Foresters will be sceptical of the models purporting to show the effect of thinning on growth and the subsequent use of these "theoretical" calculations to suggest possible methods of thinning to get optimum financial return; chapters which tend to take a hard knock at those who consider the beautiful art of a Forester is in how he wields his marking axe while pondering the individuals of the possible final crop as they will develop within his own personal thinning system. Such Foresters would be well advised to re-read these sections for, while it is relatively easy to accept the need for financial criteria in determining replacement age, degree of fire protection, intensity of roads, etc., here is a section where apparently silviculture is being asked to give way to theoretical management. Yet it is in this very field of model construction and simulation, using many other factors than those listed in this book, that the new management techniques are likely to have their greatest impact on the practising Forester and the ultimate financial success of the enterprise. The models used have tended to be relatively simple and because of this have probably introduced some bias in the considerations of type of thinning regime to be adopted; thus because the price size relationship is given on the mean tree volume insufficient weight has been accorded to those light or no thinning regimes where a very considerable part of the final volume is in trees much greater than the mean. If Foresters can accept that the methods used here (Chapters 18 and 19) have a part to play in forest management then the industry is in capable hands.

The chapters dealing with normality and yield regulation will not make very comfortable reading for those schooled in the ancient tradition of sustained yield yet one cannot help feeling that while there is logic and reason behind the arguments put over in this book the authors have not really put forward a completely satisfactory alternative solution to meet long term objectives.

Part 3 of the book deals with implementation of planning and in particular the organisation of the enterprise, the working plan and labour planning. The chapters on organisation are largely related to a State Forest Service and use the Forestry Commission terminology for the various levels of management distinguishing between functional and territorial responsibilties and indicating the role of specalists in planning. These chapters also differentiate the types of planning required at all levels. In spite of the author's criticism of the traditonal working plan in an earlier chapter we have here the suggestion that each forest should have a working plan with a factual and descriptive Part 1, a Part 2 which discusses various alternatives and sets out the major planning decisions and objectives and which the authors consider to be the most important section, and a Part 3 for detailed prescriptions which are in the Forestry Commission five-year forecasts plus one-year detailed programmes of work, all of which is quite similar to the methods adopted in many countries within the framework of a national plan with planning from above. It must be remembered, of course, that the Forestry Commission work within a fairly strictly controlled annual budget and as such detailed programmes need only go to the next higher level of management for control purposes. One can only hope that the authors' experience that flexibility and continual adjustment to changing circumstances does not result in deviation from the original objectives will continue for a long time. The chapter on labour planning seems slightly out of place here although it is agreed that this is an important field for management.

The fourth part of the book on data collection is disappointing due to the space allocated to topographical surveys and forest inventory with only a short section on forest accounts and the sources of economic data. Surely more information based on the experience of the Forestry Commission methods of collection of data of work done and costs and the detail with which these are recorded would have been of value where control is such a necessary feature of planning.

The book ends with three appendices, namely, Assessment of Labour Productivity, Annual Change in the Real Prices of Wood and Wood Products and Supply, Demand and Price plus a short glossary.

The book has been generally well presented and printed and with remarkably few mistakes. A printing error occurs in the differential equation at the foot of Page 383. Like too many economic texts the book makes frequent use of diagrams with no scale shown on the ordinates. One gets the impression that an attempt has been made to cram too much into the one volume and that certain sections could well be dispensed with while not destroying the value of the text for reasonably well-trained forestry personnel. Thus sections on the calculation of net discounted revenue, effect of geographical factors and classification of growth potential could perhaps have been left out, thereby making the book easier to handle.

