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PROJECT PLANNING AND RESEARCH ADMINISTRATION

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1. INTRODUCTION

The problems of the organisation and administration of research stations and laboratories have attracted considerable attention in recent years, and it is evident that many scientists are interested in finding practical solutions to such problems. As evidence of this interest, fifty scientists from a wide range of Government, industrial, and academic organisations attended a symposium on "the organisation and administration of biological laboratories" on the 12th and 13th September, 1969, at the Oxford College of Technology, and explored, as remedies for these problems, the application of management techniques in the biological environment, as well as the pattern of management training required by biologists. (D. J. Cook, 1969).

Various books on the planning of scientific research and the administration of research laboratories have also been published. Some of the most interesting of these include Arnon, 1968, Mardon, 1969, and McLeod, 1969. In addition, there have been many books and papers on individual management techniques which are relevant to the management of research, even though actual descriptions of the applications of these techniques to research problems may not be given. Very few descriptions of the way in which research is actually managed at individual research stations have, however, appeared, and, in biological research, this may be because very little attempt is usually made to manage research at all.

This paper is intended to summarise the methods of project planning and research administration which have been developed at the Merlewood Research Station of the Nature Conservancy, and which are currently used within that research station. It is not claimed that the methods described are the ultimate in research management, only that they have been found to work satisfactorily at Merlewood. They are, of course, still being developed, and may be expected to change as new situations arise, or as new methods become available.

2. OBJECTIVES OF RESEARCH ADMINISTRATION

The success or failure of methods of research management and administration can only be judged when the objectives of the methods are clearly defined. It would be easy to criticise almost any methods by comparing them with a set of objectives which those methods were not designed to achieve. For this reason, some care has been taken to define the objectives of research administration at Merlewood, and to discuss these objectives with the staff of the research station so that all members of the staff are clear about the reasons for the introduction of particular methods. Participation in research management can only be achieved by understanding of the objectives, and the success or failure of the methods themselves can only be measured against such objectives.

The objectives defined are as follows:-

(a) To ensure that the research undertaken at the Merlewood Research Station satisfies the objectives, timing, and resource allocations defined for, and agreed by, the Directors and the Scientific Policy Committee of the Nature Conservancy.

(b) To promote the publication of research results and methodology:-

(i) in the relevant technical and scientific journals;
(ii) in Nature Conservancy publications, where the form of the presentation makes this desirable;
(iii) in papers for internal circulation, where speed of communication is more important than the status of the method of publication.

(c) To extend the influence of research staff and results on the policy and management of the Nature Conservancy, and on the selection and management of nature reserves and other areas.

(d) To assist in the development of the relevant disciplines, in close co-operation with colleagues in other research stations, in the research institutes of other organisations, and in the universities, both at home and abroad.

(e) To provide for the continuous training and career development of the staff of the research station.

Other objectives for research administration and management could obviously be defined, but the objectives stated above are the ones towards which the methods of research management and administration described in this paper have specifically been designed.

3 INTER-RELATIONSHIP OF MANAGEMENT TECHNIQUES

The broad inter-relationships between the various techniques of management used at Merlewood are given in Figure 1. The Director of the research station is mainly concerned with three aspects of the management, i.e. with the scheme for management by objectives for individual research staff, with the project plans, and with the allocation of resources to the various projects. The project plans are the main planning documents for the scientific work of the research station, and from these plans, a number of other activities are derived, i.e. the project register, the plans for individual experiments and surveys, the research activities themselves, the allocation of the available resources, and some of the objectives of individual research officers. The objectives set in the scheme for management by objectives themselves contribute to the project plans, and are also used to create the career development and training plans for the station.

The most important part of the work of any research station is clearly the research activity itself, and one of the basic problems in research management is that of ensuring that a sufficiently large proportion of the total effort available is devoted to direct research activity. When attempts are made to evaluate the proportions of time that individual research staff spend on actual research, the results are usually disconcerting. In the scheme outlined in Figure 1, the experiment plans, the project plans, the management by objectives, and the resource allocations all impinge directly on the research activity, with the aim of increasing the amount of time and effort available for research. It is sometimes maintained that the best administration for research is "no administration", but the results of leaving the research activity unplanned and undirected do not confirm that the maximum effort is necessarily obtained in this way.

Arising from direct research activity are the various forms of publication of research results. At this stage, the diagram does little more than indicate that research results are made available in the several different forms given in the objectives above.

4. INDIVIDUAL ASPECTS OF RESEARCH MANAGEMENT

4.1 Management by Objectives

The technique of management by objectives (MbO) has been developed in industry and commerce in recent years, and attempts have also been made to apply it to the Civil Service (Garrett and Walker, 1969). In essence, its technique requires that, over a defined period of time, each individual should set down the objectives that he or she expects to achieve. These objectives are written down in summary form, and are then discussed with the individual's supervisor or senior officer. In some cases, the objectives which the individual has set himself may not be appropriate to the aims of the organisation; in others, the objectives may be appropriate but the individual far too optimistic about what can be achieved in the time available; and, more rarely, the objectives may be so unambitious as to leave a large proportion of the individual's time and energies uncommitted. The aim of the discussion is to align the aims and aspirations of the individuals with those of the organisation, and, if necessary, to redraft the objectives to satisfy this condition. Once agreement has been reached that the objectives are desirable and reasonable, the individual concerned can then take it as granted that the task of achieving those objectives has been delegated to him by his senior officer.

At the end of the prescribed period, the actual achievement is compared with the declared objectives in discussion with the supervisor, due allowance being made for unforeseen circumstances and subsequent limitations in resources. Each individual has a chance to express his own satisfaction or dissatisfaction with his progress, and to evaluate his own effectiveness to the organisation. The objectives for the next period are then set in the same way as before.

