

A LINEAR PROGRAMMING APPROACH TO MINIMIZING WOOD
PROCUREMENT COSTS FOR INTEGRATED FOREST PRODUCTS FIRMS

by

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I. INTRODUCTION

A major objective of the woodlands department of a forest products firm is to provide the wood processing mill with the required raw material at a minimum cost per unit of time. A given firm may have many alternative sources from which to procure wood. The firm may obtain wood from its own land or from the open market. The wood itself may be in the form of roundwood, chips, shavings, or slabs. The nature of the finished product largely determines the forms and the possible mixes of raw materials that can be used. However, the mix or form may be varied within certain limits by substituting one species of wood for another or by substituting slabs, chips, or shavings for roundwood.

The general wood procurement situation creates a large number of possible procurement alternatives. However, a minimum cost solution may seem intuitively obvious. That is, satisfy the mill's raw material mix requirement by purchasing wood from the cheapest source until that source is exhausted and then shift to the next cheapest source, etc. This procedure is feasible when only a short time period is considered, but the situation becomes more involved when all possible alternatives over a long time period are considered. The nature of the timber production process is such that one must consider a relatively long time period when manipulating large drains of raw material from a given area.

The ownership of standing timber or the option of purchasing land with timber creates numerous wood procurement possibilities. When standing timber is owned by the firm, the timber may be harvested at any point in time. Therefore, owned, standing timber which currently has a cost advantage over other alternatives could be retained to accumulate volume growth, and be harvested at a later time when it has an even greater cost advantage over alternative sources. The firm, in order to minimize wood procurement cost over a period of time, must consider timber growth rates, taxes, interest charges on standing timber, present and future market conditions, and external supply sources in determining the optimum harvest schedule for owned timber. A complete wood procurement plan must evaluate all possible procurement alternatives within the confines of the mill's volume and mix requirements.

The wood procurement problem may be characterized as the allocation of raw material purchases and harvests to various time periods in such a way as to meet the raw material requirements of the firm at a minimum cost. The number of procurement alternatives and the time dimension of the problem indicate that an analytical formulation of the problem is necessary to derive an optimal solution.

Linear programming is an efficient method of determining optimum plans only if there are numerous enterprises or

processes and numerous restrictions in attaining a specific objective such as maximizing profits or minimizing costs (Heady and Candler, 1958, p. 4). Since linear programming is a method which allocates various scarce resources among alternative processes, the technique will be used to formulate and analyze a wood procurement problem characteristic of many now confronting firms in the forest products industry.

Objective

The objective of this study is to demonstrate the applicability of linear programming to the problem of minimizing long term wood procurement costs for an integrated forest products firm.

Literature Review

Linear programming was developed during World War II and was being used to solve industrial and agricultural allocation problems by the mid 1950's. One of the first applications of the technique to forestry was by Coutu and Ellertsen (1960) who used a linear programming approach to consider the integration of farm woodlots into an over-all farm management program. Articles by Chappelle (1963), Schultz (1963), and Thompson (1963) have indicated that linear programming is applicable to the type of problem considered by Coutu and Ellertsen. Curtis (1962), Loucks (1964), Ellertsen and Rogers (1965), Tchong and Liittschwager (1966), and Kidd, et. al (1966) demonstrated that linear

programming can be used in forest management planning and decision-making. The applicability of the technique for maximizing net returns for wood processing industries and step-by-step instructions for preparing input data for computer analysis and for interpreting the computer output for the linear programming maximization model was set forth by Fasick and Sampson (1966).

Linear programming models for cost minimization have been used advantageously in many industries including agriculture and forestry. Douglas (1960) used the technique to compute least-cost combinations for bulk-blended fertilizers. The technique has also found usage in the formulation of least-cost rations for poultry and livestock (Oliver, 1965). The minimum complement of resources necessary to produce specified farm incomes has been solved in a similar manner by Miller and Narheim (1964). In forest industry, linear programming has been used to minimize transportation costs in pulpwood operations by Corcoran (1964) and Corcoran et. al (1966).

Other studies have been undertaken by Fabian (1958), Masse and Gibrat (1957), and Garvin (1957) for minimizing costs in the steel, electric power, and petroleum industries respectively. In other industries linear programming has been used to minimize costs of fluctuating production rates, excessive inventory carrying charges, and resource purchases (Naylor, 1963).

A linear programming model applied to the problems of planning over more than one production period and into which properties of biological growth were incorporated was set forth in a farm management plan by Swanson (1955).

II. GENERAL MODEL

A linear programming problem has three quantitative components: "...an objective, alternative methods or processes for attaining the objective, and limited resources or other restrictions (Heady and Candler, 1958, p. 2)." Any problem which has these three components can be expressed as a linear programming problem and can be formulated into a mathematical model of m linear equations with n unknowns where $m \leq n$ (Garvin, 1960, p. 3).

The general linear programming model for a cost minimization problem has the following form.

$$\text{Minimize: } Z = c_1x_1 + c_2x_2 + \dots + c_nx_n$$

$$\text{Subject to: } a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n = b_1$$

$$a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n = b_2$$

$$\vdots \quad \quad \quad \vdots \quad \quad \quad \vdots \quad \quad \quad \vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n = b_m$$

$$x_i \geq 0 \text{ for } i = 1, 2, \dots, n$$

- where: 1) $x_1, x_2, \dots, x_n$ are the alternatives to be considered in the minimization problem.
- 2) $c_1, c_2, \dots, c_n$ are the unit costs associated with each alternative.
- 3) $a_{11}, a_{12}, \dots, a_{mn}$ are technical coefficients. The coefficients indicate the amount of each resource used with or required for each of the various alternatives.

- 4) $b_1, b_2, \dots, b_m$ are constants which indicate the maximum amount of a resource available or the minimum amount of a resource required. The restrictive equations may be written as equalities or inequalities.

Each restrictive or constraining equation is a mathematical statement of importance to the problem and places some limitation on a possible optimal solution. All constraints which are relevant to the problem must be stated to insure that the resulting solution is feasible.

An extension of the linear programming model, known as linear programming over time or dynamic linear programming, can be used to create increasing or decreasing single value costs which deviate from the constant single value costs characteristic of the general linear programming model. A model which considers cost changes over time is more meaningful to decision makers, even though future costs must be predicted, than one which assumes constant costs over a long time study.

The model for linear programming over time can be characterized as a set of linear equations that are repetitive in nature. That is, the coefficients are repeated over and over again for each time period of study. Another characteristic is the sparceness of the matrix; it

contains only a limited number of non-zero coefficients (Arnoff and Sengupta, 1961, p. 169-171).

Linear programming over time should not be confused with dynamic programming which is a multi-stage process. A decision made at one stage in the dynamic programming process transforms the set of variables describing the model for the next stage (Vazsonyi, 1958, p. 252-254). Once the linear programming over time problem is formulated, it is solved for all stages as a set of linear equations, rather than being solved stage by stage as is the case in dynamic programming.

The following hypothetical example illustrates the time sequence aspect of linear programming over time.

A forest products firm processes 100 cords of wood each week in the manufacture of its product. The firm's procurement division wishes to minimize the cost of wood procurement for a two week period and still provide 100 cords of wood for the mill each week. There are three wood producers who provide the firm with wood each week. One half of the wood not purchased from the producer during the first week will be available for purchase during the second week in addition to the second week's predicted supply from that producer. The firm predicts the producers will be able to supply the following volumes of wood each week:

Week	Producer	Predicted Supply (Cords)	Cost Per Cord
1	A	60	\$ 10.00
1	B	20	12.00
1	C	50	15.00
2	A	30	10.00
2	B	50	15.00
2	C	10	20.00

The objective function (to minimize the cost of the wood requirement for a two-week period) has the form:

$$\text{Minimize } Z = 10.00A_1 + 12.00B_1 + 15.00C_1 + 10.00A_2 + 15.00B_2 + 20.00C_2$$

Subject to the following constraints:

$$\text{plant capacity, first week } A_1 + B_1 + C_1 = 100$$

$$\text{wood available from A, first week } A_1 \leq 60$$

$$\text{wood available from B, first week } B_1 \leq 20$$

$$\text{wood available from C, first week } C_1 \leq 50$$

$$\text{plant capacity, second week } A_1 + B_1 + C_1 + A_2 + B_2 + C_2 = 100$$

$$\text{wood available from A, second week } .5A_1 + A_2 \leq 60$$

$$\text{wood available from B, second week } .5B_1 + B_2 \leq 60$$

$$\text{wood available from C, second week } .5C_1 + C_2 \leq 35$$

The resulting linear programming over time matrix illustrates how these alternatives affect more than one time period.

	A_1	B_1	C_1	A_2	B_2	C_2	
plant capacity, first week	1	1	1	0	0	0	= 100
wood available from A, first week	1	0	0	0	0	0	≤ 60
wood available from B, first week	0	1	0	0	0	0	≤ 20
wood available from C, first week	0	0	1	0	0	0	≤ 50
plant capacity, second week	1	1	1	1	1	1	= 100
wood available from A, second week	.5	0	0	1	0	0	≤ 60
wood available from B, second week	0	.5	0	0	1	0	≤ 60
wood available from C, second week	0	0	.5	0	0	1	≤ 35

III. PROCEDURES

To achieve the objectives of this study, the extended general model discussed previously is applied in a case study to solve the raw material procurement problem of an integrated forest products firm. The objective of this firm is to minimize the present value of wood procurement costs over a 20 year study. A managerial constraint on this objective states that at the end of the 20 year study the firm must own standing timber to supply at least 50 percent of its requirements for a second 20 year study.

Description of the Firm's Wood Procurement Operation

For economic reasons the firm's timber shed lies within a 50 mile radius of the conversion plant. This timber shed is divided into 5 areas:

- Area 1 - the area within a 10 mile radius of the plant from which wood is hauled by truck, designated as Zone 1
- Area 2 - the area between Zone 1 and a 20 mile radius of the plant from which wood is hauled by truck, designated as Zone 2
- Area 3 - the area between Zone 2 and a 30 mile radius of the plant from which wood is hauled by truck, designated as Zone 3
- Area 4 - the area between Zone 3 and a 50 mile radius of the plant from which wood is hauled by truck

Area 5 - any location within the timber shed where
wood is hauled by rail

The timber shed is separated into the five areas to denote different prices paid by the firm to compensate for different transportation costs. All wood costs cited are per cord or cord equivalent delivered at the plant. The term cord equivalent is used for wood purchased in a form other than roundwood to show that the volume of roundwood and slabs, chips, and shavings are based on an equal unit of measure.

The firm has many alternatives from which to obtain its wood supply. At present it obtains soft hardwood (all hardwoods except hickory and oak) roundwood, oak roundwood, pine roundwood, slabs, chips and shavings from the open market. It also has the alternative of buying land with standing timber. A possible alternative would be to leave merchantable timber on purchased land, provided it meets a minimum stocking level, to be cut at some time in the future.

Design of the Case Study

The 20 year study is divided into ten periods (a period is two years in length). Each feasible supply source for wood and land is entered into the problem for each period (Appendix Table 1). These sources of supply include the possibility of buying land with standing timber in one period and harvesting the stumpage in that period or any subsequent period. Once all feasible procurement alternatives are listed, the cost per cord or cord equivalent of

each alternative (with the exception of bare land which is computed on a per acre basis) is determined (Appendix Tables 2, 3, 4, and 5).

A comparison between the cost of open market wood and the cost of wood cut from land bought with standing timber shows that the latter alternative is cheaper (an example of cost calculations is given in Appendix Table 6). To determine if land supporting stumpage justifies a higher payment that would increase the amount of land with timber available for purchase by the firm, price changes are made on both land and timber. Three price changes are made so that four separate cost minimization problems are formed, all with the same objective (Appendix Tables 2, 3, 4, and 5). Once a price change (called a "price policy") is made, the price or prices paid for land with stumpage must remain at the set level throughout the study.

To evaluate all alternatives at one point in time all costs and returns are discounted to the beginning of the study at a six percent interest rate which represents the alternate rate of return for the firm.

Sources of Data

The three major components; the objective, the alternative possibilities for achieving the objective, and the limited resources or constraints require quantification.

Alternatives

Each period the firm has the following alternatives from which to achieve its objective.

