Figure 1. *Harvard freshmen figuring out a cutting policy. The slide board "forest" still has its full complement of 100 blocks.*

Harvard Forest Management Game

Ernest M. Gould, Jr.

ABSTRACT—A programable electronic desk calculator can be used with an easily made analog "forest" and simple paper forms to create a game that soon has players coping realistically with management uncertainties.

Games that simulate real situations but compress decades of experience into a few short hours of play have been especially useful to foresters. Over the last fifteen years we have had considerable success at the Harvard Forest with a two- or three-hour forest management game for novices. College students from many backgrounds devise surprisingly ingenious policies for producing timber from their own "forest" over several decades of simulated experience. Having to think not only about the condition of their forest but also about financial survival has a salutary effect. Players quickly understand some of the risks and uncertainties with which forest owners cope, and involvement soon makes this facet of forestry fast moving and exciting. Competition between two or three small teams of players also lends zest to the occasion. Forestry instructors and extension personnel working with the owners of small woodlands or lay people may find the Harvard Forest Management Game a useful aid.

The game board consists of an easily made slide-rule-like slotted board fitted with 100 small wooden blocks placed side by side in the slot (fig. 1). As the game begins, each block has the number *10* written in pencil on its face, because each one represents a 10-acre forest stand. These stands start at zero years of age on the left and end at 99 years on the right, so that each block is one year older than its neighbor on the left. All together, they represent a balanced forest of 1,000 acres with 10-acre stands in every age class from 0 to 99 years. (Any other configuration of stand ages and acreage could be used if desired.) The fixed part of the board above and below the slot shows stand age and the salable volume of timber per acre by 10-year intervals (fig. 2).

The group is divided into a few small teams, and each play of the game represents one year. The steps by which a team operates its forest are simple. The first is to decide which stands to harvest this year; the acreage on the face of each block cut is then changed to show zero or whatever acreage is left to grow. The blocks on the right, representing the oldest stands, are simply removed from the board when they have been completely harvested. As each stand is cut, volume harvested is entered on a log delivery sheet which the instructor acting as banker processes (fig. 3). Finally, to represent regeneration, a fresh block is marked with the total acreage cut that year and is pushed in on the left as far as zero, thus forcing all the other blocks one space to the right and aging the whole forest one year. Acres burned over or blown down are salvaged, and regeneration comes in just as on intentionally harvested acres. In a year when nothing is cut or salvaged, a blank block is put in to keep the forest properly aged and to show there is a break in the age class distribution.

Students usually need only two or three plays to learn how to use the board to keep track of their forest. A good way to familiarize them with the production characteristics of the forest is to have them develop a cutting plan that will maximize yield over time. A volume curve with growth peaking at 70 years is useful to illustrate rotation length and ideas about the culmination of mean annual increment. Because some of the stands in the initial forest are older than 70, the effect on yield of harvesting them gradually or immediately can also be illustrated. It generally takes about an hour for each team to organize itself effectively, master the
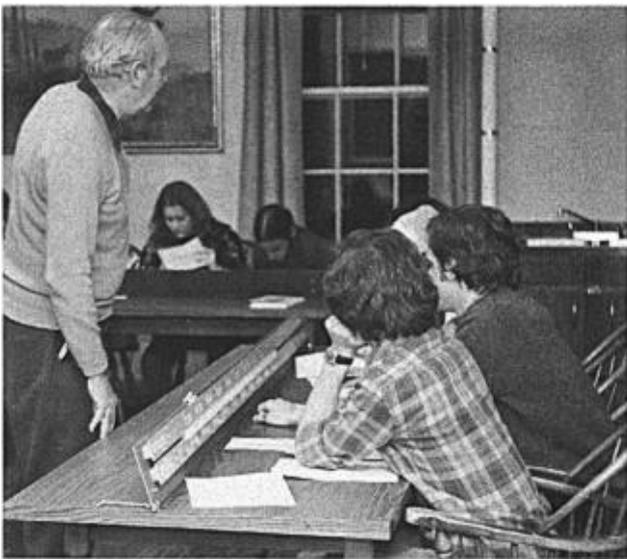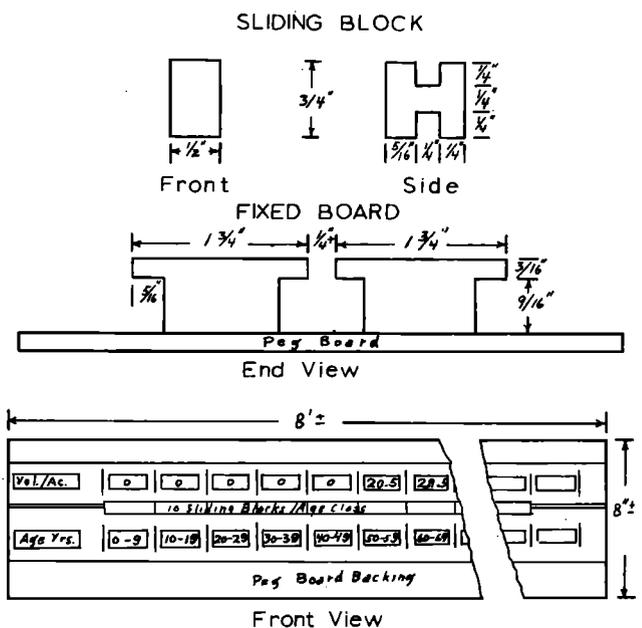