Some objections to the application of MbO in research organisations have been suggested by its critics, and most of these objections have centred on the difficulty of defining objectives which are measurable. Such a criticism would make the technique difficult if not impossible to apply in the research context, but it is clearly possible to define such objectives as, for example, the completion of a paper for a journal, the undertaking of field or laboratory work, or attendance at a certain conference. The paper by Garrett and Walker (1969) on the application of MbO to the British Civil Service makes especially heavy weather of this aspect of the technique, but the basic concept of asking individuals to define their own objectives, of reviewing these objectives in relation to the needs of the organisation, agreeing the redefined objectives, and then comparing actual progress with objectives is simple, and one that can be applied in any field of activity.

The contrast of the technique with the earlier method of "job description" is worth stressing. In the latter, each job in the organisation is described by the supervisor, and the qualities required of the individual to do that job carefully defined. In MbO, each individual sets his own objectives, rather than having them set for him, so that his motivation to achieve the objectives is greater. Similarly, MbO is more flexible, in that the objectives can change as circumstances change, and the emphasis is on the change rather than on those aspects of the job which are continuing. In the research context, where fairly rapid developments in the roles of the individuals may be expected to take place, the greater flexibility and motivation of MbO makes the technique more readily applicable than that of "job description".

MbO has been applied at Merlewood for more than two years, and the period for which objectives are set corresponds approximately with the "time span of discretion" of the individual research workers (Jeffers, 1960), i.e. the longest period which they can be expected to work on their own without needing specific direction. For the majority of the scientific and experimental officers, this period is about one year, and, as annual reports on the progress of such staff are also required, the time scale is particularly appropriate. Each member of the staff, including the Director, therefore sets his or her own objectives for this period, and discusses them with his Section Head, or with the Director. The Director discusses his objectives with the Deputy Director (Scientific) of the Nature Conservancy. Heads of Sections discuss their objectives with the Director; and all other members of the staff discuss their objectives with their Heads of Sections. It was, however, found that individual research officers also valued the opportunity of discussing their objectives with the Director, and as this provided a useful opportunity for the Director to discuss the general career development of each scientific and experimental officer, this procedure has been adopted.

In general, no difficulty has been found in finding suitable and unambiguous objectives for research staff. The completion of projects or parts of projects, in relation to the project plans described below, the writing of papers for journals, etc., the attendance at conferences and training courses, liaison with other organisations, literature reviews, etc., have all featured largely in the objectives set. Research staff have commented frequently on the value they have found in having to think clearly about what they are planning to do and to assess the priorities between competing activities. The discussion on the relationship between the objectives of individuals and the aims of the organisation is also frequently illuminating, and reveals lack of awareness of the organisation's objectives, or failure by the organisation to make its aims clear even to its own staff. Individuals are only rarely deliberately perverse in seeking to achieve objectives which are completely contrary to the interests of the wider group to which they belong, and disagreements usually spring from misunderstanding of the wider objectives of the group than from deliberate opposition.

Three basic questions have been found worth asking when the objectives of the individuals are being discussed. First, are the objectives related to the aims of the organisation, and are they achievable with the resources that are likely to be available during the period under review? Second, will the individual concerned be able to look back on the period under discussion and regard it as a period of positive progress, or, in other words, do the defined objectives provide for the necessary job satisfaction of the individual? Third, do the objectives contain a sufficient element of further training, so that the general career development of the individual is advanced? It is in the discussion of these questions that the Director has the opportunity to make personal contact with the individual on the issue with which the individual is likely to be most concerned, i.e. his own career.

Similarly, in assessing the progress that was actually achieved in relation to the objectives that were set, very little difficulty has been found in getting research workers to assess themselves frankly. Provided that external circumstances are taken into account when necessary, for example illness of the individual or his family, the failure of the organisation to provide the necessary equipment, etc., most people are very willing to admit their failures and to propose new ways in which past mistakes can be remedied, and to make a more realistic assessment of what can actually be achieved in future. The situation which is most difficult to deal with, but which occurs relatively seldom, is when an individual has achieved few if any of his defined objectives

but quotes a long list of other achievements. The view usually adopted in this case is that, if a marked change in objectives is necessary during a period for which objectives have already been agreed, they must be set down and discussed with the Section Head and the Director before these objectives can be regarded as delegated. By the same token, if the Director, or a Section Head, wishes to change a man's objectives, they must also see that these changes are reflected in newly defined objectives.

4.2 Project Plans

In addition to the objectives which are set for individual research workers under the MbO scheme, the scientific work of the research station is controlled by a series of project plans. These project plans embody the tactical aspects of the research strategy agreed by the Directors and the Scientific Policy Committee of the Nature Conservancy. Each of the strategies is divided into a series of main projects, and a project leader allocated to each project. The role of the project leader is to formulate the project plan and then to direct the project and co-ordinate the activities of the several people who may be involved in the series of activities which go to make up the complete research project. The project plan is discussed with the relevant Heads of Sections and the Director, and is the central administrative document. The complete set of project plans summarises the scientific work of the research station in a convenient way.

Project plans are generally drawn up with the same formal structure, although departures from this structure are encouraged where there is any danger that formalisation defeats the aims of the project plan. Generally, each plan starts with a review of the background against which the project was originally planned. This review is often quite short, but may, in certain cases, be fairly long, and may require a summary of past work in the field. The review of the background to the project is followed by a clear definition of the objectives of the project, and these objectives are followed by a statement of the criteria by which the success or failure of the project may be judged. The difference between an "objective" and a "criterion for success" is largely contained in the notion that a criterion for success is an expression of the results of the project or its achievement, i.e. a decision to proceed with certain stages of the project, the publication of a paper, or the derivation of a new technique, rather than with the scientific aims of the project. The major part of any project plan, however, is a critical path network setting out the logical connection between the activities which must be completed in the project, together with the associated time estimates. The discipline of network planning for research projects has proved to be invaluable, not only in providing estimates of the times required for individual activities but also for emphasising the logical inter-relationships of the activities, and for defining the critical path, i.e. the series of activities for which any delay necessarily incurs a a delay in the completion of the whole project. From the critical path network, and the estimates of times and resources associated with each activity, the expected times for the completion of the project and the resource requirements for the project can be evaluated and summarised in the project plan. An example of a project plan is given as an appendix to this paper, to illustrate the type of document that is produced.