This is not a book which will supplant the older classics on forest management, indeed it is doubtful if it should be required reading for university students, although they should certainly be taught the management principles and logical approach to decision taking which runs throughout the work. Every top manager in forestry, for example, Divisional Inspector, Principal Officer, private owner, etc., should be made to read this book and should understand the principle involved. Indeed the book could easily form a good foundation for a series of lectures on management to such senior staff. It is also essential that the next lower management level of District Inspectors, District

Forest Officers, etc., understand what this book is getting at as they too must be prepared to think on similar lines. By its very nature the book is not easy reading and many of this grade will have to make a very conscious effort to go right through it and not give up at an early stage. I would hope that many of those in charge of forests would also try to read "Forest Planning" but I feel that the changes which thinking of this type must bring to general management need to be discussed and explained to Foresters through training courses where there is ample opportunity for discussion. Indeed, the very big and important field of management relating to communications and human relations which must be understood for the implementation of any policy or plan is not really touched at all in this book and due to the size of the subject one must be thankful that it is not but must do further reading from non-forestry sources.

W. H. JACK,

The Use of Worked-Out Peatlands for Forestry.

Review of A. F. Timofeev and P. A. Lesnov, 'Lesokhozyaistvennoe osvoenie zemel posle torforazrabotok', Publ. by Lesnaya Promyshlennost, Moscow. 1967. pp. 74 (in Russian).

This booklet deserves wider recognition outside the U.S.S.R. than it is likely to get due to the unfortunate language barrier, and it is for this reason that a fairly full review may be of interest.

The peatlands of the U.S.S.R. (defined as areas having a depth of peat of over 0.5m.) cover 71.5 million hectares, which is about 70% of the total world area of peatlands. Peat working is now being carried out on about 1.2 million ha. in the U.S.S.R., and official statistics gave the area of worked-out peatlands as about 300,000 ha. on 1st January, 1963. These lands are mainly located near the heavily populated big industrial centres of European Russia, and only 8.5% of the worked-out peatlands have been reclaimed for agriculture or forestry. The rest of them lie derelict. Policy now is to develop these lands in an integrated manner: richer areas with better drainage are reclaimed for agriculture, the lower areas for fish-raising, and other areas for forestry.

The booklet itself is divided into two parts. Part I deals with the pedological and hydrological characteristics of worked-out peatland, and other aspects affecting reclamation. Most of the peatland in the U.S.S.R. is worked by the rotary-cutter milling method, and the depth of peat left after working is variable, but is usually from 0 to 1 m. or more. Peat types are distinguished according to the usual Russian classification: fen, transitional, and bog; the actual composition of each of these types may be mossy, herbaceous, or woody. Some examples of typical profiles are given, and also details on the soil chemistry, soil water and soil temperature regimes on worked-out peatlands. The last chapters of Part I deal with the natural colonization of worked-out peatlands by herbaceous vegetation and by forest tree species. Birch is the main pioneer tree species, but is found only rarely — the dense herbaceous vegetation usually prevents natural regeneration by tree species for some years. Sufficient seed trees, a residual layer of peat, and adequate drainage are the prerequisites for birch regeneration.

Part II of the booklet deals with the establishment and performance of forest plantations on worked-out peatlands, opening with a review of Russian experience. Then, detailed case-histories are given of afforestation trials on worked-out areas of peatland in three districts of European Russia: Kirov, Gorky and Yaroslavl. Soil preparation, method of establishment, and choice of planting spot are described, and details given on the survival, root systems and growth of coniferous and broad-leaved tree species. The main species dealt with is *Pinus sylvestris;* other species tried include *Picea abies, Pinus sibirica, Larix sibirica, Quercus robur,* and Poplars (especially *Populus suaveolens*). Analysis of costs for soil preparation, planting, and subsequent tending indicate that actual plantation establishment on worked-out peatland tends to be no more expensive than on other categories of land.

Some general conclusions are drawn at the end of the booklet. The salient conclusions are that the areas most suitable for afforestation are those that have been worked by rotary peat-cutters. The main factors affecting the growth of plantations of Scots pine (the main species considered) are the soil water regime and the depth of the residual peat layer. It will often be necessary to repair or improve the drainage system of the area before afforestation, and the best depth of residual peat has been found to be 10 to 50 cm., or best of all, 20 to 40 cm. Spring planting is best; on the lower-lying areas, planting should always be on the upturned turf, but on drained areas planting can be done on the turf or in the furrow. Frost heave, drought, excess moisture, and competition are particular hazards on worked-out peatlands, and cause heavy losses in the early years, so beating up and careful weeding are necessary.