1. buy pine from the open market in zone 1
2. buy pine from the open market in zone 2
3. buy pine from the open market in zone 3
4. buy pine from the open market beyond zone 3
5. buy pine from the open market to be shipped to the mill by rail
6. buy soft hardwood from the open market in zone 1
7. buy soft hardwood from the open market in zone 2
8. buy soft hardwood from the open market in zone 3
9. buy soft hardwood from the open market from distances beyond zone 3
10. buy soft hardwood from the open market which is shipped to the plant by rail
11. buy slabs from the open market
12. buy oak from the open market
13. buy pine shavings from the open market
14. buy chips from the open market
15. buy land with stumpage in zone 1
16. buy land with stumpage in zone 2
17. buy land with stumpage in zone 3
18. buy land with stumpage from distances beyond zone 3

19. buy land with stumpage from areas which supply the mill with rail wood
20. buy bare land

Constraints

The capacity of the plant and the quality of the finished product place limitations on the amounts of different woods that may be used in the manufacturing process. The constraints applicable to each period are:

1. The plant will operate at capacity processing 240,000 cords of wood.
2. The minimum pine requirement is 72,000 cords.
3. The maximum volume of oak permitted is 36,000 cords.
4. The maximum volume of slabs permitted is 40,800 cord equivalents.
5. The maximum volume of chips permitted is 48,000 cord equivalents.
6. The maximum volume of shavings is 24,000 cord equivalents.
7. The maximum combination of slabs, chips, and shavings permitted is 64,800 cord equivalents.

Assumptions

Where possible data supplied by the cooperating firm are used. When necessary information was either incomplete or unavailable, such as future prices and wood supplies,

assumptions had to be adopted (whenever possible, assumptions are based upon information available in published literature). In all instances, the assumptions were confirmed by forestry personnel of the cooperating firm.

Costs. Each alternative has an associated cost. Alternatives supplying wood are calculated on a per cord basis and alternatives involving the purchasing and planting of bare land are calculated on a per acre basis.

1. Costs of raw materials delivered to the mill at the beginning of the first period are:

	<u>Zone 1</u>	<u>Zone 2</u>	<u>Zone 3</u>	<u>Beyond Rail</u> <u>Zone 3</u>	<u>Wood</u>
pine roundwood	\$17.00	\$18.00	\$19.00	\$19.75	\$20.15
soft hardwood roundwood	13.00	14.00	15.00	15.75	16.32
oak roundwood	12.50	12.50	12.50	12.50	12.50
chips	22.10	22.10	22.10	22.10	22.10
slabs	11.50	11.50	11.50	11.50	11.50
shavings	10.72	10.72	10.72	10.72	10.72

2. Raw material costs increase at a rate of 4% annually.
3. Pine stumpage costs \$6.00 per cord at the beginning of the study and increases at a rate of 2-3/4% annually (Appendix Table 7).

4. Bare land costs at the beginning of the study is \$40.00 per acre and increase at a rate of 5% annually (Appendix Table 8).
5. Planting costs are \$15.00 per acre at the beginning of the study and increase at a rate of 4% annually (Appendix Table 9).
6. Property tax on land is \$0.48 per acre per year and remains constant throughout the study (Appendix Table 10).
7. The company can obtain 30% more land with stumpage by offering \$8.00 a cord for stumpage (Appendix Table 11).
8. The company can obtain 35% more land with stumpage by paying \$60.00 per acre for land and also obtain a 50% increase in available bare land for purchase by offering this price (Appendix Table 11).
9. The price policies that the firm can follow to obtain land with stumpage and bare land (prices of all other alternatives remain unchanged) are:

<u>Price Policy</u>	<u>Price Paid for Land</u>	<u>Price Paid for Stumpage</u>
I	\$ 40.00 per acre	\$ 6.00 per cord
II	40.00 per acre	8.00 per cord
III	60.00 per acre	6.00 per cord
IV	60.00 per acre	8.00 per cord

The fourth alternative creates a 65% increase in availability of land with stumpage over the first alternative (Appendix Table 11).

10. The cost of stumpage at \$8.00 per cord and land at \$60.00 per acre increase at the rates of 2-3/4% and 5% respectively (Appendix Tables 7 and 8).

Supply. U. S. Forest Service data and this firm's data indicate the annual growth is approximately equal to the annual cut of timber in the area. The annual cut of softwood exceeds the annual growth while the annual growth of hardwood exceeds annual cut. Therefore, the availability of wood from the open market is assumed to remain constant each period throughout the program (Appendix Table 11).

1. Twenty percent of the open market pine from any area can be purchased as standing timber with the land (this alternative is called "land with stumpage").
2. The land with stumpage alternative assumes one stocking level of pine and one site quality. Any land with timber purchased with the alternative of leaving the timber to be cut at a later time period is assumed to contain 10 cords of pine per acre with a growth rate of one-half cord per acre per year.

3. The firm can obtain 30% more land with stumpage by following Price Policy II (Appendix Table 7).
4. The firm can obtain 35% more land with stumpage by following Price Policy III (Appendix Table 7).
5. The firm can obtain 65% more land with stumpage by following Price Policy IV (Appendix Table 7).
6. It is assumed that land planted in pine will yield 20 cords per acre at the end of 20 years. In order to satisfy the managerial constraint of supplying 50 percent of the mill's raw material requirement (120,000 cords of wood each period) for a second 20 year study, a total acreage of at least 60,000 acres must be planted during the present 20 year program so that the average planted acreage will be at least 6,000 acres for all successive periods beginning with the first period.

Technology and Scale of Plant. It is assumed that the plant capacity will not change during the 40 years covered by the study and managerial constraint. It is also assumed that present technology will remain constant.

Formation of the Objective Function and Matrix

Once all constraints, alternatives, and assumptions are determined, a series of linear equations is formulated expressing the firm's procurement problem (Appendix Table 12). Each linear equation places some limitation on the problem.

The objective functions (one for each price policy) consist of all possible alternatives with their respective costs for the ten periods which cover the 20 year study (Appendix Tables 2, 3, 4, and 5). The linear equations are solved by an IBM 7040 computer.

IV. RESULTS

The solution of this problem indicates the amounts of wood and land that the firm should purchase from each alternative source of supply each period. The solutions, one for each price policy, fulfill all constraint requirements and minimize the present value of the firm's procurement costs for the 20 year program (Appendix Tables 13, 14, and 15).

During the first period (1967-1968) the firm should implement the following action based on the results of Price Policy I, the prevailing price structure.

1. buy land with stumpage in the following manner:
 - a) 100 acres in Zone 1 to be cut in the period 1977-1978 yielding 1,550 cords
 - b) 300 acres in Zone 2 to be cut in 1977-1978 yielding 4,650 cords
 - c) 500 acres in Zone 3 to be cut in 1977-1978 yielding 7,750 cords
 - d) 700 acres beyond Zone 3 to be cut in 1975-1976 yielding 10,150 cords
 - e) 900 acres of land in areas which supply the mill with wood transported by rail From this land 3,840 cords are to be cut in 1967-1968 and 7,213 cords are to be cut in 1973-1974.
2. buy open market pine in the following manner:

- a) 4,000 cords from Zone 1
 - b) 12,000 cords from Zone 2
 - c) 20,000 cords from Zone 3
 - d) 28,000 cords from beyond Zone 3
 - e) 36,000 cords from areas which supply the mill with wood transported by rail
3. buy soft hardwood in the following manner:
- a) 3,000 cords from Zone 1
 - b) 7,000 cords from Zone 2
 - c) 11,000 cords from Zone 3
 - d) 16,000 cords from beyond Zone 3
 - e) 20,000 cords from areas which supply the mill with wood transported by rail
4. buy 36,000 cords of oak
5. buy 31,200 cord equivalents of slabs and 11,960 cord equivalents of shavings.
6. buy 5,634 acres of bare land for planting

The results indicate a trend for each alternative that prevails throughout the study. These trends suggest a policy for future wood procurement. This policy indicates purchasing:

- 1. all available land with pine stumpage within a 50 mile radius of the plant
- 2. all open market pine hauled by truck
- 3. all soft hardwood

4. the maximum volume of oak permitted in the raw material mix
5. all available slabs and shavings
6. plant 6,000 acres in pine each period

Of the four price policies, Price Policy I gives the minimum present cost (Appendix Table 15). Under Price Policies II, III, and IV the alternatives of buying land with stumpage do not appear in the solution. If Price Policies II, III, or IV are implemented, the firm should implement the following action based on the results.

1. buy all open market pine hauled by truck
2. buy all open market soft hardwood available
3. buy maximum volume of oak permitted in the raw material mix
4. buy all available slabs and shavings
5. plant 6,000 acres in pine each period

V. DISCUSSION

An analysis of the results provides a better understanding of the wood procurement problem. The results and their implications are discussed and suggestions made for future research on the problem.

A lengthy time study must be considered to insure a future wood supply for the firm. A short time study would indicate that wood should be cut as close to the mill as possible and would ignore timber growth and future wood requirements. The study is separated into two-year periods to indicate the advantages, if any, of holding land with stumpage to accumulate volume growth. A multi-period study is needed to implement changes in costs, alternatives, or constraints to coincide with future expectations.

That part of the solution which pertains to the first period is the most important part to the firm as it indicates the procurement policy the firm should implement now to minimize procurement costs for the next 20 years. However, the first solution is dependent upon future expectations as set forth by the assumptions of the study.

Analysis of the Solutions

The alternatives of buying land with stumpage are preferred over the alternatives of buying the same wood from the open market. A premium payment should induce suppliers to offer more land with stumpage to the market.

To determine if premium prices can be paid for land or stumpage, Price Policies II, III, and IV were implemented into the problem to form separate studies. The solutions of the four price policies provide a better understanding of the importance of the land with stumpage alternatives. The results indicate a premium payment for land with stumpage can not be economically justified under present and future expectations. Therefore, the alternatives of purchasing land with timber appear only in the solution of Price Policy I. It also has the lowest minimum present value of the four price policies. A comparison of the total present values of Price Policies I and II reveal that the total discounted cost advantage in buying land with stumpage is less than four percent. The firm may place an additional value, not considered by this study, on owning a supply of wood that can be cut at any time to supply the mill in the event expectations change and a wood shortage occurs. Therefore, the importance of purchasing and holding land with timber may be more important than the study reveals.

Stumpage purchases close to the mill can be held for a greater length of time than those at the outer edge of the procurement area. All land with stumpage is purchased at the same price in any one period. When the stumpage is cut a price differential is incurred according to the hauling distance. The difference between hauling costs from various areas increase as the stumpage cost increases. This means

that land with stumpage at the outer edge of the procurement area loses its cost advantage at a faster rate, increasing transportation costs eventually surpass the returns from a constant growth rate, than that purchased close to the mill.

Stumpage cut from company owned land is always used to replace that wood that would appear in solution when no company owned stumpage is cut. It replaces open market pine hauled by rail until wood from that alternative is no longer needed in the solution. It is then used to replace open market pine from beyond Zone 3.

About 95,000 cords of pine are purchased each period or approximately 30 percent more than is required. If there is an adequate supply of all forms of wood, then pine, the most expensive raw material appearing in the solution, would be purchased at the minimum amount. If the available supply of slabs and shavings can be increased, this wood will be substituted for pine since the firm is able to use 25 percent more slabs and 50 percent more shavings than can be supplied under present assumptions. Lowering the amount of pine consumed toward the minimum constraint lengthens the time that stumpage can be held on company land. Thus by increasing the availability of slabs and shavings, it is possible to reduce the total cost by (1) substituting slabs and shavings for pine and by (2) reducing the cost of pine cut from company land.

The alternative of buying chips does not appear in the solution as it is the most expensive wood form in the problem. If future expectations change, there are two possible situations in which chips would be purchased. Firstly, if the future supply of pine is expected to decrease sharply, land with stumpage will be held to insure against a pine shortage and chips may be needed to fulfill the plant capacity constraint. Secondly, if the total wood supply from all alternatives except buying chips is less than the plant capacity requirement, chips will be purchased until the plant capacity; maximum slab, chip, and shaving; or maximum chip constraint is reached. In either case, chips are purchased only after all other procurement alternatives are exhausted.

To minimize costs for the study and satisfy all constraints, only the minimum acreage requirement is planted each period. Under the growth assumption, the planting constraint will supply one-half of the plant's wood requirement for a second 20 years, but it does not necessarily minimize wood procurement costs for the second 20 years. The optimal planting program for a 40 year period may be either to plant more land than the minimum requirement or be able to supply more than one-half of the required wood with the total minimum planting requirement. By planting the required 60,000 acres in the first few periods the firm will own more than one-half of its wood supply during the

second 20 years since the planted timber will have more time to accumulate growth.

