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Title: MODEL III: A Sequential Approach to Joint Optimization of the Stand Treatment and Forest Level Harvest Scheduling Problem

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Harvest scheduling and stand level optimization have generally been regarded as separable problems. Some studies have attempted to jointly optimize a wide range of stand treatments and a forest wide harvest schedule using combinations of mathematical programming techniques. The mathematical programming forest level techniques presume perfect information on production, costs and revenues over long sequences of planning periods and simultaneously optimize harvest for all periods in the planning horizon using assumed perfect knowledge of intertemporal trade-offs. This study proceeds from a completely different behavioral basis, assuming that stand level planning and harvest scheduling proceed sequentially rather than simultaneously over every period. The full array of stand-age types and management regimes is optimized using backwards recursive dynamic programming. This defines an optimal treatment for the current period

and a projected set of treatments for harvest and regeneration for each stand in the forest. The discounted present net value of each potential treatment for each stand in the current period is calculated and provided to the harvest scheduling portion of the model. The highest valued treatment from each stand constitutes the set of treatments that will be applied if there are no harvest volume constraints or if the indicated harvest is within specified volume limits. Otherwise, suboptimal stand treatments are ranked in order of increasing opportunity costs for increasing or decreasing harvest and the limit or constraint is met at minimum opportunity cost by altering sufficient stand treatments. An option of the model with harvest constraints met only at a maximum specified opportunity cost is also demonstrated. The stand-level optimization is repeated for each period in the planning horizon using new price and cost information.

MODEL III:
A sequential Approach to Joint Optimization of the Stand Treatment and Forest Level Harvest Scheduling Problem

by

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A SEQUENTIAL APPROACH TO JOINT OPTIMIZATION OF THE STAND TREATMENT AND FOREST LEVEL HARVEST SCHEDULING PROBLEM

Chapter 1

Introduction

1.1 Problem and Objective

A perennial problem in the management of even-aged forest properties is the interdependence of decisions on silvicultural treatment of individual timber stands and the scheduling of harvests over time at the forest-wide level. As Hann and Brodie (1980) note:

> "If a perfectly regulated forest structure exists or if harvest-level constraints are not important, then the joint optimization of stand and forest-level questions can be computed easily by determining each stand's optimal treatment plan and aggregating across the whole forest. Unfortunately, these conditions seldom exist and the manager is left with the problem of trying to determine suboptimal stand treatment plans that will meet forest-wide objectives and constraints."

Currently, harvest scheduling is being used in two basic ways. The more prevalent use could be described as prescriptive or normative, and involves the determination of the amount and type of harvest to be taken from a forest property. The second use is to characterize both the short-term (supply), and long-term (investment) behavior of aggregate owners in timber supply models like the Timber Assessment Market Model (TAMM) (Adams and Haynes 1982, Adams, Haynes, Dutrow, Barber, and Vasievich 1982). This latter use could be called descriptive.

The objective of this study is to develop a workable solution to the problem of determining stand treatments and scheduling harvests in such a manner that they are optimal from both an individual timber stand and a total forest perspective.

1.2 Justification and Background

Assumptions inherent in current approaches to solution of the stand and forest level optimization problem have to some extent shaped our perception of the problem. Thus in considering a revised method it is essential that we clarify the nature of the decision problem facing the forest manager. In the following discussion an industrial forestry setting is assumed. Only the emphasis on certain decision elements need be changed, however, to render the problem fully applicable to the management of public forest lands.

In approaching the stand and forest level problem, the following information is known, subject in some cases to sampling error.

- Current Inventory
    * acreage by age class
    * stocking levels by age class
    * management history
    * recent growth rates
- Current prices and costs, to include any internal differential for timber produced by the firm versus timber purchased from, or sold to, external sources (transfer price, Keipi 1977).
- Current management directives
    * short-term production rate limitations (minimum/maximum or required harvest volume derived from processing facilities)

* acceptable earning rates (alternative rate of return)

* allowable timber stand management activities

In contrast to the above elements, the following items are only assumptions in the decision process whose true values will not be known, defined, or decided until some future time.

- Future inventory based upon assumed response to current management actions

- Future prices and costs

- Future management directives including required harvest volumes

In practice, the inevitable divergence of actual future price, cost, and physical outcomes from assumptions made in the decision analysis at any given point in time leads to a continuous process of decision changes and modifications.

For example, it may be optimal to thin a stand now to a specific residual condition, planning to final harvest the stand twenty years later based upon assumptions of future conditions. But, ten years from now, even if the thinning resulted in exactly the residual stand envisioned and the stand grew exactly as projected, the decision maker will in no way be committed to the original plan to carry the stand another ten years to final harvest. His decision will be based upon information and conditions he will then know and which will almost certainly differ from what was originally assumed. Similarly, in the development of a harvest schedule for a forest for, say, a 100+ year period, there can be no pretense that the harvests so determined will actually be carried out for the entire planning period. At most the harvests calculated for the first decade or first few years of the schedule will be implemented. The remainder of the analysis is of value only to provide a rough estimate of the long term consequences of the initial harvest.

In its most basic form, the management problem is:[1] to select a set of management actions for each timber stand in the ownership from a set of allowable management actions (which includes no action) so that they:

- meet current management requirements

- are efficient according to some known set of values

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1. The spatial aspects (where is the stand that is to be harvested) of harvest scheduling are not included in this discussion as this study provides no help for this vexing aspect of the problem.

- result in an acceptable future forest condition.

1.3 Current models and assumptions

1.3.1 Stand Level Optimization

Kao (1980, 1982) and Brodie (Brodie, Adams and Kao 1978; Brodie and Kao 1979; Hann and Brodie 1983; Brodie and Haight 1984) have done the most work recently in stand level optimization. They use forward recursive dynamic programs of up to four state descriptors. Growth or yield is calculated each time a problem is solved. Stand treatments are optimized individually with no consideration of forest wide problems such as the flow of harvest over time. Philosophically, the forward recursion presumes at any stage that all past actions have been taken optimally. One major advantage of the forward recursion is the elimination of the need to round stands to the network grid using Kao's "neighborhood" technique (Brodie and Kao, 1979).

1.3.2 Forest Level Optimization

The normative forest level optimization problem is most commonly solved by linear programming or binary search models (Johnson and Scheurman, 1977; Johnson and

Tedder, 1983). Binary search methods have most commonly been used for descriptive harvest scheduling (Beuter, Johnson and Scheurman 1976). Stand level management is either fixed or selected from a limited number of predefined alternatives. Stand level alternatives may have been generated by stand level optimization procedures. However, any time a stand is harvested at a time other than that defined by the stand level optimization, the entire management regime is almost certainly non-optimal. While some of these models allow for changes in financial data during the simulation, to the author's knowledge none have extended this to automatic respecification of stand level management alternatives based on changes in financial parameters.

Forest level models all presume perfect knowledge throughout the analysis, and typically the solutions are driven by value or volume requirements at or near the end of the analysis time horizon.

1.3.3 Joint Stand and Forest Optimization

Previous work on this problem has generally been of two types:

- Nazareth (1980) and Williams (1976) used decomposition of linear programs with the decompositions based upon forward recursive dynamic programs. Even with decomposition and a relatively simple growth model which does not depict diameter relationships, the dimensionality of the linear programming approach is restrictive when a large number of different stands, each with a large number of potential management paths, are considered.

- Lyon and Sedjo (1983) and Cohan (1982) used optimal control theory and solved the problem over an infinite time horizon. Unfortunately, as is usually the case with optimal control approaches, the problem had to be abstracted to the point that results cannot be used to select specific stand management actions. For example, management input must be represented as a single, continuous and differentiable function across all possible management input. The optimal level of management input at any point in the analysis can not be disaggregated to reveal a specific set of management actions. Additionally, the harvest control variable operates only on rotation age so intermediate harvests (thinnings) are not modeled.

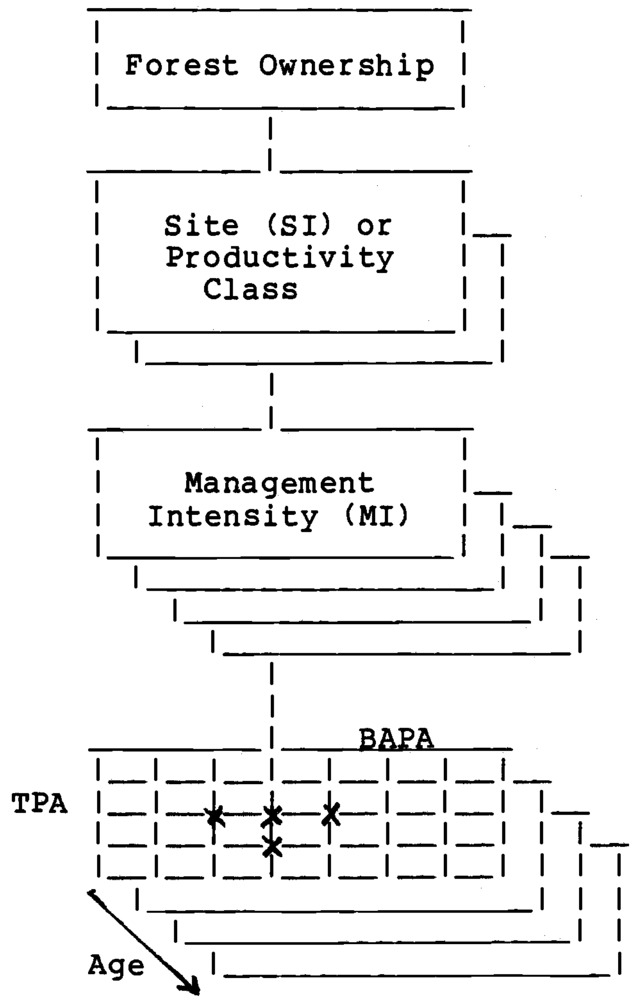
Both approaches presume perfect knowledge throughout the simulation, and the essence of the decompositions or optimal control iterations is to minimize the cost of some future harvest volume requirement.

1.4 General description of the Model III approach

Recognizing the essentially tentative nature of long-term management planning suggests an alternative approach to decision analysis. The approach that follows more closely mirrors plausible decision-maker response to the forces and variables that drive timber supply response. It provides for a high level of resource data disaggregation and flexibility in future expectations with respect to both harvest decision and silvicultural investment. Thus harvest scheduling as presented here may be seen as a link between stand-level prescription, forest-wide optimization or satisficing goals, and macro regional and subregional supply modeling.

Model III maximizes discounted net revenue from a forest ownership based upon assumptions of future prices and costs, and subject to a period by period constraint on maximum and minimum harvest levels. In any given period no constraints are imposed on future stand management.

Individual timber stands within the ownership are depicted in terms of acreage and a network of age, number of trees per acre (TPA) and basal area per acre (BAPA). Stands are grouped according to general classes of past management history or management intensity (MI), and site (SI) or productivity class as shown in Figure 1.



x = individual stands

Figure 1. Timber stand inventory structure.

The number of individual stands is limited only by the number of discrete nodes in the network. Individual stands are combined, or occasionally split, at the end of each simulation period whenever they have the same characteristics and management history, which is an extension of the Model II approach described by Johnson and Scheurman (1977), suggesting the title Model III.

Model III can be used by itself to conduct multi-period harvest scheduling simulations (stand-alone or batch mode), or as part of a larger model to conduct a number of single-period simulations (sequential - interactive mode). The general model functional operations and relationships are shown in Figure 2.

A growth model is used to calculate a yield table once for each MI-SI combination. Based upon the growth model used, at any given stand age certain nodes (specific combinations of TPA and BAPA) will not be realistic possibilities. These nodes are designated as infeasible and eliminated from further computational consideration.

For each feasible node, the stand is grown one period and harvest volume and average diameter are calculated for final harvest and all thinnings that will terminate at specific grid nodes. The resulting yield table contains all feasible growth and harvest paths, so is not limited to any specific initial inventory distribution and can be retained and used for any number of simulations.

```
                     |
Input/Output         |       Functional Elements
---------------------|---------------------------------------
                     |             GROWTH MODEL
(Batch)              |   ____________________________________
Site Class|          |  |1. Define feasible stocking nodes   |
Management|------|->|2. Calculate stand growth and       |
 Intensity|          |  | volume and diameter for all        |
                     |  | potential harvests                 |
                     |  |____________________________________|
                     |                 |
---------------------|-----------------|-----------------------
Resource Input:      |                 | DYNAMIC PROGRAM
(Batch)              |   ______________v_____________________
Existing stand|      |  | Calculate optimal post-harvest     |
 acreage      |-|->| value for all feasible stocking    |
Economic Input:      |  | nodes. Solved once each period     |
(*BSI)               |  | for each MI-SI, each age-class     |
Price and cost|-|->| with 1 or more stands.             |
 time profile |      |  |____________________________________|
Discount rate |      |                 |
                     |   ______________v_____________________
Output for Man-      |  | Calculate total value of each      |
agement override|    |  | harvest possibility for each       |
if desired           |  | existing stand.                    |
                     |  | - - - - - - - - - - - - - - - - - -|
       <-------------|--| Current period harvest and         |
                     |  | discounted value for each harvest  |
                     |  | alternative for each stand.        |
                     |  |____________________________________|
                     |                 |
---------------------|-----------------|-----------------------
                     |                 v HARVEST SCHEDULE
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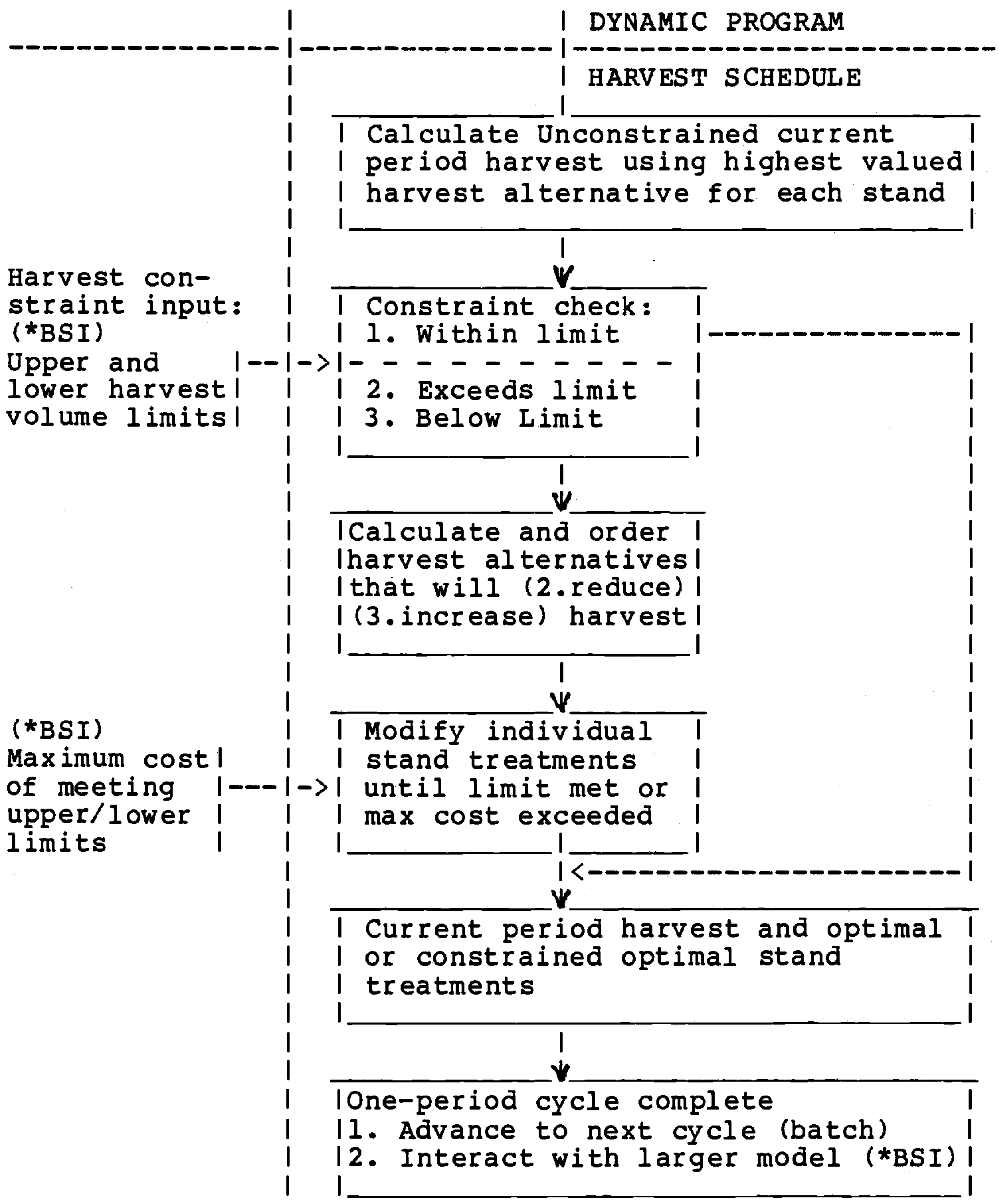
Figure 2 continued on next page

*BSI = Input by batch or sequential-interactive with another model.



*BSI = Input by batch or sequential-interactive with another model.

Figure 2. Model III functional elements and relationships.

A simulation begins with the input of existing stand inventory, and economic data. Nominal pond value and logging costs are calculated within the model based upon the diameter and volume of timber harvested. Economic input data allows for individual adjustment of prices and costs in the current and each future time period to reflect assumptions concerning future price and cost changes.

A backward recursion dynamic program (DP) is solved each period of the simulation for each age class in each MI-SI to provide the values of all feasible harvest options. The DP begins by arbitrarily considering only final harvest at stand age 100. The value of this harvest will depend on the existing stand age as shown in Figure 3. A stand that is 50-years old at the beginning of the current simulation period will be valued using decade 2020 prices and costs, while 1990 values would be used for a stand 80-years old at the beginning of the period.

Initial stand age	Future stand age					
50-years	60	70	80	90	100	
80-years	90	100				
Decade	1980	1990	2000	2010	2020	2030

Figure 3. Relationship between initial and harvest stand age and date of harvest.

The value of each feasible 90-year stocking node is the net value of its associated final harvest discounted ten years. The value of 80-year stocking nodes is determined by choosing the highest total of net revenue derived from thinning to a 90-year node plus the value of that node, and discounting that total ten years. Final harvest, represented by "thinning" to zero residual trees per acre at age 90, earns the net value of the final harvest plus the value of the bare land after harvest. Again, the prices and costs used will depend upon initial stand age.

This backward recursive process is repeated until post harvest node values have been calculated to a point ten years in advance of the current existing stand age. To this point only the value of the best, or optimal action have been retained for each node, however for existing stands, the value of all possible harvest alternatives are needed and calculated. These data are subsequently used in harvest scheduling, but can also be provided to the forest manager after the simulation for subjective evaluation and modification of stand management action.

A harvest schedule is calculated for the period by implementing the unconstrained optimal or highest valued harvest alternative for each individual existing stand. Upper and lower limits on the periodic harvest volume may be specified for an entire simulation in batch or stand-alone mode, or on a period-by-period basis in interactive mode. If the unconstrained harvest is outside these limits, each stand is reevaluated. For example, if the unconstrained harvest is above the upper limit all suboptimal harvest alternatives that will reduce harvest are arrayed in order of their efficiency in reducing harvest. Efficiency is calculated as the value foregone per harvest volume unit when compared to the unconstrained optimal action for the stand, or the opportunity cost of implementing that suboptimal harvest alternative.

The unconstrained harvest is then modified by changing individual stand harvest alternatives until the periodic harvest volume limit is met, or until a maximum specified opportunity cost is incurred.

When the optimal or constrained optimal stand treatments and total volume harvested have been calculated, one cycle is complete and the next cycle is calculated if in stand-alone mode. In interactive mode the cycle could be repeated with revised economic input until demand (price) and supply (harvest volume) are reconciled, or interactive input data could be revised and the next cycle calculated.

The dimensionality of the harvest and inventory management problem is essentially reduced to the size of one MI-SI by the extensive use of random access files

(RAF). Each MI-SI requires two RAF, one contains the yield table, and the other contains all possible management actions for each existing stand and is used as the means of communication between the harvest schedule and the DP.

1.5 Comparison of Model III and Conventional Models

Model III is not inherently better or worse than conventional harvest scheduling or optimization models. It differs primarily in the underlying assumptions, particularly as they concern future periods. Its value in any specific application will depend on the degree to which the assumptions match the decision environment. Figure 4 shows schematically the general logic structure of models using conventional linear programming (LP) or LP with extensions.

