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A FINANCIAL RETURN PROGRAM FOR FORESTRY INVESTMENTS Including Sensitivity of Results to Data Errors

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A Financial Return Program for Forestry Investments

Including Sensitivity of Results to Data Errors

by

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Abstract

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A generalized investment analysis computer program has been expanded to include a sensitivity analysis system both to facilitate the comparative analysis of competing investment opportunities and to determine the degree of data error required to influence the outcome of the investment analysis. Standard economic criteria such as internal rate of return and present net worth, are employed. The system is described in detail with computational formulae and instructions for data preparation.

Keywords: Economics, valuation, investment analysis

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INTRODUCTION

Rational land management decisions require knowledge of the financial return expected from forestry investments. While economic factors are far from the only relevant aspects of decisionmaking, they are often important ones. The long-term and complex nature of most forestry investments makes the hand computation of financial return a very laborious process. At best, hand computation restricts the number of alternative investments which can be expediently evaluated. Automation of the calculations is advantageous, both in terms of increased accuracy and in the volume of information which can be analyzed.

A number of well-documented computer programs are available which automate the financial return calculation (Hall, 1962; Row, 1963 and 1974; Schweitzer, et al, 1967; and Chappelle, 1969). These financial return programs differ in terms of user-flexibility and in the amount of data preparation required before the program can be used.

The objective in constructing the financial return program described in this handbook was to keep the program format as simple and generalized as possible while retaining all the aspects of a rigorous financial evaluation. This program is intended to be a production tool for users who require a very flexible program or who are relatively unfamiliar with complex computer operations. If a large number of complex investment cases must be analyzed, input data preparation becomes rather time consuming. One solution to the problem is to use the program developed by Row (1974) to provide the inputs for this program.

The objective of providing a simple tool was met in the construction of this program, but not without some cost. One cost is that this program requires more preparation of data, than some alternatives. While this forces the user to confront directly the assumptions he is making, it may lead to the use of rougher input data than if certain preliminary calculations were performed by the program. This tendency towards rougher data is counteracted in the program here described by the inclusion of an analysis of the sensitivity of financial return estimates to data errors. Up to six separate data input groups can be identified and subjected to sensitivity analysis to help determine if more refined data are necessary. There is little reason to expend time and money in data refinement if it takes a change in data far beyond the range of reasonable doubt to significantly influence profit estimation.

Profitability of investments is measured in terms of internal rate of return (IROR), present net worth (PNW), benefit-cost ratio (B/C), and present net worth per dollar of initial cost (PNW/IC).

The individual cases included in a batch run are then ranked according to each of the four profit level criteria in summary tables for ready comparison. If area expansion factors are provided, and the cases are mutually exclusive, the most profitable cases which exhaust any one of several budget levels are selected and tabulated. The average level of sensitivity to data errors for all the cases in the batch is also tabulated.

Sections I, II, and III of this handbook describe in detail the options available in analyzing individual cases. Section IV discusses provisions for comparisons among investment cases. Section V

contains the detailed instructions for the preparation of input cards. All technical discussions and formulae employed may be found in the appendices. A copy of the computer program, written in FORTRAN IV for the Univac 1108 (BCD) computer series, is available from the authors.

I. Individual Case Format

The basic format of individual cases is discussed in this section along with techniques employed to simplify input preparation. The detail of card punching specifications is presented in Section V.

A. *Basic transaction input.* The input for each case must be sufficient to identify the components of individual cost and benefit (return) transactions by year. As many as 60 individual transactions may be specified. Each transaction is identified by a value and a multiplier, and as a cost or a benefit. For example, in the loblolly pine reforestation case in figure 1, the commercial thinning transaction in year 30 is a benefit with a physical value of 3.1 thousand board feet and a price multiplier of $38.21 per thousand board feet. Similarly, a cost value may be designated in man-hours of labor input with a cost multiplier of dollar wage rate per man-hour. The multiplier can be ignored in either the case of return or costs by simply entering the total dollar magnitude as a value. A default multiplier of 1.0 is then used. This latter approach is illustrated in the figure 1 example by specifying the $135 site preparation and planting cost transaction in year 0 in total dollar input.

The key concept here is that a time-stream of costs and benefit transactions must be constructed before the financial return can be calculated. By design, however, the program is totally insensitive to the unit of measure of the cost and return items. For example, the return value may be externally identified as cords of pulpwood, thousands of board feet of sawlogs, or tons of chips. It may also be identified as hunting days or animal unit months of forage production. Similarly, the return multiplier may be externally differentiated by log grade or tree species if the user needs to differentiate prices in this manner. The program treats the entries merely as values and multipliers which allows a great amount of flexibility.

Some financial return programs internalize the calculation of both the values and the multipliers (Schweitzer, et al, 1967, and Row, 1974). In their programs, the physical yield, i.e. value, may be differentiated by product and grade. The price per unit, i.e., multiplier, is then determined by a regression equation internal to the program which considers the product and grade specified in the input. Such internal data manipulation often serves a useful purpose, but the aim here was to design a more general and manageable program. This program does not exclude the use of price equations; it merely requires their development and use outside of the program. The sensitivity analysis feature of this program can then be used to indicate the level of detail required to adequately describe the situation analyzed.

B. *Transaction repetition.* The program input is simplified if a cost or benefit of identical magnitude occurs at regular time intervals. An entire series of such repetitive transactions can be specified on one computer card by providing the year of the first transaction in the series, its value and multiplier, the interval between occurrences of the transactions, and the year of the last transaction of the series. The year of the last item in the series cannot be greater than that of the most distant independently entered transaction. The loblolly pine example uses this format for repeated prescribed burnings and commercial thinnings (fig. 1). This repetition format is especially convenient if annual carrying costs are incurred or if the investment induces an increase in annual allowable harvest. The program generates a transaction record for each repetition of the transaction. The total number of transactions, which equals those specified plus those generated through the repetition coding, cannot exceed 200.

C. *Extended time horizon and perpetuity.* As long as the limit on number of transactions is not violated, transactions can be specified for any number of rotations beyond the first one. For example, if the case analysis involves precommercial thinning of a 15-year-old pine stand, the management regime in the second rotation will not be identical to that in the first. The second will start with site preparation and planting which hopefully establishes stocking conditions that render another precommercial thinning unnecessary.

Before profitability of alternative investments can be validly compared, the alternatives must cover the same time horizon. Since the initial investments seldom mature at the same time, end-to-end repetition of rotations into perpetuity is one technique for achieving equal time horizons. Alternatively, any transaction or a whole rotation of transactions can be carried to perpetuity merely by

OPTION CONTROL	% INFLATION EFFECT	INTEREST RATES TO BE USED FOR PRESENT NET WORTH AND BENEFIT-COST ANALYSIS				BENEFIT INFLATION RATE	COST INFLATION RATE	SENSITIVITY PARAMETERS				DATA SHIFT	SUMMARY SUPPRESS
		1	2	3	4			PRESENT NET WORTH		INTERNAL RATE OF RETURN			
								CODE	AMOUNT	CODE	AMOUNT		
12		2.5	5.0	10.0	15.0			2	10.01		1.031		

BUDGET LEVELS
—DOLLARS—

1	2	3	4	5	6	7	8	9	10
10000.	25000.	50000.	75000.	100000.	125000.	150000.	175000.	200000.	250000.