As land costs do not vary within the procurement area, the firm will minimize long run transportation costs by purchasing land as close to the mill as possible. As per acre management costs on large tracts of land are less than those on small tracts, the firm will purchase large tracts of land whenever possible.

Stability of the Solution

A computer is needed to solve a problem of this size. By implementing various computer agendums, additional information useful to the decision maker is easily obtained at little expense.

As stated before, the solution to the study is based on future expectations. To have confidence in a solution of a long term problem based on certainty, one must know the effects of possible expectation changes on the solution. Little confidence can be placed on results that are based on a solution that varies greatly with small changes in price or quantity of the alternatives.

Marginal values, given for all alternatives that appear in the final solution, are changes in the objective row (total discounted cost) resulting from the addition of one more unit of an alternative if that alternative had appeared in the solution.

Example: The marginal value of one cord of open market pine in Zone 1 in 1967-1968, is 2.22.

This means that if one more cord of open market pine becomes available in Zone 1 in 1967-1968, it will be used to replace one cord of wood from another alternative (it will replace the most expensive alternative in solution that can be replaced) and reduce the discounted procurement cost by \$2.22.

This information can be used to determine if or how much money can be invested in a program to increase the firm's supply of a certain wood in a particular area. As an example, the firm can initiate a policy to mark all pine stands for thinning in Zone 1 free of charge to owners who will sell the cord wood to the firm. Another use of the marginal value product is to determine the profitability of increasing or decreasing output slightly.

The cost ranging agendum calculates the limits between which the cost of an alternative may vary, all other costs remaining constant, without changing the quantity of that alternative in solution. Cost ranging also indicates which alternatives will vary in quantity when the cost of the alternative being analyzed ranges beyond these limits.

Example: The cost of open market pine in Zone 1 during the first period is \$8.66 per cord. If

the cost of this pine drops below \$7.98 per cord there will be no cost advantage in buying land with stumpage in Zone 1. Instead the firm would convert the pine from the alternative "land with stumpage" to open market pine. If the cost rises above \$10.88 per cord in Zone 1 then the amount of pine obtained from Zone 1 will be reduced.

This information indicates the stability of the solution to unexpected price changes. Since the solution will remain stable over a relatively wide range the first period, any change in cost of that alternative during that period can be considered to have no effect on the procurement policy.

Right hand side ranges designate the limits between which the right hand side values (total available resources for one period) may vary before a solution change is made. It also indicates which alternatives in the solution will be effected if the ranges exceed the limits.

Example: The total amount of pine available from Zone 1 during the first period is 5,000 cords. If the amount of available pine dropped below 1,000 cords then the alternative of buying pine from the open market in Zone 1 would drop from the solution. This is due to the fact that 1,000 cords of pine can be purchased as land with timber--a separate alternative. If the amount of pine available is

raised to 8,840 cords in Zone 1 the alternative of buying land with timber to be cut in the first period and shipped by rail would be dropped from the solution.

This agendum can be used to determine how much open market pine must be bought, assuming future expectations, to be able to retain the stumpage on company owned land, especially that which supplies wood by rail, so that it can have a greater cost advantage by accumulating volume growth.

Parametric programming is another agendum which yields useful information. This agendum enables the decision maker to change any or all right hand side values by any amount and get a normal solution with the changed right hand sides. The computer changes these right hand side values by beginning at the current right hand side values and increasing or decreasing these right hand side values by small increments until the desired change is completed. The decision maker can obtain the new solution each time there is a solution change or at desired intervals if so desired.

The problem is parametric programmed so that all available resources would be increased by 100 percent. The computer is given a directive to print a solution for each 10 percent increase in available resources provided there is a change in the solution.

Example: A 10 percent increase in the availability of all resources during the first period decreases the consumption of pine shipped by rail from 36,000 cords to approximately 9,000 cords. When the availability of resources is increased 20 percent, pine by rail did not appear in solution.

Parametric programming can be used by decision makers to indicate procurement policy changes due to an underestimation or overestimation of the available supply of raw materials.

Implications for Future Study

To realize the full potential of this study the problem should be re-run periodically with up-dated information. By following this procedure future expectations are still uncertain, but estimates of growth and availability of alternatives presently assumed, can be refined. As the solution is only as reliable as the information implemented in the problem, additional research for better data can greatly improve the realibility of the results.

The model used in this study can be expanded to include a variety of site qualities and stocking levels. A relevant addition to the problem would be to expand the existing stocking level into three stocking levels of 10, 15, and 20 cords per acre. The quality of purchased land could be expanded to include two site qualities.

Example:

<u>Stocking Level (cords per acre)</u>	<u>Site Quality</u>	<u>Growth Rate (cords per acre) Per Year</u>
10	A	.5
10	B	.7
15	A	.9
15	B	1.2
20	A	1.4
20	B	1.8

By using this classification the firm is now able to separate land with stumpage into six categories, each commanding a separate price. Higher prices can be paid for land and stumpage with a faster growth rate than for the growth rate used in the present study. However, since there is the possibility that each category can be purchased in each procurement area every period and cut during that period or any subsequent period the size of the problem is greatly increased. The implementation of alternatives of purchasing six categories of land with stumpage into the present study would expand the size of the problem from 270 procurement alternatives with 425 associated costs to one of 520 procurement alternatives with 1800 associated costs.

Proposed future research for the present study is to use essentially the same data to demonstrate the applicability and advantages of the stochastic programming technique. This technique is similar to that of linear programming with the exception that future costs and supplies can be predicted with a probabilistic approach. Linear programming uses the deterministic approach which is based on known future costs and supplies.

VI. SUMMARY

The objective of this study is to demonstrate the applicability of linear programming to the forest management decision making process, specifically, to minimize the long term procurement cost for an integrated forest products firm.

The general linear programming model is formulated for a cost minimization problem and is implemented with data from a case study. The study covers 20 years and includes a managerial constraint that the firm own enough timber to supply 50 percent of the mill's requirement for a second 20 years.

A quality requirement of the firm's finished product is such that the amount of each form and species of wood used in the raw material mix is restricted by an upper or lower limit. The study is divided into ten two-year periods. Each period the mill must be supplied with the needed raw material requirements. The firm has many alternatives from which to procure wood, but each alternative is limited in quantity to the maximum amount of wood it can supply each period. The firm can process pine roundwood, soft hardwood roundwood, oak roundwood, slabs, chips, and shavings for the manufacture of its product. Wood procurement by the firm is restricted to the area within a 50 mile radius of the mill for economic reasons. The area is sub-divided into five

parts which designate price differences paid for pine roundwood and soft hardwood roundwood to compensate for increased transportation costs of the wood which is hauled long distances. Alternatives of buying land with stumpage from the five areas are implemented into the study. Once purchased, the stumpage can be cut immediately or held to accumulate volume growth and be cut when its cost advantage is greatest in relation to the entire study. The managerial constraint is implemented into the problem by requiring that an average minimum acreage must be planted in pine each period.

Assumptions regarding future expectations are incorporated into the problem so that future costs and wood supplies can be determined. When the costs of pine from the open market and pine cut from purchased land from the same area are compared, pine cut from purchased land is found to be more economical. To determine if a premium can be paid for land or stumpage to increase the supply of land with stumpage available to the firm, three premium alternatives, each affecting the supply of land with stumpage, are incorporated into the 20 year study in such a way that four problems are formed. Each problem minimizes wood procurement cost over the 20 years and fulfills the managerial constraint, but the cost of each land with stumpage alternative and its associated supply varies from problem to problem. The problems are solved on an

IBM 7040 computer.

The solutions indicate that of the four price policies studied, the one used presently by the firm has the greatest cost advantage and that a premium cannot be paid for land or stumpage to increase the availability of land with stumpage. The managerial constraint is satisfied at minimum cost by planting the minimum required acreage each two-year period.

Additional information is obtained concerning the stability of the solution to changes in future expectations by implementing various computer agendums to the problem.

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Appendix Table 1. Possible procurement activities for the study

Description of procurement alternatives	1967 to 1968	1969 to 1970	1971 to 1972	Period purchased				1981 to 1982	1983 to 1984	1985 to 1986
				1973 to 1974	1975 to 1976	1977 to 1978	1979 to 1980			
Buy open market pine round-wood from Zone 1	X ₁	X ₆₆	X ₁₂₆	X ₁₈₁	X ₂₃₁	X ₂₇₆	X ₃₁₆	X ₃₅₁	X ₃₈₁	X ₄₀₆
Buy open market pine round-wood from Zone 2	X ₂	X ₆₇	X ₁₂₇	X ₁₈₂	X ₂₃₂	X ₂₇₇	X ₃₁₇	X ₃₅₂	X ₃₈₂	X ₄₀₇
Buy open market pine round-wood from Zone 3	X ₃	X ₆₈	X ₁₂₈	X ₁₈₃	X ₂₃₃	X ₂₇₈	X ₃₁₈	X ₃₅₃	X ₃₈₃	X ₄₀₈
Buy open market pine round-wood from beyond Zone 3	X ₄	X ₆₉	X ₁₂₉	X ₁₈₄	X ₂₃₄	X ₂₇₉	X ₃₁₉	X ₃₅₄	X ₃₈₄	X ₄₀₉
Buy open market pine round-wood obtained by rail	X ₅	X ₇₀	X ₁₃₀	X ₁₈₅	X ₂₃₅	X ₂₈₀	X ₃₂₀	X ₃₅₅	X ₃₈₅	X ₄₁₀
Buy open market soft hard-wood roundwood from Zone 1	X ₆	X ₇₁	X ₁₃₁	X ₁₈₆	X ₂₃₆	X ₂₈₁	X ₃₂₁	X ₃₅₆	X ₃₈₆	X ₄₁₁
Buy open market soft hard-wood roundwood from Zone 2	X ₇	X ₇₂	X ₁₃₂	X ₁₈₇	X ₂₃₇	X ₂₈₂	X ₃₂₂	X ₃₅₇	X ₃₈₇	X ₄₁₂
Buy open market soft hard-wood roundwood from zone 3	X ₈	X ₇₃	X ₁₃₃	X ₁₈₈	X ₂₃₈	X ₂₈₃	X ₃₂₃	X ₃₅₈	X ₃₈₈	X ₄₁₃

Appendix Table 1. (Continued)

Description of Procurement Alternatives	Period Purchased									
	1967 to 1968	1969 to 1970	1971 to 1972	1973 to 1974	1975 to 1976	1977 to 1978	1979 to 1980	1981 to 1982	1983 to 1984	1985 to 1986
Buy soft hardwood round- wood from beyond Zone 3	X ₉	X ₇₄	X ₁₃₄	X ₁₈₉	X ₂₃₉	X ₂₈₄	X ₃₂₄	X ₃₅₉	X ₃₈₉	X ₄₁₄
Buy soft hardwood round- wood obtained by rail	X ₁₀	X ₇₅	X ₁₃₅	X ₁₉₀	X ₂₄₀	X ₂₈₅	X ₃₂₅	X ₃₆₀	X ₃₉₀	X ₄₁₅
Buy oak roundwood from the open market	X ₁₁	X ₇₆	X ₁₃₆	X ₁₉₁	X ₂₄₁	X ₂₈₆	X ₃₂₆	X ₃₆₁	X ₃₉₁	X ₄₁₆
Buy slabs from the open market	X ₁₂	X ₇₇	X ₁₃₇	X ₁₉₂	X ₂₄₂	X ₂₈₇	X ₃₂₇	X ₃₆₂	X ₃₉₂	X ₄₁₇
Buy chips from the open market	X ₁₃	X ₇₈	X ₁₃₈	X ₁₉₃	X ₂₄₃	X ₂₈₈	X ₃₂₈	X ₃₆₃	X ₃₉₃	X ₄₁₈
Buy shavings from the open market	X ₁₄	X ₇₉	X ₁₃₉	X ₁₉₄	X ₂₄₄	X ₂₈₉	X ₃₂₉	X ₃₆₄	X ₃₉₄	X ₄₁₉
Bare land purchase	X ₁₅	X ₈₀	X ₁₄₀	X ₁₉₅	X ₂₄₅	X ₂₉₀	X ₃₃₀	X ₃₆₅	X ₃₉₅	X ₄₂₀
Buy land with stumpage in Zone 1 Cut in 1967-1968	X ₁₆									
Buy land with stumpage in Zone 1 Cut in 1969-1970	X ₁₇	X ₈₁								
Buy land with stumpage in Zone 1 Cut in 1971-1972	X ₁₈	X ₈₂	X ₁₄₁							