The project plans drawn up for the individual projects have proved to be valuable in planning the allocation of available resources as efficiently as possible, and, particularly, so that scarce resources are not wasted. The time estimates which are derived from the networks can be used in scheduling the purchase of new equipment, and the recruitment of new staff. The completed project plans have also been used as a medium for the exchange of information about the project, and its progress, with workers from other stations and other organisations. They have been particularly useful where several research workers contribute to the same project, as a means of integrating their separate contributions.

Associated with each project plan is a control document, a copy of which is given in the appendix to this paper. This document summarises the objectives and the criteria for the success of the project, as well as giving the required completion date and an assessment of the priority of the project - expressed as a "queue index" rated from 0 to 100. The dates at which the project is reviewed are determined by examination of the critical path network. At each review date, the progress of the project is checked against the network, the completed activities being removed, and new estimates of the times being made for all the uncompleted activities. Occasionally, where marked changes in the project objectives or methods have occurred, it is necessary to redraw the critical path network completely, and to make new estimates of the times and resources necessary for the completion of the project. All of these changes are discussed with the project leader, and new estimates are made of the expected date of completion, the technical feasibility of the project, and the factor which is currently determining the rate of progress. Finally, the next date for the review of the project is set.

The review procedure outlined above has the merit of providing reasonable control of research projects without inhibiting the development of the project by continually looking over the shoulder of the project leader. The requirements for the resources necessary to complete the project are revised regularly, and provide the Director with sufficient information to plan the allocation of the resources of the station as a whole. The setting of review dates to suit the development of the project rather than at fixed intervals gives increased flexibility, and ensures that projects are only reviewed at critical stages in their development, but does not allow projects to lapse into inactivity. Finally, but by no means least, projects are terminated when they are completed, or when their technical feasibility or level of priority falls below an acceptable level.

4.3 Project Register

The project plans also provide the information for the research station's project register. This register is a complete list of all the projects which are currently being undertaken by the staff of the station, together with their objectives and the names of the project leaders. The projects are given by research strategies so as to emphasise the relationships between the projects and the broad strategies adopted in the total research programme.

The project register is an important document for the communication of the research programme to other organisations and between other research stations within the Nature Conservancy.

4.4 Experiment Plans

A further function of project plans is to identify the stages in a research project at which a detailed experiment or survey plan is necessary to control the design of experiments and surveys, the collection of data in the field, and their subsequent analysis. The desirability and form of such experiment plans has been discussed in detail by Jeffers, 1966, but the purpose of such plans is three-fold. First, they inhibit the collection of research data in unsatisfactory ways in which there is little or no chance of producing useful results. Second, they provide detailed instructions for research assistants in the carrying out of the research and for those who will be responsible for interpreting the results. Third, they provide the necessary documentation of research procedures to enable future research workers to understand the purposes of the experiments or surveys, and their practical value.

An experiment or survey plan should contain the following information:-

objects: a careful definition of the hypotheses to be tested or the estimates to be made as a result of the experiment or survey; general treatments: an account and detailed prescription of the management and treatment of the whole of the experimental area or material; experimental treatments: a detailed description and prescription

of the special treatments that are to be applied to the individual plots of an experiment or to the individual samples in a survey, in sufficient detail to enable a research assistant to conduct the experiment and to interpret the results; layout: the layout of the plots on the experimental area or sampling frame, in sufficient detail to enable the experiment to be laid out by a research assistant, or to be reconstructed by later workers, together with a plan in diagrammatic form; assessments: a list of the measurements, observations, etc., that are to be made, together with detailed instructions as to how these are to be done; analysis: an account of the method of analysis that is to be used on the collected data, including a detailed breakdown of the treatment sum of squares in an analysis of variance, the covariates to be used in analysis of covariance, if required, and the regression equations to be fitted in multiple regression analysis; expected precision: an estimate of the precision that is expected to be achieved in the experiment or survey, and the size of the difference that is expected to be test detected as significant.

The experiment plan should be written by the research worker who will be concerned with the actual experimental work, and will usually be discussed with, and approved by, the project leader. There may be several experiment or survey plans contained within a single project plan, and the project plan helps to define the need for the more detailed plans, and ensures that such plans are linked together so as to meet the overall strategy of the project. Experiment plans may, therefore, be regarded as the tactical plans within the broader strategy of the project plan.

4.5 Resource Allocation

At any given point in time, there will only be limited amounts of the various resources that are required for the undertaking of research, *e.g.* of men, money, and materials. Some of the resources may be readily interchangeable between a large number of possible projects, other resources, for example staff with a limited range of specialist skills, specialised equipment, etc., may be available for only a very limited range of projects, or may even become redundant as the broad strategy of a research organisation changes. In the majority of research organisations, the allocation of these resources to individual projects is performed by subjective methods. One reason for this is that the information about the resources that are necessary for individual projects is not usually available. The project planning techniques currently being used at the Merlewood Research Station do, however, provide reasonable estimates of the resources that are necessary for the completion of projects, and the method of revising project plans provides for a continual updating of these estimates. Attempts are, therefore, currently being made to use this information to obtain an "optimum" allocation of the resources by the means of such techniques as mathematical programming. The approach adopted is very similar to that described by Bell, et al., 1967, and by Chilcott, 1966, by which a mathematical model is used to find the optimum combination of research projects under the various constraints in the total amounts of the various resources and the times at which these resources can be made available. Although there are certain difficulties about the definition of the criterion by which an optimum is defined, the early results already indicate the value of considering research projects as members of an integrated "project portfolio" rather than for their individual qualities.

An alternative approach, to the problem of resource allocation, and particularly to the initial selection of projects for consideration, is the use of "game theory" for the selection of alternative strategies. The basic ideas behind this approach are outlined in an amusing fashion by Williams, 1966, and involve the setting up of the selection or non-selection of research projects as a game against nature, for which the out-turns are assessed for possible combinations of strategies.