CASE TITLE	CASE CODE
REFORESTATION LOBLOLLY PINE SITE 50-85 CU.FT./ACRE/YEAR	1

CASE CODE	AREA (THOUSANDS OF ACRES)
1	345.0

BENEFIT-COST	STOP CODE	YEAR	VALUE	GROUP CODE	MULTIPLIER	GROUP CODE	REP. INT. (YEAR)	REP. STOP (YEAR)	PERP. YEAR ROTATION	ITEM DESCRIPTION
C		0	135.0	1					70	SITE PREP AND PLANT
C		10	8.0	0			10	30	70	PRESCRIBED BURN
B		30	3.1	4	38.21	6	10	40	70	COMMERCIAL THINNING
B		50	4.1	4	38.21	6			70	COMMERCIAL THINNING
B		70	18.66	5	50.94	6			70	FINAL HARVEST
B	1	40	-2.52	0	50.94	6			40	FINAL HARVEST

Figure 1.—Sample card layout for a program execution.

designating the interval at which each transaction reoccurs into perpetuity.

D. *Cost and benefit inflation.* Studies have revealed that real stumpage prices have risen relative to the wholesale price of other commodities (USDA Forest Service, 1973, and Row, 1973). This program enables the user to assume any rate of real value change in cost and/or benefits, called "inflation rates" in this handbook. Real prices and costs should be used in financial analysis. Rates of value change should only be used under an assumption of relative price or cost increases (or decreases) and not merely to reflect changes in the value of the dollar, the true inflation rate.

The inflation rates can be used for either finite or perpetual rotations. When using a perpetual series of rotations, no PNW or B/C ratio is calculated if the discount rate is less than the higher inflation rate specified. The true PNW or B/C ratio in that instance would be infinite and the equations used for the calculations would fail.

E. *Incremental versus total investment analysis.* Individual cases can be evaluated as either incremental or total investments. A total investment analysis includes the costs and returns of a particular investment without regard for the foregone costs and returns of some alternative level of investment for the same area. An incremental or marginal analysis represents the costs and returns of the management regime of interest as positive numbers and the costs and returns of an alternative regime as negative inputs. The loblolly pine reforestation example is framed as an incremental investment (fig. 1).

The advantage of the marginal approach is that all costs and returns which remain the same under both investment levels, such as annual taxes, land value, and annual protection costs, can be ignored. The disadvantage of this approach is that, while the incremental investment may be profitable, the total investment might not be. The profitability of the total investment can only be estimated by evaluating the total investment.

Whichever combination of these options for formulating an investment case is used, the program provides a detailed input listing of the major options selected and of the case input (fig. 2). This listing provides good documentation of the case investment analyzed for future reference.

II. Calculation of Investment Profitability

Once the time stream of cost and return transactions has been constructed from any of the permissible steps previously outlined, the financial return of that stream is measured by four parameters. The first is internal rate of return (IROR), which is the discount rate that equates the present value of discounted costs and returns. Stated alternatively, IROR is the rate at which the investment "*grows*" into the accrued returns.

The second parameter is present net worth (PNW) which is the present value of the return minus the present value of the cost transactions. This is calculated for each of up to four specified discount rates. The PNW is a measurement for either the net return per acre or the net return for an entire tract, depending solely upon whether the program input is provided on a per acre or total tract basis. Third is the benefit-cost ratio (B/C) which is the ratio of discounted benefits to discounted costs, with discounting done at the same discount rates used in PNW calculations. The fourth parameter is the ratio of PNW to initial investment cost. This standardizes for the scale of investment among the competing investments. This makes them more comparable just as perpetual rotation standardizes the investment horizon of alternative investments. The formulae for these various calculations are shown in Appendix A.

The relative merits of these alternative financial return measures have received considerable attention in the technical literature. Each selection criterion, as typically employed, has its own disadvantages. For example, IROR does not standardize the reinvestment rate for intermediate returns. Instead, the intermediate returns of each case are assumed to be reinvested at the IROR of that case. Similarly, PNW alone does not standardize for different scales of investment between cases.

These differences among criteria can and do result in different rankings of forestry investments. Studies have shown, however, that the ranking differences are of little importance if the investments are not mutually exclusive (Haley, 1969, and Webster, 1965). Investments are mutually exclusive if the execution of one investment precludes undertaking another. A mutually exclusive example is precommercial thinning of the same area to two different stocking levels. Only the highest return investment of mutually exclusive investments should be included in the analysis. When

```
            INVESTMENT ANALYSIS SYSTEM
                    WITH
          MEASUREMENT OF THE SENSITIVITY
                    OF
             INTERNAL RATE OF RETURN
                    AND
                PRESENT NET WORTH
                    TO
              CHANGES IN INPUT


                CONTROL OPTIONS

          2 = OUTPUT LEVEL
          2 = SENSITIVITY INTEREST RATE SELECTOR
    2.50000 = FIRST INTEREST RATE
    5.00000 = SECOND INTEREST RATE
   10.00000 = THIRD INTEREST RATE
   15.00000 = FOURTH INTEREST RATE
     .00000 = BENEFIT INFLATION RATE
     .00000 = COST INFLATION RATE
          2 = PRESENT NET WORTH SENSITIVITY CODE
   10.00000 = PRESENT NET WORTH SENSITIVITY AMOUNT
          1 = RATE OF RETURN SENSITIVITY CODE
    1.00000 = RATE OF RETURN SENSITIVITY AMOUNT

BUDGET LEVELS IN THOUSANDS OF DOLLARS
    5000.0    10000.0    15000.0    30000.0    45000.0    60000.0    75000.0    90000.0   105000.0   120000.0


CASE 36
                        CASE NO.  2 OF THIS RUN


INPUT FOR PRECOMMERCIAL THIN      LOBLOLLY-SHORT      REGION 8      SITE 85-120

INTENSIFIED MANAGEMENT
                 GROUP              GROUP                                GROUP REPETITION  PERPETUITY
     YEAR  HARVEST CODE    PRICE    CODE    BENEFIT      COST  CODE  INT. STOP    YEAR    DESCRIPTION
        0                                               31.00     2     0    0       0    PRECOMMERCIAL THINNING
       10                                                8.00     0     0    0       0    PRESCRIBED BURN
       20                                                8.00     0     0    0       0    PRESCRIBED BURN
       20   5.2200    4    38.21     6     199.46                          0    0       0    COMMERCIAL THINNING
       30   4.8600    4    38.21     6     185.70                          0    0       0    COMMERCIAL THINNING
       40   7.2900    4    38.21     6     278.55                          0    0       0    COMMERCIAL THINNING
       60  31.2000    5    50.94     6    1589.33                          0    0       0    FINAL HARVEST
       60                                              135.00     1     0    0      70    SITE PREP AND PLANT
       70                                                8.00     0     0    0      70    PRESCRIBED BURN
       80                                                8.00     0     0    0      70    PRESCRIBED BURN
       90                                                8.00     0     0    0      70    PRESCRIBED BURN
       90   5.2200    4    38.21     6     199.46                          0    0      70    COMMERCIAL THINNING
      100   4.8600    4    38.21     6     185.70                          0    0      70    COMMERCIAL THINNING
      110   7.2900    4    38.21     6     278.55                          0    0      70    COMMERCIAL THINNING
      130  31.2000    5    50.95     6    1589.64                          0    0      70    FINAL HARVEST
CURRENT MANAGEMENT
                 GROUP              GROUP                                GROUP REPETITION  PERPETUITY
     YEAR  HARVEST CODE    PRICE    CODE    BENEFIT      COST  CODE  INT. STOP    YEAR    DESCRIPTION
       35  -7.3800    5    50.94     6    -375.94                          0    0      45    FINAL HARVEST
       35                                             -135.00     1     0    0      45    SITE PREP AND PLANT

AREA FOR CASE 36 IS      36.00 THOUSAND ACRES


RATE OF RETURN SEARCH FINISHED
AT  13.00%  SUM OF DISCOUNTED BENEFITS    25.198 IS LESS THAN  INITIAL COST    31.000
```