The Russians are confident that productive plantations can be raised on worked-out derelict peatlands around industrial towns and cities and so simultaneously provide much-needed amenity and green-belt forests.

W. LINNARD.

Obituaries.

Matthew Dalton

25th September 1902 — *6th November* 1967

Matt Dalton was one of the first group of half a dozen "apprentices" taken on for training by the British Forestry Commission in 1920. He went to Dundrum Forest on the 1st October of that year when he was a bare week over the minimum age for entry. Unlike his companions he already had considerable experience of forestry having worked for his father at timber in the woods of his native county, Roscommon, and was a formidable hand with axe and saw. But these tools were of small account in the forestry of the early twenties and Matt had to take to the spade, an implement with which he quickly became a master in nursery and in plantation.

Whatever Matt Dalton did he did with all his might. He was a hard worker from the start and never shirked the tough jobs. Those were the days of large and venemous Sitka spruce transplants whose lifting in the nursery was a purgatory. Others would opt for the spade or the fork but Matt always tackled the painful chore of "pulling and shaking" day after day when his forearms would be swollen and bleeding. At work he never slacked but when work was done no man was more ready to enjoy himself. All his friends remember him as a cheery companion, full of amusing stories and boyish laughter. This school-boy attitude to life was his outstanding characteristic. He could be grimly serious at times, how grim his assistants are not likely to forget, but the clouds rolled by quickly and his hearty good humour soon took over again. He never spared himself and he, perhaps unreasonably, expected the same dogged determination from others.

The second year of the two year course was spent in Baronscourt Forest, Co. Tyrone at nursery work and as an "honorary head labourer" in charge of a planting gang. In 1923 he came south to start a long term, first as a foreman and later as forester-in-charge of Aughrim Forest. Here his memory is forever green in the massive planting that stretches from the village up the valley of the Ow to the slopes of Aughavannagh. From those early days he showed discernment in the selection of species — Sitka spruce, Japanese larch and, later, *Pinus contorta* were his wise choice for this rain soaked district. Douglas fir he would plant when he had to, but always against his better judgement as he was not slow to point out. In his attitude to the forest he was certain of one thing—no one high or low, was entitled to make mistakes. If others "let the job down" Dalton told them in plain language where the fault lay, and some of his superiors in rank, new to him and his way of thinking, were at first startled by his candour.

We associate Aughrim with Dalton more than anywhere else. There he spent his formative years, there he married and there he rests in Annacurragh churchyard. But his forestry career took him far afield and at each new centre he approached the local problems with an open mind. In Cappoquin, where he spent a brief spell in the mid-thirties, he recognised the virtues of Norway spruce on the mineral soils of Dromana. Later, during the many years in charge of Mountrath he quickly realised that it was a Sitka spruce area par excellence and the slopes of the Slieve Bloom to-day bear witness to his work.

At Baunreagh he met up with timber again—timber, road-making and bridge building. Bridges were a challenge which Dalton enjoyed and there on the Delour River and later in county Donegal he went at their construction with a heart and a half.

It is hard to know if he ever aspired to rise above forester rank. He was, undoubtedly, happy in charge of a forest. He was a practical man first and foremost. His job as he saw it lay amongst the men and the trees. Office work he did not like, as many a sorely tried official can testify, and he was often painfully slow with returns, but when they eventually came they were accurate to the last figure and thorough to the last particular.