Appendix Table 1. (Continued)

Description of Procurement Alternatives	Period Purchased									
	1967 to 1968	1969 to 1970	1971 to 1972	1973 to 1974	1975 to 1976	1977 to 1978	1979 to 1980	1981 to 1982	1983 to 1984	1985 to 1986
Buy land with stumpage in Zone 1 Cut in 1973-1974	X ₁₉	X ₈₃	X ₁₄₂	X ₁₉₆						
Buy land with stumpage in Zone 1 Cut in 1975-1976	X ₂₀	X ₈₄	X ₁₄₃	X ₁₉₇	X ₂₄₆					
Buy land with stumpage in Zone 1 Cut in 1977-1978	X ₂₁	X ₈₅	X ₁₄₄	X ₁₉₈	X ₂₄₇	X ₂₉₁				
Buy land with stumpage in Zone 1 Cut in 1979-1980	X ₂₂	X ₈₆	X ₁₄₅	X ₁₉₉	X ₂₄₈	X ₂₉₂	X ₃₃₁			
Buy land with stumpage in Zone 1 Cut in 1981-1982	X ₂₃	X ₈₇	X ₁₄₆	X ₂₀₀	X ₂₄₉	X ₂₉₃	X ₃₃₂	X ₃₆₆		
Buy land with stumpage in Zone 1 Cut in 1983-1984	X ₂₄	X ₈₈	X ₁₄₇	X ₂₀₁	X ₂₅₀	X ₂₉₄	X ₃₃₃	X ₃₆₇	X ₃₉₆	
Buy land with stumpage in Zone 1 Cut in 1985-1986	X ₂₅	X ₈₉	X ₁₄₈	X ₂₀₂	X ₂₅₁	X ₂₉₅	X ₃₃₄	X ₃₆₈	X ₃₉₇	X ₄₂₁
Buy land with stumpage in Zone 2 Cut in 1967-1968	X ₂₆									
Buy land with stumpage in Zone 2 Cut in 1969-1970	X ₂₇	X ₉₀								
Buy land with stumpage in Zone 2 Cut in 1971-1972	X ₂₈	X ₉₁	X ₁₄₉							

Appendix Table 1. (Continued)

Description of Procurement Alternatives	Period Purchased									
	1967 to 1968	1969 to 1970	1971 to 1972	1973 to 1974	1975 to 1976	1977 to 1978	1979 to 1980	1981 to 1982	1983 to 1984	1985 to 1986
Buy land with stumpage in Zone 2 Cut in 1973-1974	X ₂₉	X ₉₂	X ₁₅₀	X ₂₀₃						
Buy land with stumpage in Zone 2 Cut in 1975-1976	X ₃₀	X ₉₃	X ₁₅₁	X ₂₀₄	X ₂₅₂					
Buy land with stumpage in Zone 2 Cut in 1977-1978	X ₃₁	X ₉₄	X ₁₅₂	X ₂₀₅	X ₂₅₃	X ₂₉₆				
Buy land with stumpage in Zone 2 Cut in 1979-1980	X ₃₂	X ₉₅	X ₁₅₃	X ₂₀₆	X ₂₅₄	X ₂₉₇	X ₃₃₅			
Buy land with stumpage in Zone 2 Cut in 1981-1982	X ₃₃	X ₉₆	X ₁₅₄	X ₂₀₇	X ₂₅₅	X ₂₉₈	X ₃₃₆	X ₃₆₉		
Buy land with stumpage in Zone 2 Cut in 1983-1984	X ₃₄	X ₉₇	X ₁₅₅	X ₂₀₈	X ₂₅₅	X ₂₉₉	X ₃₃₇	X ₃₇₀	X ₃₉₈	
Buy land with stumpage in Zone 2 Cut in 1985-1986	X ₃₅	X ₉₈	X ₁₅₆	X ₂₀₉	X ₂₅₆	X ₃₀₀	X ₃₃₈	X ₃₇₁	X ₃₉₉	X ₄₂₂
Buy land with stumpage in Zone 3 Cut in 1967-1968	X ₃₆									
Buy land with stumpage in Zone 3 Cut in 1969-1970	X ₃₇	X ₉₉								
Buy land with stumpage in Zone 3 Cut in 1971-1972	X ₃₈	X ₁₀₀	X ₁₅₇							

Appendix Table 1. (Continued)

Description of Procurement Alternatives	Period Purchased									
	1967 to 1968	1969 to 1970	1971 to 1972	1973 to 1974	1975 to 1976	1977 to 1978	1979 to 1980	1981 to 1982	1983 to 1984	1985 to 1986
Buy land with stumpage in Zone 3 Cut in 1973-1974	X ₃₉	X ₁₀₁	X ₁₅₈	X ₂₁₀						
Buy land with stumpage in Zone 3 Cut in 1975-1976	X ₄₀	X ₁₀₂	X ₁₅₉	X ₂₁₁	X ₂₅₈					
Buy land with stumpage in Zone 3 Cut in 1977-1978	X ₄₁	X ₁₀₃	X ₁₆₀	X ₂₁₂	X ₂₅₉	X ₃₀₁				
Buy land with stumpage in Zone 3 Cut in 1979-1980	X ₄₂	X ₁₀₄	X ₁₆₁	X ₂₁₃	X ₂₆₀	X ₃₀₂	X ₃₃₉			
Buy land with stumpage in Zone 3 Cut in 1981-1982	X ₄₃	X ₁₀₅	X ₁₆₂	X ₂₁₄	X ₂₆₁	X ₃₀₃	X ₃₄₀	X ₃₇₂		
Buy land with stumpage in Zone 3 Cut in 1983-1984	X ₄₄	X ₁₀₆	X ₁₆₃	X ₂₁₅	X ₂₆₂	X ₃₀₄	X ₃₄₁	X ₃₇₃	X ₄₀₀	
Buy land with stumpage in Zone 3 Cut in 1985-1986	X ₄₅	X ₁₀₇	X ₁₆₄	X ₂₁₆	X ₂₆₃	X ₃₀₅	X ₃₄₂	X ₃₇₄	X ₄₀₁	X ₄₂₃
Buy land with stumpage beyond Zone 3 Cut in 1967-1968	X ₄₆									
Buy land with stumpage beyond Zone 3 Cut in 1969-1970	X ₄₇	X ₁₀₈								

Appendix Table 1. (Continued)

Description of Procurement Alternatives	Period Purchased									
	1967 to 1968	1969 to 1970	1971 to 1972	1973 to 1974	1975 to 1976	1977 to 1978	1979 to 1980	1981 to 1982	1983 to 1984	1985 to 1986
Buy land with stumpage beyond Zone 3 Cut in 1971-1972	X ₄₈	X ₁₀₉	X ₁₆₅							
Buy land with stumpage beyond Zone 3 Cut in 1973-1974	X ₄₉	X ₁₁₀	X ₁₆₆	X ₂₁₇						
Buy land with stumpage beyond Zone 3 Cut in 1975-1976	X ₅₀	X ₁₁₁	X ₁₆₇	X ₂₁₈	X ₂₆₄					
Buy land with stumpage beyond Zone 3 Cut in 1977-1978	X ₅₁	X ₁₁₂	X ₁₆₈	X ₂₁₉	X ₂₆₅	X ₃₀₆				
Buy land with stumpage beyond Zone 3 Cut in 1979-1980	X ₅₂	X ₁₁₃	X ₁₆₉	X ₂₂₀	X ₂₆₆	X ₃₀₇	X ₃₄₃			
Buy land with stumpage beyond Zone 3 Cut in 1981-1982	X ₅₃	X ₁₁₄	X ₁₇₀	X ₂₂₁	X ₂₆₇	X ₃₀₈	X ₃₄₄	X ₃₇₅		
Buy land with stumpage beyond Zone 3 Cut in 1983-1984	X ₅₄	X ₁₁₅	X ₁₇₁	X ₂₂₂	X ₂₆₈	X ₃₀₉	X ₃₄₅	X ₃₇₆	X ₄₀₂	

Appendix Table 1. (Continued)

Description of Procurement Alternatives	Period Purchased									
	1967 to 1968	1969 to 1970	1971 to 1972	1973 to 1974	1975 to 1976	1977 to 1978	1979 to 1980	1981 to 1982	1983 to 1984	1985 to 1986
Buy land with stumpage beyond Zone 3 Cut in 1985-1986	X ₅₅	X ₁₁₆	X ₁₇₂	X ₂₂₃	X ₂₆₉	X ₃₁₀	X ₃₄₆	X ₃₇₇	X ₄₀₃	X ₄₂₄
Buy land with stumpage to be shipped by rail Cut in 1967-1968	X ₅₆									
Buy land with stumpage to be shipped by rail Cut in 1969-1970	X ₅₇	X ₁₁₇								
Buy land with stumpage to be shipped by rail Cut in 1971-1972	X ₅₈	X ₁₁₈	X ₁₇₃							
Buy land with stumpage to be shipped by rail Cut in 1973-1974	X ₅₉	X ₁₁₉	X ₁₇₄	X ₂₂₄						
Buy land with stumpage to be shipped by rail Cut in 1975-1976	X ₆₀	X ₁₂₀	X ₁₇₅	X ₂₂₅	X ₂₇₀					
Buy land with stumpage to be shipped by rail Cut in 1977-1978	X ₆₁	X ₁₂₁	X ₁₇₆	X ₂₂₆	X ₂₇₁	X ₃₁₁				

Appendix Table 1. (Continued)

Description of Procurement Alternatives	Period Purchased									
	1967 to 1968	1969 to 1970	1971 to 1972	1973 to 1974	1975 to 1976	1977 to 1978	1979 to 1980	1981 to 1982	1983 to 1984	1985 to 1986
Buy land with stumpage to be shipped by rail Cut in 1979-1980	X ₆₂	X ₁₂₂	X ₁₇₇	X ₂₂₇	X ₂₇₂	X ₃₁₂	X ₃₄₇			
Buy land with stumpage to be shipped by rail Cut in 1981-1982	X ₆₃	X ₁₂₃	X ₁₇₈	X ₂₂₈	X ₂₇₃	X ₃₁₃	X ₃₄₈	X ₃₇₈		
Buy land with stumpage to be shipped by rail Cut in 1983-1984	X ₆₄	X ₁₂₄	X ₁₇₉	X ₂₂₉	X ₂₇₄	X ₃₁₄	X ₃₄₉	X ₃₇₉	X ₄₀₄	
Buy land with stumpage to be shipped by rail Cut in 1985-1986	X ₆₅	X ₁₂₅	X ₁₈₀	X ₂₃₀	X ₂₇₅	X ₃₁₅	X ₃₅₀	X ₃₈₀	X ₄₀₅	X ₄₂₅