Figure 2.—Output of program controls and individual case input.

investments are not mutually exclusive, the lower return ones are simply moved farther down the investment rank to be selected when and if budgets are adequate.

If cost and return schedules include large transactions with alternating costs and returns, more than one IROR may exist (Marty, 1970, and Gansner and Larson, 1969). This sometimes occurs when evaluating incremental investments. Such a case might have an investment cost in year 0, followed by a positive value for the harvest of the intensified management regime, and finally a negative value for the foregone harvest of the less intense regime. This situation is a phenomenon of the cost and return stream and not of the IROR selection criterion. The use of IROR merely exposes some details of the shape of the PNW function. This program locates and reports all IROR's between 0 percent and 50 percent. The highest IROR where PNW is decreasing is the

IROR about which the sensitivity to data errors is measured and is the IROR used in ranking investments.

The standard profitability output from the program repeats the case title card and lists the values of the four financial return parameters (fig. 3). More detail is available if desired. By inserting a code on the master control card, the present value of each transaction in the cost-revenue stream at each of the specified discount rates is available. Appendix B shows the detailed output for the loblolly pine sample case. The transactions created by use of the repetition code are also listed in this detailed output instead of being condensed as they are in the briefer input listing in figure 2.

III. Profit Level Sensitivity to Data Changes

Anyone who has ever estimated the financial return from forestry investments knows that much of the data input must be estimated with varying degrees of certainty. For example, the estimated final harvest may deviate from the actual harvest by several percent either way. The same can be said of stumpage price and treatment cost estimates. These estimates can usually be further refined, but at a cost in both time and money.

An alternative course to refining estimates across the board is first to determine if data changes within the bounds of data uncertainty have any significant influence upon estimated financial return. If estimated financial return is influenced little by possible data errors, there is no reason to develop more refined data.

The first step in this sensitivity analysis is to record possible percentage deviations of actual data about the estimated data point. This should be done for each data element which will be subjected to separate sensitivity analysis. The second step is to establish the amount of acceptable fluctuation or error between the estimated financial return and the financial return associated with some data change. This predetermined financial return deviation can be specified in a number of alternative ways with this program:

(1) an absolute ± change about the base profit level, expressed as either a dollar change for PNW or an interest rate change for IROR,
(2) a ± percentage change about base profit level for either PNW or IROR, or
(3) a ± percentage change about the base PNW equal to the acceptable percentage change in the base IROR criterion. This last threshold concept, called the "computed" PNW threshold in the program output, places the IROR and PNW criteria on a comparable basis for sensitivity comparison.

Once the cost-return stream is constructed and these error thresholds established for data elements and financial return, the program answers the question:

"How much of a percentage change in separate data elements must occur before the estimated financial return deviates from its base estimate

PRECOMMERCIAL THIN LOBLOLLY-SHORT REGION 8 SITE 85-120

BASE DATA PROFIT LEVELS

INTERNAL RATE OF RETURN 10.8411

SPECIFIED INTEREST RATE	PRESENT NET WORTH	BENEFIT COST RATIO	PRESENT NET WORTH PER $ INITIAL COST
2.5000	586.0972	-475.7765	18.9064
5.0000	154.9534	8.9867	4.9985
10.0000	7.3042	1.2367	.2356
15.0000	-18.9154	.4177	-.6102

Figure 3.—Profit level output for example investment case.

enough to violate the predetermined financial return error threshold?"

The calculated data change necessary to violate the error threshold is compared with the possible bounds of data error previously recorded. If the calculated data change exceeds the possible data error range, further data refinement is not required. If, however, the calculated data change is less than the previously recorded data error range, more refined data must be collected to bring the estimated financial return within the predetermined error thresholds.

Six separate data element groups can be subjected to sensitivity analysis, three for costs and three for returns. The sensitivity groups codes can be assigned to either the transaction value or multiplier, and different sensitivity group codes can be assigned to the value and the multiplier of the same transaction. The *same* code cannot be used on *both* the value and multiplier of the same transaction, however, because of the way the allowable percentage changes are calculated. The sensitivity group codes can also be applied to either or both of the management regimes of an incremental analysis.

The sensitivity of each of the six data groups is calculated separately. The allowable percentage data change is separately calculated for each group of similar elements assuming all other data are unchanged. The data are then returned to their original values before sensitivity to the next group is calculated. The sensitivity to joint changes is not included in the program because of the large number of joint changes possible.

Four data groups were subjected to sensitivity analysis in the loblolly pine sample case. The position of the group codes is shown in figure 2 and the sensitivity analysis output is shown in figure 4. The allowable percentage changes are just that, percentage changes rather than direct multipliers. For example, the actual stumpage price must be 50.33 percent higher than the estimated stumpage price of the case before the estimated IROR of the case would increase by 1 percent from 3.4827 percent to 4.4827 percent. The base prices were $38.21 and $50.94 per thousand board feet for commercial thinnings and final harvests of the intense management regime, respectively. Thus, the actual prices must be as high as $57.44 and $76.58 per thousand board feet, respectively, before the estimated IROR underestimates the actual IROR by 1 percent. Conversely, actual stumpage prices must be 32.95 percent below the input prices before the actual IROR is 1 percent below the estimated IROR. The allowable data change must be applied to all of the data elements identified by the code before the profitability error threshold is violated. Appendix C provides the formulae used to calculate the allowable percentage data change.

IV. Comparison Among Investment Cases

Up to 60 individual investment cases in any one computer run can be compared or compiled in three ways once the profit measure and sensitivity analysis on each case have been conducted. First, the cases are ranked according to each of the four profit measures. This merely automates the ranking that is often done by hand and provides a ready summary of cases analyzed. Each case is identified by its title card, its assigned case number (CASE), and the order that case was entered in that particular computer run (ISN). The PNW, B/C ratio, and PNW per dollar of initial investment are all discounted at the same discount rate selected for the sensitivity analysis. Figure 5 displays a sample ranking of the investment cases by IROR.

Second, the program selects investment cases down each of the four rankings until each of up to ten budget levels is exhausted. If the cases are analyzed on a per-acre basis, an acreage expansion factor must be specified in the input. If the total costs and returns of an entire case area are directly included, an acreage expansion factor of *1* must be provided. Only initial (year zero) treatment costs are charged against the budget levels. Future costs are not.