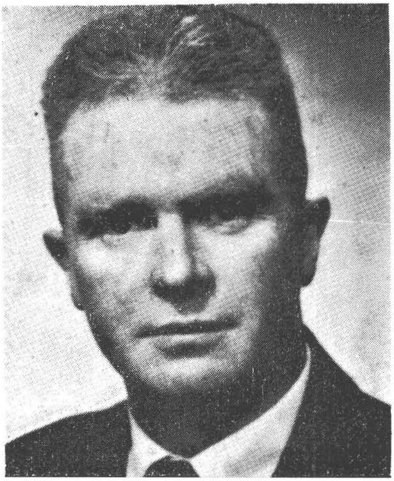
Matt rose to be Head Forester in Mountrath in 1941, but shortly afterwards transferred to Co. Donegal and was stationed at Ballybofey. He retired under the age limit on the 25th September, 1967 and planned to come south again to his first love, Aughrim, where he bought a house for his retirement. His last illness overtook him before he took up residence there and he died a short six weeks later.

He was a Foundation Member of our Society and remained a member all his life, taking an active part in its affairs and attending outings whenever they came to his locality. His interventions in discussions were always vigorous and to the point and rarely failed to be entertaining.

To his wife, a hospitable hostess to many visiting foresters, and to his two daughters we extend our heartfelt sympathy. Irish forestry will never be the same again.

H.M.F.

Gerald Scully



The sudden death of Gerald Scully at the end of last year came as a shock to his colleagues in the Forestry Service and to the members of the Society.

Gerald Thomas Scully was born at Bantry, Co. Cork in 1925 and he entered the forestry school at Avondale at the age of twenty. Following the completion of his training in 1948 he served for four years in different forests as assistant forester until he was placed in charge of Enniskerry forest in 1952. It was during his period there that he decided to pursue a course at Trinity College, Dublin. These were for him the days of great endeavour. Early in the morning he was astir to get in some study before breakfast and again often late into the night he worked, while during the day he carried out his official duties conscientiously. This is not to say though, that his life at Enniskerry was something akin to a medieval monk because with his bouncing energy he was able to participate to a reasonable extent in the social round as well.

His studies were rewarded in due course by a Diploma in Public Administration and later by the degree of B.Comm. In 1958 he competed successfully for a post of forestry inspector and was posted to Galway on land acquisition work. For many this would have been the end of formal study but not for Gerald. He continued his studies at Galway University and was awarded the degree of M.Comm. In 1963 he applied for and was awarded a scholarship by An Bórd Scoláireachtaí Comhalairte and in September of that year he entered Yale University on a Fellowship in forestry economics. At the end of the course he did an eight week study tour in the United States and Canada.

Following his return he was transferred to Sligo where he remained until his death. While there he was a member of the Sligo Rotary and the Sligo-German circle and he lectured on economics and statistics to extra-mural students of Social Science for Galway University. He also wrote articles and notes for various publications. Up to the end he remained an avid student; for him the magic never faded.

But those who knew him well will remember him not so much for his academic achievements against great odds, nor for his skill as a forester, which was considerable but rather for his excellent personal qualities. His generosity of mind was quite exceptiontal; he was incapable of harbouring enmity or spitefulness towards anyone and his philosophic view of life was an example that many could follow with advantage.

To his mother and brothers we exend our deepest sympaty in their sad and unexpected bereavement.

J.J.D.

Computermatic Stress Grading Machine

Following the demonstration at the Forest Products Research Laboratory, Princes Risborough in 1962 of the basic principles on which a machine might be produced which could automatically and continuously assess the bending strength of timber, considerable interest has been centred on the probable value of such a machine to industry. Machine grading is potentially much more accurate and faster than visual grading and could lead to increased efficiency in the structural use of timber. The Forest Products Research Laboratory has recently taken delivery of a Computermatic stress grading machine, the first of its type in Europe. The machine was developed in 1966 by the Division of Wood Technology, Forestry Commission, New South Wales, Australia. Of the three grading machines now manufactured this is the least expensive and it is basically the most suitable for use in this country. Timber is fed through the machine at speeds up to 200 ft. per minute. A load is applied to each piece of timber and the deflections are measured. A computer unit, translates deflections into bending strength ratings. The strength rating or stress grade at every 6 inches along the length of the timber is identified by a coloured dye sprayed on the surface. The machine can classify timber into four stress grades at a single control setting.