Appendix Table 2. Objective function for Price Policy I
(land \$40.00 per acre, stumpage \$6.00
per cord)

$$\begin{aligned}
 \text{Minimize } Z = & 8.66X_1 + 9.17X_2 + 9.69X_3 + 10.07X_4 + 10.71X_5 + 6.63X_6 + \\
 & 7.14X_7 + 7.65X_8 + 8.03X_9 + 8.66X_{10} + 6.37X_{11} + 6.48X_{12} + 12.49X_{13} \\
 & + 7.83X_{14} + 43.75X_{15} + 13.32X_{16} + 13.66X_{17} + 13.60X_{18} + 13.55X_{19} \\
 & + 13.48X_{20} + 13.42X_{21} + 13.36X_{22} + 13.28X_{23} + 13.15X_{24} + 13.01X_{25} \\
 & + 13.86X_{26} + 14.22X_{27} + 14.19X_{28} + 14.15X_{29} + 14.12X_{30} + 14.07X_{31} \\
 & + 14.01X_{32} + 13.98X_{33} + 13.86X_{34} + 13.71X_{35} + 14.41X_{36} + 14.79X_{37} \\
 & + 14.99X_{38} + 14.78X_{39} + 14.76X_{40} + 14.74X_{41} + 14.70X_{42} + 14.65X_{43} \\
 & + 14.56X_{44} + 14.41X_{45} + 14.80X_{46} + 15.21X_{47} + 15.22X_{48} + 15.24X_{49} + \\
 & 15.18X_{50} + 15.24X_{51} + 15.18X_{52} + 15.17X_{53} + 15.26X_{54} + 14.96X_{55} \\
 & + 15.48X_{56} + 15.92X_{57} + 15.96X_{58} + 16.02X_{59} + 16.02X_{60} + 16.04X_{61} \\
 & + 16.02X_{62} + 16.03X_{63} + 15.95X_{64} + 15.83X_{65} + 8.34X_{66} + 8.83X_{67} + \\
 & 9.32X_{68} + 9.69X_{69} + 10.30X_{70} + 6.38X_{71} + 6.86X_{72} + 7.36X_{73} + 7.73X_{74} \\
 & + 8.34X_{75} + 6.13X_{76} + 6.22X_{77} + 12.02X_{78} + 7.53X_{79} + 40.67X_{80} + \\
 & 12.70X_{81} + 13.02X_{82} + 12.91X_{83} + 12.85X_{84} + 12.79X_{85} + 12.76X_{86} + \\
 & 12.62X_{87} + 12.48X_{88} + 12.38X_{89} + 13.21X_{90} + 13.56X_{91} + 13.46X_{92} + \\
 & 13.45X_{93} + 13.40X_{94} + 13.36X_{95} + 13.28X_{96} + 13.41X_{97} + 13.04X_{98} + \\
 & 13.72X_{99} + 14.10X_{100} + 14.05X_{101} + 14.04X_{102} + 14.02X_{103} + 13.87X_{105} \\
 & + 13.81X_{106} + 13.71X_{107} + 14.11X_{108} + 14.51X_{109} + 14.47X_{110} + \\
 & 14.43X_{111} + 14.48X_{112} + 14.46X_{113} + 14.40X_{114} + 14.30X_{115} + \\
 & 14.23X_{116} + 14.75X_{117} + 15.19X_{118} + 15.20X_{119} + 15.21X_{120} + \\
 & 15.24X_{121} + 15.25X_{122} + 15.21X_{123} + 15.12X_{124} + 15.06X_{125} +
 \end{aligned}$$

Appendix Table 2. (Continued)

$8.03X_{126} + 8.50X_{127} + 8.97X_{128} + 9.33X_{129} + 9.92X_{130} + 6.14X_{131} +$
 $6.61X_{132} + 7.08X_{133} + 7.44X_{134} + 8.03X_{135} + 5.90X_{136} + 6.00X_{137} +$
 $11.57X_{138} + 7.24X_{139} + 37.56X_{140} + 12.06X_{141} + 12.35X_{142} +$
 $12.61X_{143} + 12.16X_{144} + 12.09X_{145} + 11.98X_{146} + 11.85X_{147} +$
 $11.71X_{148} + 12.56X_{149} + 12.86X_{150} + 12.81X_{151} + 12.73X_{152} +$
 $12.66X_{153} + 12.60X_{154} + 12.47X_{155} + 12.34X_{156} + 13.05X_{157} +$
 $13.40X_{158} + 13.36X_{159} + 13.31X_{160} + 13.27X_{161} + 13.19X_{162} +$
 $13.10X_{163} + 12.97X_{164} + 13.43X_{165} + 13.79X_{166} + 13.72X_{167} +$
 $13.74X_{168} + 13.69X_{169} + 13.66X_{170} + 13.56X_{171} + 13.46X_{172} +$
 $14.05X_{173} + 14.46X_{174} + 14.45X_{175} + 14.44X_{176} + 14.43X_{177} +$
 $14.42X_{178} + 14.34X_{179} + 14.24X_{180} + 7.73X_{181} + 8.17X_{182} +$
 $8.64X_{183} + 8.98X_{184} + 9.56X_{185} + 5.92X_{186} + 6.37X_{187} + 6.82X_{188}$
 $+ 7.16X_{189} + 7.73X_{190} + 5.68X_{191} + 5.78X_{192} + 11.14X_{193} + 6.98X_{194}$
 $+ 34.37X_{195} + 11.43X_{196} + 11.68X_{197} + 11.58X_{198} + 11.50X_{199} +$
 $11.38X_{200} + 11.24X_{201} + 11.09X_{202} + 11.90X_{203} + 12.19X_{204} +$
 $12.10X_{205} + 12.03X_{206} + 11.96X_{207} + 11.83X_{208} + 11.68X_{209} +$
 $12.39X_{210} + 12.70X_{211} + 12.64X_{212} + 12.60X_{213} + 12.51X_{214} +$
 $12.42X_{215} + 12.28X_{216} + 12.75X_{217} + 13.03X_{218} + 13.04X_{219} +$
 $12.99X_{220} + 12.95X_{221} + 12.85X_{222} + 12.74X_{223} + 13.36X_{224} +$
 $13.70X_{225} + 13.69X_{226} + 13.68X_{227} + 13.66X_{228} + 13.58X_{229} +$
 $13.48X_{230} + 7.43X_{231} + 7.84X_{232} + 8.31X_{233} + 8.60X_{234} +$
 $9.18X_{235} + 5.68X_{236} + 6.12X_{237} + 6.56X_{238} + 6.88X_{239} + 7.43X_{240}$
 $+ 5.47X_{241} + 5.56X_{242} + 10.71X_{243} + 6.71X_{244} + 31.08X_{245} +$

Appendix Table 2. (Continued)

10.82X₂₄₆+10.04X₂₄₇+10.92X₂₄₈+10.80X₂₄₉+10.66X₂₅₀⁺
 10.51X₂₅₁+11.29X₂₅₂+11.52X₂₅₃+11.41X₂₅₄+11.34X₂₅₅⁺
 11.21X₂₅₆+11.07X₂₅₇+11.75X₂₅₈+12.02X₂₅₉+11.94X₂₆₀⁺
 11.85X₂₆₁+11.76X₂₆₂+11.62X₂₆₃+12.05X₂₆₄+12.38X₂₆₅⁺
 12.30X₂₆₆+12.26X₂₆₇+12.16X₂₆₈+12.06X₂₆₉+12.66X₂₇₀⁺
 12.98X₂₇₁+12.94X₂₇₂+12.92X₂₇₃+12.85X₂₇₄+12.76X₂₇₅⁺
 7.15X₂₇₆+7.57X₂₇₇+8.00X₂₇₈+8.32X₂₇₉+8.84X₂₈₀+5.47X₂₈₁
 +5.90X₂₈₂+6.32X₂₈₃+6.63X₂₈₄+7.15X₂₈₅+5.26X₂₈₆+5.35X₂₈₇
 +10.31X₂₈₈+6.46X₂₈₉+27.68X₂₉₀+10.17X₂₉₁+10.51X₂₉₂⁺
 10.25X₂₉₃+10.10X₂₉₄+9.93X₂₉₅+10.62X₂₉₆+10.96X₂₉₇⁺
 10.75X₂₉₈+10.61X₂₉₉+10.45X₃₀₀+11.07X₃₀₁+11.44X₃₀₂⁺
 11.22X₃₀₃+11.12X₃₀₄+10.98X₃₀₅+11.40X₃₀₆+11.78X₃₀₇⁺
 11.60X₃₀₈+11.50X₃₀₉+11.38X₃₁₀+11.95X₃₁₁+12.36X₃₁₂⁺
 12.21X₃₁₃+12.14X₃₁₄+12.04X₃₁₅+6.90X₃₁₆+7.29X₃₁₇⁺
 7.71X₃₁₈+8.00X₃₁₉+8.51X₃₂₀+5.26X₃₂₁+5.67X₃₂₂+6.08X₃₂₃
 +6.38X₃₂₄+6.90X₃₂₅+5.06X₃₂₆+5.14X₃₂₇+9.93X₃₂₈+6.22X₃₂₉
 +24.12X₃₃₀+9.56X₃₃₁+9.74X₃₃₂+9.56X₃₃₃+9.38X₃₃₄+9.98X₃₃₅
 +10.20X₃₃₆+10.04X₃₃₇+9.87X₃₃₈+10.42X₃₃₉+10.64X₃₄₀⁺
 10.51X₃₄₁+10.35X₃₄₂+10.72X₃₄₃+10.98X₃₄₄+10.90X₃₄₅⁺
 10.73X₃₄₆+11.26X₃₄₇+11.55X₃₄₈+11.45X₃₄₉+11.34X₃₅₀⁺
 6.63X₃₅₁+7.03X₃₅₂+7.41X₃₅₃+7.71X₃₅₄+8.20X₃₅₅+5.07X₃₅₆
 +5.46X₃₅₇+5.85X₃₅₈+6.15X₃₅₉+6.63X₃₆₀+4.88X₃₆₁+4.96X₃₆₂
 +4.96X₃₆₃+5.99X₃₆₄+20.41X₃₆₅+8.91X₃₆₆+9.07X₃₆₇+8.88X₃₆₈
 +9.33X₃₆₉+9.51X₃₇₀+9.32X₃₇₁+9.73X₃₇₂+9.95X₃₇₃+9.78X₃₇₄

Appendix Table 2. (Continued)

$+10.05X_{375}+10.27X_{376}+10.12X_{377}+10.56X_{378}+10.81X_{379}+$
 $10.69X_{380}+6.38X_{381}+6.76X_{382}+7.14X_{383}+7.42X_{384}+$
 $7.89X_{385}+4.89X_{386}+5.26X_{387}+5.64X_{388}+5.92X_{389}+6.38X_{390}$
 $+4.70X_{391}+4.77X_{392}+9.20X_{393}+5.77X_{394}+16.52X_{395}+8.26X_{396}$
 $+8.40X_{397}+8.66X_{398}+8.81X_{399}+9.06X_{400}+9.22X_{401}+9.36X_{402}$
 $+9.54X_{403}+9.85X_{404}+10.06X_{405}+6.14X_{406}+6.50X_{407}+6.86X_{408}$
 $+7.14X_{409}+7.59X_{410}+4.70X_{411}+5.04X_{412}+5.40X_{413}+5.68X_{414}$
 $+6.14X_{415}+4.50X_{416}+4.58X_{417}+8.83X_{418}+5.53X_{419}+12.35X_{420}$
 $+7.60X_{421}+7.99X_{422}+8.37X_{423}+8.66X_{424}+9.14X_{425}$

Appendix Table 3. Objective function for Price Policy II
(land \$40.00 per acre, stumpage \$8.00
per cord)

$$\begin{aligned}
 \text{Minimize } Z = & 8.6X_1 + 9.17X_2 + 9.69X_3 + 10.07X_4 + 10.71X_5 + 6.63X_6 + \\
 & 7.14X_7 + 7.65X_8 + 8.03X_9 + 8.66X_{10} + 6.37X_{11} + 6.48X_{12} + 12.49X_{13} \\
 & + 7.83X_{14} + 43.75X_{15} + 15.48X_{16} + 14.72X_{17} + 16.00X_{18} + 15.93X_{19} \\
 & + 15.82X_{20} + 15.72X_{21} + 15.66X_{23} + 15.39X_{24} + 15.23X_{25} + 16.01X_{26} \\
 & + 16.54X_{27} + 16.59X_{28} + 16.52X_{29} + 16.60X_{30} + 16.37X_{31} + 16.30X_{32} \\
 & + 16.19X_{33} + 16.10X_{34} + 15.93X_{35} + 16.56X_{36} + 17.10X_{37} + 17.18X_{38} \\
 & + 17.16X_{39} + 17.10X_{40} + 17.03X_{41} + 17.00X_{42} + 16.85X_{43} + 16.80X_{44} \\
 & + 16.63X_{45} + 16.96X_{46} + 17.53X_{47} + 17.62X_{48} + 17.62X_{49} + 17.52X_{50} \\
 & + 17.53X_{51} + 17.43X_{52} + 17.38X_{53} + 17.32X_{54} + 17.18X_{55} + 17.63X_{56} \\
 & + 18.23X_{57} + 18.36X_{58} + 18.40X_{59} + 18.07X_{60} + 18.34X_{61} + 18.32X_{62} \\
 & + 18.24X_{63} + 18.18X_{64} + 18.06X_{65} + 8.34X_{66} + 8.83X_{67} + 9.32X_{68} + \\
 & 9.69X_{69} + 10.30X_{70} + 6.38X_{71} + 6.86X_{72} + 7.36X_{73} + 7.73X_{74} + \\
 & 8.34X_{75} + 6.13X_{76} + 6.22X_{77} + 12.02X_{78} + 7.53X_{79} + 40.67X_{80} + \\
 & 14.71X_{81} + 15.18X_{82} + 15.21X_{83} + 15.13X_{84} + 14.98X_{85} + 14.90X_{86} \\
 & + 14.75X_{87} + 14.60X_{88} + 14.45X_{89} + 15.22X_{90} + 15.72X_{91} + 15.76X_{92} \\
 & + 15.73X_{93} + 15.59X_{94} + 15.50X_{95} + 15.41X_{96} + 15.26X_{97} + 15.11X_{98} \\
 & + 15.74X_{99} + 16.26X_{100} + 16.35X_{101} + 16.32X_{102} + 16.21X_{103} + \\
 & 16.15X_{104} + 16.04X_{105} + 16.00X_{106} + 15.78X_{107} + 16.13X_{108} + \\
 & 16.68X_{109} + 16.78X_{110} + 16.71X_{111} + 16.68X_{112} + 16.60X_{113} + \\
 & 16.53X_{114} + 16.42X_{115} + 16.30X_{116} + 16.77X_{117} + 17.35X_{118} + \\
 & 17.50X_{119} + 17.50X_{120} + 17.43X_{121} + 17.39X_{122} + 17.34X_{123} +
 \end{aligned}$$