```
 __________________________      ___________________________
|  Batch Input             |    | Simultaneous "N"-Period   |
|"N"-Period economic data  |    | Optimization based on     |
|"N"-Period limited        |--->| perfect "N"-period        |
| Management activities    |    | knowledge of production   |
|__________________________|    | possibilities and         |
          ^                     | interperiod tradeoffs     |
          |                     |___________________________|
 _________|__________                        |
|New activities in   |                       |
|decomposition or    |<----------------------|
|heuristic version   |
|____________________|
```

Figure 4. Logical relationships in conventional linear programming models.

Table 1 summarizes and contrasts the major differences between Model III and current conventional models which use linear programming methods. Although no direct comparisons have been made, Model III should require less computer solution time and storage space than conventional LP models for similar levels of stand detail.

Table 1. Comparison of Model III and conventional models.

MODEL III	CONVENTIONAL LP & LP EXTENSION
1. Behavioral Assumptions - The Decision-maker:	
makes stand treatment decisions based on current long-term price & cost forecasts; allowable cut decision based on only current period physical constraint.	simultaneously makes stand treatment and allowable cut decisions based on perfect long-term price, cost and constraint information with complex analysis of multi-period trade-offs.
2. Decision Process Modeled:	
Sequential planning cycles based on rational expectations. All silvicultural decisions made at the time they occur, under the conditions applicable at that time.	Presumption of a single long-term plan into the distant future based on perfect knowledge. Leads to the imposition of arbitrary rules such as "thinnings must be separated by 'X' years" or "harvest oldest stands first".
3. Temporal Solution Structure:	
sequential - gives ready potential for interactive feed-back with other models.	simultaneous - leaves no opportunity for interactive feed-back except by iterative respecification.
4. Problem Specification:	
Direct input of economic data and stand inventory	Operational size problems require a matrix generator or "front end" to specify complex linkage equations.

Continued on following page.

Table 1. Continued

5. Harvest Constraint Specification:	
either fully binding or binding at a maximum specified cost.	fully binding - associated shadow price not controllable except by respecification.
6. Full range of stand treatments considered:	
for every stand in every period - no incentive for excessive aggregation.	only for decomposition extension (not practically applied yet). Tendency to over-aggregate and under-specify the range of silvicultural activities.
7. Sensitivity Analysis:	
All stand harvest alternatives can be provided for review. Problem must be resolved for sensitivity to economic parameters.	Suboptimal stand treatments not available without re-specification. Sensitivity to economic parameters available but difficult to interpret in large or complex problems.
8. Harvest volume control variable:	
Intensity of thinning or final harvest age.	Primarily final harvest age. Some limited selection between prespecified thinning regimes.

1.6 Potential Applications.

Model III is used in this study to represent the supply behavior of the industrial forestry ownership in Northwest Oregon. It could be used in a similar manner to provide supply response to a larger model such as the Timber Assessment Market Model (TAMM) (Adams and Haynes, 1982). This would provide endogenous representation of both short run supply response and longer run changes in investment in management practices. Realism would be improved as investments would be undertaken based upon the current period economic environment and some general expectation of future conditions. As the simulation progresses, some past decisions will turn out to have been nonoptimal based on deviations from the expected economic conditions, resulting in reactive modification of management throughout the life of any given stand. Past attempts to model investment behavior (Adams, Haynes, Dutrow, Barber, and Vasievich 1982 or Lyon and Sedjo 1983) have had to presume that managers had perfect knowledge of future conditions.

Model III's best use may be as a tool to develop harvest prescriptions for medium to large industrial ownerships. The level of detail, and ability to translate forest-wide harvest volume demands into specific individual stand thinning and final harvest prescriptions represents a capability not available in operational models in use today.

Chapter 2

Model III - Detailed Description of Components

2.1 The Growth Model

Yield calculations are based on the Douglas-fir simulator, DFSIM (Curtis, 1981) modified as necessary to support a backward-recursive dynamic program. In DFSIM natural stands grow differently than planted stands, and growth response following thinning depends on the intensity of the thinning and decreases after forty feet of height growth. To account for these differences, four management intensities are used to depict a fairly wide range of management activities and past stand treatments that influence growth:

- MI-1 represents a natural origin or seeded stand which has had no other cultural treatments. A 40-TPA node interval was used for this MI in order to represent a higher number of trees per acre (800) in the unthinned stand.

- MI-2 represents a natural origin or seeded stand that has had one or more commercial thinnings. Thinning is presumed to have occurred 40-feet of height growth prior to the growth period, and to have removed one-third of stand basal area, depicting infrequent thinnings.

- MI-3 represents a planted stand that has the same thinning history as in MI-2 above.

- MI-4 represents planted stands that have had frequent, lighter thinnings. Growth is based upon the assumption that 25% of stand basal area was removed at the start of the growth period.

A 20-TPA node interval was used for MI-2 through MI-4 in order to evaluate more thinning alternatives. A 10-square foot basal area node interval was used for all MI, limiting basal area to a maximum of 300ft^2/acre. All thinnings are presumed to be at a d/D ratio of 1.0 (mean diameter of harvested trees equal to the mean diameter of the stand before thinning).

A stand yield table was generated for each management intensity and productivity class combination. Ten-year growth was calculated for stands at starting ages of 30 to 90 years at 10-year intervals for all reasonable combinations of basal area and trees per acre. Reasonable combinations were those that resulted in stand height over diameter ratios within three standard errors of the regional average as defined by Curtis (1981).

Regenerated stands were grown from age 0 to 30 in one step. Regional averages were used for natural origin or seeded stands, and planting densities of 300 to 600 trees per acre in 20-tree intervals were calculated for planted stands. The maximum stand age of 100-years, and the minimum of 300-TPA surviving planting were also considered by Curtis to be the extrapolation limits of his DFSIM growth model. Erratic results were encountered when growth for stands with a small number of trees per acre was calculated so an arbitrary lower limit of 50 trees per acre was established.

The number of trees and basal area at the end of the growth period define a limited number of harvest possibilities based upon a d/D ratio of 1.0 and the requirement that the harvest leaves a residual stand at some node value (multiples of 10-feet of basal area and 20-trees per acre). Mortality capture is a variable which can be set at any value from 0 to 100% of mortality during the growth period and is a departure from DFSIM which does not include mortality capture. Mortality capture was set at zero for the examples in this study to simplify comparisons with DFSIM.

Minor rounding of two types was required to terminate each growth period at a basal area-tree node. For thinnings the d/D ratio was allowed to deviate below 1.0, and for the no harvest option, trees per acre and basal area were rounded to the nearest node. For each feasible harvest, the post-harvest node (residual trees and basal area per acre), volume harvested (cubic feet, trees 5.6 inches dbh, to a 4-inch top), and arithmetic mean diameter of harvested trees were calculated. As some of the data were integer values which would be used extensively in equality tests, volume harvested and diameter in hundredths of an inch were converted to integer and the entire array was written to a record on a random access file.

Appendix A.1 contains yield data for a number of different stands of site class 130 (King 50-year base). Model III MI-1 yields correspond almost exactly to DFSIM yields calculated using the existing stand option, while Model III MI-2, MI-3, and MI-4 yields are all higher than the DFSIM existing stand yields. The higher yields are attributable to the fact that DFSIM does not use thinning effects to accelerate growth for thinnings that occurred prior to specification of the existing stand conditions. Table 2 contains a comparison of a Site 130 natural origin DFSIM stand through age 100, and a Model III MI-1 stand that is not thinned. Even though the Model III stand was rounded to the nearest 40 trees per acre and 10 square feet of basal area per acre, the volumes differ by less than 3% over the 100-year period.

Table 2. Comparison of DFSIM and Model III yields for a Site 130 natural origin unthinned stand. TPA and BAPA in parentheses are the node the stand was rounded to for the next growth period.

	DFSIM			Model III MI-1		
AGE	TPA	BAPA	VOL	TPA	BAPA	VOL
30	737	178	3600	735	174	3603
				(720	170)	
40	473	209	6560	477	207	6448
				(480	210)	
50	342	231	9150	345	231	9116
				(360	230)	
60	269	249	11400	279	246	11263
				(280	250)	
70	221	264	13440	228	264	13369
				(240	260)	
80	189	278	15200	202	272	14845
				(200	270)	
90	165	291	16650	174	283	16221
				(160	280)	
100	147	302	18000	144	295	17528

2.2 Pond Value and Logging Costs

Pond values and felling, bucking, limbing, yarding, loading and hauling cost are derived from LeDoux (LeDoux 1983, and Fight, LeDoux and Ortman 1984) using yarding delays which varied with volume removed. All costs and pond values vary with the arithmetic mean diameter of timber harvested and are in 1980 dollars per MCF, which are considered the nominal values throughout this analysis. Nominal pond value and logging costs can be multiplied by input factors to adjust them for assumed changes specified for the period in which the harvest is taken. Table 3 shows nominal values for a range of different diameters and volume harvested.

Table 3 Representative logging costs and pond values ($/MCF). Logging costs are shown for three levels of volume per acre harvested.

DBH	Logging cost 1 MCF	2 MCF	5 MCF	Pond Value	Bf/Cf Ratio
6	687.22	646.74	619.14	450.25	1.69
12	446.68	419.01	400.80	920.61	3.79
18	364.76	318.06	290.61	1390.97	4.87
24	278.47	235.33	210.48	1704.54	5.49

2.3 The Dynamic Program

A backward recursive dynamic program was used to establish the value of each possible management action for each existing stand presuming that optimal management is practiced for the remainder of the stand's existence. Backward recursion is used because, in a single pass through the network, the _future_ value of every node representing stands of the same age is established. Had forward recursion been used, a separate DP would have to be calculated for each stand. If prices and costs were not changing, or were changing at a single well-behaved rate (linearly or exponentially), a single backward recursion DP would serve for stands of all ages. With prices and costs specified individually for each period in the planning horizon the principle of optimality (Bellman, 1962) can only be maintained for stands of a single age, and a separate DP must be calculated for each age-class containing one or more stands. The number of paths actually calculated is limited to those deemed feasible by the yield table and are substantially less than the full dimension of the grid.

Node values are carried by backward recursion through the matrix to the stage representing the end of the ten-year growth period for the age-class being solved. Costs and prices are calculated based upon their respective multipliers for the period of time they accrue in advance of current stand age. Node values are the sum of two terms which are carried separately: net discounted revenue, and discounted land value which is earned whenever the final harvest option is selected (see section 2.4 for detailed discussion of land value). To calculate node values, only the values of the best action are needed, therefore volume harvested and the path of the optimal action are not needed or retained. When completed, the DP has established the post-harvest value of each stocking level (number of trees/basal area node) for each stand in the age-class.

The second major function performed by the DP is to enumerate all possible actions for each existing stand in the age-class. The value of each potential harvest option is the sum of the net revenue, in current period costs and prices, resulting from the harvest plus the value of the post-harvest residual stocking node. The path to the next stage (potential management action taken), and volume harvested are now needed and calculated, and the results are written to a record representing that stand in a random access file (RAF). Table 4 shows a replica of the management action record for the 50-year old stand of 400 trees per acre and 260-square feet of basal area in MI-2 of the demonstration inventory.

Table 4. Management action record for MI-2 50-year old stand with 400 trees per acre and 260 square feet of basal area.

Residual stand TPA	Residual stand BAPA (sqft/a)	Total Value ($/aX100)	Harvest Volume (cu ft/a)	Harvest Net Revenue ($/aX100)
0	0	797177	12609	704677
20	-1	-12883014	11743	628133
40	-1	-12939849	10815	571298
60	60	819440	9884	515510
80	80	845097	8950	457848 *
100	90	837208	8501	457001
120	110	823365	7561	399697
140	130	818786	6618	342420
160	150	818637	5671	285125
180	170	810148	4720	222092
200	180	806792	4264	220694
220	200	800716	3308	163872
240	220	795285	2348	107457
260(12)**	240	793516	1385	50299
280(13)	260	785674	417	5022
300(14)	270	776246	0	0
320	-1	-9999899	-1	0
340	-1	-9999899	-1	0
360	-1	-9999899	-1	0
380	-1	-9999899	-1	0
400	-1	-9999899	-1	0

* = Unconstrained optimal harvest alternative.
**= Harvest queue rank in table 5.

The first two columns are the trees and basal area per acre of the post-harvest residual stand (-1 denotes an infeasible node). The third column is the total net discounted value ($ X 100) of the current harvest and all future values. The last two columns are the volume (cu ft) and net value ($ X 100) of the current period harvest alternative. A total of 14 feasible actions are listed, ranging from no harvest leaving a residual stand of 300 trees and 270 square feet of basal area worth $7,762.46

per acre in discounted future value, to final harvest of 12,609 cubic feet generating $7046.77 net revenue this period and $7971.77 in total discounted net revenue (the value of the final harvest plus an additional $925 land value for this site class). The highest valued action (*) is a thinning of 8950 cubic feet, leaving a residual stand of 80 trees and 80 square feet of basal area per acre.

If Model III were being used to generate stand prescriptions, information like that shown in Table 4 would be provided to the manager for subjective review of near-optimal alternatives.

2.4 Land Value

The literature (for example, Hann and Brodie 1981) generally has considered that a backward recursive dynamic program can not select an optimal rotation in a single pass through the matrix, but that a separate DP must be solved starting at each candidate rotation. This problem is overcome in the current approach by the use of a land value, representing the current value of all subsequent rotations, as a revenue earned whenever a stand is final harvested. At the conclusion of each DP an infinite series discounted value is calculated based upon the optimal value of the best age zero action (number of trees planted or the single regional average natural origin stand depending on Management Intensity). Even though the optimal path through the network was not recorded, the optimal rotation age can be derived from the discounted value of land. The infinite series value is used to calculate the land value to be used in the following simulation period.

There were at least three different ways that land value could have been calculated, any of which can easily be included in the model:

- The optimal infinite series value for each MI could be used for that MI in the following period, implying that after harvest the land will continue to be managed at the same management intensity.

- The optimal infinite series value for the highest valued MI in the site class could be used for all MI in the site class implying that when harvested the land will be managed at the highest valued intensity.

- The method used in this version of the model is to calculate each period a single average land value for each SI based upon the individual MI values weighted by the acreage in each MI. The average value is used for all MI in the SI in the following period. This is to some extent a compromise between the first two alternatives, but also reflects the value of the management mixture currently being practiced. In the aggregation of stands, individual stand characteristics such as distance from mills, topography, and stands near the upper or lower limits of the productivity class are lost to the calculation, but these factors may still dictate future management intensity.

This land value technique could be used in other types of optimization models such as linear programming. In the last period of a problem, the value of the stand plus land value would provide an approximation of the value of the ending or unharvested inventory to be included in the optimization.

2.5 The Harvest Scheduling Subsystem

The harvest scheduling subsystem employs starting inventory and, depending on the type of use, either interacts with another model such as TAMM to conduct a series of single period simulations (sequential -