Cases are sequentially added down a particular ranking until the summation of initial costs for the case areas equals the first budget level. The last case selected for budget inclusion and the proportion of that marginal case employed are reported along with the PNW of the investments included in that budget. The discount rate used in calculation of the budget PNW is the same one used in PNW ranking. Additions to smaller budgets are made by starting from where that budget left off in the rank and adding cases until the next budget level is exhausted. Figure 6 shows the budget output of the program.

The budget construction phase of the program will execute whenever budget levels and acreage

SENSITIVITY ANALYSIS

PRECOMMERCIAL THIN LOBLOLLY-SHORT REGION 8 SITE 85-120 36

THRESHOLD SELECTION CRITERIA

RATE OF RETURN - PLUS OR MINUS AN ABSOLUTE 1.00 PERCENT RATE OF RETURN

PRESENT NET WORTH - PLUS OR MINUS 10.00 PERCENT OF BASE PRESENT NET WORTH

THRESHOLDS SELECTED

BASE RATE OF RETURN IS 10.8411 RANGE IS 9.8411 THROUGH 11.8411
CORRESPONDING PRESENT NET WORTH RANGE IS 8.9135 THROUGH -6.6112

BASE PRESENT NET WORTH AT 5.00 PERCENT IS 154.9534 RANGE IS 139.4581 THROUGH 170.4487

RATE OF RETURN THRESHOLD IS PLUS OR MINUS 9.22 PERCENT OF THE BASE RATE OF RETURN
THIS PERCENTAGE APPLIED TO THE BASE PRESENT NET WORTH GIVES A RANGE OF 140.6602 THROUGH 169.2466

PERCENT CHANGE IN INPUT REQUIRED TO REACH UPPER AND LOWER THRESHOLDS (BY GROUP)

	---SPECIFIED LIMIT-- ---RATE OF RETURN--- UPPER THRESHOLD	LOWER THRESHOLD	---SPECIFIED LIMIT-- --PRESENT NET WORTH- UPPER THRESHOLD	LOWER THRESHOLD	---COMPUTED LIMIT--- --PRESENT NET WORTH- UPPER THRESHOLD	LOWER THRESHOLD
INPUT DATA GROUPS	11.8411	9.8411	170.4487	139.4581	169.2466	140.6602
COST ITEMS						
1. REFORESTATION	260.1950	-191.9345	77.2207	-77.2207	71.2297	-71.2297
2. PRECOMMERCIAL THINNING	-21.3263	28.7532	-49.9850	49.9850	-46.1070	46.1070
RETURN ITEMS						
4. COMMERCIAL THINNING	21.3806	-18.4850	9.5025	-9.5025	8.7653	-8.7653
5. FINAL HARVEST	-117.9946	103.8867	137.2658	-137.2658	126.6163	-126.6163
6. STUMPAGE PRICE	26.1121	-22.4861	8.8872	-8.8872	8.1977	-8.1977

Figure 4.—Sensitivity analysis output for example investment case.

CASES RANKED BY INTERNAL RATE OF RETURN

RANK	ISN	CASE LABEL				CASE	VALUE
1	1	RELEASE	DOUGLAS FIR	REGION 6	SITE 120+	39	14.7541
2	2	PRECOMMERCIAL THIN	LOBLOLLY-SHORT	REGION 8	SITE 85-120	36	10.8411
3	3	RELEASE	LONGLEAF-SLASH	REGION 8	SITE 85-120	48	8.8233
4	4	PRECOMMERCIAL THIN	LOBLOLLY-SHORT	REGION 8	SITE 50-85	37	8.6254
5	5	RELEASE	LOBLOLLY-SHORT	REGION 8	SITE 50-85	51	7.0204
6	6	RELEASE	FIR-SPRUCE	REGION 6	SITE 50-85	45	5.3315
7	7	REFORESTATION	LONGLEAF-SLASH	REGION 8	SITE 85-120	18	4.9365
8	8	REFORESTATION	LOBLOLLY-SHORT	REGION 8	SITE 85-120	20	4.8636
9	9	REFORESTATION	PONDEROSA PINE	REGION 5	SITE 120+	8	4.3920
10	10	PRECOMMERCIAL THIN	FIR-SPRUCE	REGION 6	SITE 85-120	33	3.8909
11	11	RELEASE	PONDEROSA PINE	REGION 5	SITE 85-120	42	3.5747
12	12	REFORESTATION	PONDEROSA PINE	REGION 1	SITE 85-120	5	3.2525
13	13	REFORESTATION	DOUGLAS FIR	REGION 5	SITE 85-120	2	2.8304
14	14	REFORESTATION	FIR-SPRUCE	REGION 1	SITE 85-120	12	2.4017
15	15	RELEASE	FIR-SPRUCE	REGION 5	SITE 85-120	44	2.3094
16	16	REFORESTATION	PONDEROSA PINE	REGION 6	SITE 50-85	10	2.0073
17	17	PRECOMMERCIAL THIN	LODGEPOLE PINE	REGION 1	SITE 120+	34	1.6096
18	18	RELEASE	LODGEPOLE PINE	REGION 1	SITE 85-120	46	1.5624
19	19	REFORESTATION	LODGEPOLE PINE	REGION 1	SITE 85-120	15	1.5055
20	20	PRECOMMERCIAL THIN	DOUGLAS FIR	REGION 3	SITE 50-85	25	.9866
21	21	REFORESTATION	LODGEPOLE PINE	REGION 2	SITE 50-85	16	.5110

Figure 5.—Sample IROR ranking for all cases included in a single computer run.

expansion factors are provided. The budgeting aspect should not be used, however, if any of the investment cases included in the run are mutually exclusive. The program treats all cases as if they were not mutually exclusive.

Third, a summary table of the sensitivity analysis results is constructed. The sensitivity to data errors is often quite variable from case to case. The summary table calculates the mean allowable data change for each of the data groups identified in the cases and the standard deviation about the mean. The average sensitivity of the IROR, PNW, and "computed" PNW thresholds are all reported. The mean includes the sensitivity to any data element in the cases identified by the same sensitivity group code. Therefore, it is essential that the codes be applied to data elements in each case which are comparable enough to have some meaning when averaged together. Figure 7 shows a sample of the sensitivity analysis summary table.

V. Punched Card Input Format Instructions

This section contains the instructions for preparing the computer cards necessary to perform the analysis described. There are two groups of cards: those which are permanent and those which vary from run to run. There are two types of permanent cards: sensitivity data element group names, and the STOP card. There are five types of variable cards: a master control card, a budget level card, a case title card, a case area card, and a set of cost and benefit transaction cards.

A. *Permanent cards.* Seven permanent data cards are required for each run in addition to the control and transaction cards which may vary from run to run.

1. *Sensitivity group label cards.* Each run requires six of these cards. They contain (in columns 1–26) the names of the six sensitivity analysis groups respectively. Thus, the names of the groups may be changed without program modification.

2. *Stop card.* One stop card is required for each run. This card is punched "STOP" in columns 1–4. It is the last data card in the deck.

B. *Variable cards.* The data in these cards varies according to the purpose of the run. The first three cards contain data pertaining to all cases being analyzed in the run and must always be present. The number of the remaining cards will vary both with the number of cases being analyzed and with the number of transactions for each case.