Figure 2. *Writing surfaces and block fronts are pressure-sensitive plastic tape three-quarters of an inch wide.*

mechanics of the game, and be ready for a more challenging situation.

Game Plan

The following statement given to each team has worked well as a challenge to foresters and nonforesters alike.

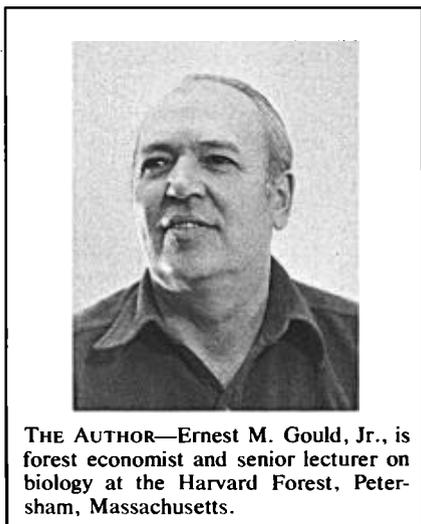To: Petersham Associated Landowners

Congratulations PAL! After a long search you have found an ideal piece of forest land. It is natural pineland supporting a perfectly balanced forest with 10 acres in every age class from 0 to 99 years. As this 1,000-acre outwash plain regenerates to pine promptly after clear cutting, silviculture is simple.

Finance.—The owner has sold the area to you without down payment for only $50,000 and will hold the mortgage and charge you 7 percent interest on unpaid balances. You have agreed to use all income to pay off the principal and interest until the property is free of debt.

Because the seller doesn't want you to feel pushed for operating funds, he has agreed to make additional loans as needed at 7 percent up to $25,000. This line of credit means that you don't have to cut timber each year if you don't want to. You will have to watch your debt level, however, to be sure it doesn't go over $75,000 (mortgage plus credit advances), or you will go bankrupt.

Because of this favorable financing, you have agreed that after you are out of debt you will pay the seller a dividend in any year you make money. The dividend rate is 20 percent of that year's net stumpage and interest income.

All your business will be handled by the bank. You will turn in the log delivery slip for the year showing the thousands of board feet cut and the price per MBF. The bank will collect the money, deposit it in your savings account after paying your debts, and pay you 5 percent interest on the balance.

Taxes of 50¢ per acre or $500 per year will be paid by the bank from your account.

Success.—After you have managed the property for sawtimber for a few decades, your success will be measured by the size of your bank account plus the value of the uncut sawtimber standing on the land plus the value of the land. Land values vary with the age of the stand each acre supports—$10 per acre where stands are 0 to 49 years old, $100 per acre where stands are aged 50 to 89 years, and $4,000 per acre for camp lots where stands are 90 years or more. The team with the largest net worth wins.