A mathematical technique can then be used to select a strategy, or combination of strategies, which gives the "best" return from the most unfavourable outcome. The technique makes a pessimistic selection of research projects, but appears to have some advantages in application.

4.6 Career Development and Training Plan

The career development and training plan arises out of the scheme for management by objectives, and is strengthened by investigation into the aims and ambitions of the research staff which is carried out at the same time as the discussion of objectives with each individual. The purpose of the plan is to define the training needs for all staff over the next five years, so that appropriate arrangements can be made for their deployment on training courses, sabbatical leave, etc. In many cases, special arrangements have to be made for the appropriate level and content of training courses, and the emphasis of the training plan is for the courses, etc., to be tailored to the needs of the staff rather than for the staff to be sent on such courses as become available. The training plan is revised after each round of discussions in the MbO scheme, so that the necessary arrangements can be made. The discussion of the development of the careers of individuals, rather than merely fitting into the organisation is, of course, part of the MbO concept, and gives each member of the research staff much greater confidence in his or her place in the organisation. It should, perhaps, be emphasised that careers are developed towards the legitimate ambitions of the individuals rather than towards the stereotypes which are held to be desirable by the organisation.

OTHER MANAGEMENT TECHNIQUES

Other management techniques have been employed at the Merlewood Research Station from time to time, and have been of some value, although they are not currently included in the regular management or research administration of the station. Some of the more important of these are as follows:-

(a) Brainstorming

The technique of "brainstorming", by which a defined problem is submitted to an uninhibited discussion, is now fairly well-known, but is still not widely used. The group of people gathered for the discussion should not usually be larger than ten or twelve in number, and should contain as wide as possible a range of disciplines and grades. There may be disadvantages in having anybody who specialises in the topic under discussion in the group, unless he is capable of taking a wide view of his specialisation. The discussion takes place ideally under informal conditions, and preferably after a few drinks or a light supper, so that all of the participants are thoroughly relaxed. The problem is then explained, and the participants asked to suggest ideas for a solution. No criticism of any idea is permitted at the session, but participants are encouraged to develop or extend any idea that is put forward, no matter how ridiculous that idea may seem at first sight. The various ideas are recorded, either directly by discrete shorthand, or indirectly by use of a tape-recorder, and are then reconsidered critically after a reasonable lapse of time.

Experience with this technique suggests that worthwhile ideas, or combinations of ideas are frequently derived, and that brainstorming sessions are useful in bringing new light to bear on problems which have suffered from an over-specialised approach. The sessions also have the merit of extending what has been called the "lateral thinking" of the members of the staff who take part, and creating a more relaxed and interdisciplinary atmosphere for the creation of new projects and ideas. The technique also helps to stress the close cross-fertilisation that is possible when different disciplines look at the same problem.

(b) Delphi Questionnaires and Group Feed Back Analysis

One of the techniques used in technological forecasting is the Delphi technique (Helmer, 1968), by which a panel of experts is asked to complete a questionnaire on their estimates of various numerical parameters. The resulting estimates are then summarised by computing the median and upper and lower quartiles and are then resubmitted to the panel, with a request that the members of the panel should reconsider their estimates in the light of the combined judgements of their colleagues. If any member still feels that he wants to retain his estimate outside the quartiles of the combined judgement, that member is asked to give reasons for maintaining so extreme a view. The new estimates are summarised, and are resubmitted to the panel, together with the reasons that have been advanced. The panel is then asked to reconsider their estimates, and, if their reconsidered estimate is still outside the computed quartiles, to submit counter-arguments to the reasons submitted. The estimates are summarised once more and submitted with the reasons and counter-reasons for a final revision of the estimates by the panel.

The usual effect of the technique is for the various estimates to converge towards an informed concensus of opinion, with the various arguments for more extreme estimates, and the counter-arguments to these extremes, being given due weight. The dominance of a small number of strong personalities, which is frequently evident in committees set up to arrive at informed estimates, is avoided, and the level of discussion is frequently higher than that achieved at a committee meeting, where the members of the committee are often influenced by external factors.

The technique can be extended to small meetings of experts (Heller, 1969), during which lectures or demonstrations are followed by Delphi-type questionnaires. The result of these questionnaires are then used in the discussion of the lectures. As a result of this discussion, a new questionnaire is completed, leading to further discussion, or to the presentation of the results to a different group. In this way, discussion of technical and scientific problems can be concentrated on the important issues, and the results made available for further work.

(c) Decision Trees

Many research decisions require the evaluation of complex situations in order to determine the advantages and disadvantages of possible alternative courses of action, and the identification of the need for specific types of information before rational decisions can be taken. Displaying these decisions as a branching tree diagram in which the probabilities of the outcomes of each decision are shown can help to evaluate the best immediate choice. Some experience with the use of formally constructed decision trees at the Merlewood Research Station suggests that this technique is valuable in helping to gain agreement about the logical choice between alternatives in group discussions.

(d) Discounted Cash Flow

This method of evaluating capital expenditure projects, taking into account taxation, etc., and the fact that the earlier a return is obtained, the more valuable it is, has come to be widely employed by Government and other agencies. Indeed, the method represents one of the few mathematical models which administrators currently understand. The major disadvantage of the method is that no provision is usually made in the calculations for testing the sensitivity of the results to changes in the input parameters, and users of the method too seldom explore this sensitivity by deliberately changing the input parameters within likely limits of variability. Because the method is widely understood and employed by those who control resources, research administrators and managers can scarcely afford to neglect it.