Appendix Table 3. (Continued)

$17.24X_{124} + 17.13X_{125} + 8.03X_{126} + 8.50X_{127} + 8.97X_{128} + 9.33X_{129}$
 $+ 9.92X_{130} + 6.14X_{131} + 6.61X_{132} + 7.08X_{133} + 7.44X_{134} + 8.03X_{135}$
 $+ 5.90X_{136} + 6.00X_{137} + 11.57X_{138} + 7.24X_{139} + 37.56X_{140} +$
 $14.11X_{141} + 14.40X_{142} + 14.38X_{143} + 14.26X_{144} + 14.20X_{145} +$
 $14.01X_{146} + 13.86X_{147} + 13.68X_{148} + 14.60X_{149} + 14.90X_{150} +$
 $14.92X_{151} + 14.82X_{152} + 14.76X_{153} + 14.63X_{154} + 14.49X_{155} +$
 $14.32X_{156} + 15.10X_{157} + 15.44X_{158} + 15.48X_{159} + 15.40X_{160} +$
 $15.37X_{161} + 15.22X_{162} + 15.11X_{163} + 14.94X_{164} + 15.48X_{165} +$
 $15.84X_{166} + 15.84X_{167} + 15.84X_{168} + 15.79X_{169} + 15.69X_{170} +$
 $15.58X_{171} + 15.44X_{172} + 16.10X_{173} + 16.50X_{174} + 16.56X_{175} +$
 $16.54X_{176} + 16.53X_{177} + 16.44X_{178} + 16.35X_{179} + 16.22X_{180} +$
 $7.73X_{181} + 8.17X_{182} + 8.64X_{183} + 8.98X_{184} + 9.56X_{185} + 5.92X_{186}$
 $+ 6.37X_{187} + 6.82X_{188} + 7.16X_{189} + 7.73X_{190} + 5.68X_{191} + 5.78X_{192}$
 $+ 11.14X_{193} + 6.98X_{194} + 34.37X_{195} + 13.32X_{196} + 13.54X_{197} +$
 $13.58X_{198} + 13.46X_{199} + 13.31X_{200} + 13.14X_{201} + 12.97X_{202} +$
 $13.68X_{203} + 14.04X_{204} + 14.10X_{205} + 13.99X_{206} + 13.89X_{207} +$
 $13.73X_{208} + 13.56X_{209} + 14.18X_{210} + 14.55X_{211} + 14.64X_{212} +$
 $14.55X_{213} + 14.44X_{214} + 14.32X_{215} + 14.16X_{216} + 14.53X_{217} +$
 $14.88X_{218} + 15.04X_{219} + 14.94X_{220} + 14.88X_{221} + 14.76X_{222} +$
 $14.62X_{223} + 15.14X_{224} + 15.55X_{225} + 15.69X_{226} + 15.63X_{227} +$
 $15.59X_{228} + 15.48X_{229} + 15.36X_{230} + 7.43X_{231} + 7.87X_{232} +$
 $8.31X_{233} + 8.60X_{234} + 9.18X_{235} + 5.68X_{236} + 6.12X_{237} + 6.56X_{238}$
 $+ 6.88X_{239} + 7.43X_{240} + 5.47X_{241} + 5.56X_{242} + 10.71X_{243} +$
 $6.71X_{244} + 31.08X_{245} + 12.47X_{246} + 12.82X_{247} + 12.79X_{248} +$

Appendix Table 3. (Continued)

12.64X₂₄₉+12.47X₂₅₀+12.29X₂₅₁+12.94X₂₅₂+13.30X₂₅₃+
 13.28X₂₅₄+13.18X₂₅₅+13.02X₂₅₆+12.85X₂₅₇+13.40X₂₅₈+
 13.80X₂₅₉+13.80X₂₆₀+13.69X₂₆₁+13.57X₂₆₂+13.41X₂₆₃+
 13.70X₂₆₄+14.17X₂₆₅+14.16X₂₆₆+14.09X₂₆₇+13.98X₂₆₈+
 13.84X₂₆₉+14.31X₂₇₀+14.77X₂₇₁+14.80X₂₇₂+14.76X₂₇₃+
 14.66X₂₇₄+14.54X₂₇₅+7.15X₂₇₆+7.57X₂₇₇+8.00X₂₇₈+8.32X₂₇₉
 +8.84X₂₈₀+5.47X₂₈₁+5.90X₂₈₂+6.32X₂₈₃+6.63X₂₈₄+7.15X₂₈₅
 +5.26X₂₈₆+5.35X₂₈₇+10.31X₂₈₈+6.46X₂₈₉+27.68X₂₉₀+
 11.75X₂₉₁+12.08X₂₉₂+12.00X₂₉₃+11.83X₂₉₄+11.63X₂₉₅+
 12.19X₂₉₆+12.52X₂₉₇+12.50X₂₉₈+12.34X₂₉₉+12.15X₃₀₀+
 12.64X₃₀₁+13.01X₃₀₂+12.98X₃₀₃+12.85X₃₀₄+12.67X₃₀₅+
 12.98X₃₀₆+13.34X₃₀₇+13.35X₃₀₈+13.23X₃₀₉+13.08X₃₁₀+
 13.52X₃₁₁+13.93X₃₁₂+13.96X₃₁₃+13.86X₃₁₄+13.73X₃₁₅+
 6.90X₃₁₆+7.29X₃₁₇+7.71X₃₁₈+8.00X₃₁₉+8.51X₃₂₀+5.26X₃₂₁
 +5.67X₃₂₂+6.08X₃₂₃+6.38X₃₂₄+6.90X₃₂₅+5.06X₃₂₆+5.14X₃₂₇
 +9.93X₃₂₈+6.22X₃₂₉+24.12X₃₃₀+11.15X₃₃₁+11.30X₃₃₂+
 11.21X₃₃₃+11.02X₃₃₄+11.46X₃₃₅+11.76X₃₃₆+11.69X₃₃₇+
 11.50X₃₃₈+11.90X₃₃₈+12.20X₃₄₀+12.16X₃₄₁+11.99X₃₄₂+
 12.20X₃₄₃+12.55X₃₄₄+12.51X₃₄₅+12.37X₃₄₆+12.74X₃₄₇+
 13.11X₃₄₈+13.10X₃₄₉+12.97X₃₅₀+6.63X₃₅₁+7.03X₃₅₂+
 7.41X₃₅₃+7.71X₃₅₄+8.20X₃₅₅+5.07X₃₅₆+5.46X₃₅₇+5.85X₃₅₈
 6.15X₃₅₉+6.63X₃₆₀+4.88X₃₆₁+4.96X₃₆₂+9.56X₃₆₃+5.99X₃₆₄
 +20.41X₃₆₅+10.40X₃₆₆+10.53X₃₆₇+10.41X₃₆₈+10.82X₃₆₉+
 10.97X₃₇₀+10.86X₃₇₁+11.22X₃₇₂+11.41X₃₇₃+11.31X₃₇₄+

Appendix Table 3. (Continued)

$11.54X_{375} + 11.73X_{376} + 11.66X_{377} + 12.05X_{378} + 12.27X_{379} +$
 $12.22X_{380} + 6.38X_{381} + 6.76X_{382} + 7.14X_{383} + 7.42X_{384} + 7.89X_{385}$
 $+ 4.89X_{386} + 5.26X_{387} + 5.64X_{388} + 5.92X_{389} + 6.38X_{390} + 4.70X_{391}$
 $+ 4.77X_{392} + 9.20X_{393} + 5.77X_{394} + 16.52X_{395} + 9.67X_{396} + 9.76X_{397}$
 $+ 9.80X_{398} + 10.18X_{399} + 10.47X_{400} + 10.59X_{401} + 10.76X_{402} +$
 $10.91X_{403} + 11.26X_{404} + 11.43X_{405} + 6.14X_{406} + 6.50X_{407} +$
 $6.86X_{408} + 7.14X_{409} + 7.59X_{410} + 4.70X_{411} + 5.04X_{412} + 5.40X_{413}$
 $+ 5.68X_{414} + 6.14X_{415} + 4.50X_{416} + 4.58X_{417} + 8.83X_{418} + 5.53X_{419}$
 $12.35X_{420} + 8.84X_{421} + 9.22X_{422} + 9.60X_{423} + 9.89X_{424} + 10.36X_{425}$

Appendix Table 4. Objective function for Price Policy III
(land \$60.00 per acre, stumpage \$6.00
per cord)

$$\begin{aligned}
 \text{Minimize } Z = & 8.66X_1 + 9.17X_2 + 9.69X_3 + 10.07X_4 + 10.71X_5 + 6.63X_6 + \\
 & 7.14X_7 + 7.65X_8 + 8.03X_9 + 8.66X_{10} + 6.37X_{11} + 6.48X_{12} + 12.49X_{13} + \\
 & 7.83X_{14} + 56.98X_{15} + 16.75X_{16} + 15.47X_{17} + 16.81X_{18} + 16.64X_{19} + \\
 & 16.46X_{20} + 16.26X_{21} + 16.07X_{22} + 15.82X_{23} + 15.52X_{24} + 15.21X_{25} + \\
 & 17.28X_{26} + 17.53X_{27} + 17.40X_{28} + 17.24X_{29} + 17.10X_{30} + 16.91X_{31} + \\
 & 16.71X_{32} + 16.52X_{33} + 16.22X_{34} + 15.91X_{35} + 17.83X_{36} + 18.09X_{37} + \\
 & 18.14X_{38} + 17.87X_{39} + 17.73X_{40} + 17.58X_{41} + 17.41X_{42} + 17.18X_{43} + \\
 & 16.93X_{44} + 16.61X_{45} + 18.23X_{46} + 18.52X_{47} + 18.44X_{48} + 18.33X_{49} + \\
 & 18.15X_{50} + 18.07X_{51} + 17.89X_{52} + 17.71X_{53} + 17.44X_{54} + 17.16X_{55} + \\
 & 18.90X_{56} + 19.22X_{57} + 19.18X_{58} + 19.12X_{59} + 19.00X_{60} + 18.88X_{61} + \\
 & 18.73X_{62} + 18.57X_{63} + 18.32X_{64} + 18.04X_{65} + 8.34X_{66} + 8.83X_{67} + \\
 & 9.32X_{68} + 9.69X_{69} + 10.30X_{70} + 6.38X_{71} + 6.86X_{72} + 7.36X_{73} + 7.73X_{74} \\
 & + 8.34X_{75} + 6.13X_{76} + 6.22X_{77} + 12.02X_{78} + 7.53X_{79} + 52.84X_{80} + \\
 & 15.96X_{81} + 16.16X_{82} + 15.99X_{83} + 15.77X_{84} + 15.56X_{85} + 15.38X_{86} + \\
 & 15.10X_{87} + 14.82X_{88} + 14.50X_{89} + 16.47X_{90} + 16.70X_{91} + 16.54X_{92} + \\
 & 16.36X_{93} + 16.94X_{94} + 15.98X_{95} + 15.76X_{96} + 15.49X_{97} + 15.17X_{98} + \\
 & 16.99X_{99} + 17.24X_{100} + 17.12X_{101} + 16.96X_{102} + 16.79X_{103} + \\
 & 16.63X_{104} + 16.38X_{105} + 16.15X_{106} + 15.84X_{107} + 17.38X_{108} + \\
 & 17.65X_{109} + 17.55X_{110} + 17.35X_{111} + 17.26X_{112} + 17.08X_{113} + \\
 & 16.88X_{114} + 16.64X_{115} + 16.35X_{116} + 18.02X_{117} + 18.33X_{118} + \\
 & 18.28X_{119} + 18.13X_{120} + 18.01X_{121} + 17.87X_{122} + 17.69X_{123} +
 \end{aligned}$$