interactive mode), or controls a multi-period simulation (stand-alone mode).

Inventory is described by: site or productivity class (SI) using King's 50-year index; management intensity (MI); age at the beginning of the simulation in 10-year classes with age corresponding to the top of the class; number of trees per acre and basal area per acre rounded to the nearest node. Existing stands less than thirty years old are entered by age-class and equivalent number of trees per acre node at stand origin.

In an attempt to reduce the dimensionality of the problem, random access files (RAF) are used to store nearly all pertinent stand information. In fact only one relatively small array spans the entire MI-SI inventory. This required the development of a very different approach to inventory management and manipulation, one which primarily involves meticulous record keeping. Each MI-SI requires two RAF, one contains the yield table, and the other contains stand information and actions. Another RAF contains two inventory arrays for each MI-SI, one for the current period and one for the next period. The inventory arrays contain the number of acres and record number of each individual stand in the MI-SI identified by age, number of trees per acre, and basal area per acre at the beginning of a ten-year period. Theoretically, 600 separate stands could be recognized at each age based upon the dimensionality of this array.

A simulation period begins with the solution of a DP for each MI-SI. The DP enumerates the value of all possible harvests for each existing stand, flagging the highest valued action, and records the value and harvest volume on the stand record in the action RAF. An unconstrained harvest is then calculated for the entire ownership by using the highest valued action for each stand. If upper or lower bounds on the total periodic harvest have been specified, the total volume harvested is then compared to the bounds and the harvest is modified (as described below) if they are violated.

For example, if the harvest must be decreased, each stand is reexamined and each harvest alternative that would decrease harvest is considered. If the optimal action for a stand is no harvest, no additional alternatives need be considered because all other alternatives would result in an increase in volume harvested and therefore not contribute to meeting the upper (maximum) harvest bound. The opportunity cost ($/MCF) of changing to each harvest alternative is calculated, and the stand identification is placed in a harvest queue (Table 5) ranked in order of increasing opportunity cost. If harvest must be increased, the procedure begins with the final harvest alternative (zero residual TPA) and moves in increasing residual trees per acre toward the unconstrained optimum.

A possible problem of nonconvexity is avoided by constructing a convex hull of the alternatives considered for each stand. This is done by starting with the no harvest alternative and only considering larger harvests if they have a lower opportunity cost. The entries ranked 12, 13, and 14 in Table 5 are the alternatives for the 50-year old stand shown in Table 4. Of the eleven possible alternatives that reduced harvest from the unconstrained optimum for this stand, only these three were elements of the convex hull. Figure 5 shows the value of each alternative for this stand as a function of its associated harvest volume. The slope of a line connecting the unconstrained optimum value of $8451 (thinning harvest of 8.950 MCF) with any other value represents the opportunity cost ($/MCF) of changing to that alternative.

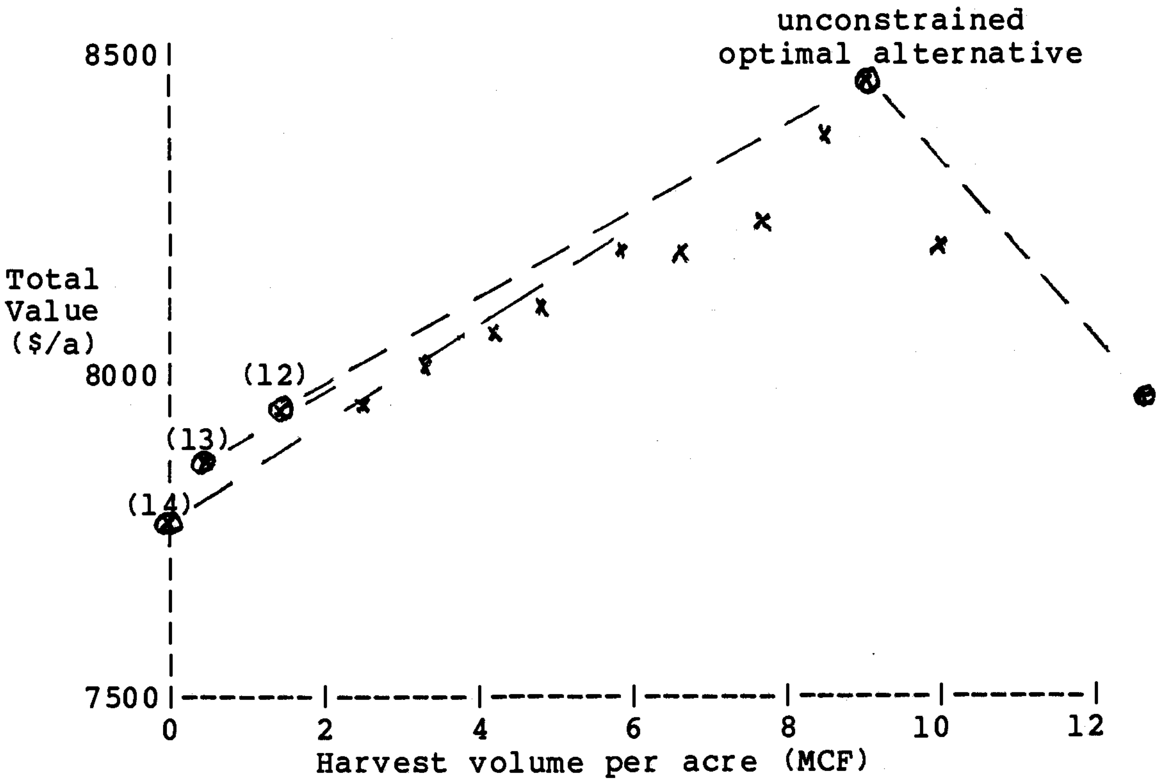


Figure 5. Value of harvest alternatives for MI-2 50-year old stand with 400 trees per acre and 260 square feet of basal area. [1]

The 260 tree residual stand alternative (the 12th ranked stand in the harvest queue shown in Table 4), with a harvest of 1385 cu ft and total value of $7935.16 reduces harvest per acre by 7565 cu ft (8950 minus 1385) at a cost of $515.81 (8450.97 minus 7935.16) per acre, or at an opportunity cost of $68.18/MCF (515.81 divided by 7.565) which is more efficient, or dominates all higher

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1. Each of the elements in this figure are listed in Table 4, page 29. Circled points are elements of the convex hull set; numbers in parentheses are the queue rank from Table 5.

harvest alternatives.

Table 5. Portion of the harvest modification queue.

Rank	MI	SI	Rec Nr	Resid TPA Node*	Opportunity Cost ($/MCF)X100
1	3	1	5	9	872
2	3	1	5	12	892
3	1	1	4	5	1393
4	2	1	1	20	1422
5	3	1	8	3	2087
6	2	1	7	4	2406
7	1	1	8	2	2503
8	4	1	4	14	3494
9	2	1	9	3	5142
10	2	1	6	5	5394
11	2	1	4	9	6813
12	2	1	5	13**	6818***
13	2	1	5	14**	6963
14	2	1	5	15**	7692
15	3	1	8	4	7707
16	1	1	5	7	7814
17	2	1	6	6	7959
18	2	1	7	7	8204
19	4	1	5	10	8716
20	1	1	6	5	9313
21	2	1	6	10	9593
22	4	1	6	5	9785
23	2	1	9	4	10089
- - -	- - -	- - -	- - -	- - -	- - -
48	4	1	7	5	18349
49	1	1	7	5	18603****
50	4	1	7	7	18722
- - -	- - -	- - -	- - -	- - -	- - -
70	4	1	8	7	36967
71	4	1	4	15	40872
72	2	1	2	12	57397
73	1	1	3	8	60237

* TPA node interval is 40 for MI-1, 20 for other MI.
** Elements of convex hull set from Fig 5 and Table 4.
*** Minimum opportunity cost alternative in Table 4.
**** Marginal harvest reducing alternative for harvest schedule shown in Appendix B-2.

When all legitimate alternatives for every MI-SI have been placed in the queue, the unconstrained harvest is modified by working down the queue, modifying the indicated best alternative for stands until the constraint is met. This involves changing action on only part of the last stand changed to meet the constraint, and the opportunity cost recorded for that stand is the shadow price of the constraint in dollars per unit of volume. Appendix B.1 shows the first decade unconstrained harvest schedule for the demonstration inventory which had a total harvest of 6.944 MMCF. Appendix B.2 shows the same harvest schedule when constrained to a maximum harvest of 3 MMCF for the decade. Forty-nine alternatives were considered from the queue in Table 5 and the 49th ranked alternative was used for 8 of the 25 acres of this stand, with an opportunity cost of $186.03/MCF which is the marginal cost, or shadow price of the constraint. In working down the queue, management action was changed three times for the stand shown in Figure 5, leaving it at the 14th ranked no-harvest alternative.

An option is also available wherein a maximum opportunity cost can be set for the upper and/or lower bounds. In this case, management actions are modified until either the bound is met, or the maximum opportunity cost is exceeded. Appendix B.3 shows the Appendix B.1 harvest schedule constrained to a maximum periodic harvest of 3 MMCF, but not to exceed an opportunity cost of

$100/MCF. In this case, only the first 22-ranked alternatives were implemented, resulting in a periodic harvest of 4.968 MMCF.

The indicated action for each stand is then implemented and periodic reports are written. The inventory index arrays alternate as current and future inventory records. Stands are placed in the future inventory within the SI based on the following rules. If final harvested they go to age zero in the MI having the highest "land value". Otherwise, age is increased ten years and MI is assigned as shown in Table 6 depending on whether the stand was thinned or not thinned in the current period. The current inventory array is zeroed out and the future inventory record is designated as current completing the transition to the next period.

Table 6. Reassignment of management intensity

Current MI	New MI: Harvest Operation: None	Thinned	Final Harvest
1	1	2	Highest valued MI
2	2	2	" " "
3	3	4	" " "
4	3	4	" " "

Chapter 3

Results

This chapter presents selected results from a large number of harvest schedules solved with Model III.A small 1000-acre demonstration inventory (Appendix A.1) of Site 130 forest, is used first to show the sensitivity and response of the model to variations in any of the user-controlled parameters. This is followed by results of harvest schedules of the 848,593-acres of Industrial Forest ownership in Northwest Oregon to demonstrate the use of the model with a large realistic inventory and multiple site classes.

3.1 Demonstration inventory

The demonstration inventory (Appendix A.1) has ten 25-acre stands in each Management Intensity. Stands range from 20 to 90 in age, and are generally well stocked, averaging 91% of DFSIM regional average. Nominal data, which produced the harvest schedules shown in Appendix B.1

through B.4 and which are used as the basis for comparison, consisted of the following:

- Pond value and logging costs are constant in real 1980 dollars over the next 100 years.

- Planting costs are $100 per acre plus $0.25 per seedling planted.

- The real discount rate is 4%.

- Initial bare land value averages $925 per acre for Site 130.

- No mortality capture is included in harvest volumes.

- Unless otherwise indicated, the harvest values shown are the unconstrained optimum for the first decade.

3.1.1 Nominal Results

Table 7 contains a summary of the results of the nominal harvest schedule (the first decade of the schedule shown in Appendix B.1).

Table 7. Selected results from the nominal data harvest schedule.
Volume harvested = 6.944 MMCF

Net value of harvest = 6.835 million dollars

	Optimal Rotation	Land Value	Harvest Volume (MCF)	Harvest Value (M$)
MI-1	80	751.86	1.894	1.654
MI-2	90	618.48	1.873	1.589
MI-3	80	1091.06	1.710	1.902
MI-4	80	1236.30	1.467	1.690

A specific management regime beyond the current period through eventual final harvest is never explicitly calculated for any existing stand. It is embedded in the dynamic program's calculation of future value based on unconstrained optimal future management and can be reconstructed from a multi-period unconstrained harvest schedule. Table 8 shows the reconstructed optimal management regimes for both natural origin and planted stands.

Table 8. Optimal management regimes with nominal data. Age is at the beginning of the 10-year period; harvest is at the end of the 10-year period.

	Natural origin				Planted			
AGE	MI	TPA	BAPA	HARVEST	MI	TPA	BAPA	HARVEST
0	1	1000	NA	0	4	300	NA	0
20	1	1000	NA	0	3	300	NA	0
30	1	720	170	0	3	280	130	585
40	1	480	210	207	4	220	170	5485
50	2	320	220	7824	4	80	90	0
60	2	80	80	0	3	80	130	8230
70	2	80	110	1485	4	Regenerated		
80	2	60	110	7738				
90	4	Regenerated						

In both the natural and planted stand the optimal regimes include a small, noncommercial or low-valued thinning (net revenue is -$0.20/acre for the natural stand and $144.98/acre for the planted stand). This type of thinning is essentially an investment that increases the value of future harvests through increased diameter growth.

These results show two minor artifacts in the model solution. The fact that the land value for MI-2 is less than that of MI-1 (see Table 7) is attributable to the use of a 20-tree node interval for MI-2 in order to evaluate more thinnings expected in this MI. The 20-tree interval limits the maximum number of trees per acre to 400, while as seen in Table 8, the optimal number of trees for a natural stand remains above 400-TPA through age 40. This problem could be eliminated by using a 40-tree interval for MI-2; however since thinned stands should have less than 400 TPA, and natural origin stands stay in MI-1 until thinned, the 20-tree interval was retained.

The second artifact concerns the optimal rotation age. The reported optimal rotation (80-years for MI-4) is calculated for a theoretical stand that remains in that MI throughout its lifetime, while in tracing the optimal action from period to period it can be seen that the stand alternates between MI-3 and MI-4 depending on whether it was thinned during the preceding period. The methodology used does not permit calculating land value for the composite MI.

3.1.2 General

Table 9 contains selected results from a number of different harvest schedules using the demonstration inventory (Appendix A.1). The sensitivity of the model to changes in the values of parameters is discussed in the following sections. In general, rotation age is much more sensitive to changes in parameter values in MI-1 than it is in MI-4. This in part is attributable to the more restricted number of harvest alternatives available with the 40-TPA node interval used in MI-1, and also reflects the fact that without thinning growth response, the timing of the final harvest is the only management control that can be adjusted.

Rotation age response is also somewhat sticky and asymmetrical due to the discrete 10-year choices available. For example, it would appear that the rotation age for MI-4 with nominal data is less than but rounds to 80 years. Thus we see rotation shortening responses to changes in some parameters without a corresponding lengthening response when the parameter is changed in the also resulted. With increasing prices, the rotation for MI-1 and MI-2 went to the limit of the model at 100 years, while rotations remained at 80 years for MI-3 and MI-4. With decreasing prices, rotation age shortened to 60 years for MI-1, MI-2, and MI-3, and to 70 years for MI-4. The compound rate of price change has the effect of modifying the discount rate for prices but not costs (1.04/1.01=1.0297 or approximately 3%) and these results are similar to those obtained when the discount rate was varied.

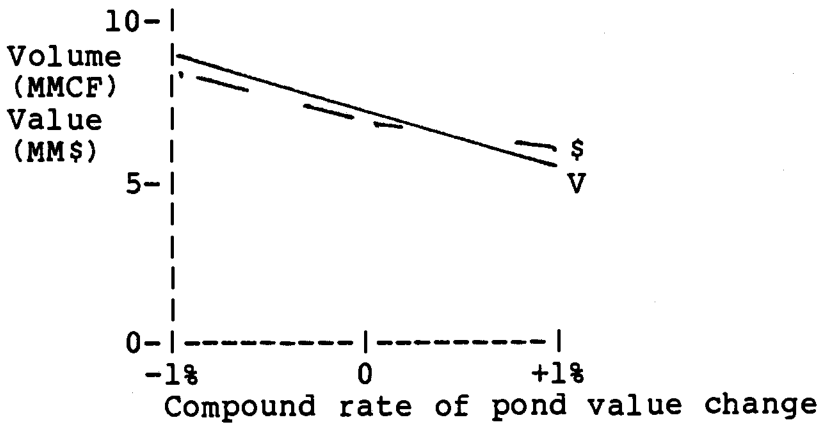

Figure 10. First period volume and value when pond value changes at a compound rate of +1% and -1% per year.

3.1.4 Logging Costs

The change in first period volume and value when logging cost varied ±25% (see Figure 11) were similar to the results obtained when pond value varied the same amount however, changes in management action were more pronounced. Rotation age lengthened to 90 years for MI-1 with an increase in costs, and declined to 80 and 70 years respectively for MI-2 and MI-4 with a decrease in cost. As was the case when pond value varied, small thinnings were added or eliminated in young stands. Additionally, when logging costs were low three stands that had been thinned at nominal values were final harvested. This is due to the value of the existing stands increasing with the decreased cost while the value growth decreases due to the smaller relative diameter premium (see Figure 7). Both changes contribute to a decreased value growth per cent and result in these stands being beyond financial maturity (Duerr, 1960).

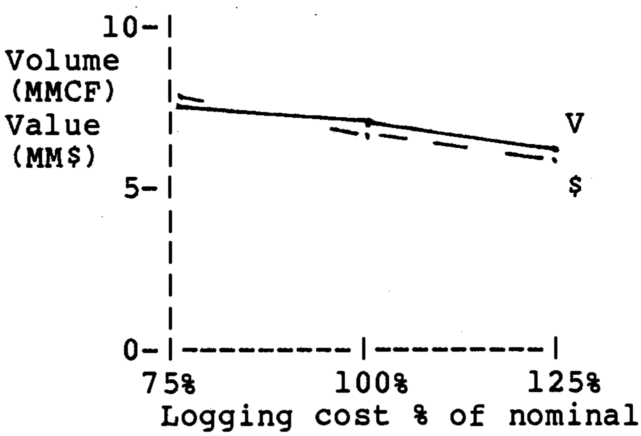

Figure 11. First period volume and value when logging costs vary ±25%.

3.1.5 Pond Value and Logging Costs

When both pond value and logging costs were varied ± 25% the mean stumpage value (harvest value divided by harvest volume) changed with pond value however the change in logging cost appears to dominate the supply (harvest volume) response. When compared to results with nominal values, changes in management were minimal when both pond value and logging costs were increased. However when they were decreased four stands that had been thinned with nominal data were final harvested and thinning intensity was increased on three stands.

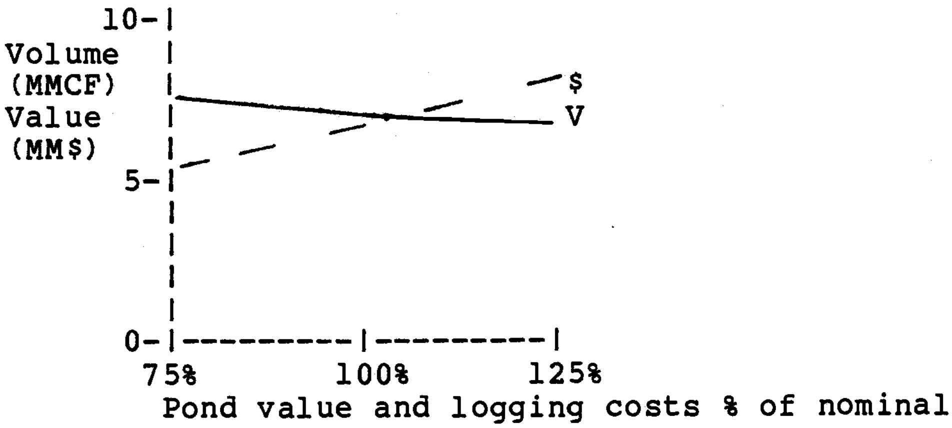

Figure 12. First period harvest volume and value when pond value and logging costs change ±25%.

3.1.6 Discount Rate

The model was, as expected, very sensitive to changes in the discount rate as shown in Figure 13. Harvest volume increased 43% when the discount rate was increased from 3% to 5%. Optimal rotations increased to 100 years for MI-1 and MI-2 at the 3% discount rate, and decreased to 50-years for MI-1, 60-years for MI-2, and to 70-years for MI-3 and MI-4 at a 5% discount rate.

believed the current market price is a temporary deviation from the long run trend. When the first period pond value was low, many commercial thinnings were changed to small improvement thinnings, and five stands that had been final-harvested at nominal pond value were thinned and retained. When the first period pond value was high, ten stands were final-harvested that had been thinned with nominal values.

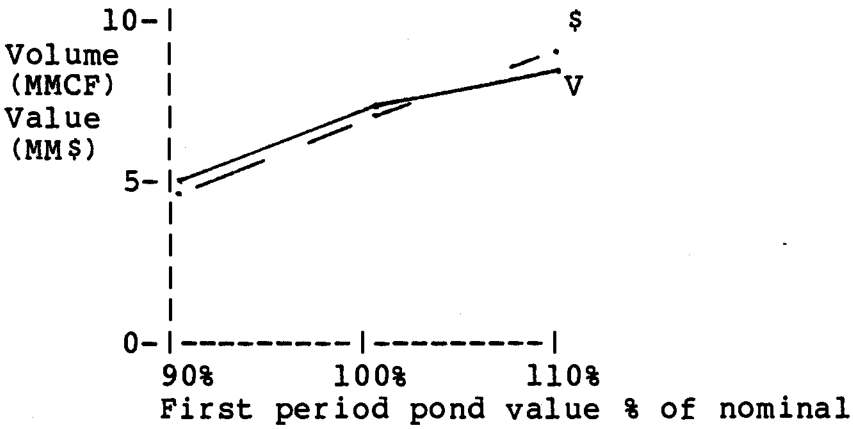

Figure 9. First period harvest volume and value when first-period pond value changes ±10%.

3.1.3.3 Nominal Prices changing at a 1% Compound Rate

As should be expected, the model is also very sensitive to long term price changes, with an approximately 60% variation in harvest volume between a +1% and a -1% long term change in pond value as shown in Figure 10. In this case, major changes in rotation age opposite direction.

Table 9. First decade harvest results with demonstration inventory as individual parameters vary.

Parameter	Harvest Volume (MMCF)	Harvest Value (MM$)	MI-4 Land Value ($/acre)	Rotation Age MI-1 (yrs)	Rotation Age MI-4 (yrs)
All Nominal	6.994	6.835	1236	80	80
Pond Value					
PV + 25%	7.353	9.456	1709	80	80
PV - 25%	6.602	4.499	764	80	80
PV + 10% 1st Period	8.685	9.127	1236	80	80
PV - 10% 1st Period	4.616	4.351	1236	80	80
PV incr 1%/year	5.496	5.625	2602	100	80
PV decr 1%/year	9.048	8.375	492	60	70
Logging Cost					
LC + 25%	6.423	6.015	1073	90	80
LC - 25%	7.838	8.006	1420	80	70
PV & LC + 25%	6.919	8.525	1545	80	80
PV & LC - 25%	7.547	5.492	927	80	80
TAMM PV&LC 6-periods	2.303	0.705	714	90	80
TAMM PV&LC constant	5.751	1.599	222	70	80
Diameter Premium					
50%	8.654	6.801	1099	70	70
None	9.288	9.978	1774	50	60
Discount Rate					
5%	8.651	8.176	601	50	70
3%	6.056	6.071	2668	100	80
Land Value ($/acre)					
1	6.590	6.484	1236	90	80
500	6.769	6.649	1236	90	80
1500	7.768	7.523	1234	60	70

When comparing these results to the accepted theory (for example Samuelson, 1976 or Duerr 1960), it should be noted that their examples use stumpage price (the net difference between pond value and logging costs). In Model III pond value and logging costs are treated separately , thus either an increase in pond value, or a decrease in logging costs results in an increase in stumpage price. However, due to the different diameter responses in the two functions, the resulting change in stumpage price is somewhat complex.

Figure 6 shows graphically the LeDoux pond value and logging cost data from Table 3.

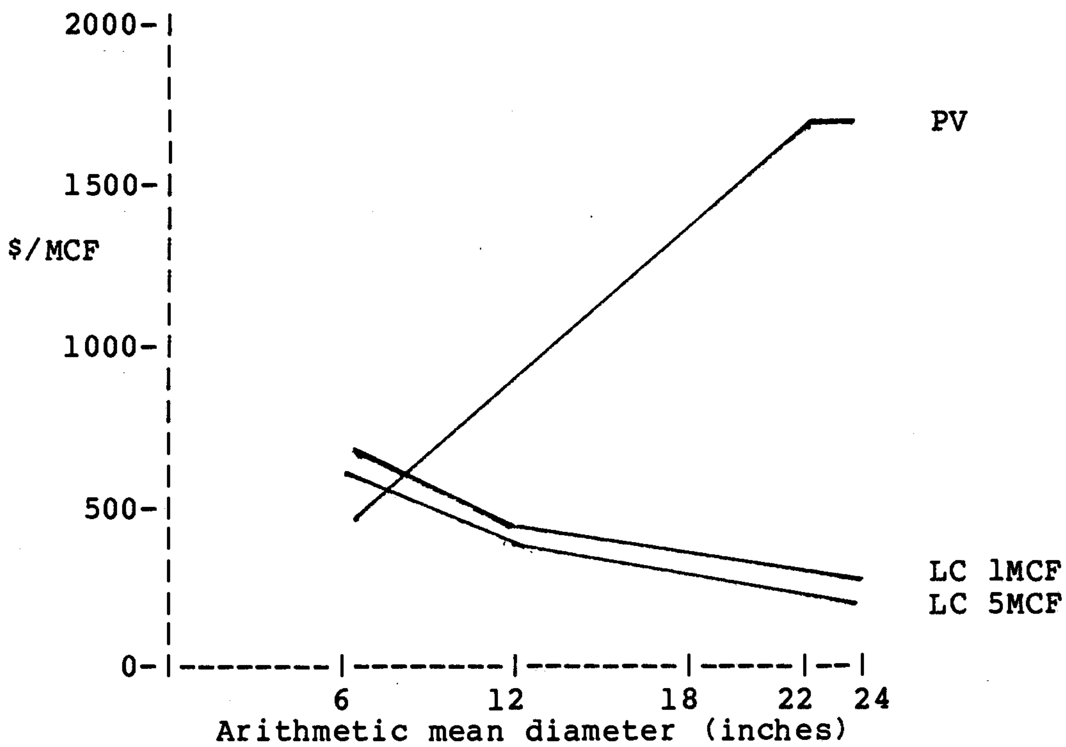

Figure 6. Logging costs and pond value

