Purdue's Forest Management Game

ABSTRACT—Systems analysis is very effective in determining the overall effect of biological and financial decisions on a total forest management system. The pedagogic use of a competitive simulation model enables students of forest management to visualize the operational problems of the forest manager from the total systems point of view. Students were receptive to and enjoyed the game, believed that the game provided them with experience in making decisions within a management-oriented environment, and felt that the game environment provided an opportunity to visualize interrelations between the biological and financial components of a forest management system.

A PRINCIPAL objective of forest management is to integrate biological and financial information into a cohesive body of functional knowledge, which is used to regulate, plan, and control the production of goods and services from a forest property. The concepts and procedures of systems analysis may be used to analyze, interpret, and implement the policies needed to fulfill this objective.

The systems analysis approach to problem solving can also be used in teaching forest management. Forest management has traditionally been thought of as a subject which integrates both biological and financial information in a decision-making evironment, but such integration has not always been realized. Consequently, many forest management students leave the classroom without sufficient exposure to an integrative total systems point of view. This approach provides a framework for visualizing internal and external environmental factors as an integrated whole and involves the coordinated organization and management of each system component in order to meet a particular objective established for the entire system (See *10* for detailed discussion of the systems concept).

The essence of the systems approach is described by Hare (*9*, p. 9) who states:

> It treats problems of the complex system at a level of abstraction once removed from intermediate detail, although requiring selected detail for its execution. It deals with the formulation and evaluation of precise alternatives, with the selection of activities and their level, with the integration of short- and long-range plans, with the specification of values and objectives, and with the implementation of strategies of diagnosis, trouble-shooting, repair and control.

The modern forest manager should approach the subject within this same context, thus providing a basic framework allowing him to handle managerial problems involving a variety of alternatives, conditions, and choices he will encounter in later work. Christiansen (*4*) further discusses the application of systems analysis procedures to forest resource management problems.

Simulation is an operations research technique which has been applied to a variety of systems-oriented forestry problems. Its use presupposes the construction of a model[1] of the system under study. Simulation is contemporarily defined as the process of conducting experiments on a model suitable for processing on a digital computer rather than on the real system (*13, 15*).

Management Games

Business, or management, games are a special form of simulation where several teams or individuals compete against each other within a simulated environment controlled by certain game rules. By participating in a dynamic competitive process, students are able to gain experience in a shorter time than in real world situations. Kibbee, Craft, and Nanus (*11*) state that the two unique characteristics which enable games to contribute so powerfully to management education are

[1] A model is a simplified formal definition of a real system which retains enough relevant particulars such that it can be used for purposes of prediction and control of the real system.

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A detailed description of the game in the form of a user's manual may be obtained from the Dep. Forestry and Conserv., Purdue Univ., W. Lafayette, Ind. 47907. This manual is available in limited quantities for $1.50.

the novel use of the time dimension, and the objectivity of the feedback. The student must evaluate the large amount of information which he receives after each period of play and decide what is important to him and what is of little or no value. Computer simulation compresses the time horizon, thus allowing the student to view the effects of earlier decisions. As stated by Paulik (*17*, p. 36):

> Simulation models of this type permit the students to test their analytical skills as well as their decision-making abilities in "realistic" management situations. The student players have to analyze the management situation, formulate critical problems and apply their analytical tools to solve the problems and to develop short-term management tactics and long-range management policies.

The degree of interaction between players—the effect of the decisions and actions of one player on another—is an important feature of most management games. Although most management games involve economic competition, not all games possess the interaction characteristic. That is, players may compete for maximum economic performance uninfluenced by another team's decisions.

Involvement and Motivation

A second important feature of management games is the involvement and motivation that players exhibit when playing a game. By competing, students are encouraged to be more conscientious and to learn new analytical techniques. While high motivation may not be unique to gaming, no other educational tool provides an equally dynamic systems-oriented environment allowing students to obtain such rapid feedback of decision results. Other important features of games are their educational value for teaching team organization, control, and communication, and their effectiveness in teaching the importance and difficulty of setting goals and long-range plans (*6*).

