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The Electronic Digital Computer in Forestry

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SINCE the last Congress of the International Union of Forest Research Organizations (IUFRO), one of the notable developments in forest research and management has been the increased use of electronic digital computers. Indeed, it is no exaggeration to say that this development has completely transformed the scientific background against which these congresses are held. For the first time in the history of man it is now possible to make an attack on some of the problems which underlie our fundamental knowledge of forestry, and many of our existing techniques have been outdated by the more powerful mathematical tools that have been made possible by the computer.

This paper is intended to provide a brief description of electronic digital computers, review the present situation of their application in forest research, and to make recommendations for their more effective use in the period up to the next congress.

Electronic digital computers

The electronic digital computer is a machine which is characterized by the ability to store numerical information, and to carry out arithmetic and logical processes on this information by obeying a sequence of instructions also stored within the machine. The word "digital" indicates that the form in which the computer stores and manipulates the information is closely akin to that by which we have become accustomed to handling numerical information, that is as a series of digits. This is in contrast to certain other types of computers which are able to store and manipulate numerical information in the form of physical quantities, for example, as electrical potentials or resistances.

The sequence of stored instructions by which the computer is controlled is called a program, and these instructions are specially written for each problem that the computer is called upon to undertake. By means of these programs, the computer can be made to perform any desired mathematical operation or logical process quickly and efficiently. The effort of programming can be further reduced by taking care to generalize the procedures in the solution of individual problems so that the resulting programs can be used for a number of separate applications.

It is the speed at which the computer is able to obey the sequence of instructions in order to follow through a particular computation, and the accuracy of the calculations even at these very high speeds, which constitute the main advantages in using electronic computers as opposed to other forms of calculating machines. A further advantage, however, lies in the fact that once the program has been prepared for a particular computation, the computer will obey the sequence of instructions faithfully, without deviation, and any number of similar computations can then be made without expert supervision. In this way, a small number of experts can undertake a vast program of research, without fear that their instructions may be misinterpreted in the handling of the information.

> A future was foreseen for computers, which were at the time large machines only just being introduced into forestry research. But the extent to which they would become everyday tools for the forest manager was evidently still beyond the imagination.

Use of computers by forest research organizations

In March 1960, the President of IUFRO carried out a survey by correspondence of the use that was being made of electronic digital computers by forest research organizations. The results of this survey indicated that extensive use of electronic computers was taking place in Australia, Canada, Sweden, Switzerland, the United Kingdom, the United States, and that less extensive use was being made

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of these machines in Japan, the Netherlands and New Zealand. Valuable experience in the application of computers was therefore being gained in all these countries. Rather surprisingly, many organizations stated categorically that they were not interested in the application of electronic computers to problems of forest research, and some were clearly confused between computing methods based on punched cards and electric desk machines and those based on electronic digital computers. While it was expected that forest research organizations in countries in which electronic computers were being actively developed would be the ones most aware of their possibilities, and the ones which would have easiest access to computers, it was not expected that so many organizations would have been unaware of the possible economies in the use of these machines.

It should perhaps be stressed at this point that the computer is of the greatest importance in those countries which have only a small reserve of trained scientific staff, as it relieves this small body of experts of the tedium of calculation and routine handling of information, and enables them to devote their energies to more worthwhile matters.

Applications of electronic computers in forestry

In countries making extensive use of electronic computers in forest research, the first applications of these machines were very naturally concerned with the speeding up of computations which were already being undertaken by other means. Examples of this class of computation are given by the calculations involved in large-scale forest enumerations, in the construction of yield tables and volume tables, and in the mathematical analysis of designed experiments and surveys.

In all of these applications, little advantage was taken of the basic properties of the computers, except that of the speed of calculations, and the form of the calculations was little different from that which would have been used by more conventional computing aids. Later, however, it became apparent that the most important use of computers was in their extension to types of computation that had never before been attempted, not merely because they would take too long, but also because they were too complex to be handled by the conventional computing machines. Examples of these calculations are multivariate analysis of complex problems, such as the effects of site on choice of species and on growth, of the relative values of physical properties of timber in assessing its quality, of taxonomy of plants and animals important in forestry, and of crop-weather relationship. Other applications of this kind include the building of mathematical models to simulate practical problems, as in the various techniques known as operational research, e.g., Monte-Carlo methods, linear programing, the queue theory, and the theory of games.

The present phase of the advanced use of the electronic computer in forest research is in the greater exploitation of the basic processes and principles of the computer, in the ability to sort, store, and handle information rapidly and in new ways, as opposed to the substitution of these processes for the more usual and slower methods in previously elaborated theories. These developments will undoubtedly lead to entirely new methods of forest research, exploiting computer techniques to the full, and based on completely automatic data processing systems.

International library of programs

As more and more forest research organizations come to use electronic computers, the stock of programs for computations of interest to foresters will increase rapidly. To avoid waste of time in duplicating work that has already been done, therefore, and to make available the work of any individual organization to the widest possible field of application, it will be desirable to arrange for the interchange of the basic programs that are written. There are however a number of difficulties. First, different machines use different order codes or languages for their programing and, even among the machines made by the same manufacturer, there is frequently no common language between the machines. On the international scale, the problem is further aggravated by the fact that the persons writing the programs do not speak the same language.

In the United States, there has been some success among a certain range of computers in the use of a common language, capable of being obeyed by a number of machines, and known as "Fortran," and this common language between machines may well help to solve the worst of the problems of the communication of computer programs for that continent. In Europe, an alternative common language between machines is being pioneered, that of "Algol." It is too soon to say whether or not this language will be as successful as "Fortran" has been in the United States, but it may well enable programs to be interchangeable on a wide range of future machines, if not on those already existing.

In the light of this difficulty, perhaps the best that can be done to avoid duplication of effort is to keep a register of existing programs, and to revise this register as new programs are developed.

In addition to the library of existing programs, it would also be desirable to maintain an index of those organizations and individuals who are actively using computers, and particularly those which have computing time to spare, and which would be prepared to take on computing work for other organizations on repayment. Although it will probably always be possible to have such computations done by nonforestry organizations, or by commercial computer firms, experience has shown that there are many advantages in having forestry calculations done by organizations that are also concerned with forestry.

Further developments

In the years between the present congress and the next congress, there will be many developments in the field of electronic computers, and in their application to problems of forest research and management. The use by forest research organizations of computer facilities existing in other organizations is essentially a temporary phase and, in a very few years' time, many forest research organizations will have their own electronic computers, and will have developed advanced methods of research based on modern data processing and computer techniques.

There is no substitute for foresters themselves becoming involved in this process, and for foresters themselves learning to program the machines, if the best possible use is to be made of the exciting and almost unlimited possibilities which these machines have disclosed. Actual programing is the only constructive way of becoming familiar with the machines and their possibilities, and it is important that the realization of what these possibilities are should be spread to the largest possible number of foresters. The author of this paper believes that so powerful an apparatus has never before been placed in the hands of the forester to enable him to fulfill his part in the great project for the preservation and rational utilization of the world's forests. The danger is rather that the electronic computer will be ignored in forestry rather than misused.