1. *Master control card.* This card contains 14 data fields as follows:

Field	Card *columns*	*Format*	*Information*
1	1	I1	Output control code—Code *1* for detailed discounted benefit-cost tables for each interest

COMPARATIVE CASE RANKINGS - - PRESENT NET WORTHS AND BENEFIT-COST RATIOS AT 5.0% INTEREST

	--RATE OF RETURN--		-PRESENT NET WORTH		BENEFIT-COST RATIO		-PNW/INITIAL COST-	
RANK	CASE	VALUE	CASE	VALUE	CASE	VALUE	CASE	VALUE
1	(39)	14.7541	(39)	187.5914	(36)	8.9867	(39)	6.2530
2	(36)	10.8411	(36)	154.9534	(39)	7.0860	(36)	4.9985
3	(48)	8.8233	(48)	123.4543	(48)	4.3111	(48)	2.4207
4	(37)	6.6254	(37)	74.6600	(37)	3.8790	(37)	2.4084
5	(51)	7.0204	(51)	54.6600	(51)	2.1900	(51)	1.0718
6	(45)	5.3315	(45)	4.6343	(45)	1.1205	(45)	.1220
7	(18)	4.9365	(18)	-4.2434	(18)	.9660	(18)	-.0314
8	(20)	4.8636	(20)	-9.1556	(20)	.9281	(20)	-.0678
9	(8)	4.3920	(42)	-19.3460	(8)	.7411	(33)	-.2934
10	(33)	3.8909	(33)	-28.1709	(33)	.7088	(8)	-.3316
11	(42)	3.5747	(46)	-32.9560	(42)	.3884	(42)	-.6241
12	(5)	3.2525	(44)	-35.6083	(2)	.3398	(5)	-.8074
13	(2)	2.8304	(25)	-45.2013	(5)	.3213	(2)	-.8147
14	(12)	2.4017	(8)	-48.4142	(12)	.1789	(44)	-.8685
15	(44)	2.3094	(34)	-50.2173	(44)	.1482	(34)	-.9300
16	(10)	2.0073	(5)	-79.1288	(10)	.0982	(46)	-.9416
17	(34)	1.6096	(12)	-95.7264	(15)	.0906	(12)	-.9768
18	(46)	1.5624	(15)	-116.1774	(34)	.0824	(25)	-.9826
19	(15)	1.5055	(2)	-119.7682	(46)	.0679	(15)	-1.0562
20	(25)	.9866	(10)	-169.8074	(16)	.0230	(10)	-1.0613
21	(16)	.5110	(16)	-195.1557	(25)	.0192	(16)	-1.1616

TOTAL PRESENT NET WORTH AT FIXED BUDGET LEVELS WITH RANK OF MARGINAL CASES
(BUDGET LEVELS AND PRESENT NET WORTHS IN THOUSANDS OF DOLLARS)

	RANKING CRITERIA											
	--INTERNAL RATE OF RETURN--			-----PRESENT NET WORTH-----			-----BENEFIT/COST RATIO----			-PNW PER $ OF INITIAL COST-		
BUDGET LEVELS	MARGINAL CASE RANK	TOTAL PRESENT NET WORTH	% MARGINAL CASE	MARGINAL CASE RANK	TOTAL PRESENT NET WORTH	% MARGINAL CASE	MARGINAL CASE RANK	TOTAL PRESENT NET WORTH	% MARGINAL CASE	MARGINAL CASE RANK	TOTAL PRESENT NET WORTH	% MARGINAL CASE
5000.0	5	17898.16	88.1	5	17898.16	88.1	5	17898.16	88.1	5	17898.16	88.1
10000.0	8	18004.22	9.0	8	18004.22	9.0	8	18004.22	9.0	8	18004.22	9.0
15000.0	8	17665.12	89.6	8	17665.12	89.6	8	17665.12	89.6	8	17665.12	89.6
30000.0	13	8808.29	68.1	17	8120.04	11.4	12	8793.95	92.4	13	8808.29	68.1
45000.0	19	-5523.82	39.2	20	-5482.82	54.0	19	-5631.16	50.4	20	-5482.82	54.0
60000.0	**	-22382.75	.0	**	-22382.75	.0	**	-22382.75	.0	**	-22382.75	.0
75000.0	**	-22382.75	.0	**	-22382.75	.0	**	-22382.75	.0	**	-22382.75	.0
90000.0	**	-22382.75	.0	**	-22382.75	.0	**	-22382.75	.0	**	-22382.75	.0
105000.0	**	-22382.75	.0	**	-22382.75	.0	**	-22382.75	.0	**	-22382.75	.0
120000.0	**	-22382.75	.0	**	-22382.75	.0	**	-22382.75	.0	**	-22382.75	.0

* INDICATES THAT THE CASE AT THIS RANK USES UP THE STATED BUDGET EXACTLY
** INDICATES THAT THIS BUDGET LEVEL WILL COVER ALL THE CASES IN THIS RUN

Figure 6.—Sample output of case ranking by four profit criteria and budget level constraints.

MEANS AND STANDARD DEVIATIONS OF SENSITIVITY PERCENTAGES BY CRITERION AND ITEM

ALL CASES

	CRITERION AND LIMIT											
	----ROR-UPPER LIMIT---			----ROR-LOWER LIMIT---			--PNW-SPECIFIED LIMIT-			--PNW-COMPUTED LIMIT--		
	N	MEAN %	SD	N	MEAN %	SD	N	MEAN %	SD	N	MEAN %	SD
COST ITEMS												
1. REFORESTATION	18	-2185.07	5999.3871	16	258.95	815.2878	18	8330.8322504.8637		18	68873.20**********	
2. PRECOMMERCIAL THINNING	17	-387817.26**********		15	102524.80**********		17	269.56	574.0387	17	805.15	1538.6100
3. RELEASE	7	-38.86	19.7255	7	143.79	171.2711	7	17.57	21.0300	7	28.96	19.4452
RETURN ITEMS												
4. COMMERCIAL THINNING	21	129.93	111.9883	19	-72.14	46.2010	21	98.01	181.6389	21	1115.40	3126.2472
5. FINAL HARVEST	21	5342.7421965.9064		19	-1607.56	7033.6333	21	2523.32	9313.1119	21	23932.4594565.2352	
6. STUMPAGE PRICE	21	86.43	55.0972	19	-42.03	13.9182	21	75.41	137.5107	21	802.78	2052.8686

THE 21 CASES HAD A MEAN RATE OF RETURN OF 4.5729% WITH A STANDARD DEVIATION OF 3.6299

0 CASES HAD MORE THAN ONE INTERNAL RATE OF RETURN

Figure 7.—Sample sensitivity analysis summary table.