When logging costs are subtracted from pond value the resulting nominal stumpage value is as shown in Figure 7. Also shown is the stumpage value obtained when pond value is increased 25% and when logging costs are decreased 25%. As can be seen, both lead to higher stumpage value, however the slope of the function is greater when pond value increases, and less when logging costs decreases, when compared to the nominal curve. This seemingly minor difference has a profound effect on optimal management actions discussed in the following sections.

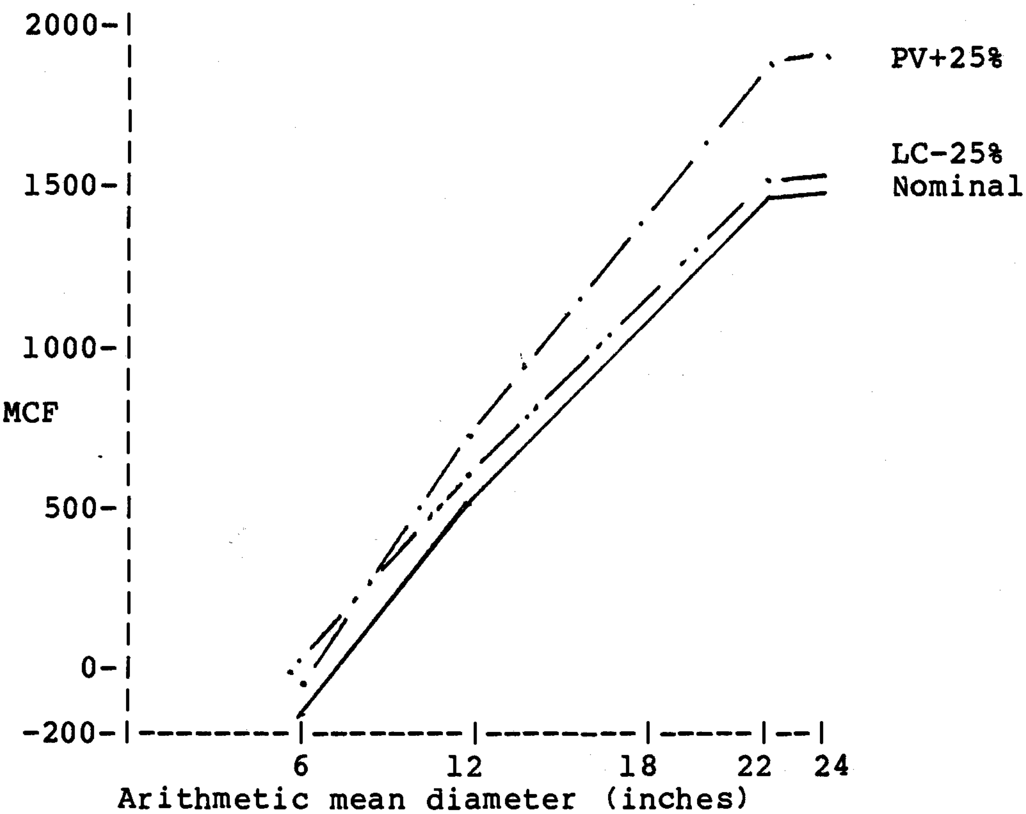

Figure 7. Resulting stumpage value when logging costs or pond value change.

3.1.3 Pond Value

The model exhibited a fairly wide range of responses to differences in the specification of current and future prices. Perhaps it should be repeated that within the philosophy of the model, the first period price is known, while future prices are assumed. Although not shown here, if the model is used in conjunction with a timber market model such as The Timber Assessment Market Model (TAMM) (Adams and Haynes, 1982) both current price and future price assumptions can be respecified each period.

3.1.3.1 Constant Prices at Different Levels

Figure 8 shows the volume and value of the first period harvest when prices are assumed to be constant at ±25% of nominal prices. The model is very insensitive to this wide range of price change as there is essentially little opportunity to improve the solution by temporally redistributing harvests. Harvest volume varies 11% in response to the 50% variation in pond value.

The optimal rotation remains at 80 years throughout this price range. When pond value increases, the current value of the stand increases and, due to the change in the slope of the net stumpage value function (Figure 7), value growth also increases. This results in little change in the relative value growth (Duerr's, 1960, marginal value growth) so no major change in management is indicated. Similarly negating decreases in value and value growth obtain when pond value is lower.

The most frequent change in management was the addition of small investment type thinnings in young stands with high pond value, and the elimination of this type of thinning with low pond value. Changes in pond value influence both the current cost and future value of this type of thinning.

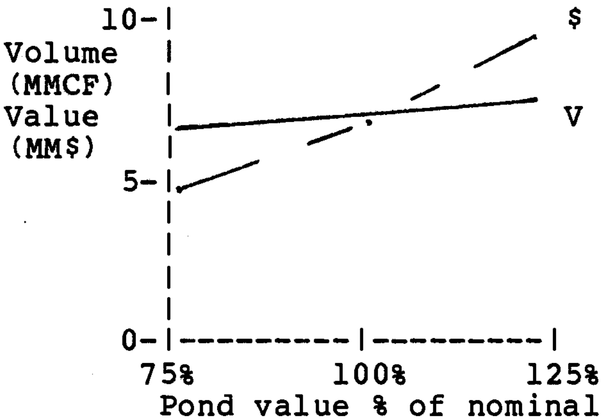

Figure 8. First period harvest volume and value when pond value changes ±25%.

3.1.3.2 First Period Price ±10% From Nominal Constant Price

The model is much more sensitive to this one period change in price as harvests can either be accelerated or delayed to take advantage of the one period price differential. Again, rotations do not change, however volume harvested varies nearly 100% in response to the 20% variation in prices as shown in Figure 9. Behaviorally, this would represent the supply response of one who

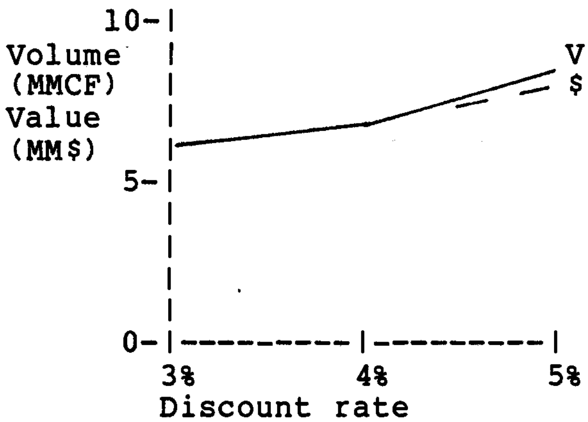

Figure 13. First period volume and value when the discount changes from 3% to 5%.

3.1.7 Land Value

The average land value for Site 130 at nominal values was $925/acre, based upon individual MI land values ranging from $618/acre for MI-2 to $1236/acre for MI-4. The model was almost totally insensitive to values less than the average (see Figure 14), down to and including $1/acre. Optimal rotation increased to 90 years for MI-1 at land values below $925, but remained the same for all other MI. Slightly more response was shown when land value was increased to $1500/acre, $300 more than the land value of MI-4. In this case, harvest increased 12% above the nominal rate, and rotations shortened to 60-years for MI-1 and MI-2, and to 70-years for MI-4. The $1 land value approximates the single rotation present net worth maximizing, or Duerr type A decision model, and the $1500 land value represents a situation where land or soil rent is negative (Samuelson 1976, Duerr 1960).

Changes in parameters such as price, cost and discount rate all effect land value and could have minor secondary influences on management actions in the succeeding period when the new land value will be used. Even when nominal values were used for five decades, land value for site 130 changed from $925 in the first decade to $1081 in the fifth decade due to the shift of inventory into the higher valued MI-3 and MI-4.

The relative insensitivity of the model to fairly major changes in land value reinforces the assumption that an approximate land value, updated each period, is an adequate basis for the backward recursion approach to determination of rotation age in one pass through the dynamic program.

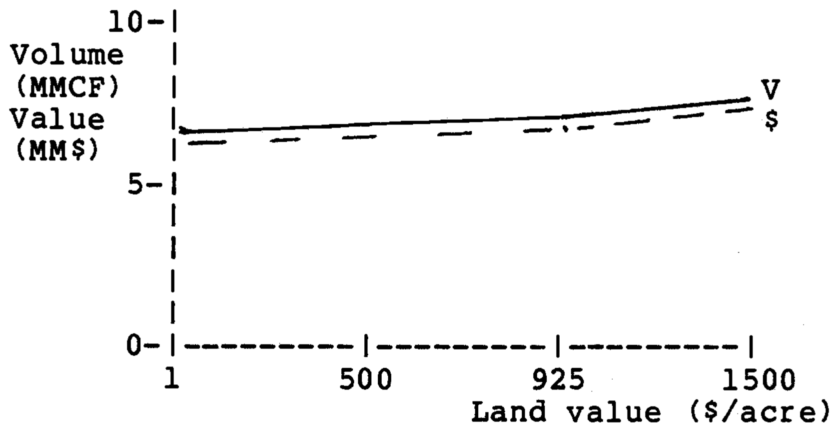

Figure 14. First period volume and value when land value varies from $1 to $1500 per acre.

3.1.8 TAMM prices and costs

A five-period harvest schedule was calculated using Timber Assessment Market Model (TAMM) (Adams and Haynes, 1980) prices and costs projected over the period 1980 to 2030 to illustrate the use of the Model in timber supply modeling. TAMM uses stumpage prices and logging costs that are regional averages which do not vary with diameter or volume harvested, and are in 1967 dollars. Pond value was approximated by adding TAMM stumpage prices and logging costs. Indices were then calculated for each of the five decades to correct Model III pond values and logging costs (based on an average diameter of 18-inches and an average volume removal of 5 MCF/acre) to TAMM forecasts. These indices are shown in Figure 15.

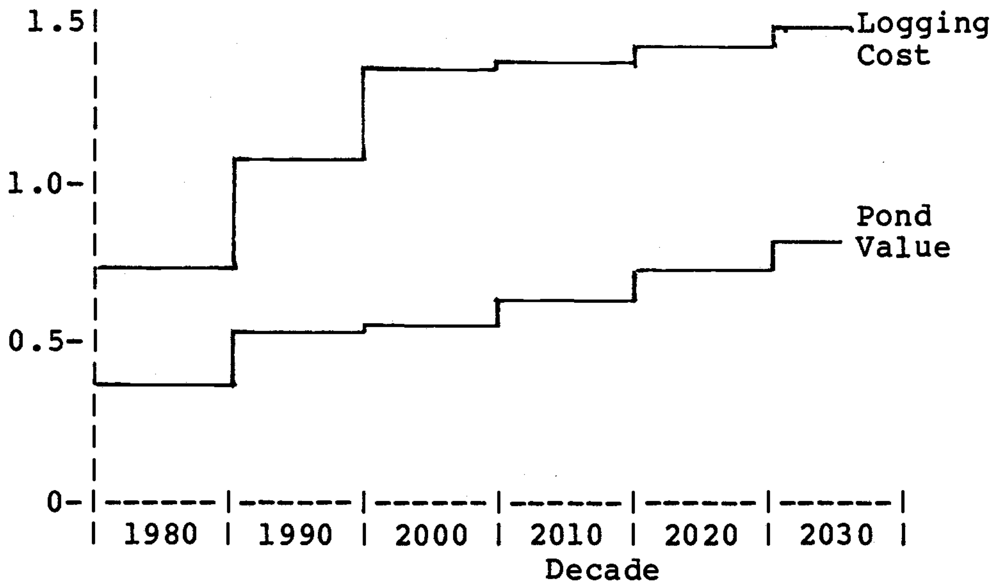

Figure 15. Pond value and logging cost multipliers used to index model III to TAMM projections.

Two peculiarities of the index values, both of which produced somewhat surprising results in the harvest schedule should be noted. First, the index values for logging costs is 0.7 in 1980, while the pond value index is only 0.36. This may be attributable to a difference in data bases, TAMM uses volume-weighted all species averages for National Forest sales in the entire Douglas-fir region (which included old growth), while LeDoux used second growth data from Northwest Oregon. Secondly, the TAMM projections for the decade 2000 shows a fairly substantial increase in logging costs with almost no increase in pond value.

The resulting harvest schedule shown in Figure 16 avoided the undesirable cost/price situation in 2000 by accelerating harvests in 1990 and postponing other harvests until 2010.

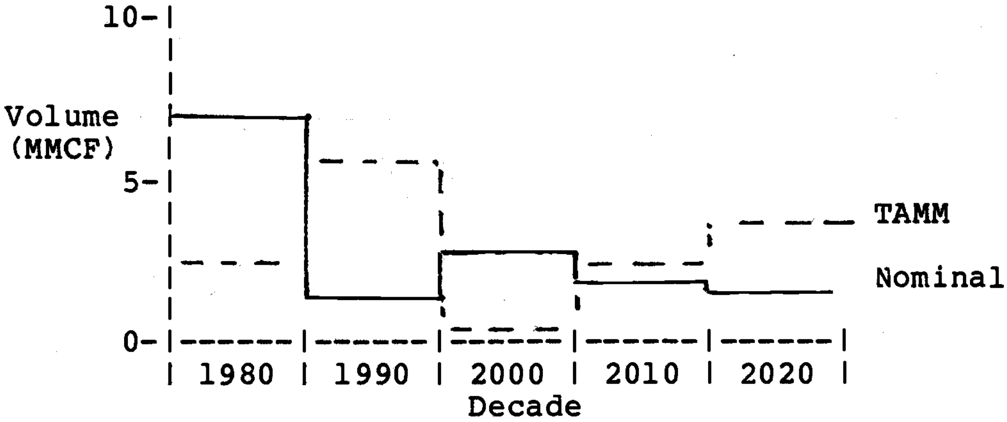

Figure 16. Periodic harvest volume (MMCF) using nominal and TAMM indexed pond values and logging costs.

With nominal costs and prices, the large first-decade harvest is a reduction of the inventory which is overstocked, both based on stands above rotation age, and above stocking levels that exploit diameter growth. Thereafter, the harvest stabilizes at approximately 2 MMCF per decade. Mean stumpage price for the first decade is $984/MCF using nominal data, and $306/MCF using TAMM data.

If the 1980 TAMM pond value and logging cost indices are assumed to be constant over the next 100 years, first period harvest is reduced to 5.751 MMCF, and rotation ages shorten by 10-years for MI-1 and MI-2 when compared to nominal results.

3.1.9 Price and Cost Diameter Premium

In order to examine the sensitivity of the model to the diameter relationships (premiums) in the logging cost and pond value functions, harvest schedules were calculated with the diameter relationships reduced by 50%, and when the diameter relationship is removed entirely (ie, pond value and logging costs independent of the diameter of timber harvested). As shown in Figure 17, the first period harvest increased substantially as the diameter premium was reduced. With no diameter premium, rotations shortened to 40 years for MI-1, MI-2, and MI-3, and to 50 years for MI-4. Management regimes included very few thinnings and MI-1, the natural origin unthinned stand, had the highest land value.

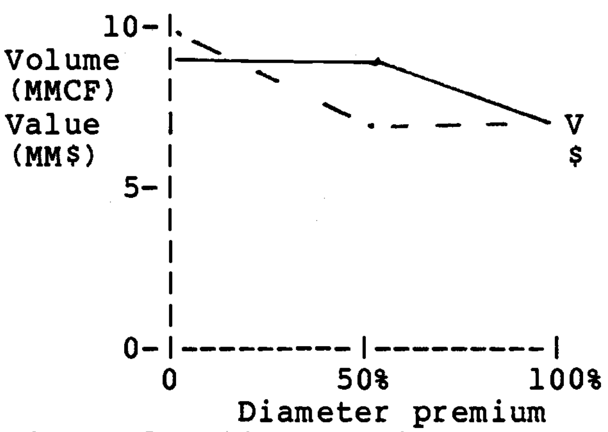

Figure 17. First period volume and value when diameter premium varies from 0% (none) to 100% (full).

3.1.10 Constrained Harvest Schedules

A five-decade harvest schedule was calculated with the periodic harvest volume constrained to be 3 MMCF per decade (Appendix B.2). In each period the unconstrained harvest was higher than 3 MMCF and the shadow price of the constraint declined from $186/MCF in the first period (the 49th ranked alternative in the harvest queue shown in Table 5, page 37) to $77/MCF in the fifth period as the inventory was gradually depleted and the forced reduction in harvest became smaller.

Another harvest schedule (Appendix B.3) was calculated with an upper harvest limit of 4 MMCF (maximum opportunity cost of $100/MCF) and a lower limit of 3 MMCF (maximum opportunity cost of $125/MCF). Harvest volumes and opportunity cost per decade are shown in Figure 18. In the first decade the upper bound was violated and the harvest was reduced by implementing the first 22-ranked alternatives in the harvest queue (Table 5). The 23rd alternative would have exceeded the $100 limit associated with the upper bound. In the second decade the unconstrained harvest fell within the allowable range so no modification was required, while in the third decade the lower limit was violated but met within the allowable cost. In the last two decades the lower limit was violated and the harvests modified to the maximum allowable cost. In the last decade 85% of the forest was age 30 or under leaving only ten viable alternatives to increase harvest. The first three were implemented (the opportunity cost of the third alternative was $92.96 per MCF) while the fourth alternative had an opportunity cost of $156/MCF which exceeded the $125/MCF limit specified for the lower bound.

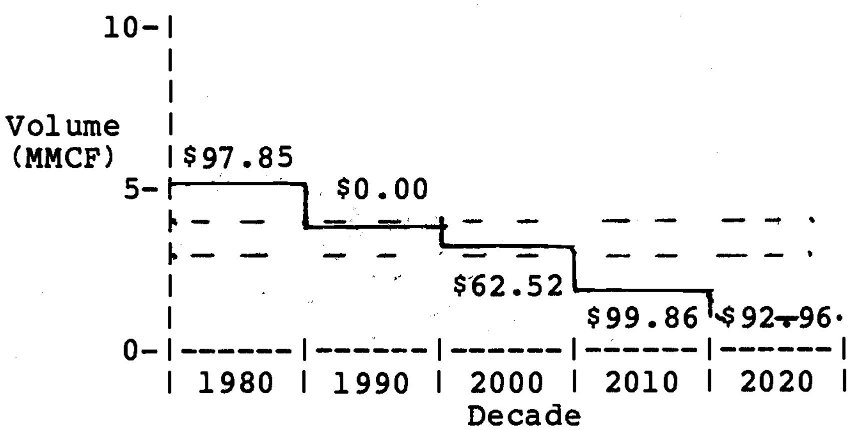

Figure 18. Periodic harvest volume (MMCF) and opportunity costs using nominal values when harvest is constrained between 3 and 4 MMCF per decade.

3.2 Northwest Oregon Forest Industry Inventory

To demonstrate the ability of the model to handle a large, realistic inventory, an attempt was made to obtain the inventory of the industrial forest ownership in

Northwest Oregon (Clackamas, Clatsop, Columbia, Hood River, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill Counties). The data could not be obtained at a reasonable cost in the form best used by Model III, that is with individual stands described by age-class, basal area and trees per acre, and general past management history. A highly aggregated inventory, listing age-class and volume per acre for three stocking classes and three site classes was obtained from Dr. P. L. Tedder, Oregon State University (Tedder, 1983), and was used with the following exceptions:

- Unmanageable stands totaling 143,593 acres were excluded.

- Site class 80 totaling 27,619 acres was excluded.

This left a manageable inventory of 848,616 acres, 80% in site class 108 and the remaining 20% in site class 130. Trees per acre and basal area per acre were reconstructed by comparing the conifer volume per acre to a DFSIM regional average stand at the age of the midpoint of the class and using that proportion or per cent of stocking to calculate the trees per acre and basal area per acre of the regional average stand at the beginning age of the class. Approximately 10% of the 40-year old stands were assumed to have been thinned (MI-2), and plantation origin

(MI-3) was assumed for 50% of the zero aged stands, 25% of the 10-year old stands, and 10% of the 20-year stands. All remaining stands were considered to be natural origin unthinned (MI-1), resulting in the inventory shown in Appendix A.2.

3.2.1 Nominal Data

A 5-period harvest schedule using nominal data (see page 41) produced the results shown in Figure 19 and Appendix B.4.

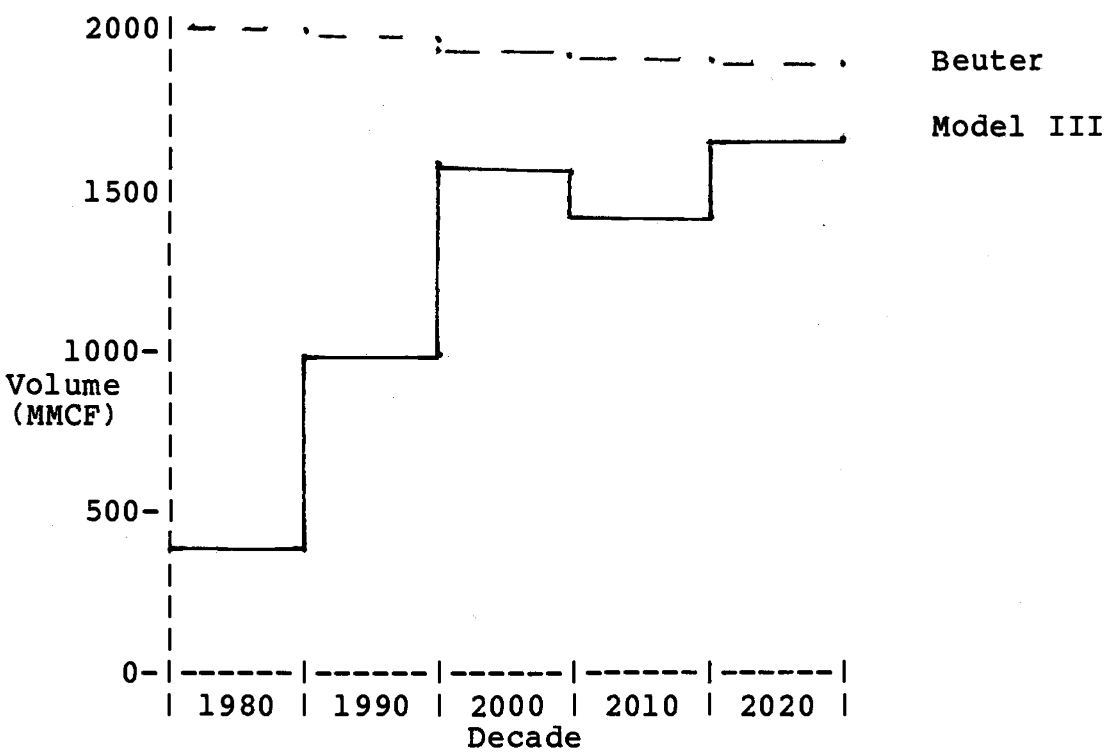

Figure 19. Harvest projection for Northwest Oregon forest industry ownership with nominal data.

The harvest starts low, reflecting the predominately young, understocked condition of the inventory and, beginning in the third decade appears to be stabilizing at a 10-year harvest volume of 1.5 billion cubic feet. This is a much more pronounced increase, and a lower stabilizing level than the approximately 2 billion cubic feet projected by Beuter (Beuter, 1976)[1] however, if the Site class 80 and unmanaged lands were included (20% increase in area) the sustainable harvest levels would be comparable. The difference in the increase in harvest over the first three decades is attributable to the fact that Beuter's model was maximizing volume harvested, subject to harvest sustainability constraints, while Model III is optimizing discounted value, and the young initial inventory has more value if left to grow one or two more decades.

Rotation ages for Site class 108 are 90-years for MI-1, 80-years for MI-2 and MI-3, and 70-years for MI-4. The mean stumpage value of the first decade harvest is $646/MCF reflecting the younger, smaller diameter of the volume harvested when compared to the demonstration inventory.

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1. The Northwest Oregon Forest Industry area contains all of Beuter's North Willamette timbershed, most of his North Coastal, and part of his Mid-Willamette timbersheds. The two billion cubic foot figure is based on a rough approximation proportioned by percent of the timbershed included in the Northwest Oregon area.

3.2.2 TAMM Price and Cost Data

When TAMM pond values and logging costs are used, the harvest schedule shows a reluctance to harvest in the decade 2000 similar to the demonstration inventory run, and harvest volumes are lower than the nominal harvest schedule throughout the first five decades as shown in Figure 20 and Appendix B.5.

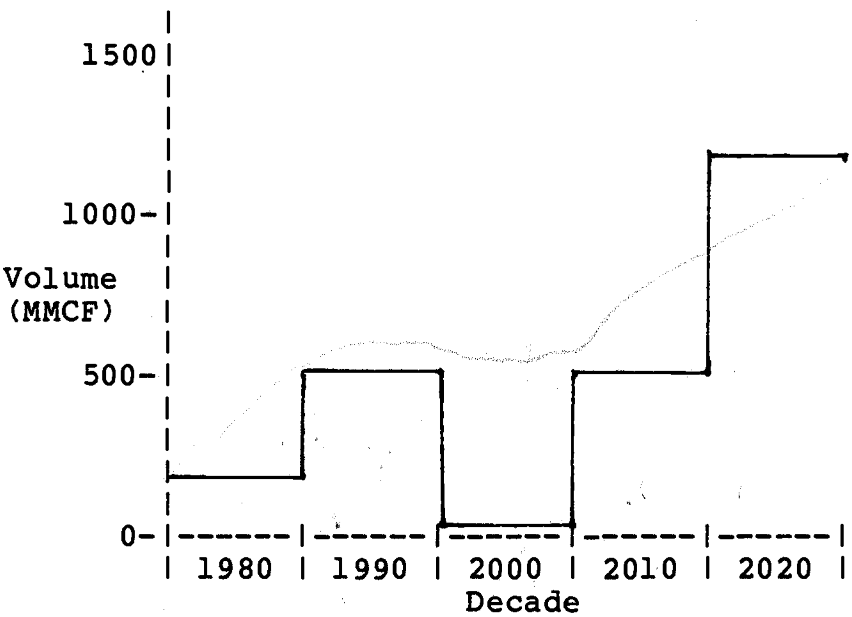
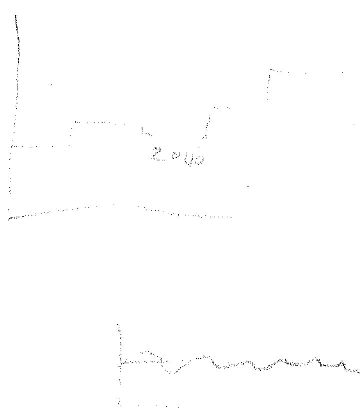
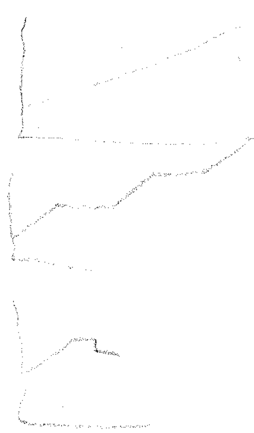


Figure 20. Harvest projection for Northwest Oregon forest industry ownership with TAMM data.





3.3 Computational Considerations

The computer programs used in Model III are written in FORTRAN 77, and are ANSI standard. They are currently operating on a Control Data Corporation CYBER 170-720 computer.

Computation times for representative type harvest schedules are shown in table 10. Several factors concerning the different harvest scheduling problems should be noted when comparing computation times:

- The NW Oregon inventory has two site classes (SI) each with four management intensity classes (MI) while the demonstration inventory only has one SI.
- The total number of stands decreases from 40 (demonstration) or 42 (NW Oregon) in the first period to anywhere between 8 and 36 in the fifth period, depending on the inventory and type of harvest schedule calculated.
- In the one-period harvest schedules the inventory does not have to be advanced to a subsequent period, while in the five-period schedules inventory has to be advanced four times.

- The unconstrained harvest schedules do not require the calculation of the opportunity cost of suboptimal harvest alternatives.

Total central memory requirements were 122,100 octal words for the demonstration inventory problems and 142,500 for the NW Oregon inventory.

Table 10. Computation time requirements[2]

Type harvest schedule	type inventory: Demonstration	type inventory: NW Ore
1-period unconstrained	97 (40)	102 (42)
5-period unconstrained	285 (12)	581 (36)
5-period constrained max opportunity cost	300 (8)	600 (31)
5-period constrained	310 (22)	593 (30)

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2. Times shown are seconds of central processer resources used. Total number of individual stands in the last period of the simulation are shown in parentheses.

Chapter 4

Applications and Extensions

The primary purpose of this work was the development of the basic concept of Model III and a demonstration that it will solve a realistically rigorous problem. In the process of this research a number of extensions of, and applications for, the model were conceptually considered. These opportunities for further research will be briefly developed in this chapter.

4.1 Model III as a Prescriptive Harvest Scheduling Tool.

Many integrated forest products firms furnish all or part of the raw material needs of their mills from their own (fee) timber lands. Due to tax and other advantages, profit margins from processing of fee timber are higher than for timber purchased from external sources. With Model III a firm could specify minimum and maximum timber volume requirements with opportunity cost limits set to reflect the profit differential between internal and external profit margins. Model III can provide a specific harvesting prescription for each distinct stand class based upon the most efficient (in terms of minimum future value foregone) plan to meet the requirements, if they can be met from company holdings. If they can not, it will identify the portion which efficiently should be supplied from fee lands and the portion to be procured from other sources. Additionally, even without a constrained harvest, the complete listing of harvest alternatives and corresponding values for each stand class can be provided to the forest manager so that he can objectively evaluate alternatives other than the one calculated by the model as optimal. In many cases an alternative with a slightly lower value may be judged to be superior based on considerations which could not be specified in the model.

When used prescriptively, the model should be specified with the smallest tree and basal area node intervals that can be supported by the computer and inventory data available so that as many harvest alternatives as possible can be considered.

4.2 Timber Supply Modeling

Model III could be used to endogenously model timber supply from ownerships (such as forest industry) that are basically profit motivated, as part of a larger model such as TAMM. Assumptions concerning pond value and logging costs for the next 100-years would be specified once each period. Model III would solve for a supply volume based on the assumption that current prices are on the long term schedule. This supply volume would be used by the market model to derive a tentative market-clearing price for the current period. If this price is sufficiently different from the initial price used, Model III would resolve for the current period harvest, using the new price as a first period departure from the long term trend producing a supply schedule similar to that shown in Figure 9 page 50. These two points on the supply curve should be adequate to interpolate for a final market solution, however, additional iterations could be performed until some prespecified tolerance is met. If the Market Model operates on annual cycles an interface such as the growth-drain model used in the Timber Resource Inventory Model (TRIM) (Tedder, 1983) could be used.