6. RESEARCH ACTIVITY

It is scarcely necessary to stress that no amount of management and administration can replace the need for direct research activity. Indeed, the whole purpose of the various methods of management and project planning described in this paper is to enable all members of the research staff to devote the maximum proportion of their time to direct research activities, i.e. to thinking, the formulation of hypotheses, the design of experiments and surveys, the collection of data and observations in the field and in the laboratory, the processing and analysis of data, the interpretation of results, and the writing of clear and informative papers. The need for research management derives from the unfortunate fact that, without some degree of control, direct research activity tends to become confused, purposeless, and inefficient. The close collaboration between scientists, often of widely different disciplines, which is so characteristic of modern science, is particularly liable to suffer from inefficient or inadequate management.

Research activity must include thinking and contemplation. Many young scientists fall into the trap of wanting to be physically busy all the time, so that they are continually collecting data, doing experiments, or processing data without taking the necessary time to think out the aims of their research, or the methods which they will use, and without allowing sufficient time to interpret and present results. In this, they are no more culpable than the manager or administrator who surrounds himself by a daily turmoil of interviews, committee meetings, and correspondence, so that he never has time to think through the major issues of the affairs he is controlling. The end result of such a turmoil is, perhaps, more serious for the scientist, in that lack of rigorous thinking ultimately destroys his reputation as a scientist.

One topical aspect of research activity is the increased use of electronic digital computers. Now that these machines are readily available to scientists, it is important that data collected by scientists should be collected in machine-readable form, or should be put into machine-readable form at the earliest possible opportunity. Only inefficient and backward scientists analyse data manually when they can undertake almost any form of mathematical or clerical process quickly and cheaply on modern computers. The speed and power of the available machines is, however, not the only reason for using them. By making research data machine-readable, one ensures that data are not lost, and that they are readily available to one's colleagues and organisation. Furthermore, the fact that electronic computers have to be programmed ensures that a complete and unambiguous record is kept of the methods of analysis and the clerical processes that are carried out during the course of the research.

Finally, the length of time that it takes to write up research results for publication should never be underestimated. Even with the use of electronic computers for the analysis and handling of research data, the time needed to write up the results can be estimated approximately as the time required for the collection of the basic data multiplied by a factor of three or four. Thus, if it takes three or four weeks of actual field time to collect data, it is necessary to allow at least twelve to sixteen weeks for the analysis and writing up of the results for publication. Without the use of computers, it may be necessary to multiply the data collection time by a factor of ten to obtain a reasonable estimate.

7. INTERNAL COMMUNICATIONS

Communications within a research organisation are vitally important, but many organisations leave these communications to chance and to casual encounters. In a small organisation, the individual members of staff may know each other sufficiently well for real communication of ideas to be possible, particularly if they meet regularly over tea, coffee, or lunch. As the size of an organisation increases, however, the problems of communication become more difficult, and, even in quite small organisations, a single individual who opts out of regular and informal gatherings because of personality difficulties, or because he is so absorbed in his own activities, can cause a serious breakdown in communications. With the formation of separate sections in an organisation, and, especially, the dispersion of the units within separate buildings, communication can be severely restricted.

The system of internal communications currently used at the Merlewood Research Station is summarised in Table 1. The meetings shown in this table are supplemented by chance meetings over tea and coffee in the mornings or afternoons, for which the probabilities are increased by serving drinks at a single point in the station rather than in the separate laboratories. Too much reliance cannot, however, be placed on chance meetings as there is a tendency for sectional or hierarchical grouping to take place even on these occasions.

The weekly meeting of the Director and the Heads of Sections is an informal affair, which takes place over coffee on Monday mornings, and provides an opportunity to discuss the programme for the coming week, or to raise issues which have emerged during the past week. An interesting feature of such meetings is that they occasionally develop into general discussions of policy and help to create a feeling of unity among the senior staff of the station. The meetings are usually fairly short, but may last for an hour or more if there are important administrative or technical points to discuss.

Each section also holds a rather similar informal meeting for all members of the section, including any visiting workers. The aim of such meetings is to pass on any administrative or executive decisions, to discuss the week's work and the allocations of priorities for the more junior members of the section, and to resolve any difficulties that have occurred. They act as a safety valve for the feelings of staff towards the organisation, and, through the Section Head, provide a means of communication upwards and downwards for the essential business of the organisation. Again, the meetings are usually fairly short. Some sections like to hold these meetings early in the week, others at the end of the week, but the timing and length of the meetings is at the discretion of the Section Head.

A formal meeting of the senior staff of the research station, including the Director, the Section Heads, and all scientific officers, is held every quarter, and usually shortly after the meetings of the Scientific Policy Committee of the Nature Conservancy. Part of their purpose is to enable the Director to inform the senior staff of the station of any changes in policy. The meetings are conducted formally, with the Director in the chair, and are fully minuted. Much of the discussion tends to be concentrated on administrative questions, but research policy and questions of research methods and equipment are also frequently raised. It is open for any member of the staff to ask for a subject to be included on the agenda. The meetings usually last one to two hours, and, apart from providing a useful opportunity for discussion by a wider group of the research staff, provide experience in the conduct of formal meetings for the more junior scientific officers.

During the autumn, winter, and early spring, staff seminars are held every fortnight. These staff seminars are open to any member of the staff of the research station, as well as to visiting workers. Attendance is voluntary, and widely different numbers attend according to the topic of the talk. Some of the seminars are given by visiting guest speakers, but the largest proportion of the talks are given by our own staff, and include talks on new techniques, on the research currently being undertaken by individuals or by sections, or on general developments in particular disciplines or industries. The seminars provide a forum for discussions of the broadest kind. They help to educate the more junior members of the staff in new techniques or in the trends of modern scientific ideas, they keep specialist research workers in touch with the work of their colleagues, and they stimulate the discussion of controversial ideas by staff at all levels. The seminars have a special function in providing training in public speaking and lecturing and the conduct of discussions by young scientists. By practising on his colleagues, a young scientist can improve his own style of presentation, particularly if indications of irritating mannerisms, ponderous delivery, or bad timing are given tactfully by the Director or the appropriate Head of Section. Diffident speakers can be encouraged in this way, and, as the importance of public speaking for scientists can scarcely be over-emphasised, the staff seminars would almost be worth running for this reason alone.