Field	Card *columns*	*Format*	*Information*
			rate specified in fields 3–6 of this card and for each interest rate involved in the rate of return sensitivity (as in Appendix B). Code *2* for present net worth and benefit-cost ratio summary tables only (as figure 3).
2	2	I1	Interest rate selector code—*1*, *2*, *3*, or *4*, respectively to indicate which of the four interest rates entered in fields 3–6 of this card is to be used as the base in the sensitivity analysis of present net worth. Use code zero (*0*) to suppress all sensitivity analysis and summary tables.
3	3–10	F8.4	First interest rate (expressed as a percentage)—the first (usually but not necessarily the lowest) interest rate to be analyzed for each case. If 0.0 percent is to be analyzed it must be entered in this field (field 3). A zero or blank in fields 4 or 5 precludes the analysis of any interest rates subsequently entered in fields 4–6. Note: The 0.0 percent interest rate cannot be analyzed for cases involving perpetual series as specified in field 10 of the *Transaction Cards*.
4–6	11–34	3F8.4	The second, third, and fourth interest rates respectively to be analyzed for each case—Any or all may be omitted. The first zero or blank field of fields 4–6 negates any valid interest rates to the right of it.
7	35–42	F8.4	Benefit inflation rate[1] (expressed as a percentage)—Must be less than any interest rate in fields 3–6 if perpetual discounting is used for any transaction.
8	43–50	F8.4	Cost inflation rate[1]—See field 7 above.
9	51	I1	Present net worth sensitivity code—Code *1* if the value in field 10 is an absolute amount to be added to and subtracted from PNW to establish upper and lower thresholds. Code *2* if the value in field 10 is a percentage of the PNW. Leave blank if no sensitivity analysis is wanted.
10	52–59	F8.4	PNW sensitivity amount—See field 9 above.
11	60	I1	IROR sensitivity code—Code *1* if the value in field 12 is an absolute amount to be added to and subtracted from the IROR to establish upper and

[1] Inflation rate as used here, in appendix A, and in figure 1 refers to rates of real value or real price increases or decreases and not to changes in the value of the dollar alone.

Field	Card columns	Format	Information
			lower thresholds. Code *2* if the value in field 12 is a percentage of the IROR. Leave blank if no sensitivity analysis is wanted.
12	61–68	F8.4	IROR sensitivity amount—See field 11 above.
13	69	I1	Data sift code—Code *1* if only intensified management *Transaction Cards* are to be included in the financial analysis. Code *2* if only current management *Transaction Cards* are to be included in the financial analysis. (Current management *Transaction Cards* must be distinguished by the minus sign on the value in field 4). Code *3* if all *Transaction Cards* are to be included, i.e., an incremental investment is subjected to financial analysis.
14	70	I1	Summary suppression code—Code *1* to suppress summary tables or leave blank to print tables.

2. *Budget level card.* This card contains up to ten budget levels in the format 10F8.4. The expanded initial costs of the ranked cases will be examined at each budget level to determine which cases would be made operational at that budget level for each of four ranking criteria. (Expanded initial cost is the product of the total cost in the beginning year times the area expansion factor from the *Case Area Card.*) This card must be included, but it may be left blank if no budget levels are to be used.

3. *Case title card.* One of these cards is required for each of up to 60 cases in a run. Columns 1–72 contain any alpha-numeric information which will identify the case in the program output. Columns 73–75 contain a unique numeric case code for each case in the run. This code is assigned by the user. Columns 76–80 should be blank.

4. *Case area card.* If the values in the *Transaction Cards* are per-acre estimates, this card carries the area expansion factor for that case in thousands of acres. Columns 1–3 contain the same unique case code as columns 73–75 of the *Case Title Card.* Columns 4–11 contain the area expansion factor in the format F8.4. This card is mandatory for each case. If the expansion factor is zero or blank, it will be set at 1.0 by the program implying that the *Transaction Cards* carry the costs and returns for the whole tract.

5. *Transaction cards.* The program allows up to 60 of these cards for each case to be analyzed. Repetitious transaction records generated by fields 8–9 may add records up to a total of 200 transactions. These cards each provide for 11 fields of information as follows:

Field	Card columns	Format	Information
1	1	A1	Alphabetic benefit-cost code—Code B for *Transaction Cards* describing benefit transactions or C for cards describing cost transactions. Any other code will be reset to B and a warning printed.
2	2	I1	Stop Code—Code *1* on the last *Transaction Card* of each case. Leave blank on *all* others. Cards with field 2 coded must be followed either by a *Case Title Card* or by the *Stop Card.*
3	3–6	I4	Year–Enter the year of the transaction relative to zero as the present or base year.
4	7–16	F10.4	Value–For benefits, this may be harvest volume per acre. For costs, this may be the number of units of expenditure. Enter the value as a negative number for the current management regime of a marginal analysis. The current management *Transaction Cards* must all follow the intensified management cards.
5	17–19	I3	Value sensitivity group code—Enter the group to which the value belongs for sensitivity analysis. Enter *1*, *2*, *3*, *4*, *5*, or *6* depending upon which group the value falls in. The codes correspond sequentially to the titles in *Sensitivity Group Label Cards.* Leave blank if no

Field	Card columns	Format	Information
			sensitivity analysis is wanted for this value.
6	20–29	F10.4	Value multiplier—for benefits, this may be stumpage price. For costs this may be the cost per unit of expenditure. This multiplier must not be negative. If zero or blank, it will be reset to 1.0.
7	30–32	I3	Multiplier sensitivity group code—Enter a sensitivity code from among those described in the *Sensitivity Group Label Cards*. The code must be different than that shown in field 5 or may be blank. It cannot be the same as the code in field 5.
8	33–36	I4	Repetition interval—For identical transactions occurring at regular intervals, beginning at the year specified in field 3, enter the interval in years. The additional transaction records are generated by the program, bypassing the necessity of coding and keypunching a separate card for each occurrence of the transaction. Leave blank for nonrepetitive transactions.
9	37–40	I4	Repetition stop year—Enter the year (relative to zero as the present or base year) beyond which repetitious transaction records will not be generated. This entry may not be higher than the highest year specified in field 3 of any *Transaction Card* for the case. If it is equal to the highest year, or if the transaction is nonrepetitive, this entry may be omitted.
10	41–44	I4	Perpetuity year—If the transaction is to be discounted as a perpetual series, enter the recurrence period in years. If this field is coded, any 0.0 percent interest rates specified on the *Master Control Card* will be ignored for the case in question. Any or all of the Transaction Cards may include a perpetuity year and the perpetuity codes may differ among transactions. Leave this field blank when discounting a terminable or finite series.
11	45–72	7A4	Description—Up to 28 alphanumeric characters may be used as a label for the transaction described by each *Transaction Card*.

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APPENDIX A—PROFIT LEVEL COMPUTATION

Present net worth (PNW) and benefit-cost ratios (B/C) are computed from the discounted values of each transaction in the schedule of transactions which defines an investment opportunity. The sum of the discounted benefit transactions minus the sum of the discounted cost transactions is the PNW of the investment opportunity. The corresponding quotient of these two sums is the B/C ratio for the investment opportunity.

One of the following two equations is used to discount each transaction depending upon whether the transaction is to be discounted as a one-time occurrence (finite discounting) or as a perpetual series into infinity (perpetual discounting).

A. Finite discounting formula:

$$DV = A \times \frac{1}{\left(\frac{R}{N}\right)^{Y}}$$

B. Perpetual discounting formula:

$$DV = A \times \frac{\left(\frac{R}{N}\right)^{P-Y}}{\left(\frac{R}{N}\right)^{P-1}}$$

Where:

A = The value of the transaction expressed in current dollars.