In this type of application the precision needed for individual stand prescriptions is not required and a coarser tree/basal area grid could be used to conserve computer time and storage. Some experimentation with the size of the grid interval indicated that while individual stand prescriptions changed somewhat, the total volume harvested varied less than 3% when the tree interval was raised to 40 with the basal area interval remaining at 10. With this size grid, computation time and storage space are reduced by nearly 50%.

Major differences were encountered when the tree interval remained at 20 and the basal area interval was raised to 20. This latter combination, apparently due to the rounding effect on tree diameter, actually resulted in a fairly substantial increase in the volume and value of the harvest. Additional trials with both tree and basal area intervals increased should be evaluated if the model is used for a large number of replications such as would be required in timber supply modeling.

4.3 Stochastic or Semistochastic Harvest Scheduling

Since Model III is able to handle a large number of different stand classes without a significant increase in computation time and with no increase in computation space, it is well suited to some type of stochastic modeling. For example, instead of being deterministic, the post harvest residual stand could be distributed over a number of neighboring nodes representing variability in the planned harvest, or a portion of a thinned MI-4 stand could be placed in MI-3 where less growth response to thinning would be realized. Stands thus perturbed from the optimal path would be managed in an optimal manner based upon their new description. The DP could be easily modified to calculate the expected value of a specified distribution of outcomes within the MI. Consideration of outcomes outside of the MI, however, would entail a major additional computational burden.

4.4 Variations and Embellishments

Fertilization, precommercial thinning, additional thinning ratios, and species other than Douglas-fir are not now included in Model III, but could be incorporated as described below.

4.4.1 Fertilization

In DFSIM fertilization effects are essentially reduced to zero by the end of a 10-year growth period. A fixed fertilization policy such as 200 pounds at each thinning could be included in the MI-2 and MI-4 growth calculations with no other modifications required. Optimizing fertilization would require the creation of additional MI for each possible rate of fertilizer application.

4.4.2 Precommercial Thinning

As precommercial thinning only influences the stand characteristics at the time of earliest commercial entry (generally 30 years age), and as no other management actions take place between stand establishment and that age, MI-2 and MI-4 could have juvenile growth based upon precommercial thinning with MI-1 and MI-3 representing unthinned juvenile stands. The thinning would be evaluated for all stands at age 10 and the thinning (including no thinning) would be be optimized based on the present and assumed future cost and price data prevailing for the current period. Thinned stands would be placed in MI-2 or MI-4 at the optimal residual trees per acre, while unthinned stands would remain in MI-1 or MI-3.

4.4.3 Additional d/D Thinning Ratios

Additional thinning types (d/D ratios below 1.0) could be considered with the addition of a separate record in the yield Random Access File (RAF) for each ratio considered. This would also increase the number of entries in the Management Action record for each existing stand but would not necessitate the use of any additional files. Ratios above 1.0 result in a unique change in height for the remainder of a stand's existence. Thus ratios above 1.0 could not be considered with a precalculated yield table such as that used in Model III.

4.4.4 Timber Species

It should be stressed that while DFSIM was used as the basic growth model, Model III could be used with most other whole stand growth models that use age, number of trees and basal area per acre as stand descriptors. To model an ownership comprised of several species, each of which grows as essentially a pure stand, would require that a new "site class" be established for each species. If a mixed species growth model is available that uses the Model III stand descriptors, it could be used so long as composite logging cost and pond value data were available.

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Appendices

Appendix A

YIELD AND INVENTORY DATA

A.1 DEMONSTRATION INVENTORY

Each stand represents 25 acres, site 130(King).

			Volume[1]				
Age	TPA	BAPA	DFSIM Existing	MI-1	MI-2	Region Ave	%[2] stock
20	1000	NA	3600	3603	- -	3600	100
20	600	NA	3600	- -	3603	3600	100
30	240	60	3117	3118	3150	6560	48
40	400	180	8453	8453	8680	9150	95
50	240	160	8502	8539	8780	11400	77
50	400	260	12318	12318	12609	11400	111
60	240	220	12270	12270	12635	13440	94
60	320	300	15565	15565	15952	13440	119
70	160	200	11813	11813	12304	15200	81
80	160	240	14765	14765	15207	16650	91
90	160	280	17528	17528	18026	18000	100

----

1. All volumes are per acre, cubic foot, trees 5.6 inch DBH and larger, to a 4-inch top

2. Mean stocking for the entire demonstration inventory is 91% of regional average.

Age	TPA	BAPA	DFSIM Existing	MI-3	MI-4[3]	Reg Ave	% stock
20	300	NA	3210	3221	3221	3210	100
20	400	NA	3416	3416	3416	3416	NA
30	160	60	3390	3443	3739	6240	60
30	320	120	5735	5857	6242	6240	100
40	280	180	8883	9147	9392	9250	102
50	200	180	9680	10010	10259	12060	85
60	200	240	13463	13886	14044	14490	97
70	160	240	14211	14642	14788	16560	89
80	160	300	17777	18245	18349	18180	101
90	80	180	11908	12237	12372	19600	63

----

3. Regional average for MI-3 and MI-4 is an unthinned stand with 300 TPA surviving planting.

A.2 NORTHWEST OREGON FOREST INDUSTRY INVENTORY DATA

A.2.1 SITE 130 (King)

AGE	TPA	BAPA	ACRES	% STOCKING[4]
MI-1				
70	80	100	15855	37
60	80	70	6323	20
60	200	180	15856	67
40	400	180	3794	85
40	520	230	6323	107
30	600	140	5704	83
30	520	130	30032	68
30	800	190	44201	116
20	400	NA	5691	54
10	400	NA	4005	54
10	560	NA	6673	78
0	560	NA	11429	78
SUBTOTAL			155886	79
MI-2[5]				
40	400	180	2530	85
MI-3				
20	300	NA	632	54
10	300	NA	2669	54
0	300	NA	10877	54
SUBTOTAL			14178	54
SI-130 SUBTOTAL			172594	77

----

4. Percentage of DFSIM regional average

5. Acreages in MI-2 and MI-3 were arbitrarily assigned based on general regional averages

A.2.2 SITE 108 (King)

AGE	TPA	BAPA	ACRES	% STOCKING
MI-1				
90	160	200	11679	73
80	80	80	6323	24
70	80	70	6323	32
70	160	130	10574	53
70	320	270	5704	116
60	80	50	15576	27
50	440	200	6323	93
50	320	150	11063	69
40	280	80	20250	43
40	560	170	60895	88
30	440	70	68499	46
30	760	120	78282	83
30	800	130	30840	115
20	280	NA	20477	32
20	520	NA	51204	54
20	720	NA	24722	78
10	520	NA	47103	54
10	720	NA	18293	78
0	520	NA	27275	54
0	720	NA	45151	78
SUBTOTAL			566556	67
MI-2				
40	280	80	10000	43
MI-3				
20	300	NA	10712	32
10	300	NA	12871	32
10	400	NA	3478	54
0	300	NA	9983	32
0	400	NA	62422	54
SUBTOTAL			99466	47
SI-108 SUBTOTAL			676022	64
TOTAL			848616	66

Appendix B

Selected 5-Decade Harvest Schedules

B.1 Demonstration Inventory With Nominal Data, Unconstrained

B.2 Demonstration Inventory With Nominal Data, Constrained to 3 MMCF per Decade

B.3 Demonstration Inventory With Nominal Data, Constrained Between 3 and 4 MMCF per Decade

B.4 NW Oregon Forest Industry With Nominal Data

B.5 NW Oregon Forest Industry With TAMM Data

Appendix B.1. Demonstration Inventory With Nominal Data, 5-Period Unconstrained
YEAR 1980 UNCONSTRAINED HARVEST = 6.94 MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	1000	10	25	30	720	170	25	1	0	.00	.00	.00	.00
30	240	60	25	40	200	90	25	2	240	-27.12	6.00	-678.00	.00
40	400	180	25	50	280	200	25	2	337	5.45	8.43	136.25	.00
50	240	160	25	60	80	80	25	2	4838	2485.27	120.95	62131.75	.00
50	400	260	25	60	80	80	25	2	8640	4419.28	216.00	110482.00	.00
60	240	220	25	70	80	100	25	2	7152	5021.92	178.80	125548.00	.00
60	320	300	25	70	80	100	25	2	10451	7643.84	261.28	191096.00	.00
70	160	200	25	0	300	10	25	4	11813	10741.36	295.33	268534.00	.00
80	160	240	25	0	300	10	25	4	14765	15418.85	369.13	385471.25	.00
90	160	280	25	0	300	10	25	4	17528	20460.44	438.20	511511.00	.00
TOTAL			250.0								1894.10	1654232.25	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	600	10	25	30	380	100	25	2	1129	-144.35	28.23	-3608.75	.00
30	240	60	25	40	200	90	25	2	289	-25.74	7.23	-643.50	.00
40	400	180	25	50	340	220	25	2	0	.00	.00	.00	.00
50	240	160	25	60	80	80	25	2	5094	2564.91	127.35	64122.75	.00
50	400	260	25	60	80	80	25	2	8950	4578.48	223.75	114462.00	.00
60	240	220	25	70	80	100	25	2	7528	5119.56	188.20	127989.00	.00
60	320	300	25	70	60	80	25	2	11880	8553.95	297.00	213848.75	.00
70	160	200	25	80	60	100	25	2	6834	6138.27	170.85	153456.75	.00
80	160	240	25	0	300	10	25	4	15207	15773.41	380.18	394335.25	.00
90	160	280	25	0	300	10	25	4	18026	20990.06	450.65	524751.50	.00
TOTAL			250.0								1873.43	1588713.75	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	300	10	25	30	280	130	25	3	0	.00	.00	.00	.00
20	400	10	25	30	320	130	25	4	236	-32.19	5.90	-804.75	.00
30	160	60	25	40	120	80	25	4	734	194.68	18.35	4867.00	.00
30	320	120	25	40	280	170	25	3	0	.00	.00	.00	.00

40	280	180	25	50	60	60	25	4	6713	3859.52	167.83	96488.00	.00
50	200	180	25	60	60	80	25	4	6290	4725.41	157.25	118135.25	.00
60	200	240	25	70	60	90	25	4	9291	8719.54	232.28	217988.50	.00
70	160	240	25	0	300	10	25	4	14642	16442.87	366.05	411071.75	.00
80	160	300	25	0	300	10	25	4	18245	23974.13	456.13	599353.25	.00
90	80	180	25	0	300	10	25	4	12237	18188.97	305.93	454724.25	.00
TOTAL			250.0								1709.70	1901823.25	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	300	10	25	30	280	130	25	3	0	.00	.00	.00	.00
20	400	10	25	30	360	140	25	3	0	.00	.00	.00	.00
30	160	60	25	40	160	110	25	3	0	.00	.00	.00	.00
30	320	120	25	40	240	160	25	4	794	115.70	19.85	2892.50	.00
40	280	180	25	50	180	170	25	4	2394	1225.60	59.85	30640.00	.00
50	200	180	25	60	60	80	25	4	6539	4995.24	163.48	124881.00	.00
60	200	240	25	70	60	90	25	4	9449	8888.63	236.23	222215.75	.00
70	160	240	25	80	60	110	25	4	8790	9812.84	219.75	245321.00	.00
80	160	300	25	0	300	10	25	4	18349	24180.27	458.73	604506.75	.00
90	80	180	25	0	300	10	25	4	12372	18400.34	309.30	460008.50	.00
TOTAL			250.0								1467.18	1690465.50	

TOTAL PERIODIC HARVEST = 6.944 MMCF REVENUE = $ 6835234.75
REVISED LAND VALUES - SITE 130 = $ 924.42
YEAR 1990 UNCONSTRAINED HARVEST = 1.27 MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	720	170	25	40	480	210	25	1	0	.00	.00	.00	.00
TOTAL			25.0								.00	.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	60	100	25	0	300	10	25	4	7124	8414.57	178.10	210364.25	.00
70	80	100	75	80	80	130	75	2	0	.00	.00	.00	.00
70	60	80	25	0	300	10	25	4	5644	5690.45	141.10	142261.25	.00
60	80	80	100	70	80	110	100	2	0	.00	.00	.00	.00
50	340	220	25	60	80	80	25	2	7690	3822.22	192.25	95555.50	.00

50	280	200	25	60	80	80	25	2	7073	3968.07	176.83	99201.75	.00
40	200	90	50	50	80	60	50	2	2614	679.41	130.70	33970.50	.00
30	380	100	25	40	300	140	25	2	187	-31.51	4.68	-787.75	.00
TOTAL			350.0								823.65	580565.50	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM			TO						PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	280	170	25	50	240	210	25	3	0	.00	.00	.00	.00
40	160	110	25	50	140	140	25	4	439	161.66	10.98	4041.50	.00
30	360	140	25	40	320	200	25	3	0	.00	.00	.00	.00
30	280	130	50	40	220	170	50	4	585	144.98	29.25	7249.00	.00
TOTAL			125.0								40.23	11290.50	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM			TO						PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	60	110	25	0	300	10	25	4	7834	10554.56	195.85	263864.00	.00
70	60	90	50	80	60	120	50	3	0	.00	.00	.00	.00
60	60	80	50	70	60	110	50	3	0	.00	.00	.00	.00
50	180	170	25	60	60	80	25	4	6096	5035.60	152.40	125890.00	.00
50	60	60	25	60	60	90	25	3	0	.00	.00	.00	.00
40	240	160	25	50	200	200	25	4	339	38.66	8.48	966.50	.00
40	120	80	25	50	80	90	25	4	1254	548.76	31.35	13719.00	.00
30	320	130	25	40	240	170	25	4	895	172.99	22.38	4324.75	.00
0	300	10	250	10	300	10	250	4	0	.00	.00	.00	.00
TOTAL			500.0								410.45	408764.25	

TOTAL PERIODIC HARVEST = 1.274 MMCF REVENUE = $ 1000620.25
REVISED LAND VALUES - SITE 130 = $ 989.80

YEAR 2000 UNCONSTRAINED HARVEST = 2.71 MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM			TO						PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	480	210	25	50	320	220	25	2	207	-.20	5.18	-5.00	.00
TOTAL			25.0								5.18	-5.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
80	80	130	75	0	300	10	75	4	8993	10166.40	674.48	762480.00	.00
70	80	110	100	80	60	110	100	2	1485	1242.00	148.50	124200.00	.00
60	80	80	50	70	80	110	50	2	0	.00	.00	.00	.00
50	80	60	50	60	80	90	50	2	0	.00	.00	.00	.00
40	300	140	25	50	260	180	25	2	0	.00	.00	.00	.00
TOTAL			300.0								822.98	886680.00	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
80	60	120	50	0	300	10	50	4	8337	11842.01	416.85	592100.50	.00
70	60	110	50	0	300	10	50	4	7443	10128.64	372.15	506432.00	.00
60	60	90	25	70	60	120	25	3	0	.00	.00	.00	.00
50	240	210	25	60	60	70	25	4	8201	6226.51	205.03	155662.75	.00
40	320	200	25	50	60	60	25	4	7501	4160.53	187.53	104013.25	.00
TOTAL			175.0								1181.55	1358208.50	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
60	60	80	25	70	60	110	25	3	0	.00	.00	.00	.00
50	200	200	25	60	60	80	25	4	7562	6562.13	189.05	164053.25	.00
50	140	140	25	60	60	90	25	4	4266	3379.77	106.65	84494.25	.00
50	80	90	25	60	80	130	25	3	0	.00	.00	.00	.00
40	240	170	25	50	80	90	25	4	5410	3339.70	135.25	83492.50	.00
40	220	170	50	50	80	90	50	4	5485	3951.38	274.25	197569.00	.00
10	300	10	250	20	300	10	250	4	0	.00	.00	.00	.00
0	300	10	75	10	300	10	75	4	0	.00	.00	.00	.00
TOTAL			500.0								705.20	529609.00	

TOTAL PERIODIC HARVEST = 2.715 MMCF REVENUE = $ 2774492.50
REVISED LAND VALUES - SITE 130 = $ 1013.43

YEAR 2010 UNCONSTRAINED HARVEST = 1.86 MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
80	60	110	100	0	300	10	100	4	7738	9796.57	773.80	979657.00	.00
70	80	110	50	80	60	110	50	2	1485	1242.00	74.25	62100.00	.00
60	80	90	50	70	60	90	50	2	1399	1187.89	69.95	59394.50	.00
50	320	220	25	60	80	80	25	2	7824	4238.64	195.60	105966.00	.00
50	260	180	25	60	80	80	25	2	6096	3265.49	152.40	81637.25	.00
TOTAL			250.0								1266.00	1288754.75	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
70	60	120	25	0	300	10	25	4	8010	11542.11	200.25	288552.75	.00
70	60	110	25	0	300	10	25	4	7443	10128.64	186.08	253216.00	.00
60	80	130	25	0	300	10	25	4	8230	10257.43	205.75	256435.75	.00
TOTAL			75.0								592.08	798204.50	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
60	60	90	25	70	60	120	25	3	0	.00	.00	.00	.00
60	60	80	25	70	60	110	25	3	0	.00	.00	.00	.00
60	60	70	25	70	60	100	25	3	0	.00	.00	.00	.00
50	80	90	75	60	80	130	75	3	0	.00	.00	.00	.00
50	60	60	25	60	60	90	25	3	0	.00	.00	.00	.00
20	300	10	250	30	280	130	250	3	0	.00	.00	.00	.00
10	300	10	75	20	300	10	75	4	0	.00	.00	.00	.00
0	300	10	175	10	300	10	175	4	0	.00	.00	.00	.00
TOTAL			675.0								.00	.00	

TOTAL PERIODIC HARVEST = 1.858 MMCF REVENUE = $ 2086959.25
REVISED LAND VALUES - SITE 130 = $ 1070.95

YEAR 2020 UNCONSTRAINED HARVEST = 1.71 MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 80 LAND VALUE = $ 612.38

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
80	60	110	50	0	300	10	50	4	7738	9796.57	386.90	489828.50	.00
70	60	90	50	80	60	120	50	2	0	.00	.00	.00	.00
60	80	80	50	70	80	110	50	2	0	.00	.00	.00	.00
TOTAL			150.0								386.90	489828.50	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
70	60	120	25	0	300	10	25	4	8010	11542.11	200.25	288552.75	.00
70	60	110	25	0	300	10	25	4	7443	10128.64	186.08	253216.00	.00
70	60	100	25	0	300	10	25	4	6860	8743.90	171.50	218597.50	.00
60	80	130	75	0	300	10	75	4	8230	10257.43	617.25	769307.25	.00
60	60	90	25	70	60	120	25	3	0	.00	.00	.00	.00
30	280	130	250	40	220	170	250	4	585	144.98	146.25	36245.00	.00
TOTAL			425.0								1321.33	1565918.50	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
20	300	10	75	30	280	130	75	3	0	.00	.00	.00	.00
10	300	10	175	20	300	10	175	4	0	.00	.00	.00	.00
0	300	10	175	10	300	10	175	4	0	.00	.00	.00	.00
TOTAL			425.0								.00	.00	

TOTAL PERIODIC HARVEST = 1.708 MMCF REVENUE = $ 2055747.00
REVISED LAND VALUES - SITE 130 = $ 1080.98

Appendix B.2. Demonstration Inventory With Nominal Data, 5-Period Constrained to 3 MMCF per Decade

YEAR 1980 UNCONSTRAINED HARVEST = 6.94 MMCF
SHADOW PRICE OF THE HARVEST CONSTRAINT = $ 186.03 MANAGEMENT WAS MODIFIED FOR 49 STANDS.
THE MODIFIED ACTION FOR THE MARGINAL STAND IS:

SITE = 130 MI = 1

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
60	320	300	8	70	200	250	8	2	2599	1587.24	20.79	12697.92	186.03

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	1000	10	25	30	720	170	25	1	0	.00	.00	.00	.00
30	240	60	25	40	200	90	25	2	240	-27.12	6.00	-678.00	.00
40	400	180	25	50	280	200	25	2	337	5.45	8.43	136.25	.00
50	240	160	25	60	200	190	25	1	0	.00	.00	.00	13.93
50	400	260	25	60	320	270	25	1	0	.00	.00	.00	123.51
60	240	220	25	70	200	240	25	1	0	.00	.00	.00	93.13
60	320	300	17	70	80	100	17	2	10451	7643.84	177.67	129945.28	.00
70	160	200	25	80	160	220	25	1	0	.00	.00	.00	177.73
80	160	240	25	90	80	150	25	2	6092	6021.03	152.30	150525.75	121.20
90	160	280	25	0	300	10	25	4	17528	20460.44	438.20	511511.00	.00
TOTAL			250.0								782.59	791440.28	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	600	10	25	30	400	100	25	2	0	.00	.00	.00	14.22
30	240	60	25	40	200	90	25	2	289	-25.74	7.23	-643.50	.00
40	400	180	25	50	340	220	25	2	0	.00	.00	.00	.00
50	240	160	25	60	200	180	25	2	0	.00	.00	.00	113.15
50	400	260	25	60	300	270	25	2	0	.00	.00	.00	76.92
60	240	220	25	70	220	250	25	2	0	.00	.00	.00	113.00
60	320	300	25	70	240	290	25	2	872	560.44	21.80	14011.00	143.04
70	160	200	25	80	60	100	25	2	6834	6138.27	170.85	153456.75	.00
80	160	240	25	90	120	220	25	2	2403	2115.45	60.08	52886.25	167.44
90	160	280	25	0	300	10	25	4	18026	20990.06	450.65	524751.50	.00
TOTAL			250.0								710.60	744462.00	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	300	10	25	30	280	130	25	3	0	.00	.00	.00	.00
20	400	10	25	30	320	130	25	4	236	-32.19	5.90	-804.75	.00
30	160	60	25	40	120	80	25	4	734	194.68	18.35	4867.00	.00
30	320	120	25	40	280	170	25	3	0	.00	.00	.00	.00
40	280	180	25	50	240	220	25	3	0	.00	.00	.00	8.92
50	200	180	25	60	180	210	25	3	0	.00	.00	.00	171.30