Appendix Table 4. (Continued)

$17.46X_{124} + 17.46X_{125} + 8.03X_{126} + 8.50X_{127} + 8.97X_{128} + 9.33X_{129}$
 $+ 9.92X_{130} + 6.14X_{131} + 6.61X_{132} + 7.08X_{133} + 7.44X_{134} + 8.03X_{135}$
 $+ 5.90X_{136} + 6.00X_{137} + 11.57X_{138} + 7.24X_{139} + 48.64X_{140} + 15.18X_{141}$
 $+ 15.35X_{142} + 15.14X_{143} + 14.90X_{144} + 14.70X_{145} + 14.43X_{146} +$
 $14.14X_{147} + 13.82X_{148} + 15.68X_{149} + 15.86X_{150} + 15.69X_{151} +$
 $15.47X_{152} + 15.27X_{153} + 15.05X_{154} + 14.77X_{155} + 14.46X_{156} +$
 $16.17X_{157} + 16.40X_{158} + 16.24X_{159} + 16.05X_{160} + 15.88X_{161} +$
 $15.79X_{162} + 15.39X_{163} + 15.08X_{164} + 16.55X_{165} + 16.79X_{166} +$
 $16.60X_{167} + 16.48X_{168} + 16.30X_{169} + 16.10X_{170} + 15.86X_{171} +$
 $15.58X_{172} + 17.17X_{173} + 17.46X_{174} + 17.32X_{175} + 17.18X_{176} +$
 $17.04X_{177} + 16.86X_{178} + 16.63X_{179} + 16.36X_{180} + 7.73X_{181} +$
 $8.17X_{182} + 8.64X_{183} + 8.98X_{184} + 9.56X_{185} + 5.92X_{186} + 6.37X_{187}$
 $+ 6.82X_{188} + 7.16X_{189} + 7.73X_{190} + 5.68X_{191} + 5.78X_{192} + 11.14X_{193}$
 $+ 6.98X_{194} + 44.27X_{195} + 14.42X_{196} + 14.52X_{197} + 14.30X_{198} +$
 $14.07X_{199} + 13.79X_{200} + 13.48X_{201} + 13.15X_{202} + 14.88X_{203} +$
 $15.03X_{204} + 14.82X_{205} + 14.59X_{206} + 14.37X_{207} + 14.07X_{208} +$
 $13.74X_{209} + 15.37X_{210} + 15.54X_{211} + 15.36X_{212} + 15.16X_{213} +$
 $14.92X_{214} + 14.66X_{215} + 14.34X_{216} + 15.73X_{217} + 15.87X_{218} +$
 $15.76X_{219} + 15.55X_{220} + 15.36X_{221} + 15.10X_{222} + 14.80X_{223} +$
 $16.34X_{224} + 16.54X_{225} + 16.41X_{226} + 16.24X_{227} + 16.07X_{228} +$
 $15.82X_{229} + 15.54X_{230} + 7.43X_{231} + 7.87X_{232} + 8.31X_{233} + 8.60X_{234}$
 $+ 9.18X_{235} + 5.68X_{236} + 6.12X_{237} + 6.56X_{238} + 6.88X_{239} + 7.43X_{240}$
 $+ 5.47X_{241} + 5.56X_{242} + 10.71X_{243} + 6.71X_{244} + 39.75X_{245} +$

Appendix Table 4. (Continued)

13.61X₂₄₆+13.97X₂₄₇+13.46X₂₄₈+13.19X₂₄₉+12.88X₂₅₀+
 12.54X₂₅₁+14.07X₂₅₂+14.18X₂₅₃+13.95X₂₅₄+13.73X₂₅₅+
 13.43X₂₅₆+13.10X₂₅₇+14.53X₂₅₈+14.68X₂₅₉+14.48X₂₆₀+
 14.24X₂₆₁+13.98X₂₆₂+13.66X₂₆₃+14.84X₂₆₄+15.04X₂₆₅+
 13.84X₂₆₆+14.65X₂₆₇+14.38X₂₆₈+14.09X₂₆₉+15.44X₂₇₀+
 15.64X₂₇₁+15.48X₂₇₂+15.31X₂₇₃+15.06X₂₇₄+14.79X₂₇₅+
 7.15X₂₇₆+7.57X₂₇₇+8.00X₂₇₈+8.32X₂₇₉+8.84X₂₈₀+5.47X₂₈₁
 +5.90X₂₈₂+6.32X₂₈₃+6.63X₂₈₄+7.15X₂₈₅+5.26X₂₈₆+5.35X₂₈₇
 +10.31X₂₈₈+6.46X₂₈₉+35.01X₂₉₀+12.80X₂₉₁+12.97X₂₉₂+
 12.60X₂₉₃+12.27X₂₉₄+11.93X₂₉₅+13.24X₂₉₆+13.42X₂₉₇+
 13.28X₂₉₈+12.78X₂₉₉+12.46X₃₀₀+13.69X₃₀₁+13.90X₃₀₂+
 13.58X₃₀₃+13.30X₃₀₄+12.98X₃₀₅+14.03X₃₀₆+14.24X₃₀₇+
 13.95X₃₀₈+13.68X₃₀₉+13.38X₃₁₀+14.57X₃₁₁+14.82X₃₁₂+
 14.56X₃₁₃+14.31X₃₁₄+14.04X₃₁₅+6.90X₃₁₆+7.29X₃₁₇+
 7.71X₃₁₈+8.00X₃₁₉+8.51X₃₂₀+5.26X₃₂₁+5.67X₃₂₂+6.08X₃₂₃
 +6.38X₃₂₄+6.90X₃₂₅+5.06X₃₂₆+5.14X₃₂₇+9.93X₃₂₈+6.22X₃₂₉
 +30.02X₃₃₀+12.02X₃₃₁+12.02X₃₃₂+11.70X₃₃₃+11.34X₃₃₄+
 12.43X₃₃₅+12.48X₃₃₆+12.18X₃₃₇+11.83X₃₃₈+12.87X₃₃₉+
 12.91X₃₄₀+12.65X₃₄₁+12.31X₃₄₂+13.18X₃₄₃+13.26X₃₄₄+
 13.00X₃₄₅+12.69X₃₄₆+13.71X₃₄₇+13.82X₃₄₈+13.59X₃₄₉+
 13.30X₃₅₀+6.63X₃₅₁+7.03X₃₅₂+7.41X₃₅₃+7.71X₃₅₄+8.20X₃₅₅
 +5.07X₃₅₆+5.46X₃₅₇+5.85X₃₅₈+6.15X₃₅₉+6.63X₃₆₀+4.88X₃₆₁
 +4.96X₃₆₂+9.56X₃₆₃+5.99X₃₆₄+24.78X₃₆₅+11.18X₃₆₆+

Appendix Table 4. (Continued)

$11.17X_{367} + 10.79X_{368} + 11.60X_{369} + 11.60X_{370} + 11.24X_{371} +$
 $12.00X_{372} + 12.04X_{373} + 11.69X_{374} + 12.32X_{375} + 12.36X_{376} +$
 $12.04X_{377} + 12.83X_{378} + 12.90X_{379} + 12.60X_{380} + 6.38X_{381} +$
 $6.76X_{382} + 7.14X_{383} + 7.42X_{384} + 7.89X_{385} + 4.89X_{386} + 5.26X_{387}$
 $+ 5.64X_{388} + 5.92X_{389} + 6.38X_{390} + 4.70X_{391} + 4.77X_{392} + 9.20X_{393}$
 $+ 5.77X_{394} + 19.24X_{395} + 10.34X_{396} + 10.28X_{397} + 10.74X_{398} +$
 $10.70X_{399} + 11.14X_{400} + 11.11X_{401} + 11.43X_{402} + 11.43X_{403} +$
 $11.93X_{404} + 11.95X_{405} + 11.95X_{406} + 6.50X_{407} + 6.86X_{408} +$
 $7.14X_{409} + 7.59X_{410} + 4.70X_{411} + 5.04X_{412} + 5.40X_{413} + 5.68X_{414}$
 $+ 6.14X_{415} + 4.50X_{416} + 4.58X_{417} + 8.83X_{418} + 5.53X_{419} + 13.29X_{420}$
 $+ 9.51X_{421} + 9.89X_{422} + 10.27X_{423} + 10.56X_{424} + 11.04X_{425}$

Appendix Table 5. Objective function for Price Policy IV
(land \$60.00 per acre, stumpage \$8.00
per cord)

$$\begin{aligned}
 \text{Minimize } Z = & 8.66X_1 + 9.17X_2 + 9.69X_3 + 10.07X_4 + 10.71X_5 + 6.63X_6 + \\
 & 7.14X_7 + 7.65X_8 + 8.03X_9 + 8.66X_{10} + 6.37X_{11} + 6.48X_{12} + 12.49X_{13} \\
 & + 7.83X_{14} + 56.98X_{15} + 19.09X_{16} + 17.69X_{17} + 19.22X_{18} + 18.02X_{19} \\
 & + 18.79X_{20} + 18.57X_{21} + 18.35X_{22} + 18.08X_{23} + 17.76X_{24} + 17.43X_{25} \\
 & + 19.62X_{26} + 19.85X_{27} + 19.81X_{28} + 19.62X_{29} + 19.43X_{30} + 19.22X_{31} \\
 & + 18.99X_{32} + 18.78X_{33} + 18.46X_{34} + 18.14X_{35} + 20.17X_{36} + 20.41X_{37} \\
 & + 20.40X_{38} + 20.25X_{39} + 20.07X_{40} + 19.89X_{41} + 19.68X_{42} + 19.44X_{43} \\
 & + 19.17X_{44} + 18.84X_{45} + 20.57X_{46} + 20.84X_{47} + 20.85X_{48} + 20.71X_{49} \\
 & + 20.49X_{50} + 20.38X_{51} + 20.16X_{52} + 19.97X_{53} + 19.68X_{54} + 19.38X_{55} \\
 & + 21.24X_{56} + 21.54X_{57} + 21.59X_{58} + 21.49X_{59} + 21.33X_{60} + 21.19X_{61} \\
 & + 21.00X_{62} + 20.82X_{63} + 20.55X_{64} + 20.26X_{65} + 8.34X_{66} + 8.83X_{67} + \\
 & 9.32X_{68} + 9.69X_{69} + 10.30X_{70} + 6.38X_{71} + 6.86X_{72} + 7.36X_{73} + 7.73X_{74} \\
 & + 8.34X_{75} + 6.13X_{76} + 6.22X_{77} + 12.02X_{78} + 7.53X_{79} + 52.84X_{80} + \\
 & 18.00X_{81} + 18.33X_{82} + 18.25X_{83} + 18.00X_{84} + 17.75X_{85} + 17.53X_{86} \\
 & + 17.24X_{87} + 16.94X_{88} + 16.59X_{89} + 18.51X_{90} + 18.87X_{91} + 18.80X_{92} \\
 & + 18.59X_{93} + 18.36X_{94} + 18.14X_{95} + 17.90X_{96} + 17.60X_{97} + 17.26X_{98} \\
 & + 19.03X_{99} + 19.41X_{100} + 19.39X_{101} + 19.18X_{102} + 18.98X_{103} + \\
 & 18.79X_{104} + 18.53X_{105} + 18.27X_{106} + 17.93X_{107} + 19.41X_{108} + \\
 & 19.83X_{109} + 19.81X_{110} + 19.58X_{111} + 19.44X_{112} + 19.24X_{113} + \\
 & 19.02X_{114} + 18.76X_{115} + 18.44X_{116} + 20.06X_{117} + 20.50X_{118} + \\
 & 20.54X_{119} + 20.36X_{120} + 20.20X_{121} + 20.03X_{122} + 19.83X_{123} + \\
 & 19.58X_{124} + 19.28X_{125} + 8.03X_{126} + 8.50X_{127} + 8.97X_{128} + 9.33X_{129}
 \end{aligned}$$