The annual programme conference of the Merlewood Research Station lasts for two days, and takes place in November immediately after the senior staff meeting in that month. The aim of the conference, which is open to all members of the research station as well as to visiting workers and a small number of specially invited scientists from organisations working in closely related fields, is to review the work of the research station and to discuss the objectives of future research. It is an opportunity for the staff of the station to see the objectives of the research, to understand the orientation of existing and new projects, and to gain an understanding of the main priorities for future work. At the time of this programme conference, the project register is also revised for the coming year. The contribution to the discussion by the invited scientists is frequently important in stressing the relationship of the work of the station to work that is being undertaken in related fields. The form of the conference is deliberately varied from year to year. In some years, the main emphasis is on the definition of research strategies; in others, each section is asked to present its current and future work in the way which seems most appropriate at the time. Alternatively, discussion can be centred on particular topics or on the needs of the Nature Conservancy as a whole. The important feature of the programme conference is, however, that, once each year, the staff of the research station should pause, take stock of its achievements, and consider the directions in which future research should move, and that it should do these things as a concerted effort, with all levels of staff making their contribution to the discussions and hearing the reasons for decisions which ultimately have to be made.

Finally, a small safety committee, made up of the representatives from the scientific and experimental officers, the scientific assistants and the office staff, meets as required to consider the subject of the safety of the staff and property of the station. The safety committee is an advisory body, making its recommendation to the Director, but it plays an important and valuable role in anticipating conditions and situations which contain hazards to the health and safety of the staff. The membership of some of the more junior members of the staff is important to the functioning of the committee, as those who have to do the actual work in the laboratories and workshops are frequently those who are most exposed to dangers, and capable of recognising the hazards.

The various methods of internal communication outlined above have proved to be effective in building up good internal communications, and helping each member of the staff of the research station to see his or her role more clearly, against the background of the organisation as a whole. The meetings themselves do not take up an amount of time which is disproportionate to the importance of good communications, and go a long way to preventing wasteful alternatives for ensuring that staff have an opportunity to discuss ideas and decisions. In reviewing these various meetings, however, the importance of written communications, recording decisions that have been taken as a result of discussion, should not be forgotten. Information on paper has the over-riding advantage that it can be read when the recipient is ready to absorb it, and also that the responsibility for reading or ignoring it is left to the individual. It also provides a permanent record of decisions which may be lacking if all decisions are made verbally or on the telephone.

9. THE RESPONSIBILITY OF THE DIRECTOR

It is appropriate to end this paper on project planning and administration by summarising the responsibilities of the Director of a research station. These responsibilities themselves help to define the aims of the various methods of research administration that have been introduced at the Merlewood Research Station, and are conveniently expressed at three levels.

The first of these levels is the responsibility to science as a whole, by ensuring that all of the work carried out at the station is firmly based on the scientific method. This entails the correct use of experimental or survey design, the rigorous checking of instruments and equipment, and the maintenance of the highest scientific standards for all scientific work. It also entails the painstaking editing and checking of all publications which go out under the names of members of the staff or under the name of the organisation as a whole. It involves the rejection of any compromise with ideas which are politically or socially expedient, if those ideas are not based on observation or experiment. To express this responsibility in these terms may sound pompous or naive, but the fulfilment of the responsibility is essential to the reputation of the organisation and the individual scientists it employs.

The second responsibility is towards the organisation itself, in seeing that the resources allocated to the research station are directed towards the strategies and projects agreed with the Directors of the organisation, and with the Scientific Policy Committee. Only by adequate methods of project planning can this responsibility be fulfilled, and research managed towards clearly defined objectives.

The third responsibility is towards the staff of the research station in seeing that their careers are properly developed and planned towards the goals which each individual has a right to set for him- or herself. This responsibility entails the training of each individual to undertake increasingly important roles in the organisation and in the wider context of the scientific world. Ultimately, it entails the Director of the research station training people to do his job, so that the succession in the control of the project planning and research administration is ensured.

If, in addition, the research director can undertake an active programme of research himself, so that he is able to provide a lead to his team, and to set, by example, the sort of standards that are required from such research, he will be able to lead rather than to push. The advantages of the methods of project planning and research administration described in the paper are that they not only enable a director to fulfil his essential responsibilities, but they also enable him to devote as much as 40 per cent of his own time to direct research.