60	200	240	25	70	180	270	25	3	0	.00	.00	.00	179.43
70	160	240	25	80	120	220	25	4	2539	2655.41	63.48	66385.25	150.21
80	160	300	25	90	80	180	25	4	7916	10174.14	197.90	254353.50	175.45
90	80	180	25	0	300	10	25	4	12237	18188.97	305.93	454724.25	.00
TOTAL			250.0								591.55	779525.25	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	300	10	25	30	280	130	25	3	0	.00	.00	.00	.00
20	400	10	25	30	360	140	25	3	0	.00	.00	.00	.00
30	160	60	25	40	160	110	25	3	0	.00	.00	.00	.00
30	320	120	25	40	280	180	25	4	121	-12.97	3.03	-324.25	34.94
40	280	180	25	50	240	220	25	3	0	.00	.00	.00	121.70
50	200	180	25	60	180	220	25	3	0	.00	.00	.00	110.25
60	200	240	25	70	100	150	25	4	6346	5930.67	158.65	148266.75	183.49
70	160	240	25	80	60	110	25	4	8790	9812.84	219.75	245321.00	.00
80	160	300	25	90	80	180	25	4	8019	10375.75	200.48	259393.75	162.05
90	80	180	25	0	300	10	25	4	12372	18400.34	309.30	460008.50	.00
TOTAL			250.0								891.20	1112665.75	

TOTAL PERIODIC HARVEST = 2.997 MMCF REVENUE = $ 3440791.20
REVISED LAND VALUES - SITE 130 = $ 924.42

YEAR 1990 UNCONSTRAINED HARVEST = 6.42 MMCF
SHADOW PRICE OF THE HARVEST CONSTRAINT = $ 137.68 MANAGEMENT WAS MODIFIED FOR 43 STANDS.
THE MODIFIED ACTION FOR THE MARGINAL STAND IS:

SITE = 130 MI = 2

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST

80	60	100	16	90	60	120	16	2	0	.00	.00	.00	137.68

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	160	220	25	90	80	140	25	2	5510	4967.60	137.75	124190.00	101.98
70	200	240	25	80	80	120	25	2	7516	6783.24	187.90	169581.00	75.27
60	320	270	25	70	200	220	25	2	2672	1715.90	66.80	42897.50	117.54
60	200	190	25	70	80	100	25	2	5620	4226.07	140.50	105651.75	.00
30	720	170	25	40	480	210	25	1	0	.00	.00	.00	.00
TOTAL			125.0								532.95	442320.25	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
90	120	220	25	0	300	10	25	4	14410	17487.74	360.25	437193.50	.00
90	80	150	25	0	300	10	25	4	10500	13082.41	262.50	327060.25	.00
80	60	100	9	0	300	10	9	4	7124	8414.57	64.12	75731.13	.00
70	240	290	25	80	120	180	25	2	6641	6005.01	166.03	150125.25	113.67
70	220	250	25	80	160	230	25	2	2209	1554.67	55.23	38866.75	136.63
70	200	250	8	80	120	190	8	2	4615	3898.10	36.92	31184.80	129.13
70	80	100	17	80	80	130	17	2	0	.00	.00	.00	.00
60	300	270	25	70	240	280	25	2	0	.00	.00	.00	131.00
60	200	180	25	70	180	210	25	2	0	.00	.00	.00	64.38
50	340	220	25	60	280	250	25	2	0	.00	.00	.00	41.54
50	280	200	25	60	240	230	25	2	0	.00	.00	.00	59.07
40	200	90	50	50	200	130	50	2	0	.00	.00	.00	45.37
30	400	100	25	40	360	150	25	2	0	.00	.00	.00	.00
TOTAL			325.0								945.04	1060161.68	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	180	270	25	80	100	190	25	4	5724	5971.22	143.10	149280.50	123.80
60	180	220	25	70	100	160	25	4	4662	4311.85	116.55	107796.25	109.76
60	180	210	25	70	60	90	25	4	7729	7040.50	193.23	176012.50	.00
50	240	220	50	60	220	260	50	3	0	.00	.00	.00	125.77
40	280	170	25	50	240	210	25	3	0	.00	.00	.00	.00
40	160	110	25	50	140	140	25	4	439	161.66	10.98	4041.50	.00
30	360	140	25	40	320	200	25	3	0	.00	.00	.00	.00
30	280	130	50	40	220	170	50	4	585	144.98	29.25	7249.00	.00

TOTAL			250.0								493.10	444379.75	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
90	80	180	50	0	300	10	50	4	12372	18400.34	618.60	920017.00	.00
80	120	220	25	0	300	10	25	4	14156	18494.64	353.90	462366.00	.00
80	60	110	25	90	60	140	25	3	0	.00	.00	.00	108.34
70	100	150	25	80	100	180	25	3	0	.00	.00	.00	117.56
40	280	180	25	50	240	220	25	3	0	.00	.00	.00	121.70
40	120	80	25	50	80	90	25	4	1254	548.76	31.35	13719.00	.00
30	320	130	25	40	240	170	25	4	895	172.99	22.38	4324.75	.00
0	300	10	100	10	300	10	100	4	0	.00	.00	.00	.00
TOTAL			300.0								1026.23	1400426.75	

TOTAL PERIODIC HARVEST = 2.997 MMCF REVENUE = $ 3347288.43
REVISED LAND VALUES - SITE 130 = $ 938.64

YEAR 2000 UNCONSTRAINED HARVEST = 5.92 MMCF
SHADOW PRICE OF THE HARVEST CONSTRAINT = $ 105.96 MANAGEMENT WAS MODIFIED FOR 38 STANDS.
THE MODIFIED ACTION FOR THE MARGINAL STAND IS:

SITE = 130 MI = 3

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
50	240	210	11	60	200	230	11	4	601	396.25	6.61	4358.75	105.96

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	480	210	25	50	320	220	25	2	207	-.20	5.18	-5.00	.00
TOTAL			25.0								5.18	-5.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
90	80	140	25	0	300	10	25	4	9894	11708.89	247.35	292722.25	.00
90	60	120	16	0	300	10	16	4	8606	11447.63	137.70	183162.08	.00
80	160	230	25	90	80	140	25	2	6507	6327.20	162.68	158180.00	86.40
80	120	190	8	90	60	120	8	2	5436	5606.83	43.49	44854.64	68.90
80	120	180	25	90	80	150	25	2	3137	2923.67	78.43	73091.75	105.20

80	80	130	17	90	80	160	17	2	0	.00	.00	.00	76.66
80	80	120	25	90	80	150	25	2	0	.00	.00	.00	44.06
70	240	280	25	80	100	150	25	2	7781	6648.86	194.53	166221.50	87.06
70	200	220	25	80	120	170	25	2	3994	2953.06	99.85	73826.50	104.48
70	180	210	25	80	100	150	25	2	4626	3743.90	115.65	93597.50	90.89
70	80	100	25	80	80	130	25	2	0	.00	.00	.00	.00
60	280	250	25	70	120	140	25	2	6539	4603.78	163.48	115094.50	82.18
60	240	230	25	70	200	250	25	2	228	12.40	5.70	310.00	94.30
50	200	130	50	60	180	160	50	2	0	.00	.00	.00	26.32
40	360	150	25	50	280	180	25	2	151	-22.51	3.78	-562.75	.00
TOTAL			366.0								1252.61	1200497.97	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
90	60	140	25	0	300	10	25	4	9815	14639.68	245.38	365992.00	.00
80	100	180	25	0	300	10	25	4	11862	15252.10	296.55	381302.50	.00
60	220	260	50	70	60	90	50	4	9985	9385.65	499.25	469282.50	.00
50	240	220	25	60	60	80	25	4	8246	6269.40	206.15	156735.00	.00
50	240	210	14	60	60	70	14	4	8201	6226.51	114.81	87171.14	.00
40	320	200	25	50	280	240	25	3	0	.00	.00	.00	33.40
TOTAL			175.0								1362.14	1460483.14	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	100	190	25	0	300	10	25	4	12552	16875.68	313.80	421892.00	.00
70	100	160	25	80	80	160	25	4	1778	1969.81	44.45	49245.25	78.62
70	60	90	25	80	60	120	25	3	0	.00	.00	.00	.00
50	140	140	25	60	120	170	25	4	479	154.22	11.98	3855.50	67.77
50	80	90	25	60	80	130	25	3	0	.00	.00	.00	.00
40	240	170	25	50	220	220	25	3	0	.00	.00	.00	48.11
40	220	170	50	50	200	220	50	3	0	.00	.00	.00	55.59
10	300	10	100	20	300	10	100	4	0	.00	.00	.00	.00
0	300	10	134	10	300	10	134	4	0	.00	.00	.00	.00
TOTAL			434.0								370.23	474992.75	

TOTAL PERIODIC HARVEST = 2.997 MMCF REVENUE = $ 3140327.61
REVISED LAND VALUES - SITE 130 = $ 972.65

YEAR 2010 UNCONSTRAINED HARVEST = 5.03 MMCF

SHADOW PRICE OF THE HARVEST CONSTRAINT = $ 97.95 MANAGEMENT WAS MODIFIED FOR 21 STANDS.
THE MODIFIED ACTION FOR THE MARGINAL STAND IS:

SITE = 130 MI = 2

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
70	120	140	11	80	120	170	11	2	0	.00	.00	.00	97.95

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
90	80	160	17	0	300	10	17	4	11092	14479.03	188.56	246143.51	.00
90	80	150	50	0	300	10	50	4	10500	13082.41	525.00	654120.50	.00
90	80	140	25	0	300	10	25	4	9894	11708.89	247.35	292722.25	.00
90	60	120	8	0	300	10	8	4	8606	11447.63	68.85	91581.04	.00
80	120	170	25	90	80	140	25	2	3156	2884.95	78.90	72123.75	91.17
80	100	150	50	90	80	150	50	2	1505	1345.00	75.25	67250.00	92.88
80	80	130	25	90	80	160	25	2	0	.00	.00	.00	77.88
70	200	250	25	80	80	130	25	2	7970	7031.38	199.25	175784.50	69.63
70	120	140	14	80	100	150	14	2	927	561.78	12.98	7864.92	85.59
60	180	160	50	70	140	160	50	2	1358	886.96	67.90	44348.00	60.93
50	320	220	25	60	260	240	25	2	0	.00	.00	.00	85.87
50	280	180	25	60	240	210	25	2	0	.00	.00	.00	32.28
TOTAL			350.0								1464.04	1651938.47	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
80	60	120	25	0	300	10	25	4	8337	11842.01	208.43	296050.25	.00
60	80	130	25	70	80	160	25	3	0	.00	.00	.00	91.21
50	280	240	25	60	60	70	25	4	9226	7064.80	230.65	176620.00	.00
50	220	220	25	60	60	80	25	4	8307	7090.98	207.68	177274.50	.00
50	200	220	50	60	60	90	50	4	7900	7235.18	395.00	361759.00	.00
TOTAL			150.0								1041.75	1011703.75	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
80	80	160	25	0	300	10	25	4	10876	15247.84	271.90	381196.00	.00
70	60	90	50	80	60	120	50	3	0	.00	.00	.00	.00
60	200	230	11	70	60	90	11	4	8917	8313.61	98.09	91449.71	.00
60	120	170	25	70	60	110	25	4	4954	5380.57	123.85	134514.25	.00
60	60	80	25	70	60	110	25	3	0	.00	.00	.00	.00
60	60	70	14	70	60	100	14	3	0	.00	.00	.00	.00
20	300	10	100	30	280	130	100	3	0	.00	.00	.00	.00
10	300	10	134	20	300	10	134	4	0	.00	.00	.00	.00
0	300	10	116	10	300	10	116	4	0	.00	.00	.00	.00
TOTAL			500.0								493.84	607159.96	

TOTAL PERIODIC HARVEST = 3.000 MMCF REVENUE = $ 3270802.18
REVISED LAND VALUES - SITE 130 = $ 998.28

YEAR 2020 UNCONSTRAINED HARVEST = 3.68 MMCF
SHADOW PRICE OF THE HARVEST CONSTRAINT = $ 77.18 MANAGEMENT WAS MODIFIED FOR 8 STANDS.
THE MODIFIED ACTION FOR THE MARGINAL STAND IS:

SITE = 130 MI = 2

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
80	80	130	1	90	60	120	1	2	2092	2224.01	2.09	2224.01	77.18

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
90	80	160	25	0	300	10	25	4	11092	14479.03	277.30	361975.75	.00
90	80	150	50	0	300	10	50	4	10500	13082.41	525.00	654120.50	.00
90	80	140	25	0	300	10	25	4	9894	11708.89	247.35	292722.25	.00
80	120	170	11	90	60	110	11	2	4921	4427.87	54.13	48706.57	58.48
80	100	150	14	90	60	110	14	2	3833	3866.50	53.66	54131.00	60.93
80	80	130	24	0	300	10	24	4	8993	10166.40	215.83	243993.60	.00
70	140	160	50	80	80	120	50	2	3642	2821.59	182.10	141079.50	62.85
60	260	240	25	70	100	120	25	2	7374	5295.02	184.35	132375.50	38.00

AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
60	240	210	25	70	100	120	25	2	5938	3743.65	148.45	93591.25	67.59
TOTAL			250.0								1888.18	2022695.92	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	60	120	50	0	300	10	50	4	8337	11842.01	416.85	592100.50	.00
70	80	160	25	0	300	10	25	4	10299	14539.34	257.48	363483.50	.00
70	60	110	25	0	300	10	25	4	7443	10128.64	186.08	253216.00	.00
70	60	100	14	80	60	130	14	3	0	.00	.00	.00	16.94
30	280	130	100	40	220	170	100	4	585	144.98	58.50	14498.00	.00
TOTAL			214.0								918.90	1223298.00	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	60	110	25	0	300	10	25	4	7557	10354.61	188.93	258865.25	.00
70	60	90	11	80	60	120	11	3	0	.00	.00	.00	.00
60	60	90	50	70	60	120	50	3	0	.00	.00	.00	.00
60	60	80	25	70	60	110	25	3	0	.00	.00	.00	.00
60	60	70	25	70	60	100	25	3	0	.00	.00	.00	.00
20	300	10	134	30	280	130	134	3	0	.00	.00	.00	.00
10	300	10	116	20	300	10	116	4	0	.00	.00	.00	.00
0	300	10	150	10	300	10	150	4	0	.00	.00	.00	.00
TOTAL			536.0								188.93	258865.25	

TOTAL PERIODIC HARVEST = 2.998 MMCF REVENUE = $ 3507083.18
REVISED LAND VALUES - SITE 130 = $ 1050.76

Appendix B.3. Demonstration Inventory With Nominal Data, 5-Period Constrained Between 3 and 4 MMCF per Decade

YEAR 1980 UNCONSTRAINED HARVEST = 6.94 MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	1000	10	25	30	720	170	25	1	0	.00	.00	.00	.00
30	240	60	25	40	200	90	25	2	240	-27.12	6.00	-678.00	.00
40	400	180	25	50	280	200	25	2	337	5.45	8.43	136.25	.00
50	240	160	25	60	200	190	25	1	0	.00	.00	.00	13.93
50	400	260	25	60	280	260	25	2	118	-7.07	2.95	-176.75	78.14
60	240	220	25	70	200	240	25	1	0	.00	.00	.00	93.13
60	320	300	25	70	80	100	25	2	10451	7643.84	261.28	191096.00	.00
70	160	200	25	80	80	130	25	2	4677	4129.36	116.93	103234.00	25.03
80	160	240	25	0	300	10	25	4	14765	15418.85	369.13	385471.25	.00
90	160	280	25	0	300	10	25	4	17528	20460.44	438.20	511511.00	.00
TOTAL			250.0								1202.90	1190593.75	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	600	10	25	30	400	100	25	2	0	.00	.00	.00	14.22
30	240	60	25	40	200	90	25	2	289	-25.74	7.23	-643.50	.00
40	400	180	25	50	340	220	25	2	0	.00	.00	.00	.00
50	240	160	25	60	180	170	25	2	864	268.61	21.60	6715.25	68.13
50	400	260	25	60	300	270	25	2	0	.00	.00	.00	76.92
60	240	220	25	70	200	240	25	2	209	5.22	5.23	130.50	95.93
60	320	300	25	70	140	170	25	2	7213	5307.97	180.33	132699.25	82.04
70	160	200	25	80	60	100	25	2	6834	6138.27	170.85	153456.75	.00
80	160	240	25	90	60	110	25	2	8861	9003.37	221.53	225084.25	51.42
90	160	280	25	0	300	10	25	4	18026	20990.06	450.65	524751.50	.00
TOTAL			250.0								1057.40	1042194.00	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	300	10	25	30	280	130	25	3	0	.00	.00	.00	.00
20	400	10	25	30	320	130	25	4	236	-32.19	5.90	-804.75	.00
30	160	60	25	40	120	80	25	4	734	194.68	18.35	4867.00	.00
30	320	120	25	40	280	170	25	3	0	.00	.00	.00	.00

40	280	180	25	50	240	220	25	3	0	.00	.00	.00	8.92
50	200	180	25	60	60	80	25	4	6290	4725.41	157.25	118135.25	.00
60	200	240	25	70	60	90	25	4	9291	8719.54	232.28	217988.50	.00
70	160	240	25	80	80	150	25	4	6446	6954.01	161.15	173850.25	77.07
80	160	300	25	0	300	10	25	4	18245	23974.13	456.13	599353.25	.00
90	80	180	25	0	300	10	25	4	12237	18188.97	305.93	454724.25	.00
TOTAL			250.0								1336.98	1568113.75	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	300	10	25	30	280	130	25	3	0	.00	.00	.00	.00
20	400	10	25	30	360	140	25	3	0	.00	.00	.00	.00
30	160	60	25	40	160	110	25	3	0	.00	.00	.00	.00
30	320	120	25	40	280	180	25	4	121	-12.97	3.03	-324.25	34.94
40	280	180	25	50	200	190	25	4	1551	666.01	38.78	16650.25	87.16
50	200	180	25	60	100	130	25	4	4183	2991.79	104.58	74794.75	97.85
60	200	240	25	70	60	90	25	4	9449	8888.63	236.23	222215.75	.00
70	160	240	25	80	60	110	25	4	8790	9812.84	219.75	245321.00	.00
80	160	300	25	0	300	10	25	4	18349	24180.27	458.73	604506.75	.00
90	80	180	25	0	300	10	25	4	12372	18400.34	309.30	460008.50	.00
TOTAL			250.0								1370.38	1623172.75	

TOTAL PERIODIC HARVEST = 4.968 MMCF REVENUE = $ 5424074.25
REVISED LAND VALUES - SITE 130 = $ 924.42

YEAR 1990 UNCONSTRAINED HARVEST = 3.92 MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	200	240	25	0	300	10	25	4	14112	12880.95	352.80	322023.75	.00
60	200	190	25	70	80	100	25	2	5620	4226.07	140.50	105651.75	.00
30	720	170	25	40	480	210	25	1	0	.00	.00	.00	.00
TOTAL			75.0								493.30	427675.50	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
90	60	110	25	0	300	10	25	4	7980	9982.44	199.50	249561.00	.00
80	80	130	25	0	300	10	25	4	8993	10166.40	224.83	254160.00	.00

80	60	100	25	0	300	10	25	4	7124	8414.57	178.10	210364.25	.00
70	200	240	25	0	300	10	25	4	14545	13099.05	363.63	327476.25	.00
70	140	170	25	0	300	10	25	4	10774	9928.46	269.35	248211.50	.00
70	80	100	25	80	80	130	25	2	0	.00	.00	.00	.00
60	300	270	25	70	80	100	25	2	9330	6428.36	233.25	160709.00	.00
60	280	260	25	70	60	80	25	2	9992	7086.39	249.80	177159.75	.00
60	180	170	25	70	60	80	25	2	6000	4235.51	150.00	105887.75	.00
50	340	220	25	60	80	80	25	2	7690	3822.22	192.25	95555.50	.00
50	280	200	25	60	80	80	25	2	7073	3968.07	176.83	99201.75	.00
40	200	90	50	50	80	60	50	2	2614	679.41	130.70	33970.50	.00
30	400	100	25	40	360	150	25	2	0	.00	.00	.00	.00
TOTAL			350.0								2368.23	1962257.25	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
50	240	220	25	60	60	80	25	4	8246	6269.40	206.15	156735.00	.00
40	280	170	25	50	240	210	25	3	0	.00	.00	.00	.00
40	160	110	25	50	140	140	25	4	439	161.66	10.98	4041.50	.00
30	360	140	25	40	320	200	25	3	0	.00	.00	.00	.00
30	280	130	50	40	220	170	50	4	585	144.98	29.25	7249.00	.00
TOTAL			150.0								246.38	168025.50	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	150	25	0	300	10	25	4	10299	13807.37	257.48	345184.25	.00
80	60	110	25	0	300	10	25	4	7834	10554.56	195.85	263864.00	.00
70	60	90	50	80	60	120	50	3	0	.00	.00	.00	.00
60	100	130	25	70	60	110	25	4	2836	2624.34	70.90	65608.50	.00
60	60	80	25	70	60	110	25	3	0	.00	.00	.00	.00
50	200	190	25	60	60	80	25	4	7052	5755.17	176.30	143879.25	.00
40	280	180	25	50	180	170	25	4	2394	1225.60	59.85	30640.00	.00
40	120	80	25	50	80	90	25	4	1254	548.76	31.35	13719.00	.00
30	320	130	25	40	240	170	25	4	895	172.99	22.38	4324.75	.00
0	300	10	175	10	300	10	175	4	0	.00	.00	.00	.00
TOTAL			425.0								814.10	867219.75	

TOTAL PERIODIC HARVEST = 3.922 MMCF REVENUE = $ 3425178.00
REVISED LAND VALUES - SITE 130 = $ 961.94

YEAR 2000 UNCONSTRAINED HARVEST = 2.37 MMCF
SHADOW PRICE OF THE HARVEST CONSTRAINT = $ 62.52 MANAGEMENT WAS MODIFIED FOR 3 STANDS.
THE MODIFIED ACTION FOR THE MARGINAL STAND IS:

SITE = 130 MI = 2

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
60	80	80	27	0	300	10	23	4	5396	4449.76	124.11	102344.48	62.52

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	480	210	25	50	80	60	25	2	6745	2282.12	168.63	57053.00	29.26
TOTAL			25.0								168.63	57053.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	130	25	0	300	10	25	4	8993	10166.40	224.83	254160.00	.00
70	80	100	50	0	300	10	50	4	6880	6369.54	344.00	318477.00	27.09
70	60	80	50	0	300	10	50	4	5644	5690.45	282.20	284522.50	.00
60	80	80	27	70	80	110	27	2	0	.00	.00	.00	.00
50	80	60	50	60	80	90	50	2	0	.00	.00	.00	.00
40	360	150	25	50	280	180	25	2	151	-22.51	3.78	-562.75	.00
TOTAL			250.0								854.80	856596.75	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	60	120	50	0	300	10	50	4	8337	11842.01	416.85	592100.50	.00
70	60	110	25	0	300	10	25	4	7443	10128.64	186.08	253216.00	.00
50	240	210	25	60	60	70	25	4	8201	6226.51	205.03	155662.75	.00
40	320	200	25	50	60	60	25	4	7501	4160.53	187.53	104013.25	.00
TOTAL			125.0								995.48	1104992.50	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	60	110	25	0	300	10	25	4	7557	10354.61	188.93	258865.25	.00
60	60	80	50	70	60	110	50	3	0	.00	.00	.00	.00
50	180	170	25	60	60	80	25	4	6096	5035.60	152.40	125890.00	.00

50	140	140	25	60	60	90	25	4	4266	3379.77	106.65	84494.25	.00
50	80	90	25	60	80	130	25	3	0	.00	.00	.00	.00
40	240	170	25	50	80	90	25	4	5410	3339.70	135.25	83492.50	.00
40	220	170	50	50	80	90	50	4	5485	3951.38	274.25	197569.00	.00
10	300	10	175	20	300	10	175	4	0	.00	.00	.00	.00
0	300	10	200	10	300	10	200	4	0	.00	.00	.00	.00
TOTAL			600.0								857.48	750311.00	

TOTAL PERIODIC HARVEST = 3.000 MMCF REVENUE = $ 2871297.73
REVISED LAND VALUES - SITE 130 = $ 1051.58

YEAR 2010 UNCONSTRAINED HARVEST = .989 MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 80 LAND VALUE = $ 612.38

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	80	110	27	0	300	10	27	4	7483	7524.93	202.04	203173.11	.00
60	80	90	50	0	300	10	50	4	5995	5467.95	299.75	273397.50	57.78
50	280	180	25	0	300	10	25	4	9689	5442.24	242.23	136056.00	35.38
50	80	60	25	60	60	70	25	2	689	273.77	17.23	6844.25	99.86
TOTAL			127.0								761.24	619470.86	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	60	110	50	0	300	10	50	4	7443	10128.64	372.15	506432.00	.00
60	80	130	25	0	300	10	25	4	8230	10257.43	205.75	256435.75	.00
TOTAL			75.0								577.90	762867.75	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
60	60	90	25	0	300	10	25	4	6091	7441.25	152.28	186031.25	32.61
60	60	80	25	0	300	10	25	4	5497	6142.42	137.43	153560.50	93.07
60	60	70	25	70	60	100	25	3	0	.00	.00	.00	.00
50	80	90	75	60	80	130	75	3	0	.00	.00	.00	.00

50	60	60	25	60	60	90	25	3	0	.00	.00	.00	.00