The American Management Association (in conjunction with IBM) developed the first management game in 1957 (*19*). Following this, literally hundreds of management games were written in the social, behavioral, and physical sciences. While others (*5, 14*) have developed forest management simulation models, the Harvard University forest simulator (*7*) has been the only effort which explicitly considers the business gaming approach.[2] In addition to these forest management simulators, other forestry-oriented management games have been developed (*12, 18, 20*).

The Purdue University Forest Management Game

The Purdue University Forest Management Game is designed to simulate the operations of an industrial forest property so that forest management students may observe how the various biological and financial factors associated with operational forest management interact to affect the behavior of the forest system. The game concentrates on the preparation of an annual budget of expenditures and an annual schedule of management activities, thus emphasizing operational or middle management activities more strongly than policy formulation and long-range planning.

The biological basis for the game is a hypothetical forest property composed of a single even-aged species growing on four sites. For management purposes the forest is divided into three districts. Each district is further subdivided into 60 compartments and is conceptually organized as an investment center (*1*). All management activities must therefore be budgeted on a total compartment basis. In addition, to keep the game simple, all harvest cuts are considered to be clear cuts.

Capital Investments

The only capital investments included in the game are land and timber. Equipment is not included as a capital asset, hence decisions and analysis concerning additional purchases, methods of depreciation, salvage values, etc., are not required. The financial control system is evaluated through the use of: (1) after-tax profit, (2) gross sales, (3) net income percentage, (4) return on investment, and (5) correlation between actual vs. budgeted cash expenditures. In addition to the financial control system, each investment center is evaluated through the use of two biological criteria: (1) the annual cubic-foot growth rate, and (2) the trend toward sustention of production as measured by the number of compartments which are regenerated following harvest operations.

The goal of each district is to provide a pulpmill with a fixed amount of wood fiber in the most efficient manner possible. The district performing the best job of management, as measured by the above listed financial and biological criteria, receives the highest budget appropriation for the following year. Hence, the three districts compete for a share of the total timberlands budget.

Management Activities

Annually each team allocates its budget among several management activities which are included in the model. Very briefly, the activities requiring annual decisions are: (1) the number of cubic feet to sell from harvest cuts, (2) the cost of selling this volume, (3) the number of acres to prepare for sale in two years (all compartments must be so prepared in advance of the actual cutting to allow time for cruising, road construction, timber marking, etc.), (4) the cost of sale preparation, (5) the number of acres to schedule for sale this year due to a schedule change (it is possible to alter the three year harvest schedule if desired), (6) the cost of this schedule change, (7) the number of acres to thin, (8) the cost of thinning, (9) the number of acres to plant, (10) the cost of planting, (11) the number of acres to burn and disk, (12) the cost of burning and disking, (13) the number of acres to disk, (14) the cost of disking, (15) the number of acres to burn, (16) the cost of burning, (17) the number of acres requiring no site preparation, (18) the cost of fire control, (19) the property tax expense, (20) the number of Continuous Forest Inventory (CFI) plots, (21) the cost of CFI, and (22) the road maintenance expense.

In addition to preparing the annual budget of expenditures, each team also prepares an annual schedule of management activities, specifying the compart-

[2] For additional references concerning forestry-oriented simulation studies, see: B. B. Bare, The development and evaluation of a forest management game. Unpubl. Ph.D. thesis, Purdue Univ., 188 p. 1969. Also (*8, 16*).

ment numbers where the various management activities are to occur. The actual decisions requiring attention when developing the annual schedule are: (1) the compartment numbers where sale preparation activities are to occur, (2) the compartment numbers where thinning is to occur, (3) the residual basal areas for the compartments to be thinned, (4) the compartment numbers where site preparation is to occur, (5) the type of site preparation for each compartment being prepared, and (6) the compartment numbers where planting is to occur. This information, along with the annual budget of expenditures, is submitted to the game moderator on three data cards. When the moderator receives the data cards for all three management teams, he activates the computer program which proceeds to simulate the operations of the forest for one year (Fig. 1).