Uncertainty.—Your management policy should be planned to maximize your returns over time and avoid bankruptcy. The chances of a fire destroying any growing stock are about 1 in 25, but as fires are generally put out promptly only a few acres burn. Burnt timber on any blocks designated will be salvaged, but will be worth only half the going price. There is a chance of about 1 in 100 that a hurricane will wipe out any timber you have above the red marks on the board. This widespread damage will disrupt the market, and prices will drop to $3 per MBF, then gradually recover.

The market.—Stumpage prices over the last 50 years have varied considerably, but since the Depression lows

Figure 3. Log delivery slip made out by a team to show the acres and volume cut in each age class during the year. By looking at the volume given for 1 acre, one can see the yield-table values for various age classes—for example 0 MBF from 0 to 49 years because nothing is shown, then 20.5 for 50 to 59 years, 29.5 for 60 to 69 years, etc. The guide for estimating the cut on 1 to 10 acres in each age class is simply for the convenience of the player.

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AGE OF ST'ND CUT	GUIDE FOR ESTIMATING THE MBF CUT ON THE NUMBER OF ACRES SHOWN BELOW BY AGE CLASSES					LOG DELIVERY SLIP (MBF)	
						PLAN'D CUT	SALVG'D CUT
50–59	1ac. 20.5	2ac. 41.0	3ac. 61.5	4ac. 82.0	5ac. 102.5		
	6ac. 123.0	7ac. 143.5	8ac. 164.0	9ac. 184.5	10ac. 205.0		
60–69	1ac. 29.5	2ac. 59.0	3ac. 88.5	4ac. 118.0	5ac. 147.5		
	6ac. 177.0	7ac. 206.5	8ac. 236.0	9ac. 265.5	10ac. 295.0		
70–79	1ac. 35.2	2ac. 70.4	3ac. 105.6	4ac. 140.8	5ac. 176.0		10ac. 352
	6ac. 211.2	7ac. 246.4	8ac. 281.6	9ac. 316.8	10ac. 352.0		
80–89	1ac. 37.5	2ac. 75.0	3ac. 112.5	4ac. 150.0	5ac. 187.5		
	6ac. 225.0	7ac. 262.5	8ac. 300.0	9ac. 337.5	10ac. 375.0		
90–99	1ac. 39.0	2ac. 78.0	3ac. 117.0	4ac. 156.0	5ac. 195.0	70ac. 2730	
	6ac. 234.0	7ac. 273.0	8ac. 312.0	9ac. 251.0	10ac. 390.0		
100–109	1ac. 40.0	2ac. 80.0	3ac. 120.0	4ac. 160.0	5ac. 200.0		
	6ac. 240.0	7ac. 280.0	8ac. 320.0	9ac. 360.0	10ac. 4000		
110–119	1ac. 40.0	2ac. 80.0	3ac. 120.0	4ac. 160.0	5ac. 2000		
	6ac. 2400	7ac. 2800	8ac. 320.0	9ac. 360.0	10ac. 4000		
120–129	1ac. 39.75	2ac. 79.5	3ac. 119.25	4ac. 159.0	5ac. 198.75		
	6ac. 238.5	7ac. 278.25	8ac. 318.0	9ac. 357.75	10ac. 397.5		
130–139	1ac. 39.5	2ac. 79.0	3ac. 118.5	4ac. 158.0	5ac. 197.5		
	6ac. 237.0	7ac. 276.5	8ac. 316.0	9ac. 355.5	10ac. 395.0		
140–149	1ac. 39.25	2ac. 78.5	3ac. 117.75	4ac. 157.0	5ac. 196.25		
	6ac. 235.5	7ac. 274.75	8ac. 314.0	9ac. 353.25	10ac. 392.5		
TEAM_____/_____				TOTAL MBF		2730	352
PLAY NO.___/___				$/MBF		15	7.50

there has been a general upward trend. However, erratic change has been the rule—prices have gone up or down 10 percent in 36 of the last 50 years, have doubled or better six times in successive years, and four times have fallen by half or more.

In the last five years, prices per MBF have been $15, $20, $30, $10, and (last year) $15. Construction is now active, but there is some uncertainty about timber demand this year because of a tight money policy and the impounding of urban renewal funds.

