APPLICATION OF COMPUTER IN FORESTRY

by

Raja Walayat Hussain*

Abstract. *In forest research computer is mainly used in the analysis of experimental and survey data, in studying the complex relationships between plants and their environment and for the simulation of biological and economic situations. In forest management it finds its use in financial control of forest operations, for estimating and controlling forest production, for allocation of resources and for planning and control of new planting programs. In information management it finds its application in maintaining upto-date records of long range experiments and personal files of employees.*

Different decision making techniques such as linear programing, simulation, operation research and network planning are described and important programs developed by United States Forest Service are discussed.

Introduction. Most statistical investigations in forestry research and management involve collection and analysis of a mass of numerical data. In the past, analyses were conducted with desk and hand calculators which have limited storage capacity for arithmetical operations, at the most 16 digits. This limited the scope of study. It was also very slow: by the time the results were available it was frequently too late for them to be of maximum value.

The results derived from analysis of data should be accurate, complete, concise, relevant and should be available to management as early as possible. It is here that the use of computer which is the most precise and powerful tool available for the analysis of practical problems is urgently required. The computer can carry out long and involved calculations and can process a large amount of data when given proper instructions through a program. It carries out a series of steps involving arithmetical operations, sorting, comparing, choosing and ranking without human intervention. It is specially useful when the volume of data to be analysed is large, when analysis requires a good deal of repetition, when results are required urgently, when greater accuracy is desired, and when complex processes such as linear programing and simulation are involved.

Computers are employed in three broad avenues of forestry-research, management and information management. The following analyses of research results can be conducted by computer:

Analysis of variance and covariance of experimental data, a pre-requisite for all field, nursery, and laboratory investigations.

* The author is Forest Mensuration Officer in the Pakistan Forest Institute, Peshawar.

Sampling surveys, for assessment of growing stock of timber or medicinal plants.

Regression analysis, extensively employed in the preparation of volume and yield tables.

Time series analysis, in marketing.

Multivariate analysis, for site classification, effect of cultural treatments on yield and timber properties, ecological and taxonomic studies, in Genetics using factor, canonical and discriminant analysis.

Sequential sampling, employed in assessing the incidence of insect and fungal infestations.

Computer based techniques. The following techniques involving the use of computer have found wide applications in the management of living natural resources:

Linear programing. This technique determines the optimal allocation of limited resources to satisfy a given objective when there are competing uses or activities needing these resources. It has wide application in forestry in situations where the common factor is the necessity for allocating limited resources to different uses: watershed managment, wood production, grazing, wild life habitat. It requires that a mathematical model called the objective function be constructed to describe the problem. The method used for solving the model is an algebraic procedure (simplex) which approaches the optimal solution by iteration and is well adapted for computer solution. The planner can decide how much to cut, from where and at what time to meet some specified objective satisfying at the same time certain restrictions. If the objective is to maximise yield of a forest area then with the help of this technique a cutting schedule can be worked out with such restrictions as the necessity of site protection, equal volume or value yields, improvement in age class distribution by the end of rotation. In linear programing it is assumed that:

(*i*) All the coefficients in the mathematical model are constant when actually they may not be known or constant. In such cases parametric linear programing is used which allows coefficients to vary with consequent variations in the objective function. Another technique known as non-linear programing is developed which permits the mathematical model of the objective and constraint functions to express non-linear relationships.

(*ii*) that there is a precise knowledge of all future states at all stages in a program which my not be true e.g., growth and allowable cuts are not precisely known for the future. In such cases dynamic programing technqiue is used.

Goal programing is a variation of linear programing in which mathematical model is so constructed that the single objective to be maximised or minimised is composed of several goals.

Simulation. Simulation is another decision making technique. By this experiments are performed on a model which simulates real life and obtains alternative solutions of a system. Unlike linear programing this technique does not generate optimal solutions but, rather, shows alternative results that allow the investigator to make a decision on the levels of his input variables that are best for his purposes. The resulting decisions may or may not be the same as the optimal solution.

Simulation studies require the construction of a model to describe the system under investigation. It is obvious that this requires a clear understanding of the system and the objectives of the study. To start with the system is best described on a qualitative basis using a block or flow diagram. First a mathematical model is constructed, describing the operation of the system in terms of the individual elements of the system. Then it is operated to simulate the actual behaviour of the system. The operation consists of feeding input data into the model and observing the solutions. By repeating the operation for various levels and combinations of the input variables a series of solutions can be otbained. The solution in conjuction with the input data are then compared to decide on the most satisfactory configuration of the input variables. Simulation studies involve much calculation work therefore are usually carried out on digital computers.

This technique has been applied in forestry in the following fields:

(*i*) Forest sampling

(*ii*) Forest management operations

(*iii*) Fire protection

(*iv*) Insect population

(*v*) Stand growth

(*vi*) Harvesting machines

Operations research. Operations research was developed for solving logistic, strategic, and tactical military problems during World War 2. Since then it has been applied to civilian as well as military problems that involve the conduct and coordination of operations or activities within any kind of organization. It is, thus, a scientific approach to decision making regarding the operation of organizational systems. Since the development of opertions research as a recognized field, a methodology and body of techniques have been evolved which give coherence to this decision-making approach.