The updated forest conditions are stored on a magnetic tape for future reference and several types of annual reports are produced. These reports are provided for thinning, harvesting, site preparation, planting, fire, and inventory. In addition, the annual budget of expenditures, the unit cost information, an income statement, and a net worth statement are produced for each team and for the game moderator. Following the evaluation of each district's performance, the moderator distributes the annual reports along with the appropriate budgets for the next year and the above described process starts again.

Educational Value of the Game

In order to evaluate the educational value of the game and also to obtain the response of the participating students, the Purdue University Forest Management Game was included in a financial management course taken by all forest production students during their senior year. It thus encouraged the students to apply previously studied biological and financial concepts to a specific management problem. In addition, it was hoped that the students would find it advantageous to review and/or resynthesize previously studied material.

Each student was assigned to a management team of four members; each team was responsible for managing one district of a forest. Because of class size, three separate forests, each divided into three districts, were established for the gaming experiment.

A post-game questionnaire filled out by the students at the conclusion of the exercise revealed that virtually all (i.e., 31 of 32) of the students felt that the gaming exercise had training value for them. The game stimulated discussions concerning relationships between biological manipulations and the ensuing financial performance of the manager; it provided an opportunity for visualizing the total forest system and for integrating many concepts learned in other courses; and it provided realistic experience in decision-making through rapid feedback of results. Thirty students believed that the game aided their understanding of annual budgeting and scheduling. It provided an opportunity to develop an anual budget and schedule and then to test the value of their decisions in terms of both biological and financial performance evaluators. They also believed that actually preparing a budget