20	300	10	175	30	140	70	175	4	1445	103.41	252.88	18096.75	97.38
10	300	10	200	20	300	10	200	4	0	.00	.00	.00	.00
0	300	10	248	10	300	10	248	4	0	.00	.00	.00	.00
TOTAL			798.0								542.58	357688.50	

TOTAL PERIODIC HARVEST = 1.882 MMCF REVENUE = $ 1740027.11
REVISED LAND VALUES - SITE 130 = $ 1146.17

YEAR 2020 UNCONSTRAINED HARVEST = .789 MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 80 LAND VALUE = $ 612.38

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
60	60	70	25	70	60	100	25	2	0	.00	.00	.00	.00
TOTAL			25.0								.00	.00	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	60	100	25	0	300	10	25	4	6860	8743.90	171.50	218597.50	.00
60	80	130	75	0	300	10	75	4	8230	10257.43	617.25	769307.25	.00
60	60	90	25	0	300	10	25	4	5982	7237.42	149.55	180935.50	31.45
TOTAL			125.0								938.30	1168840.25	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	140	70	175	40	140	130	175	3	0	.00	.00	.00	.00
20	300	10	200	30	140	70	200	4	1445	103.41	289.00	20682.00	92.96
10	300	10	248	20	300	10	248	4	0	.00	.00	.00	.00
0	300	10	227	10	300	10	227	4	0	.00	.00	.00	.00
TOTAL			850.0								289.00	20682.00	

TOTAL PERIODIC HARVEST = 1.227 MMCF REVENUE = $ 1189522.25
REVISED LAND VALUES - SITE 130 = $ 1202.55

Appendix B.4 NW Oregon Forest Industry With Nominal Data

YEAR 1980 UNCONSTRAINED HARVEST = 380. MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 90 LAND VALUE = $ 749.96

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	80	100	15855	80	80	130	15855	1	0	.00	.00	.00	.00
60	80	70	6323	70	80	90	6323	1	0	.00	.00	.00	.00
60	200	180	15856	70	80	100	15856	2	5076	3457.03	80485.06	54814667.68	.00
40	400	180	3794	50	280	200	3794	2	337	5.45	1278.58	20677.30	.00
40	520	230	6323	50	320	220	6323	2	735	153.95	4647.41	973425.85	.00
30	600	140	5704	40	440	190	5704	1	0	.00	.00	.00	.00
30	520	130	30032	40	400	180	30032	1	0	.00	.00	.00	.00
30	800	190	44201	40	480	210	44201	1	0	.00	.00	.00	.00
20	400	10	5691	30	360	140	5691	1	0	.00	.00	.00	.00
10	400	10	4005	20	400	10	4005	1	0	.00	.00	.00	.00
10	560	10	6673	20	560	10	6673	1	0	.00	.00	.00	.00
0	560	10	11429	10	560	10	11429	1	0	.00	.00	.00	.00
TOTAL			155886.0								86411.04	55808770.83	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	400	180	2530	50	340	220	2530	2	0	.00	.00	.00	.00
TOTAL			2530.0								.00	.00	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	300	10	632	30	280	130	632	3	0	.00	.00	.00	.00
10	300	10	2669	20	300	10	2669	3	0	.00	.00	.00	.00
0	300	10	10877	10	300	10	10877	3	0	.00	.00	.00	.00
TOTAL			14178.0								.00	.00	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 108 MI = 1 OPTIMUM ROTATION =100 LAND VALUE = $ 414.04

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
90	160	200	11679	0	300	10	11679	4	10279	9398.41	120048.44	109764030.39	.00
80	80	80	6323	0	300	10	6323	4	4710	3754.97	29781.33	23742675.31	.00
70	80	70	6323	80	80	90	6323	1	0	.00	.00	.00	.00
70	160	130	10574	80	80	90	10574	2	2811	1482.49	29723.51	15675849.26	.00
70	320	270	5704	80	80	90	5704	2	8221	5092.99	46892.58	29050414.96	.00
60	80	50	15576	70	80	70	15576	1	0	.00	.00	.00	.00
50	440	200	6323	60	120	80	6323	2	5224	1646.14	33031.35	10408543.22	.00
50	320	150	11063	60	200	140	11063	2	1236	243.68	13673.87	2695831.84	.00
40	280	80	20250	50	240	110	20250	2	29	-21.75	587.25	-440437.50	.00
40	560	170	60895	50	400	190	60895	2	286	2.61	17415.97	158935.95	.00
30	440	70	68499	40	400	110	68499	1	0	.00	.00	.00	.00
30	760	120	78282	40	560	170	78282	1	0	.00	.00	.00	.00
30	800	130	30840	40	600	180	30840	1	0	.00	.00	.00	.00
20	280	10	20477	30	280	100	20477	1	0	.00	.00	.00	.00
20	520	10	51204	30	480	120	51204	1	0	.00	.00	.00	.00
20	720	10	24722	30	560	110	24722	1	95	-34.80	2348.59	-860325.60	.00
10	520	10	47103	20	520	10	47103	1	0	.00	.00	.00	.00
10	720	10	18293	20	720	10	18293	1	0	.00	.00	.00	.00
0	520	10	27275	10	520	10	27275	1	0	.00	.00	.00	.00
0	720	10	45151	10	720	10	45151	1	0	.00	.00	.00	.00
TOTAL			566556.0								293502.90	190195517.83	

SITE = 108 MI = 2 OPTIMUM ROTATION = 80 LAND VALUE = $ 361.40

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
40	280	80	10000	50	240	110	10000	2	45	-22.59	450.00	-225900.00	.00
TOTAL			10000.0								450.00	-225900.00	

SITE = 108 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 602.11

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
20	300	10	10712	30	300	100	10712	3	0	.00	.00	.00	.00
10	300	10	12871	20	300	10	12871	3	0	.00	.00	.00	.00
10	400	10	3478	20	400	10	3478	3	0	.00	.00	.00	.00
0	300	10	9983	10	300	10	9983	3	0	.00	.00	.00	.00
0	400	10	62442	10	400	10	62442	3	0	.00	.00	.00	.00
TOTAL			99486.0								.00	.00	

SITE = 108 MI = 4 OPTIMUM ROTATION = 70 LAND VALUE = $ 761.91

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
TOTAL			.0								.00	.00	

TOTAL PERIODIC HARVEST = 380.364 MMCF REVENUE = $
245778388.66
REVISED LAND VALUES - SITE 130 = $ 776.05

REVISED LAND VALUES - SITE 108 = $ 440.94
YEAR 1990 UNCONSTRAINED HARVEST = 980. MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
80	80	130	15855	0	300	10	15855	4	8810	9967.11	139682.55	158028529.05	.00
70	80	90	6323	0	300	10	6323	4	6155	5463.84	38918.07	34547860.32	.00
40	480	210	44201	50	320	220	44201	2	207	-.20	9149.61	-8840.20	.00
40	440	190	5704	50	280	190	5704	2	1102	218.95	6285.81	1248890.80	.00
40	400	180	30032	50	280	200	30032	2	337	5.45	10120.78	163674.40	.00
30	360	140	5691	40	240	170	5691	2	631	83.35	3591.02	474344.85	.00
20	560	10	6673	30	400	140	6673	2	260	-37.23	1734.98	-248435.79	.00
20	400	10	4005	30	360	140	4005	1	0	.00	.00	.00	.00
10	560	10	11429	20	560	10	11429	1	0	.00	.00	.00	.00
TOTAL			129913.0								209482.82	194206023.43	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
70	80	100	15856	80	80	130	15856	2	0	.00	.00	.00	.00
50	340	220	2530	60	80	80	2530	2	7690	3822.22	19455.70	9670216.60	.00
50	320	220	6323	60	80	80	6323	2	7824	4238.64	49471.15	26800920.72	.00
50	280	200	3794	60	80	80	3794	2	7073	3968.07	26834.96	15054857.58	.00
TOTAL			28503.0								95761.81	51525994.90	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM AGE	FROM TPA	FROM BAPA	ACRES	TO AGE	TO TPA	TO BAPA	ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
30	280	130	632	40	220	170	632	4	585	144.98	369.72	91627.36	.00
20	300	10	2669	30	280	130	2669	3	0	.00	.00	.00	.00
10	300	10	10877	20	300	10	10877	3	0	.00	.00	.00	.00
TOTAL			14178.0								369.72	91627.36	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 108 MI = 1 OPTIMUM ROTATION = 90 LAND VALUE = $ 414.77

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	90	6323	0	300	10	6323	4	5229	4617.79	33062.97	29198286.17	.00
70	80	70	15576	80	80	90	15576	1	0	.00	.00	.00	.00
40	600	180	30840	50	400	190	30840	2	434	.83	13384.56	25597.20	.00
40	560	170	78282	50	400	190	78282	2	286	2.61	22388.65	204316.02	.00
40	400	110	68499	50	360	150	68499	1	0	.00	.00	.00	.00
30	560	110	24722	40	440	160	24722	1	0	.00	.00	.00	.00
30	480	120	51204	40	360	160	51204	2	226	.54	11572.10	27650.16	.00
30	280	100	20477	40	120	80	20477	2	2029	464.89	41547.83	9519552.53	.00
20	720	10	18293	30	560	110	18293	1	95	-34.80	1737.84	-636596.40	.00
20	520	10	47103	30	480	120	47103	1	0	.00	.00	.00	.00
10	720	10	45151	20	720	10	45151	1	0	.00	.00	.00	.00
10	520	10	27275	20	520	10	27275	1	0	.00	.00	.00	.00
TOTAL			433745.0								123693.95	38338805.68	

SITE = 108 MI = 2 OPTIMUM ROTATION = 80 LAND VALUE = $ 361.40

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	90	16278	0	300	10	16278	4	5327	4704.66	86712.91	76582455.48	.00
60	200	140	11063	70	80	80	11063	2	3708	1761.26	41021.60	19484819.38	.00
60	120	80	6323	70	120	110	6323	2	0	.00	.00	.00	.00
50	400	190	60895	60	100	70	60895	2	5621	1772.58	342290.80	107941259.10	.00
50	240	110	30250	60	100	70	30250	2	2645	648.23	80011.25	19608957.50	.00
TOTAL			124809.0								550036.56	223617491.46	

SITE = 108 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 602.11

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	300	100	10712	40	280	160	10712	3	0	.00	.00	.00	.00
20	400	10	3478	30	300	90	3478	4	197	-46.66	685.17	-162283.48	.00
20	300	10	12871	30	300	100	12871	3	0	.00	.00	.00	.00
10	400	10	62442	20	400	10	62442	3	0	.00	.00	.00	.00
10	300	10	9983	20	300	10	9983	3	0	.00	.00	.00	.00

TOTAL			99486.0								685.17	-162283.48	

SITE = 108 MI = 4 OPTIMUM ROTATION = 70 LAND VALUE = $ 761.91

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
0	300	10	18002	10	300	10	18002	4	0	.00	.00	.00	.00
TOTAL			18002.0								.00	.00	

TOTAL PERIODIC HARVEST = 980.030 MMCF REVENUE = $
507617659.35
REVISED LAND VALUES - SITE 130 = $ 757.70

REVISED LAND VALUES - SITE 108 = $ 441.73

YEAR 2000 UNCONSTRAINED HARVEST = .156E+04MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	360	140	4005	40	240	170	4005	2	631	83.35	2527.16	333816.75	.00
20	560	10	11429	30	400	140	11429	2	260	-37.23	2971.54	-425501.67	.00
TOTAL			15434.0								5498.70	-91684.92	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	130	15856	0	300	10	15856	4	8993	10166.40	142593.01	161198438.40	.00
60	80	80	12647	70	80	110	12647	2	0	.00	.00	.00	.00
50	320	220	44201	60	80	80	44201	2	7824	4238.64	345828.62	187352126.64	.00
50	280	200	30032	60	80	80	30032	2	7073	3968.07	212416.34	119169078.24	.00
50	280	190	5704	60	80	80	5704	2	6546	3372.49	37338.38	19236682.96	.00
40	240	170	5691	50	60	60	5691	2	6356	3844.95	36172.00	21881610.45	.00
30	400	140	6673	40	340	200	6673	2	0	.00	.00	.00	.00
TOTAL			120804.0								774348.35	508837936.69	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	280	130	2669	40	220	170	2669	4	585	144.98	1561.37	386951.62	.00
20	300	10	10877	30	280	130	10877	3	0	.00	.00	.00	.00
TOTAL			13546.0								1561.37	386951.62	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	220	170	632	50	80	90	632	4	5485	3951.38	3466.52	2497272.16	.00
0	300	10	22178	10	300	10	22178	4	0	.00	.00	.00	.00
TOTAL			22810.0								3466.52	2497272.16	

SITE = 108 MI = 1 OPTIMUM ROTATION = 90 LAND VALUE = $ 414.77

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	90	15576	0	300	10	15576	4	5229	4617.79	81446.90	71926697.04	.00
50	360	150	68499	60	280	170	68499	1	0	.00	.00	.00	.00
40	440	160	24722	50	360	200	24722	1	0	.00	.00	.00	.00
30	560	110	18293	40	440	160	18293	1	0	.00	.00	.00	.00
30	480	120	47103	40	360	160	47103	2	226	.54	10645.28	25435.62	.00
20	720	10	45151	30	560	110	45151	1	95	-34.80	4289.35	-1571254.80	.00
20	520	10	27275	30	480	120	27275	1	0	.00	.00	.00	.00
TOTAL			246619.0								96381.53	70380877.86	

SITE = 108 MI = 2 OPTIMUM ROTATION = 80 LAND VALUE = $ 361.40

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	120	110	6323	80	60	70	6323	2	3002	2093.94	18981.65	13239982.62	.00
70	80	80	11063	80	60	80	11063	2	1097	822.07	12136.11	9094560.41	.00
60	100	70	91145	70	100	100	91145	2	0	.00	.00	.00	.00
50	400	190	109122	60	100	70	109122	2	5621	1772.58	613374.76	193427474.76	.00
40	360	160	51204	50	300	200	51204	2	18	-21.24	921.67	-1087572.96	.00
40	120	80	20477	50	80	90	20477	2	1008	392.72	20640.82	8041727.44	.00
TOTAL			289334.0								666055.01	222716172.27	

SITE = 108 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 602.11

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	280	160	10712	50	260	210	10712	3	0	.00	.00	.00	.00
30	300	100	12871	40	280	160	12871	3	0	.00	.00	.00	.00
20	400	10	62442	30	300	90	62442	4	197	-46.66	12301.07	-2913543.72	.00
20	300	10	9983	30	300	100	9983	3	0	.00	.00	.00	.00
TOTAL			96008.0								12301.07	-2913543.72	

SITE = 108 MI = 4 OPTIMUM ROTATION = 70 LAND VALUE = $ 761.91

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	300	90	3478	40	280	150	3478	3	0	.00	.00	.00	.00
10	300	10	18002	20	300	10	18002	4	0	.00	.00	.00	.00
0	300	10	22601	10	300	10	22601	4	0	.00	.00	.00	.00
TOTAL			44081.0								.00	.00	

TOTAL PERIODIC HARVEST = 1559.613 MMCF REVENUE = $
801813981.96
REVISED LAND VALUES - SITE 130 = $ 749.15

REVISED LAND VALUES - SITE 108 = $ 441.17
YEAR 2010 UNCONSTRAINED HARVEST = .142E+04MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	80	110	12647	80	60	110	12647	2	1485	1242.00	18780.80	15707574.00	.00
60	80	80	79937	70	80	110	79937	2	0	.00	.00	.00	.00
50	60	60	5691	60	60	90	5691	2	0	.00	.00	.00	.00
40	340	200	6673	50	60	60	6673	2	7405	3428.19	49413.57	22876311.87	.00
40	240	170	4005	50	60	60	4005	2	6356	3844.95	25455.78	15399024.75	.00
30	400	140	11429	40	340	200	11429	2	0	.00	.00	.00	.00
TOTAL			120382.0								93650.14	53982910.62	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	280	130	10877	40	220	170	10877	4	585	144.98	6363.05	1576947.46	.00
TOTAL			10877.0								6363.05	1576947.46	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
50	80	90	632	60	80	130	632	3	0	.00	.00	.00	.00
40	220	170	2669	50	80	90	2669	4	5485	3951.38	14639.47	10546233.22	.00

10	300	10	22178	20	300	10	22178	4	0	.00	.00	.00	.00
0	300	10	15856	10	300	10	15856	4	0	.00	.00	.00	.00
TOTAL			41335.0								14639.47	10546233.22	

SITE = 108 MI = 1 OPTIMUM ROTATION = 90 LAND VALUE = $ 414.77

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
60	280	170	68499	0	300	10	68499	4	7713	4094.46	528332.79	280466415.54	.00
50	360	200	24722	60	80	70	24722	2	5881	2361.60	145390.08	58383475.20	.00
40	440	160	18293	50	360	200	18293	1	0	.00	.00	.00	.00
30	560	110	45151	40	440	160	45151	1	0	.00	.00	.00	.00
30	480	120	27275	40	360	160	27275	2	226	.54	6164.15	14728.50	.00
TOTAL			183940.0								679887.02	338864619.24	

SITE = 108 MI = 2 OPTIMUM ROTATION = 80 LAND VALUE = $ 361.40

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	60	80	11063	0	300	10	11063	4	4793	4813.85	53024.96	53255622.55	.00
80	60	70	6323	90	60	90	6323	2	0	.00	.00	.00	.00
70	100	100	91145	80	60	80	91145	2	2093	1514.24	190766.49	138015404.80	.00
60	100	70	109122	70	100	100	109122	2	0	.00	.00	.00	.00
50	300	200	51204	60	80	80	51204	2	5953	2889.72	304817.41	147965222.88	.00
50	80	90	20477	60	80	130	20477	2	0	.00	.00	.00	.00
40	360	160	47103	50	300	200	47103	2	18	-21.24	847.85	-1000467.72	.00
TOTAL			336437.0								549456.71	338235782.51	

SITE = 108 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 602.11

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
50	260	210	10712	60	60	70	10712	4	6859	4597.51	73473.61	49248527.12	.00
40	280	160	12871	50	260	210	12871	3	0	.00	.00	.00	.00
40	280	150	3478	50	260	200	3478	3	0	.00	.00	.00	.00
30	300	100	9983	40	280	160	9983	3	0	.00	.00	.00	.00
TOTAL			37044.0								73473.61	49248527.12	

SITE = 108 MI = 4 OPTIMUM ROTATION = 70 LAND VALUE = $ 761.91

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	300	90	62442	40	280	150	62442	3	0	.00	.00	.00	.00
20	300	10	18002	30	220	80	18002	4	244	-49.68	4392.49	-894339.36	.00
10	300	10	22601	20	300	10	22601	4	0	.00	.00	.00	.00

0	300	10	15576	10	300	10	15576	4	0	.00	.00	.00	.00
TOTAL			118621.0								4392.49	-894339.36	

TOTAL PERIODIC HARVEST = 1421.862 MMCF REVENUE = $
791560680.81
REVISED LAND VALUES - SITE 130 = $ 796.23

REVISED LAND VALUES - SITE 108 = $ 459.38
YEAR 2020 UNCONSTRAINED HARVEST = .166E+04MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 80 LAND VALUE = $ 751.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 130 MI = 2 OPTIMUM ROTATION = 90 LAND VALUE = $ 618.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	60	110	12647	0	300	10	12647	4	7738	9796.57	97862.49	123897220.79	.00
70	80	110	79937	80	60	110	79937	2	1485	1242.00	118706.45	99281754.00	.00
60	60	90	5691	70	60	120	5691	2	0	.00	.00	.00	.00
50	60	60	10678	60	60	90	10678	2	0	.00	.00	.00	.00
40	340	200	11429	50	60	60	11429	2	7405	3428.19	84631.75	39180783.51	.00
TOTAL			120382.0								301200.68	262359758.30	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 1091.06

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
60	80	130	632	0	300	10	632	4	8230	10257.43	5201.36	6482695.76	.00
TOTAL			632.0								5201.36	6482695.76	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 1236.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
50	80	90	2669	60	80	130	2669	3	0	.00	.00	.00	.00
40	220	170	10877	50	80	90	10877	4	5485	3951.38	59660.35	42979160.26	.00
20	300	10	22178	30	280	130	22178	3	0	.00	.00	.00	.00
10	300	10	15856	20	300	10	15856	4	0	.00	.00	.00	.00
TOTAL			51580.0								59660.35	42979160.26	

SITE = 108 MI = 1 OPTIMUM ROTATION = 90 LAND VALUE = $ 414.77

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
50	360	200	18293	60	80	70	18293	2	5881	2361.60	107581.13	43200748.80	.00
40	440	160	45151	50	360	200	45151	1	0	.00	.00	.00	.00
TOTAL			63444.0								107581.13	43200748.80	

SITE = 108 MI = 2 OPTIMUM ROTATION = 80 LAND VALUE = $ 361.40

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
90	60	90	6323	0	300	10	6323	4	5447	5922.22	34441.38	37446197.06	.00
80	60	80	91145	0	300	10	91145	4	4793	4813.85	436857.99	438758358.25	.00
70	100	100	109122	80	60	80	109122	2	2093	1514.24	22P392.35	165236897.28	.00
60	80	130	20477	70	60	130	20477	2	1504	1573.53	30797.41	32221173.81	.00
60	80	80	51204	70	60	90	51204	2	758	388.14	38812.63	19874320.56	.00
60	80	70	24722	70	60	80	24722	2	660	277.05	16316.52	6849230.10	.00
50	300	200	47103	60	80	80	47103	2	5953	2889.72	280404.16	136114481.16	.00
40	360	160	27275	50	300	200	27275	2	18	-21.24	490.95	-579321.00	.00
TOTAL			377371.0								1066513.38	835921337.22	

SITE = 108 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 602.11

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
50	260	210	12871	60	60	70	12871	4	6859	4597.51	88282.19	59174551.21	.00
50	260	200	3478	60	60	70	3478	4	6439	4033.45	22394.84	14028339.10	.00
40	280	160	9983	50	260	210	9983	3	0	.00	.00	.00	.00
40	280	150	62442	50	260	200	62442	3	0	.00	.00	.00	.00
TOTAL			88774.0								110677.03	73202890.31	

SITE = 108 MI = 4 OPTIMUM ROTATION = 70 LAND VALUE = $ 761.91

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
60	60	70	10712	70	60	100	10712	3	0	.00	.00	.00	.00
30	220	80	18002	40	200	140	18002	4	54	-35.57	972.11	-640331.14	.00
20	300	10	22601	30	220	80	22601	4	244	-49.68	5514.64	-1122817.68	.00
10	300	10	15576	20	300	10	15576	4	0	.00	.00	.00	.00
0	300	10	79562	10	300	10	79562	4	0	.00	.00	.00	.00
TOTAL			146453.0								6486.75	-1763148.82	

TOTAL PERIODIC HARVEST = 1657.321 MMCF REVENUE = $
1262383441.83

REVISED LAND VALUES - SITE 130 = $ 804.85
REVISED LAND VALUES - SITE 108 = $ 484.78

Appendix B.5 NW Oregon Forest Industry With TAMM Data
YEAR 1980 UNCONSTRAINED HARVEST = 181. MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 90 LAND VALUE = $ 371.29

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	80	100	15855	80	80	130	15855	1	0	.00	.00	.00	.00
60	80	70	6323	70	80	90	6323	1	0	.00	.00	.00	.00
60	200	180	15856	70	160	190	15856	1	0	.00	.00	.00	.00
40	400	180	3794	50	280	200	3794	2	337	-71.21	1278.58	-270170.74	.00
40	520	230	6323	50	360	240	6323	1	0	.00	.00	.00	.00