DV = The discounted value of A.

Y = The year of first occurrence of the transaction in terms of zero as the current year.

P = The number of years between recurrences of the transaction (when discounting perpetually).

R = The annual interest (or discount) rate expressed in decimals plus 1. (e.g., when the interest is 5 percent then R = 1.05.)

N = The estimated rate of annual inflation expressed in decimals plus 1. (e.g., when the inflation rate is estimated to be 2.5 percent N = 1.025.)

R must be greater than N when equation (B) is to be used.

The internal rate of return (IROR) is defined as the interest rate at which the PNW of the investment is zero and the B/C ratio is 1.0. For any given investment, there will usually be only one such interest rate. However, there may be more than one such rate depending upon the magnitude and the signs of the transaction values.

The search for IROR begins at one of two interest rates. If all transactions are to be finitely discounted (Equation A used throughout) or if the estimated rate of inflation is zero, the starting interest rate is 0.0001 percent. If any transaction is to be discounted perpetually, and the highest inflation rate is not zero, the starting interest rate is equal to the inflation rate plus 0.0001 percent. In the first instance, zero percent cannot be used because transactions cannot be discounted perpetually at zero percent interest. In the second instance, the benefit inflation rate cannot be used as a starting point because with perpetual discounting, the interest rate must be greater than the inflation rate (R>N).

Starting with the beginning interest rate, subsequent internal rates are tested in increments of 1.0 percent until a change in the sign of the PNW occurs. At this point an IROR has been detected. The estimate of IROR is refined by subtracting 1.0 from the interest rate and further testing at an interval of 0.1 percent again until another change in the sign of the PNW occurs. This process is repeated until IROR is correct to five decimal places.

After each IROR is computed, the testing rate returns to the rate which detected the presence of that IROR. The testing then resumes at 1.0 percent intervals.

Seldom will the testing continue up to the maximum test rate of 50 percent interest. A rate would commonly be attained before that where the sum of the discounted benefit transactions is less than the sum of the positive costs in the year zero. Beyond this point, no higher interest rates need be tested because the sign of the present net worth cannot change again. The search is terminated at this point.

APPENDIX B—SAMPLE DETAIL PROFIT LEVEL OUTPUT

```
 FORESTATION   LOBLOLLY PINE   SITE 50-85 CU.FT./ACRE/YEAR              1

DISCOUNTED BENEFITS AND COSTS AT  2.5000% INTEREST      PNW =    124.42949829      BCR =     1.68249105

 YEAR        BENEFIT    GROUP  DESCRIPTION                 YEAR        COST       GROUP  DESCRIPTION
                                                              0     164.14443056   1 0   SITE PREP AND PLANT
                                                             10       7.59877729   0 0   PRESCRIBED BURN
                                                             20       5.93615268   0 0   PRESCRIBED BURN
   30      68.66179501   4 6   COMMERCIAL THINNING
                                                             30       4.63731298   0 0   PRESCRIBED BURN
   40      53.63848452   4 6   COMMERCIAL THINNING
   50      55.41916883   4 6   COMMERCIAL THINNING
   70     205.20710134   5 6   FINAL HARVEST
   40     -76.18037790   0 6   FINAL HARVEST

TOTAL     306.74617180                                 TOTAL     182.31667351
-------------------------------------------------------------------------------------------------------------

DISCOUNTED BENEFITS AND COSTS AT  5.0000% INTEREST      PNW =    -78.78712867      BCR =      .47369081

 YEAR        BENEFIT    GROUP  DESCRIPTION                 YEAR        COST       GROUP  DESCRIPTION
                                                              0     139.58771317   1 0   SITE PREP AND PLANT
                                                             10       5.07820724   0 0   PRESCRIBED BURN
                                                             20       3.11757873   0 0   PRESCRIBED BURN
   30      28.33826018   4 6   COMMERCIAL THINNING

                                                             30       1.91392290   0 0   PRESCRIBED BURN
   40      17.39723351   4 6   COMMERCIAL THINNING
   50      14.12568004   4 6   COMMERCIAL THINNING
   70      32.30227194   5 6   FINAL HARVEST
   40     -21.25315230   0 6   FINAL HARVEST

TOTAL      70.91029336                                 TOTAL     149.69742204
-------------------------------------------------------------------------------------------------------------

DISCOUNTED BENEFITS AND COSTS AT 10.0000% INTEREST      PNW =   -130.85081364      BCR =      .06474422

 YEAR        BENEFIT    GROUP  DESCRIPTION                 YEAR        COST       GROUP  DESCRIPTION
                                                              0     135.17115755   1 0   SITE PREP AND PLANT
                                                             10       3.08825675   0 0   PRESCRIBED BURN
                                                             20       1.19065667   0 0   PRESCRIBED BURN
   30       6.79686183   4 6   COMMERCIAL THINNING
                                                             30        .45904969   0 0   PRESCRIBED BURN
   40       2.62048447   4 6   COMMERCIAL THINNING
   50       1.33621672   4 6   COMMERCIAL THINNING
   70       1.20512719   5 6   FINAL HARVEST
   40      -2.90038317   0 6   FINAL HARVEST

TOTAL       9.05830702                                 TOTAL     139.90912066
-------------------------------------------------------------------------------------------------------------

DISCOUNTED BENEFITS AND COSTS AT 15.0000% INTEREST      PNW =   -135.64641326      BCR =      .01416077

 YEAR        BENEFIT    GROUP  DESCRIPTION                 YEAR        COST       GROUP  DESCRIPTION
                                                              0     135.00761219   1 0   SITE PREP AND PLANT
                                                             10       1.97758915   0 0   PRESCRIBED BURN
                                                             20        .48882979   0 0   PRESCRIBED BURN
   30       1.78907278   4 6   COMMERCIAL THINNING
                                                             30        .12083125   0 0   PRESCRIBED BURN
   40        .44223143   4 6   COMMERCIAL THINNING
   50        .14457505   4 6   COMMERCIAL THINNING
   70        .05359771   5 6   FINAL HARVEST
   40       -.48102786   0 6   FINAL HARVEST

TOTAL       1.94844912                                 TOTAL     137.59486238
-------------------------------------------------------------------------------------------------------------
```

APPENDIX B—SAMPLE DETAIL PROFIT LEVEL OUTPUT

(Continued)

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SENSITIVITY ANALYSIS

DISCOUNTED BENEFITS AND COSTS AT  4.4827% INTEREST      PNW =     -60.12898889      BCR =        .60629938

 YEAR       BENEFIT    GROUP  DESCRIPTION                 YEAR       COST       GROUP  DESCRIPTION
                                                            0     141.57493414   1 0   SITE PREP AND PLANT
                                                           10       5.41128552   0 0   PRESCRIBED BURN
                                                           20       3.49026428   0 0   PRESCRIBED BURN
   30      33.33227216   4 6   COMMERCIAL THINNING
                                                           30       2.25121086   0 0   PRESCRIBED BURN
   40      21.49922386   4 6   COMMERCIAL THINNING
   50      18.34014679   4 6   COMMERCIAL THINNING
   70      46.29437425   5 6   FINAL HARVEST
   40     -26.86731117   0 6   FINAL HARVEST