Written policy.—After each year's price is posted you must decide on your harvest, update the forest to reflect this change, make out a log delivery sheet, and give it to the banker. All this should be done within one minute, because thereafter the price drops $1 each quarter minute. Faced by this need for prompt decision each year, it will pay you to lay plans in advance and write out instructions for yourself. You may want contingency plans that tell you how much timber to cut and which age classes to cut when the price is high or low. Other guides and reasons such as your debt position will no doubt occur to you.

Game Operator Activities

Each team reacts to identical annual events and the instructor schedules any price, fire, or hurricane he chooses for each year. Thus to him the game is certain, but to the students these events are uncertain. Of course, it is possible to devise a game where events are determined by chance, so that everyone will have to cope. Because our game session at the Harvard Forest has usually been limited to two or three hours, we have found it best to schedule happenings to illustrate the most important points. After a period to read the problem statement and ask questions, the teams have 15 or 20 minutes to develop and write out their initial plans for cutting; then the first year's events are posted. Each team completes that play, after which there is another period to consider and revise policy in light of the first year's experience summarized in the annual statement produced by the bank *(fig. 4)*. The banker also posts each bank balance, so that every team knows its relative standing. Then the next year's price is posted together with the age of any blocks which have been wiped out by fire or hurricane, and play continues.

After about five to ten plays made one year at a time, policies are generally revised less and less, and so it is possible to speed up and post a decade of events at one time. However, each team must now follow its written policy for ten years and can only revise at the end of the decade. More time is given to fill out ten log delivery sheets at once, and the banker posts team standings at the end of the decade.

We generally have dealt with groups of 10 or 15 students divided into three teams and have always received enthusiastic responses. Seeing the forest change in front of their eyes in response to planned cutting and unplanned fires and storms seems to make a strong impression on the players. The board also helps visualize and test the effects of various forest changes during the planning stage, when an initial cutting policy is being developed. But the most gratifying result has been the obvious way the game stimulates the players to think about and discuss some of the really difficult decisions faced by the managers with real forests and financial responsibilities.

Another important aspect of this simple board game is that it logically leads to more complex simulation

Price per MBF	15·00 •
MBF cut this year	2730·00 •
Price per MBF	7·50 •
MBF salvaged this year	352·00 •
. . . .	• • • • •
Starting bank account −	50000·00 A
. . . .	• • •.• •
Stumpage income	43590·00 A
Interest on bank balance	0·00 A
Total	43590·00 A
. . . .	• • • • •
Interest paid on loan −	3500·00 A
Fixed costs −	500·00 •
Dividend paid on income −	0·00 A
Total −	4000·00 A
. . . .	• • • • •
Net return this year	39590·00 A
Ending bank balance −	10410·00 A
. . . .	• • • • •
Stumpage to date	43590·00 A
Interest to date	0·00 A
. . . .	• • • • •

Figure 4. Annual statement calculated by the banker. Figures at the right are simply the calculator tape clipped to the edge of the page to show the year's operation. The data on cut came from the log delivery slip and the constants were those given in the problem statement. A desk top calculator was programed to store the interest and dividend rates and fixed cost, and the banker merely had to give a starting bank balance (negative = a loan), any accumulated stumpage or interest income to date, and the year's cut and its price. The rest was automatically calculated and printed for a team's yearly operation. The calculations are those implied by the problem statement. This annual report is clipped to the right side of a file folder while the accompanying log delivery sheet is clipped to the left side.

and problem-solving techniques. A computerized version was published some years ago and has been useful to teachers (Gould and O'Regan 1965). Another outgrowth that has not yet been published should be mentioned. This is a paper-and-pencil scheme for scheduling harvests and choosing management regimes for a property made up of several forest stands. The format is similar to that used for a hand solution of the "transportation problem" in linear programing, but each line is equivalent to the board game. Although this model of a forest can be used to lay out the effects over time of many forest policies, it gets cumbersome as the management options increase. Fortunately the format leads students to think in linear programing terms without really knowing it, and it is easy for them to move to computer linear programing solutions. However, the simple board game is an excellent way to catch the attention of beginners even if they never use more complex forest simulators. ■

Literature Cited

Gould, E. M., Jr., and W. G. O'Regan. 1965. Simulation, a step toward better forest management. Harvard For. Pap. 13., 86 p.