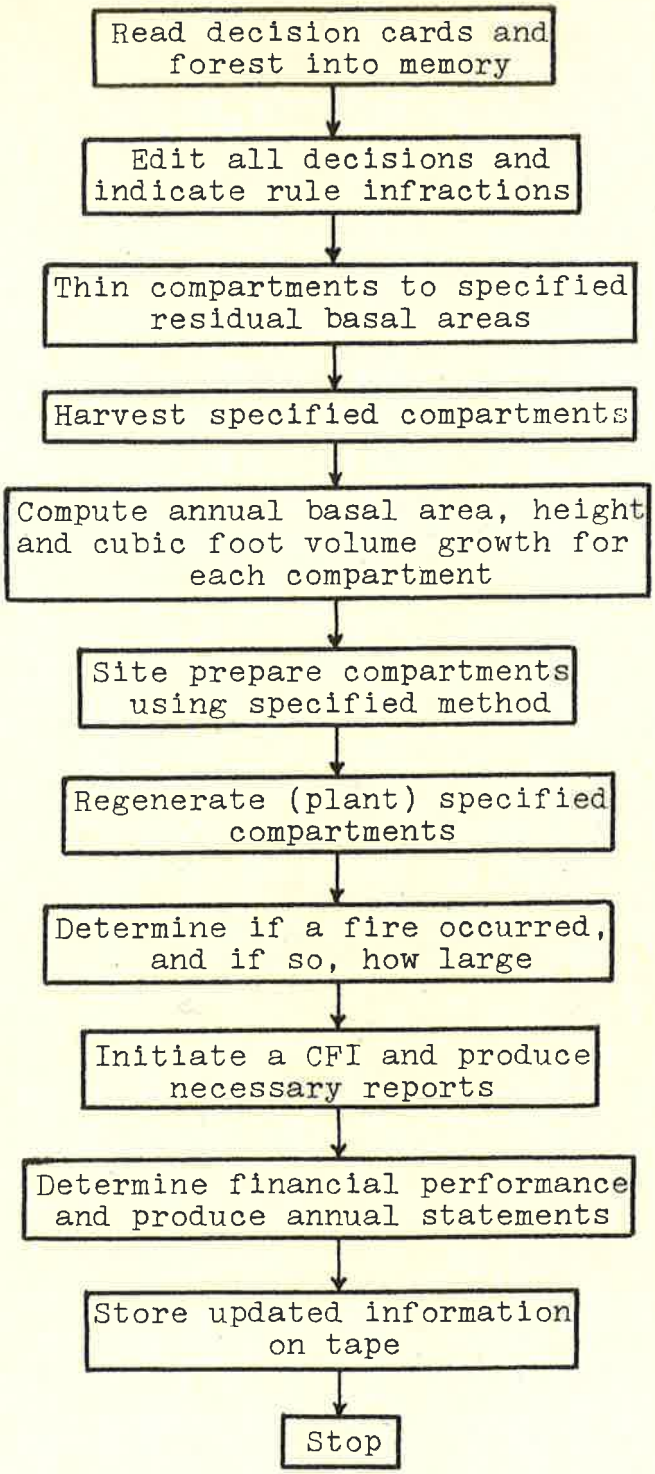

Fig. 1.—Macro flow chart of the forest management game is shown.

allowed them to better understand the steps involved in the budgeting process. The students all felt that the game should be played in future forest management courses. In fact, 75 percent of the students felt that the use of the gaming approach should be investigated in other forestry courses.

Review of Concepts

It was also learned that the game stimulated some degree of review of the concepts learned in other forestry courses. Fifty percent of the participants stated that the game inspired them to review the principles of

forest economics and mensuration, while 75 percent were stimulated to review some of the principles learned in silviculture, forest management, and financial management. A few found it advantageous to review material studied in forest biometry and fire control.

While 28 of 32 students believed that the game helped them visualize the interrelationships between the biological and financial components of the forest system, many believed that more biological factors and alternatives were needed. Others stated that financial factors dominated the biological considerations because of the short time covered by the gaming experiment (i.e., seven simulated years).

Approximately 75 percent of the students believed that more management activities should be included in the game. Most wanted to include additional land uses such as recreation, grazing, watershed, etc., while others wanted more timber-oriented activities. Examples of the latter were: (1) more species and products, (2) more destructive agents (i.e., insects, disease, and wind), (3) more silvicultural opportunities for thinning, regenerating, and site preparing, and (4) more general management alternatives such as road construction, building maintenance, and equipment replacement.[3]

Computer Experience

At the beginning of the gaming experiment approximately 50 percent of the students were somewhat apprehensive about using a computer, but at the conclusion only three felt that their lack of computer knowledge influenced their performance in the game. Thus, it is safe to assume that forestry students inexperienced in the use of computers can participate in the game with little, if any, detrimental effect on their performance.

The problem of evaluating team performance was complicated by the difficulty of selecting quantitative performance criteria which adequately measured both the biological and financial components of the forest management system. In addition, the students realized that time would not permit the game to be run longer than five to ten simulated years. Thus, there was a great tendency for them to overemphasize short-term profit goals in lieu of those associated with long-range sustained yield. This problem can be minimized by playing the game for longer periods of time or by introducing additional performance criteria which measure long-range objectives.[4]

Short-term Criteria

Concerning the performance evaluators used in the gaming exercise, 75 percent of the students stated that short-term criteria (i.e., after-tax profit, return on investment, net income percentage, etc.) were emphasized more strongly than the long-range evaluators (i.e., cubic-foot growth rate, and number of nonregenerated compartments). This was especially true with the thinning component of the game. Many student teams thinned quite heavily in older compartments in order to increase their short-term profit standing. This in turn caused them to receive a larger budget appropriation the following year. It is possible that this would be the best strategy in the long run, but it can only be determined by playing the game for longer simulated periods of time.

While it is difficult to determine if a student learns material better by participating in a management game that he does in the traditional lecture-case study approach, it is quite clear that he becomes highly motivated to perform well in the game and that he exhibits considerable enthusiasm concerning the material being presented (for example, contradicting conclusions are reported by *2, 3*).

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[3] A revised version of the game incorporates many of these suggested activities.

[4] Procedures are currently being implemented in the game to provide for the long-term projection of strategies developed by each team during the first five to ten years of simulated play. This will enable a more realistic evaluation of long-term performance. Total managerial effectiveness will then be a function of both short- and long-term performance.