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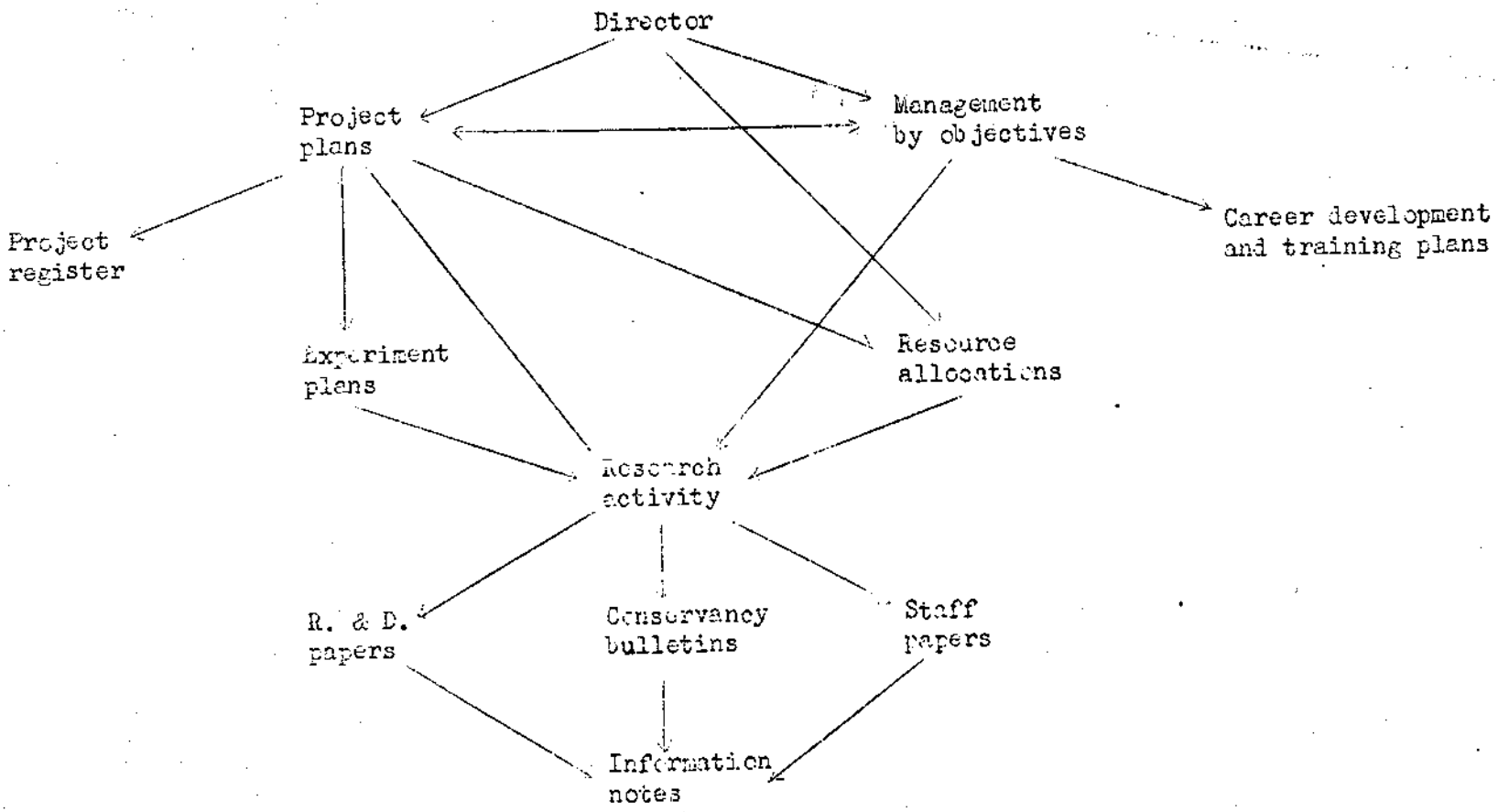
Figure 1. Diagrammatic representation of relationship between management techniques



Project Plan

Project 302/4

MEASUREMENT OF SOIL AND AIR TEMPERATURE AND SOLAR RADIATION

O. W. Heal

Summary Objectives: Measurement of seasonal changes in temperature at different levels in the soil and vegetation and estimation of total solar energy input.

BACKGROUND

Temperature recording: information on temperatures in soil and among vegetation, is required by various I.B.P. workers at Moor House. It was decided that this would be most conveniently supplied by Conservancy staff, therefore a Grant 50 point recorder, with thermistors, was purchased in 1968. The more automatic limpet logger was not purchased because of its poor performance in trials at Merlewood by K. L. Bocock.

Solar radiation: I.B.P. recommended that all main P.T. sites should record energy input as solar radiation using Kipp solarimeter and Kent recorders. Such an instrument was installed at Moor House in 1966. This proved unsatisfactory because of:

1. mechanical faults in the recorder; and

2. variable current cycling from the generator which caused erratic running of the clock.

A replacement instrument - a battery operated Lintronic recorder giving an hourly print-out - was ordered in late 1968.

OBJECTIVES

1. To provide I.B.P. workers with measurements of air and soil temperatures showing spatial (especially vertical) and temporal (daily, seasonal and annual) variation. These are to be in the form of punched tape and/or printed, giving raw data and daily, weekly, monthly, and yearly means ± standard errors.

   Measurements are to be supplied for at least the following projects:-

   1.1 Above the vegetation and among Calluna, Eriophorum, and Rubus plants for correction of laboratory estimates of photosynthesis and respiration (302/6/7/8) and studies on psyllids (302/10).