TOTAL      92.59870590                                 TOTAL     152.72769479
-------------------------------------------------------------------------------------------------------------

DISCOUNTED BENEFITS AND COSTS AT  3.4827% INTEREST      PNW =         .00000007      BCR =        1.00000000

 YEAR       BENEFIT    GROUP  DESCRIPTION                 YEAR       COST       GROUP  DESCRIPTION
                                                            0     148.52266774   1 0   SITE PREP AND PLANT
                                                           10       6.24990180   0 0   PRESCRIBED BURN
                                                           20       4.43810351   0 0   PRESCRIBED BURN
   30      46.66275814   4 6   COMMERCIAL THINNING
                                                           30       3.15153156   0 0   PRESCRIBED BURN
   40      33.13558476   4 6   COMMERCIAL THINNING
   50      31.12010372   4 6   COMMERCIAL THINNING
   70      95.21364445   5 6   FINAL HARVEST
   40     -43.76988638   0 6   FINAL HARVEST

TOTAL     162.36220468                                 TOTAL     162.36220461
-------------------------------------------------------------------------------------------------------------

DISCOUNTED BENEFITS AND COSTS AT  2.4827% INTEREST      PNW =     127.70121759      BCR =        1.69841789

 YEAR       BENEFIT    GROUP  DESCRIPTION                 YEAR       COST       GROUP  DESCRIPTION
                                                            0     164.56772517   1 0   SITE PREP AND PLANT
                                                           10       7.63127427   0 0   PRESCRIBED BURN
                                                           20       5.97163481   0 0   PRESCRIBED BURN
   30      69.18917677   4 6   COMMERCIAL THINNING
                                                           30       4.67293154   0 0   PRESCRIBED BURN
   40      54.14200585   4 6   COMMERCIAL THINNING
   50      56.03413633   4 6   COMMERCIAL THINNING
   70     208.18753562   5 6   FINAL HARVEST
   40     -77.00807119   0 6   FINAL HARVEST

TOTAL     310.54478338                                 TOTAL     182.84356579
-------------------------------------------------------------------------------------------------------------
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APPENDIX C—SENSITIVITY COMPUTATION

Sensitivity analysis as used here refers to the measurement of the sensitivity of certain profit level criteria such as internal rate of return and present net worth to changes in the input transaction values which define a given investment opportunity. The measurement is expressed as the percentage change in the transaction value (or group of values) required to effect a specified change in the profit level criterion. These specified changes are expressed by the user in terms of an absolute change or a percentage change in the criterion. For example, the user could measure the amount of change in input required to change the internal rate of return by plus or minus an absolute 1.0 percent interest or by plus or minus 10 percent of the internal rate of return. The specification of change in criteria effectively defines an *upper threshold* and a *lower threshold* for each criterion with respect to sensitivity.

Transactions may be considered independently or in groups. Each transaction may be in more than one group, and any group may include one or more transactions. All the transactions in any group must be of the same type, i.e., costs or benefits.

I. *Sensitivity of Internal Rate of Return*

When the transactions which define a given investment opportunity are discounted at an interest rate equal to the IROR, the PNW is zero by definition. When the discounting is done at the ± error threshold interest rates, the PNW will not be zero. In order to change the IROR from the base rate to the threshold rate, the PNW must be changed to zero when computed at the error threshold interest rate. Changes in the PNW can be effected either by changing benefits or costs. The two formulae used to calculate percentage changes in sensitivity data groups are:

a. for benefit transaction groups:

$$PC = -\left(\frac{PNW_T}{\Sigma BG_T}\right) \times 100$$

b. for cost transaction groups:

$$PC = \left(\frac{PNW_T}{\Sigma CG_T}\right) \times 100$$

Where:

PC = The percentage change in the transaction values of the group required to change the IROR to the error threshold interest rate.

PNW_T = The present net worth when transactions are discounted at the error threshold interest rate.

ΣBG_T = The sum of the discounted transactions in a benefit group discounted at the threshold interest rate.

ΣCG_T = The sum of the discounted transactions in a cost group discounted at the threshold interest rate.

Example:

Given discounted values of transactions at the threshold interest rate (X percent) are:

	Discounted benefits	*Discounted costs*	
Group A	$10.00	$54.00	
	22.00	93.00	Group B
	43.00	10.00	
	$75.00	$157.00	

Using equation (a) for group A:

$$PC = -\frac{-\$82.00}{\$32.00} \times 100 = 256.25 \text{ percent}$$

If each value in the benefit transactions in Group A is raised 256.25 percent, the schedule will be:

	Discounted benefits	*Discounted costs*	
Group A	$35.625	$ 54.00	
	78.375	93.00	Group B
	43.000	10.00	
	$157.00	$157.00	

PNW = zero

Using equation (b) for Group B:

$$PC = \frac{-\$82.00}{\$103.00} \times 100 = -79.61 \text{ percent}$$

If the cost transactions in Group B are lowered by 79.61 percent, the schedule will be:

	Discounted benefits	*Discounted costs*	
Group A	$10.00	$54.00	
	22.00	18.96	Group B
	43.00	2.04	
	$75.00	$75.00	

PNW = zero

II. *Sensitivity of Present Net Worth*

The value of PNW for an investment opportunity always implies some specified interest rate at which the transactions have been discounted. The sensitivity thresholds for PNW must be reached assuming that same discount rate. The two formulae for calculating the percentage change in sensitivity groups are:

c. for benefit transaction groups:

$$PC = \left(\frac{PNWT - PNW}{\Sigma BG}\right) \times 100$$

d. for cost transaction groups:

$$PC = \left(\frac{PNW - PNWT}{\Sigma CG}\right) \times 100$$

Where:

PC = The percentage change in the transaction values of the group, required to change present net worth to the present net worth threshold.

PNW = The present net worth of the transaction schedule discounted at a specified interest rate.

PNWT = The specified present net worth threshold.

ΣBG = The sum of the discounted transactions in a benefit group, discounted at the specified interest rate.

ΣCG = The sum of the discounted transactions in a cost group discounted at the specified interest rate.

Example:

Given the same schedule of discounted values as used in the IROR example and a specified PNW error threshold level of $10:

	Discounted benefits	*Discounted costs*	
Group A	$10.00	$54.00	
	22.00	93.00	Group B
	43.00	10.00	
	$75.00	$157.00	

PNW = −$82.00

Using equation (c) for Group A:

$$PC = \frac{\$10 - (-\$82)}{\$32} \times 100 = 287.5 \text{ percent}$$

If the benefit transactions in Group A are raised by 287.5 percent, the schedule will be:

	Discounted benefits	*Discounted costs*	
Group A	$38.75	$54.00	
	85.25	93.00	Group B
	43.00	10.00	
	$167.00	$157.00	

PNW = $10.00

Using equation (d) for Group B:

$$PC = \frac{-\$82 - \$10}{\$103} \times 100 = -89.32 \text{ percent}$$

If the cost transactions in Group B are lowered by 89.32 percent, the schedule will be:

	Discounted benefits	*Discounted costs*	
Group A	$10.00	$54.00	
	22.00	9.93	Group B
	43.00	1.07	
	$75.00	$65.00	

PNW = $10.00

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