30	600	140	5704	40	440	190	5704	1	0	.00	.00	.00	.00
30	520	130	30032	40	360	170	30032	2	53	-26.57	1591.70	-797950.24	.00
30	800	190	44201	40	480	210	44201	1	0	.00	.00	.00	.00
20	400	10	5691	30	360	140	5691	1	0	.00	.00	.00	.00
10	400	10	4005	20	400	10	4005	1	0	.00	.00	.00	.00
10	560	10	6673	20	560	10	6673	1	0	.00	.00	.00	.00
0	560	10	11429	10	560	10	11429	1	0	.00	.00	.00	.00
TOTAL			155886.0								2870.27	-1068120.98	

SITE = 130 MI = 2 OPTIMUM ROTATION =100 LAND VALUE = $ 302.64

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	400	180	2530	50	340	220	2530	2	0	.00	.00	.00	.00
TOTAL			2530.0								.00	.00	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 626.15

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	300	10	632	30	280	130	632	3	0	.00	.00	.00	.00
10	300	10	2669	20	300	10	2669	3	0	.00	.00	.00	.00
0	300	10	10877	10	300	10	10877	3	0	.00	.00	.00	.00
TOTAL			14178.0								.00	.00	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 712.36

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 108 MI = 1 OPTIMUM ROTATION =100 LAND VALUE = $ 173.86

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
90	160	200	11679	0	300	10	11679	4	10279	2250.87	120048.44	26287910.73	.00
80	80	80	6323	90	80	100	6323	1	0	.00	.00	.00	.00
70	80	70	6323	80	80	90	6323	1	0	.00	.00	.00	.00
70	160	130	10574	80	120	130	10574	2	1015	-16.88	10732.61	-178489.12	.00
70	320	270	5704	80	240	260	5704	2	492	-35.16	2806.37	-200552.64	.00
60	80	50	15576	70	80	70	15576	1	0	.00	.00	.00	.00
50	440	200	6323	60	320	210	6323	2	308	-62.63	1947.48	-396009.49	.00
50	320	150	11063	60	240	160	11063	2	500	-54.06	5531.50	-598065.78	.00
40	280	80	20250	50	280	120	20250	1	0	.00	.00	.00	.00
40	560	170	60895	50	400	190	60895	2	286	-62.09	17415.97	-3780970.55	.00
30	440	70	68499	40	400	110	68499	1	0	.00	.00	.00	.00
30	760	120	78282	40	560	170	78282	1	0	.00	.00	.00	.00
30	800	130	30840	40	600	180	30840	1	0	.00	.00	.00	.00
20	280	10	20477	30	120	50	20477	2	772	-199.32	15808.24	-4081475.64	.00
20	520	10	51204	30	480	120	51204	1	0	.00	.00	.00	.00
20	720	10	24722	30	560	110	24722	1	95	-40.70	2348.59	-1006185.40	.00
10	520	10	47103	20	520	10	47103	1	0	.00	.00	.00	.00
10	720	10	18293	20	720	10	18293	1	0	.00	.00	.00	.00
0	520	10	27275	10	520	10	27275	1	0	.00	.00	.00	.00
0	720	10	45151	10	720	10	45151	1	0	.00	.00	.00	.00
TOTAL			566556.0								176639.21	16046162.11	

SITE = 108 MI = 2 OPTIMUM ROTATION =100 LAND VALUE = $ 195.14

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
40	280	80	10000	50	240	110	10000	2	45	-24.57	450.00	-245700.00	.00
TOTAL			10000.0								450.00	-245700.00	

SITE = 108 MI = 3 OPTIMUM ROTATION = 90 LAND VALUE = $ 314.27

FROM AGE	FROM TPA	FROM BAPA	FROM ACRES	TO AGE	TO TPA	TO BAPA	TO ACRES	MI	PER ACRE HARVEST	PER ACRE REVENUE	TOTAL HARVEST	TOTAL REVENUE	OPP COST
20	300	10	10712	30	260	90	10712	4	58	-29.94	621.30	-320717.28	.00
10	300	10	12871	20	300	10	12871	3	0	.00	.00	.00	.00
10	400	10	3478	20	400	10	3478	3	0	.00	.00	.00	.00
0	300	10	9983	10	300	10	9983	3	0	.00	.00	.00	.00
0	400	10	62442	10	400	10	62442	3	0	.00	.00	.00	.00
TOTAL			99486.0								621.30	-320717.28	

SITE = 108 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 389.39

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
TOTAL			.0								.00	.00	

TOTAL PERIODIC HARVEST = 180.581 MMCF REVENUE = $ 14411623.85
REVISED LAND VALUES - SITE 130 = $ 391.22

REVISED LAND VALUES - SITE 108 = $ 194.84
YEAR 1990 UNCONSTRAINED HARVEST = 505. MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION = 90 LAND VALUE = $ 371.90

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	130	15855	0	300	10	15855	4	8810	3841.76	139682.55	60911104.80	.00
70	160	190	15856	80	80	120	15856	2	4664	1342.95	73952.38	21293815.20	.00
70	80	90	6323	80	80	110	6323	1	0	.00	.00	.00	.00
50	360	240	6323	60	240	230	6323	2	783	-108.68	4950.91	-687183.64	.00
40	480	210	44201	50	320	220	44201	2	207	-74.72	9149.61	-3302698.72	.00
40	440	190	5704	50	320	210	5704	1	0	.00	.00	.00	.00
30	360	140	5691	40	280	190	5691	1	0	.00	.00	.00	.00
20	560	10	6673	30	440	150	6673	1	0	.00	.00	.00	.00
20	400	10	4005	30	360	140	4005	1	0	.00	.00	.00	.00
10	560	10	11429	20	560	10	11429	1	0	.00	.00	.00	.00
TOTAL			122060.0								227735.45	78215037.64	

SITE = 130 MI = 2 OPTIMUM ROTATION =100 LAND VALUE = $ 302.89

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
50	340	220	2530	60	280	250	2530	2	0	.00	.00	.00	.00
50	280	200	3794	60	240	230	3794	2	0	.00	.00	.00	.00
40	360	170	30032	50	280	200	30032	2	243	-95.20	7297.78	-2859046.40	.00
TOTAL			36356.0								7297.78	-2859046.40	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 564.41

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	280	130	632	40	220	170	632	4	585	-94.73	369.72	-59869.36	.00
20	300	10	2669	30	280	130	2669	3	0	.00	.00	.00	.00
10	300	10	10877	20	300	10	10877	3	0	.00	.00	.00	.00
TOTAL			14178.0								369.72	-59869.36	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 646.69

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
TOTAL			.0								.00	.00	

SITE = 108 MI = 1 OPTIMUM ROTATION =100 LAND VALUE = $ 173.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
90	80	100	6323	0	300	10	6323	4	5880	1688.64	37179.24	10677270.72	.00
80	80	90	6323	0	300	10	6323	4	5229	1523.72	33062.97	9634481.56	.00
70	80	70	15576	80	80	90	15576	1	0	.00	.00	.00	.00
50	280	120	20250	60	240	140	20250	1	0	.00	.00	.00	.00
40	600	180	30840	50	440	200	30840	1	0	.00	.00	.00	.00
40	560	170	78282	50	400	190	78282	2	286	-98.39	22388.65	-7702165.98	.00
40	400	110	68499	50	360	150	68499	1	0	.00	.00	.00	.00
30	560	110	24722	40	440	160	24722	1	0	.00	.00	.00	.00
30	480	120	51204	40	400	170	51204	1	0	.00	.00	.00	.00
20	720	10	18293	30	560	110	18293	1	95	-63.13	1737.84	-1154837.09	.00
20	520	10	47103	30	440	110	47103	1	25	-32.56	1177.58	-1533673.68	.00
10	720	10	45151	20	720	10	45151	1	0	.00	.00	.00	.00
10	520	10	27275	20	520	10	27275	1	0	.00	.00	.00	.00
TOTAL			439841.0								95546.27	9921075.53	

SITE = 108 MI = 2 OPTIMUM ROTATION =100 LAND VALUE = $ 195.46

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	240	260	5704	0	300	10	5704	4	13031	3176.38	74328.82	18118071.52	.00
80	120	130	10574	0	300	10	10574	4	7332	1843.68	77528.57	19495072.32	.00
60	320	210	6323	70	260	220	6323	2	624	-51.08	3945.55	-322978.84	.00
60	240	160	11063	70	220	190	11063	2	0	.00	.00	.00	.00
50	400	190	60895	60	340	220	60895	2	0	.00	.00	.00	.00
50	240	110	10000	60	220	140	10000	2	0	.00	.00	.00	.00
30	120	50	20477	40	80	70	20477	2	664	-100.83	13596.73	-2064695.91	.00
TOTAL			125036.0								169399.67	35225469.09	

SITE = 108 MI = 3 OPTIMUM ROTATION = 90 LAND VALUE = $ 247.14

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	400	10	3478	30	300	90	3478	4	197	-104.86	685.17	-364703.08	.00
20	300	10	12871	30	300	100	12871	3	0	.00	.00	.00	.00
10	400	10	62442	20	400	10	62442	3	0	.00	.00	.00	.00

AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
10	300	10	9983	20	300	10	9983	3	0	.00	.00	.00	.00
TOTAL			88774.0								685.17	-364703.08	

SITE = 108 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 322.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	260	90	10712	40	220	140	10712	4	408	-116.58	4370.50	-1248804.96	.00
0	300	10	11679	10	300	10	11679	4	0	.00	.00	.00	.00
TOTAL			22391.0								4370.50	-1248804.96	

TOTAL PERIODIC HARVEST = 505.405 MMCF REVENUE = $ 118829158.46
REVISED LAND VALUES - SITE 130 = $ 373.17

REVISED LAND VALUES - SITE 108 = $ 192.41
YEAR 2000 UNCONSTRAINED HARVEST = 37.6 MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION =100 LAND VALUE = $ 371.98

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	110	6323	90	80	130	6323	1	0	.00	.00	.00	.00
50	320	210	5704	60	240	220	5704	2	493	-114.18	2812.07	-651282.72	.00
40	280	190	5691	50	240	230	5691	1	0	.00	.00	.00	.00
30	440	150	6673	40	320	190	6673	1	0	.00	.00	.00	.00
30	360	140	4005	40	280	190	4005	1	0	.00	.00	.00	.00
20	560	10	11429	30	440	150	11429	1	0	.00	.00	.00	.00
TOTAL			39825.0								2812.07	-651282.72	

SITE = 130 MI = 2 OPTIMUM ROTATION =100 LAND VALUE = $ 302.89

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	120	15856	90	80	150	15856	2	0	.00	.00	.00	.00
60	280	250	2530	70	220	260	2530	2	229	-91.65	579.37	-231874.50	.00
60	240	230	10117	70	200	250	10117	2	228	-107.47	2306.68	-1087273.99	.00
50	320	220	44201	60	260	240	44201	2	0	.00	.00	.00	.00
50	280	200	30032	60	240	230	30032	2	0	.00	.00	.00	.00
TOTAL			102736.0								2886.05	-1319148.49	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 522.14

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	280	130	2669	40	220	170	2669	4	585	-168.70	1561.37	-450260.30	.00

20	300	10	10877	30	280	130	10877	3	0	.00	.00	.00	.00
TOTAL			13546.0								1561.37	-450260.30	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 599.92

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	220	170	632	50	200	220	632	3	0	.00	.00	.00	.00
0	300	10	15855	10	300	10	15855	4	0	.00	.00	.00	.00
TOTAL			16487.0								.00	.00	

SITE = 108 MI = 1 OPTIMUM ROTATION =100 LAND VALUE = $ 173.86

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	90	15576	90	80	110	15576	1	0	.00	.00	.00	.00
60	240	140	20250	70	200	150	20250	1	0	.00	.00	.00	.00
50	440	200	30840	60	320	210	30840	2	308	-146.11	9498.72	-4506032.40	.00
50	360	150	68499	60	280	170	68499	1	0	.00	.00	.00	.00
40	440	160	24722	50	360	200	24722	1	0	.00	.00	.00	.00
40	400	170	51204	50	320	200	51204	1	0	.00	.00	.00	.00
30	560	110	18293	40	440	160	18293	1	0	.00	.00	.00	.00
30	440	110	47103	40	360	160	47103	1	0	.00	.00	.00	.00
20	720	10	45151	30	560	110	45151	1	95	-83.42	4289.35	-3766496.42	.00
20	520	10	27275	30	440	110	27275	1	25	-41.69	681.88	-1137094.75	.00
TOTAL			348913.0								14469.94	-9409623.57	

SITE = 108 MI = 2 OPTIMUM ROTATION =100 LAND VALUE = $ 195.81

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	260	220	6323	80	220	230	6323	2	557	-43.03	3521.91	-272078.69	.00
70	220	190	11063	80	200	210	11063	2	0	.00	.00	.00	.00
60	340	220	60895	70	280	230	60895	2	0	.00	.00	.00	.00
60	220	140	10000	70	200	160	10000	2	0	.00	.00	.00	.00
50	400	190	78282	60	340	220	78282	2	0	.00	.00	.00	.00
40	80	70	20477	50	80	110	20477	2	0	.00	.00	.00	.00
TOTAL			187040.0								3521.91	-272078.69	

SITE = 108 MI = 3 OPTIMUM ROTATION = 90 LAND VALUE = $ 201.05

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	300	100	12871	40	280	160	12871	3	0	.00	.00	.00	.00
20	400	10	62442	30	300	90	62442	4	197	-141.01	12301.07	-8804946.42	.00

20	300	10	9983	30	300	100	9983	3	0	.00	.00	.00	.00
TOTAL			85296.0								12301.07	-8804946.42	

SITE = 108 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 277.40

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	220	140	10712	50	200	190	10712	3	0	.00	.00	.00	.00
30	300	90	3478	40	280	150	3478	3	0	.00	.00	.00	.00
10	300	10	11679	20	300	10	11679	4	0	.00	.00	.00	.00
0	300	10	28924	10	300	10	28924	4	0	.00	.00	.00	.00
TOTAL			54793.0								.00	.00	

TOTAL PERIODIC HARVEST = 37.552 MMCF REVENUE = $ -20907340.19
REVISED LAND VALUES - SITE 130 = $ 364.41

REVISED LAND VALUES - SITE 108 = $ 191.76
YEAR 2010 UNCONSTRAINED HARVEST = 515. MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION =100 LAND VALUE = $ 371.98

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
90	80	130	6323	0	300	10	6323	4	9079	4443.65	57406.52	28097198.95	.00
50	240	230	5691	60	200	260	5691	1	0	.00	.00	.00	.00
40	320	190	6673	50	240	210	6673	2	541	-42.87	3610.09	-286071.51	.00
40	280	190	4005	50	240	230	4005	1	0	.00	.00	.00	.00
30	440	150	11429	40	320	190	11429	1	0	.00	.00	.00	.00
TOTAL			34121.0								61016.61	27811127.44	

SITE = 130 MI = 2 OPTIMUM ROTATION =100 LAND VALUE = $ 302.89

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
90	80	150	15856	0	300	10	15856	4	10500	6182.39	166488.00	98027975.84	.00
70	220	260	2530	80	80	120	2530	2	8813	2825.60	22296.89	7148768.00	.00
70	200	250	10117	80	80	130	10117	2	7970	2579.10	80632.49	26092754.70	.00
60	260	240	44201	70	220	260	44201	2	0	.00	.00	.00	.00
60	240	230	30032	70	200	250	30032	2	228	-98.99	6847.30	-2972867.68	.00
60	240	220	5704	70	200	240	5704	2	209	-96.98	1192.14	-553173.92	.00
TOTAL			108440.0								277456.81	127743456.94	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 514.45

FROM	TO	PER ACRE	TOTAL

AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
50	200	220	632	60	180	260	632	3	0	.00	.00	.00	.00
30	280	130	10877	40	260	190	10877	3	0	.00	.00	.00	.00
TOTAL			11509.0								.00	.00	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 592.23

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
40	220	170	2669	50	200	220	2669	3	0	.00	.00	.00	.00
10	300	10	15855	20	300	10	15855	4	0	.00	.00	.00	.00
TOTAL			18524.0								.00	.00	

SITE = 108 MI = 1 OPTIMUM ROTATION =100 LAND VALUE = $ 173.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
90	80	110	15576	0	300	10	15576	4	6388	2434.42	99499.49	37918525.92	.00
70	200	150	20250	80	160	160	20250	2	372	-113.39	7533.00	-2296147.50	.00
60	280	170	68499	70	240	190	68499	1	0	.00	.00	.00	.00
50	360	200	24722	60	280	220	24722	2	144	-76.32	3559.97	-1886783.04	.00
50	320	200	51204	60	280	230	51204	1	0	.00	.00	.00	.00
40	440	160	18293	50	360	200	18293	1	0	.00	.00	.00	.00
40	360	160	47103	50	280	190	47103	2	158	-80.39	7442.27	-3786610.17	.00
30	560	110	45151	40	440	160	45151	1	0	.00	.00	.00	.00
30	440	110	27275	40	360	160	27275	1	0	.00	.00	.00	.00
TOTAL			318073.0								118034.73	29948985.21	

SITE = 108 MI = 2 OPTIMUM ROTATION =100 LAND VALUE = $ 195.80

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	220	230	6323	90	200	250	6323	2	0	.00	.00	.00	.00
80	200	210	11063	90	180	230	11063	2	0	.00	.00	.00	.00
70	280	230	60895	80	220	230	60895	2	909	-110.31	55353.56	-6717327.45	.00
70	200	160	10000	80	180	180	10000	2	0	.00	.00	.00	.00
60	340	220	78282	70	280	230	78282	2	0	.00	.00	.00	.00
60	320	210	30840	70	280	230	30840	2	0	.00	.00	.00	.00
50	80	110	20477	60	80	150	20477	2	0	.00	.00	.00	.00
TOTAL			217880.0								55353.56	-6717327.45	

SITE = 108 MI = 3 OPTIMUM ROTATION = 90 LAND VALUE = $ 193.48

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST

50	200	190	10712	60	180	220	10712	3	0	.00	.00	.00	.00
40	280	160	12871	50	260	210	12871	3	0	.00	.00	.00	.00
40	280	150	3478	50	260	200	3478	3	0	.00	.00	.00	.00
30	300	100	9983	40	280	160	9983	3	0	.00	.00	.00	.00
TOTAL			37044.0								.00	.00	

SITE = 108 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 270.26

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	300	90	62442	40	280	150	62442	3	0	.00	.00	.00	.00
20	300	10	11679	30	220	80	11679	4	244	-161.24	2849.68	-1883121.96	.00
10	300	10	28924	20	300	10	28924	4	0	.00	.00	.00	.00
TOTAL			103045.0								2849.68	-1883121.96	

TOTAL PERIODIC HARVEST = 514.711 MMCF REVENUE = $ 176903120.18
REVISED LAND VALUES - SITE 130 = $ 361.71

REVISED LAND VALUES - SITE 108 = $ 196.70
YEAR 2020 UNCONSTRAINED HARVEST = .118E+04MMCF

SITE = 130 MI = 1 OPTIMUM ROTATION =100 LAND VALUE = $ 371.98

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
60	200	260	5691	70	80	140	5691	2	7230	3447.00	41145.93	19616877.00	.00
50	240	230	4005	60	200	260	4005	1	0	.00	.00	.00	.00
40	320	190	11429	50	240	210	11429	2	541	-5.93	6183.09	-67773.97	.00
TOTAL			21125.0								47329.02	19549103.03	

SITE = 130 MI = 2 OPTIMUM ROTATION =100 LAND VALUE = $ 302.89

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
80	80	130	10117	90	80	160	10117	2	0	.00	.00	.00	.00
80	80	120	2530	90	80	150	2530	2	0	.00	.00	.00	.00
70	220	260	44201	80	80	120	44201	2	8813	3732.18	389543.41	164966088.18	.00
70	200	250	30032	80	60	100	30032	2	9635	4178.55	289358.32	125490213.60	.00
70	200	240	5704	80	80	120	5704	2	7949	3392.64	45341.10	19351618.56	.00
50	240	210	6673	60	200	230	6673	2	601	87.66	4010.47	584955.18	.00
TOTAL			99257.0								728253.30	310392875.52	

SITE = 130 MI = 3 OPTIMUM ROTATION = 80 LAND VALUE = $ 506.52

FROM				TO					PER ACRE		TOTAL		

AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
60	180	260	632	70	60	110	632	4	9298	5478.87	5876.34	3462645.84	.00
50	200	220	2669	60	180	260	2669	3	0	.00	.00	.00	.00
40	260	190	10877	50	240	240	10877	3	0	.00	.00	.00	.00
TOTAL			14178.0								5876.34	3462645.84	

SITE = 130 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 584.30

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
20	300	10	15855	30	280	130	15855	3	0	.00	.00	.00	.00
0	300	10	22179	10	300	10	22179	4	0	.00	.00	.00	.00
TOTAL			38034.0								.00	.00	

SITE = 108 MI = 1 OPTIMUM ROTATION =100 LAND VALUE = $ 173.86

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
70	240	190	68499	80	200	200	68499	1	0	.00	.00	.00	.00
60	280	230	51204	70	240	250	51204	1	0	.00	.00	.00	.00
50	360	200	18293	60	280	220	18293	2	144	-71.26	2634.19	-1303559.18	.00
40	440	160	45151	50	360	200	45151	1	0	.00	.00	.00	.00
40	360	160	27275	50	280	190	27275	2	158	-74.70	4309.45	-2037442.50	.00
TOTAL			210422.0								6943.64	-3341001.68	

SITE = 108 MI = 2 OPTIMUM ROTATION =100 LAND VALUE = $ 195.80

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
90	200	250	6323	0	300	10	6323	4	13262	5928.37	83855.63	37485083.51	.00
90	180	230	11063	0	300	10	11063	4	12311	5733.31	136196.59	63427608.53	.00
80	220	230	60895	90	200	250	60895	2	0	.00	.00	.00	.00
80	180	180	10000	90	160	200	10000	2	0	.00	.00	.00	.00
80	160	160	20250	90	140	180	20250	2	140	-90.61	2835.00	-1834852.50	.00
70	280	230	109122	80	220	230	109122	2	909	-53.07	99191.90	-5791104.54	.00
60	280	220	24722	70	240	240	24722	2	0	.00	.00	.00	.00
60	80	150	20477	70	80	190	20477	2	0	.00	.00	.00	.00
50	280	190	47103	60	260	230	47103	2	0	.00	.00	.00	.00
TOTAL			309955.0								322079.12	93286735.00	

SITE = 108 MI = 3 OPTIMUM ROTATION = 90 LAND VALUE = $ 185.66

FROM				TO					PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
60	180	220	10712	70	80	130	10712	4	5269	2505.27	56441.53	26836452.24	.00

50	260	210	12871	60	220	240	12871	4	281	-85.55	3616.75	-1101114.05	.00
50	260	200	3478	60	220	230	3478	4	251	-89.62	872.98	-311698.36	.00
40	280	160	9983	50	260	210	9983	3	0	.00	.00	.00	.00
40	280	150	62442	50	260	200	62442	3	0	.00	.00	.00	.00
TOTAL			99486.0								60931.26	25423639.83	

SITE = 108 MI = 4 OPTIMUM ROTATION = 80 LAND VALUE = $ 262.33

	FROM				TO				PER ACRE		TOTAL		
AGE	TPA	BAPA	ACRES	AGE	TPA	BAPA	ACRES	MI	HARVEST	REVENUE	HARVEST	REVENUE	OPP COST
30	220	80	11679	40	200	140	11679	4	54	-65.59	630.67	-766025.61	.00
20	300	10	28924	30	220	80	28924	4	244	-156.58	7057.46	-4528919.92	.00
0	300	10	15576	10	300	10	15576	4	0	.00	.00	.00	.00
TOTAL			56179.0								7688.12	-5294945.53	

TOTAL PERIODIC HARVEST = 1179.101 MMCF REVENUE = $ 443479052.01
REVISED LAND VALUES - SITE 130 = $ 390.09

REVISED LAND VALUES - SITE 108 = $ 193.01