The following steps summarize the methodology adopted in this technique:

(*i*) Observation and formulation of the problem in the context of the entire system.

(*ii*) Construction of a mathematical model which includes the essential elements that will allow a solution relevant to the real-life situation and the decision maker's

objectives. The model is tested and modified till it is considered valid for the problem.

(*iii*) Development of procedures for obtaining solutions to the model.

(*iv*) Developing a solution that either gives an optimal value to a chosen measure of the system or yields alternative values which can be evaluated for their desirability.

Thus operations research utilizes such techniques as model formulation, simulation, and mathematical programing. It also requires a team approach, since any single individual is unlikely to have all the knowledge and skills necessary for the solution of an operation research problem.

The application of operations research to foresty problems has been growing in recent years. Studies on the minimization of forest fire costs, insect pest control by chemical methods, use of linear programing in forest management, and simulation studies are examples of the application of operations research.

Net work planning. This technique is also known as CPA (Critical Path Analysis) or PERT (Program Evaluation and Review Technique). It has its special use in forest inventory and research and management projects. Projects are planned as a series of activities-design, collection and analysis of data—and these activities are to be completed within given period of time so as not to delay the completion of project.

Packaged programs. The following are some packaged computerised programs developed by USFS for assisting the management of renewable natural resources:

(1) FOREST: This program simulates the growth and reproduction of plots in pure or mixed crops and even or unevenaged forest stands. It considers many aspects of natural forest growth such as seed production, seed dispersal, germination, competition, mortality, stocking and site changes. Input is a set of real or generated tree locations and associated tree characteristics. The growth of each tree in then predicted for a number of projection periods based on potential growth functions modified by competition measures developed from relative tree size, crowding and shade tolerance. Reproduction is introduced by the seed and sprout production of the overstorey. Numerous site alterations and harvesting options are specfiied for implementation as the stand develops over time. Output is in the form of periodic stand tables with yield for numerous products.

(2) TIMBER RAM (Resource Allocation Method): TIMBER RAM is a long range planning method for commercial timber lands under multiple—use management. It produces cutting and reforestation schedules with tables showing volume, price and cost. Schedules are calculated using linear programing techniques.

(3) RANGE RAM (Resource Allocation Method): RANGE RAM is a computerised planning method designed to assist range managers in developing and selecting alternatives in spatial and temporal allocation of resources. It helps in formulation of plans that maximise the production of range outputs and net revenue or minimize the cost of management while meeting a variety of constraints on range productivity, budget level, and economic returns.

(4) TEVAP (Timber Evaluation And Planning): This provides a quick means of obtaining guidance from a large volume of information. Thus a forest manager can obtain a management (working) plan whenever he wants. Because large amounts of computation and analysis are automatically done by the computer, working plans can be prepared at any time and not necessarily at intervals of 10 years.

(5) SNOWMELT: The program simulates winter snow accumulation energy balances, snow pack conditions and resultant snow melt with a sensitivity to slope, aspect, temperature, radiation and forest cover density.

Computers can also be used to store a large amount of data which is at present stored in files: periodic measurements of permanent sample plots, recurrent observations on long range experiments, compartment history files, and personal files of employees.

References

1. ANON. (1974). FOREST—A computer model for simulating the growth and reproduction of mixed species forest stands. Research Report R 2635. College of Agricultural and Life Sciences, University of Wisconsin, Madison.

2. BELL, ENOCH F. (1976) Goal programing for land use planning. Technical Report PNW-53 Pacific Northwest Forest and Range Experiment Station Portland, Oregon.

3. DAME, C.W. N.C. MEADER and J.B. WHITE. (1977). Goal programing in land use planning. Jour. For. June, 1977.

4. HUSCH B., C.I. MILLER and T.W. BEER;. (1972). Forest Mensuration. The Ronald Press Co., New York.

5. HUSSAIN, R.W., M. RAFIQ and W. KHAN. (1977). Computer approach and its application to statistical techniques, Project Report for P.G.D.C.S. Course (1976-77). Q.A. University Islamabad.

6. JEFFERS, J.N.R. (1966). The use of electronic digital computers in forest research and management. The new generation. Proceedings of the 6th World Forestry Congress, Madrid. Spain.

7. JEFFERS, J.N.R. (1968). The contribution of statistical methods to forest research and management.

8. JENSEN, H.C. (1976). RANGE RAM a long-term planning method for managing grazing lands USDA Forest Service Research Paper PSW-120 Pacific Southwest Forest and Range Experiment Station Berkely, California.

9. MARSHALL, J.A. and GLENN H. DIETSCH. (1976). Computerization of data handling for long-term forest research plots. Northwest Science Vol. 50 No. 4.

10. MYERS C.A. (1974). Computerized preparation of timber management plans: TEVAP 2. USDA Forest Service Research Paper RM-115 Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

11. NAVON, D.I. (1971). TIMBER RAM a long-range planning method for commercial timber lands under multiple use management. USDA Forest Service Research Paper PSW-70. Pacific Southwest Forest and Range Experiment Station Berkeley, California.

12. SOLOMON, RHEY M., P.F. FFOLLIOTT, M.B. BAKER JR., and J.R. THOMPSON. (1976). Computer simulation of snowmelt. USDA Forest Service Research Paper RM-174. Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.