It is claimed in Australia that the Computermatic machine can stress grade both planed and sawn timber. The Forest Products Research Laboratory is now carrying out trials to determine the adjustments and modifications which may be needed to make the machine perform satisfactorily especially from the viewpoint of accuracy under conditions obtaining in this country.

ANNOUNCEMENT

Under the auspices of The Natural Environment Research Council a symposium on Peatland Forestry will be held in Edinburgh from 9th to 11th September 1968 inclusive.

The aim of the symposium is to bring together people working on both practical and fundamental problems of growing trees on peat in order to stimulate the exchange of ideas, promote liaison and define the most urgent problems.

The programme will consist of four sections:

(1) Afforestation of peat.
(2) Water relations of trees on peat.
(3) Site preparation and planting.
(4) Nutrition of trees on peat.

The symposium will be held at Pollock Halls of Residence, Edinburgh University, where accommodation and meals will also be available.

The symposium fee is three guineas and those wishing to attend should register with:

Mr. A. H. F. BROWN, Merlewood Research Station,
Grange-over-Sands, Lancashire.

A New Deal for Private Forestry in Northern Ireland.

Introduction of a new system of Grants

Introduction

In 1927 a Planting Grant Scheme was introduced for the first time in Northern Ireland to encourage private planting by giving financial assistance.

Over the years the minimum qualifying area was reduced from 5 acres to 2 acres and the assistance increased from £4 per acre to £22 12s. 0d. per acre.

The response was slow at first and up until 1945 the annual area planted under the Scheme seldom exceeded 30 acres.

In 1946, however, 162 acres were planted and by 1953 the acreage had risen to 379 acres. Over the last 4 years the average area planted has been 500 acres. To date a total of 8,000 acres has been planted under the Scheme. Forestry Division N.I. are at present planting 500 acres per annum.

Position in Great Britain

Following the years of felling and devastation of private woodlands during the second world war the Forestry Commission introduced in 1947 a Dedication Scheme which went considerably further than the earlier Planting Grant Schemes. Private owners could obtain in return for the efficient planning and management of their woods, annual maintenance grants for the whole of their productive area. The Scheme had many legal and management complications and was not considered suitable for Northern Ireland. In Great Britain, however, over 3,00 estates have entered the Scheme which now covers almost 1 million acres.

The annual area planted in Great Britain by private owners is now approximately 30,000 acres compared with approximately 50,000 planted by the Forestry Commission, while in England alone private planting exceeds Forestry Commission planting by 50 per cent.

It is obvious that private forestry in Northern Ireland is falling behind its counterpart in Great Britain and that the time has come to make a new effort to increase the area and efficiency of private forestry.

New Grants for Planting and Maintenance of Woodlands

With effect from 1st October, 1968, the following grants will be available where planting and maintenance has been carried out to the satisfaction of the Ministry:—

£20 per acre immediately after planting.
£10 per acre 5 years after planting.
£5 per acre 10 years after planting.
£5 per acre 15 years after planting.
£5 per acre 20 years after planting.

In addition where heavy clearing of scrub has to be undertaken prior to planting a further £10 per acre will be payable, thereby increasing the initial £20 grant to £30 per acre.

The Poplar Planting Grant and the Thinning Grants are now discontinued. No further grants will be paid for the line planting of poplars but where the land is considered more suitable for poplars than for other species the normal grants may be paid for block planting of poplars.

Conclusion

The new Scheme is much more suited to our own conditions than the Forestry Commission's Dedication Scheme and gives private owners approximate parity of treatment with owners in Great Britain.

The grants are payable in the first 20 years of the life of the crop during the time when expenditure is greatest and before much income has been earned from the sale of thinnings.

Owners will now be encouraged not only to plant for the future but to maintain their woods efficiently through the formative years until they reach the production stage.

It is hoped that this encouragement will greatly increase the area of land planted with trees in Northern Ireland and enable private forestry to make a greater contribution to our economy.

*Supply of Young **Trees***

The two Schemes at present in operation for the provision of plants, (a) Young Trees Scheme (minimum 500) and (b) 100 Trees Scheme, will continue as before though the prices and species available may change from year to year.