   1.2 In litter for correction of respiration measurements of decomposing vegetation (302/1).

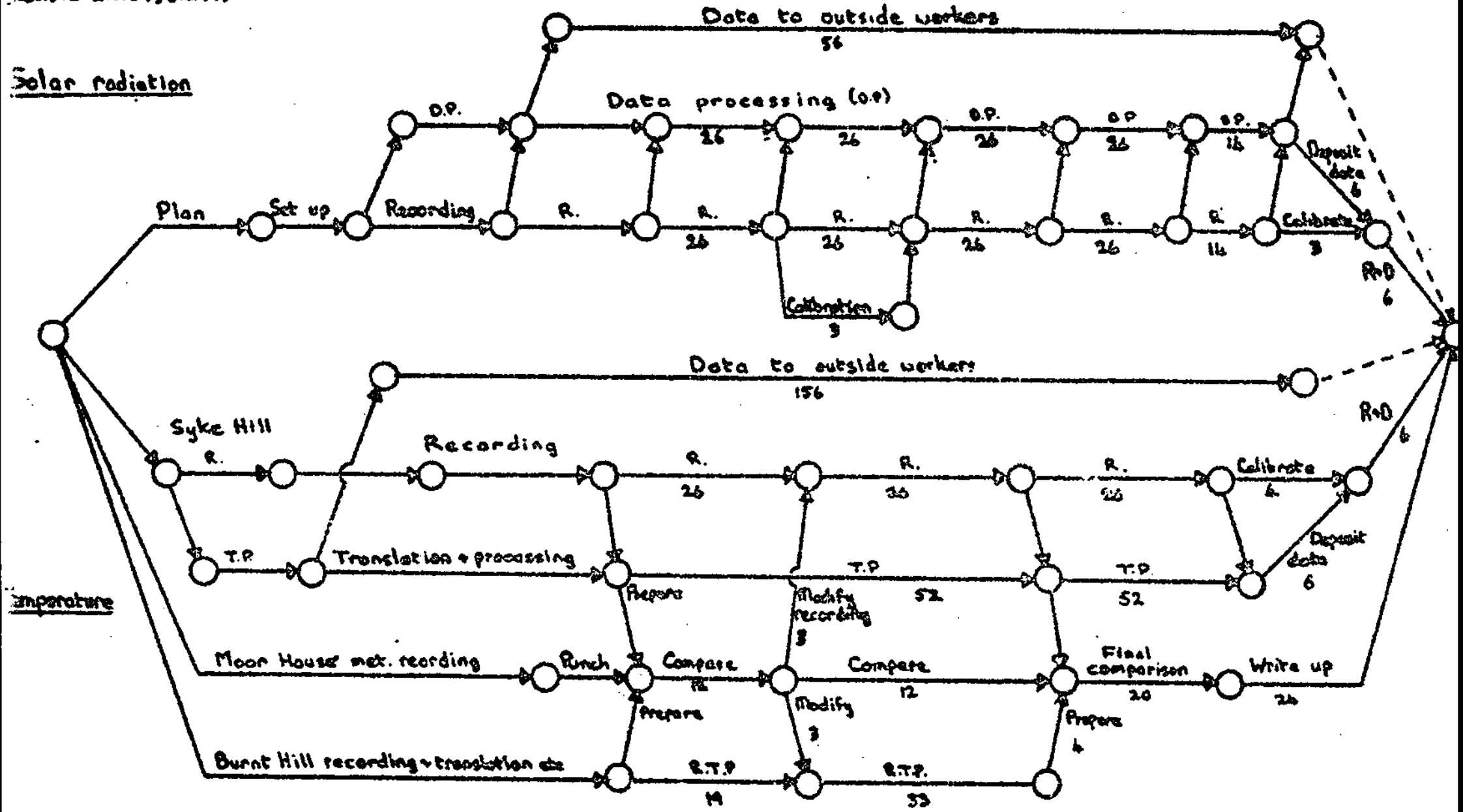
   1.3 At 0, 3, 6 cm. depth in peat to relate to faunal population and distribution changes and to correct laboratory estimates of respiration (302/12/13/14/17).

   1.4 From 0-20 cm. in peat to correct laboratory measurements of microbial activity and relate to growth temperatures of bacteria (302/15/16).

2. To test the hypothesis that there is no difference in the micro-climates in and above Sphagnum on Syke Hill and Burnt Hill. These are the sites used for the main vegetation study (302/5) and for intensive Sphagnum production measurements (302/6) respectively.

Project 302/4

(revised 2.7.69, 6.8.70)



Time shown in weeks :-

Starting date	April, 1968	**Project Leader** O. W. Heal	**No.** 302/4
Short title	Measurement of soil and air temperature and solar radiation		
Definition	To provide I.B.P. workers with:- 1. measurements of air and soil temperature showing daily, seasonal, annual, and spatial variation; 2. measurements of solar radiation showing daily, seasonal, and annual variation.		
Criteria of success	1. Lintronic recorder set up and running by April, 1969. 2. Data punched up to date, computer program ready to supply data to I.B.P. Workers, June, 1969. 3. Comparison of Syke Hill and Burnt Hill, by July, 1970. 4. Paper to J. Ecol. by Spring, 1972. 5. R. & D. paper on tempertura method and data deposited by Dec, 1972. 6. R. & D. paper on radiation method and data deposited by Dec, 1972.		
RQD completion date	December, 1972.		
Queue index	65		

Review date	**Expected Completion on date**	**Tech-feasibility index**	**Rate-determining factor**		**Reports issued**
June, 1969	Dec, 1972	0.8	Data processing		
January, 1970	Dec, 1972	0.75	Data processing		Data distributed to outside workers
11 May, 1970	Dec, 1972	0.7	Definition of analysis		
1 Sept, 1970					

3. To calculate thermal diffusion rates in blanket bog and, if possible, relate these to standard meteorological recording at Moor House so that further measurements at Syke Hill are unnecessary.

4. To provide I.B.P. workers with measurements of energy input as solar radiation showing daily, seasonal, and annual variation. The data to be in the form of punched tape and/or print-out.

CRITERIA FOR SUCCESS

1. Lintronic recorder set up and running satisfactorily by April, 1969.

2. Data punched up to date and computer program available for extraction of data for individual probes with mean ± S.E. for days, weeks, months, and years, for supply to outside workers by June, 1969. Note circulated to all participants specifying data available, format, and method of obtaining (possibly in parallel with K. L. Bocock re Meathop data).

3. Preliminary comparison of Syke Hill and Burnt Hill data by July, 1970, and implementation of any proposed modifications to recordings.

4. Acceptance by Journal of Ecology of paper on temperature regime in a moorland, by Spring, 1972.

5. Production of short Research and Development Paper on solar radiation measurements and summary of results, covering data deposited in Merlewood data bank by December, 1972.

6. Production of Research and Development Paper on temperature measurements and summary of results, covering data deposited in Merlewood data bank by December, 1972.

SUMMARY OF RESOURCE ALLOCATION

ALL instrumentation has been purchased. Manpower commitment as follows:-

	S.S.O. (O. W. Heal)	Moor House I.B.P. S.A. (S. Carrick)
1969	0.10	0.50
1970	0.10	0.50
1971	0.20	0.50
1972	0.10	0.50

Table 1. Summary of Internal Meetings

Meeting	Frequency	Director	Section Heads	Scientific Officers	Experimental Officers	Scientific Assistants	Office Staff	Visiting Workers
Heads of Sections	Weekly	✓	✓					
Section	Weekly		✓	✓	✓	✓		✓
Senior staff	Quarterly	✓	✓	✓				
Staff seminars	Fortnightly	✓	✓	✓	✓	✓	✓	✓
Programme Conference		✓	✓	✓	✓	✓	✓	✓
Safety Committee	As required			✓	✓	✓	✓	