Appendix Table 5. (Continued)

+9.92X₁₃₀+6.14X₁₃₁+6.61X₁₃₂+7.08X₁₃₃+7.44X₁₃₄+8.03X₁₃₅
 +5.90X₁₃₆+6.00X₁₃₇+11.57X₁₃₈+7.24X₁₃₉+48.64X₁₄₀⁺
 17.23X₁₄₁+17.40X₁₄₂+17.26X₁₄₃+17.00X₁₄₄+16.76X₁₄₅⁺
 16.48X₁₄₆+16.15X₁₄₇+15.80X₁₄₈+17.72X₁₄₉+17.90X₁₅₀⁺
 17.81X₁₅₁+17.56X₁₅₂+17.33X₁₅₃+17.10X₁₅₄+16.78X₁₅₅⁺
 16.43X₁₅₆+17.63X₁₅₇+18.45X₁₅₈+18.36X₁₅₉+18.14X₁₆₀⁺
 17.94X₁₆₁+17.68X₁₆₂+17.41X₁₆₃+17.06X₁₆₄+18.60X₁₆₅⁺
 18.84X₁₆₆+18.72X₁₆₇+18.58X₁₆₈+18.36X₁₆₉+18.15X₁₇₀⁺
 17.87X₁₇₁+17.55X₁₇₂+19.22X₁₇₃+19.50X₁₇₄+19.45X₁₇₅⁺
 19.28X₁₇₆+19.10X₁₇₇+18.91X₁₇₈+18.64X₁₇₉+18.34X₁₈₀⁺
 7.73X₁₈₁+8.17X₁₈₂+8.64X₁₈₃+8.98X₁₈₄+9.56X₁₈₅+5.92X₁₈₆
 +6.37X₁₈₇+6.82X₁₈₈+7.16X₁₈₉+7.73X₁₉₀+5.68X₁₉₁+5.78X₁₉₂
 +11.14X₁₉₃+6.98X₁₉₄+44.27X₁₉₅+16.20X₁₉₆+16.46X₁₉₇⁺
 16.30X₁₉₈+16.04X₁₉₉+15.73X₂₀₀+15.34X₂₀₁+15.05X₂₀₂⁺
 16.66X₂₀₃+16.96X₂₀₄+16.82X₂₀₅+16.56X₂₀₆+16.31X₂₀₇⁺
 15.93X₂₀₈+15.64X₂₀₉+17.16X₂₁₀+17.47X₂₁₁+17.36X₂₁₂⁺
 17.13X₂₁₃+16.86X₂₁₄+16.52X₂₁₅+16.24X₂₁₆+17.51X₂₁₇⁺
 17.80X₂₁₈+17.76X₂₁₉+17.52X₂₂₀+17.30X₂₂₁+16.96X₂₂₂⁺
 16.70X₂₂₃+18.12X₂₂₄+18.47X₂₂₅+18.41X₂₂₆+18.21X₂₂₇⁺
 18.01X₂₂₈+17.68X₂₂₉+17.44X₂₃₀+7.43X₂₃₁+7.87X₂₃₂⁺
 8.31X₂₃₃+8.60X₂₃₄+9.18X₂₃₅+5.68X₂₃₆+6.12X₂₃₇+6.56X₂₃₈
 +6.88X₂₃₉+7.43X₂₄₀+5.47X₂₄₁+5.56X₂₄₂+10.71X₂₄₃+6.71X₂₄₄
 +39.75X₂₄₅+15.28X₂₄₆+15.49X₂₄₇+15.34X₂₄₈+15.02X₂₄₉⁺
 14.69X₂₅₀+14.32X₂₅₁+15.74X₂₅₂+15.97X₂₅₃+15.82X₂₅₄⁺

Appendix Table 5. (Continued)

15.56X₂₅₅+15.24X₂₅₆+14.88X₂₅₇+16.20X₂₅₈+16.47X₂₅₉+
 16.35X₂₆₀+16.08X₂₆₁+15.79X₂₆₂+15.44X₂₆₃+16.51X₂₆₄+
 16.84X₂₆₅+16.71X₂₆₆+16.48X₂₆₇+16.20X₂₆₈+15.87X₂₆₉+
 17.12X₂₇₀+17.43X₂₇₁+17.35X₂₇₂+17.14X₂₇₃+16.88X₂₇₄+
 16.57X₂₇₅+7.15X₂₇₆+7.57X₂₇₇+8.00X₂₇₈+8.32X₂₇₉+8.84₂₈₀
 +5.47X₂₈₁+5.90X₂₈₂+6.32X₂₈₃+6.63X₂₈₄+7.15X₂₈₅+5.26X₂₈₆
 +5.35X₂₈₇+10.31X₂₈₈+6.46X₂₈₉+35.01X₂₉₀+14.37X₂₉₁+
 14.58X₂₉₂+14.35X₂₉₃+14.00X₂₉₄+13.64X₂₉₅+14.82X₂₉₆+
 15.03X₂₉₇+14.85X₂₉₈+14.51X₂₉₉+14.17X₃₀₀+15.27X₃₀₁+
 15.51X₃₀₂+15.32X₃₀₃+15.02X₃₀₄+14.69X₃₀₅+15.60X₃₀₆+
 15.84X₃₀₇+15.70X₃₀₈+15.40X₃₀₉+15.09X₃₁₀+16.15X₃₁₁+
 16.43X₃₁₂+16.31X₃₁₃+16.04X₃₁₄+15.75X₃₁₅+6.90X₃₁₆+
 7.29X₃₁₇+7.71X₃₁₈+8.00X₃₁₉+8.51X₃₂₀+5.26X₃₂₁+5.67X₃₂₂
 +6.08X₃₂₃+6.38X₃₂₄+6.90X₃₂₅+5.06X₃₂₆+5.14X₃₂₇+9.93X₃₂₈
 +6.22X₃₂₉+30.02X₃₃₀+13.50X₃₃₁+13.60X₃₃₂+13.35X₃₃₃+
 12.97X₃₃₄+13.91X₃₃₅+14.06X₃₃₆+13.82X₃₃₇+13.46X₃₃₈+
 14.35X₃₃₉+14.50X₃₄₀+14.30X₃₄₁+13.94X₃₄₂+14.66X₃₄₃+
 14.85X₃₄₄+14.65X₃₄₅+14.32X₃₄₆+15.19X₃₄₇+15.41X₃₄₈+
 15.24X₃₄₉+14.93X₃₅₀+6.63X₃₅₁+7.03X₃₅₂+7.41X₃₅₃+7.71X₃₅₄
 +8.20X₃₅₅+5.07X₃₅₆+5.46X₃₅₇+5.85X₃₅₈+6.15X₃₅₉+6.63X₃₆₀
 +4.88X₃₆₁+4.96X₃₆₂+9.56X₃₆₃+5.99X₃₆₄+24.78X₃₆₅+12.67X₃₆₆
 +12.64X₃₆₇+12.35X₃₆₈+13.09X₃₆₉+13.08X₃₇₀+12.80X₃₇₁+
 13.49X₃₇₂+13.51X₃₇₃+13.25X₃₇₄+13.81X₃₇₅+13.83X₃₇₆+
 13.60X₃₇₇+14.32X₃₇₈+14.38X₃₇₉+14.16X₃₈₀+6.38X₃₈₁+

Appendix Table 5. (Continued)

$6.76X_{382} + 7.14X_{383} + 7.42X_{384} + 7.89X_{385} + 4.89X_{386} + 5.26X_{387} +$
 $5.64X_{388} + 5.92X_{389} + 6.38X_{390} + 4.70X_{391} + 4.77X_{392} + 9.20X_{393} +$
 $5.77X_{394} + 19.24X_{395} + 11.75X_{396} + 11.65X_{397} + 12.15X_{398} +$
 $12.06X_{399} + 12.55X_{400} + 12.48X_{401} + 12.84X_{402} + 12.80X_{403} +$
 $13.34X_{404} + 13.32X_{405} + 6.14X_{406} + 6.50X_{407} + 6.86X_{408} + 7.14X_{409}$
 $+ 7.59X_{410} + 4.70X_{411} + 5.04X_{412} + 5.40X_{413} + 5.68X_{414} + 6.14X_{415}$
 $+ 4.50X_{416} + 4.58X_{417} + 8.83X_{418} + 5.53X_{419} + 13.29X_{420} + 10.69X_{421}$
 $+ 11.07X_{422} + 11.44X_{423} + 11.74X_{424} + 12.21X_{425}$

Appendix Table 6. Determination of
present value cost of wood

Alternative X₂₀₀ - buy land with stumpage in Zone 1 in 1973-1974 and cut in 1981-1982 using Price Policy I

1. Total cost per acre

a)	stumpage cost per cord in 1973-1974 (Appendix Table 7)	= \$ 7.25
b)	stumpage cost per acre in 1973-1974 ("1d")(10)	= \$ 72.50
c)	"1b" compounded at 6% to 1981-1982	= \$ 122.45
d)	cost of one acre of land in 1973-1974 (Appendix Table 8) and holding it until 1981-1982 at 6%	= \$ 95.06
e)	cost of one acre of land in 1981-1982 (Appendix Table 8)	= \$ 83.12
f)	cost of holding land from 1973-1974 to 1981-1982 ("1d"- "1e")	= \$ 11.94
g)	property tax for one year (This cost is expensed by the firm. The firm's income tax rate is 48% so that every dollar spend is, in effect, costing the firm only \$0.52. (.52)(\$0.48)	= \$ 0.25
h)	accumulated property taxes compounded at 6% (Appendix Table 10)	= \$ 2.87
i)	total cost ("1c"+"1f"+"1h")	= \$ 137.26

Appendix Table 6. (Continued)

2. Total return per acre	
a) stumpage cost per cord, in 1981-1982 (Appendix Table 7)	= \$ 9.01
b) stumpage value per acre in 1981-1982 including growth of 4.5 cords ("2a") (14.5)	= \$ 130.64
c) amount subject to capital gains tax treatment ("2b"- "1b")	= \$ 58.14
d) savings by using capital gains tax treatment (capital gains are taxed at 25% rate instead of a 48% rate, a 23% savings) ("2c")(.23)	= \$ 13.37
e) total returns ("2b"+"2d")	= \$ 144.01
3. Profit per acre ("2e"- "1i")	= \$ 6.75
4. Profit per cord ("3" ÷ 14.5)	= \$.46
5. Profit per cord discounted to beginning of study at 6% ("4")(.417)	= \$.19
6. Cost of open market pine in Zone 1 in 1981-1982 (open market wood costs increase at a rate of 4%)(\$17.00) (1.800)	= \$ 15.91
7. Cost of open market pine discounted to beginning of study at 6% ("6")(.417)	= \$ 6.63
8. Present cost per cord of pine bought as land with stumpage in 1973-1974 and cut	

Appendix Table 6. (Continued)

in 1981-1982 ("7"- "5")	= \$ 6.44
9. Planting costs per cord (the cost of the land with stumpage alternative includes planting costs and property taxes incurred until the end of the study)	
a) planting cost in 1981-1982 Appendix Table 9)	= \$ 27.00
b) property taxes compounded to 1985-1986 at 6% ("1g")(5.637)	= \$ 1.41
c) cost of holding planted land until 1985-1986 at 6% ("9a")(1.338)	= \$ 36.13
d) cost of land per acre in 1981-1982 (Appendix Table 8)	= \$ 83.12
e) cost of holding land from 1981-1982 to 1985-1986 at 6% ("9d")(.338)	= \$ 28.09
f) total cost per acre of planting and taxes to 1985-1986 ("9b"+"9c"+"9e")	= \$ 65.63
g) cost per acre of planting and taxes discounted to beginning of study at 6% ("9f")(.311)	= \$ 20.41
h) present cost of planting and taxes on a per cord basis ("9g"÷ 14.5)	= \$ 1.41
10. Total present cost per cord of alternative X ₂₀₀ ("8"+"9h")	= \$ 7.85

Appendix Table 7. Stumpage costs used in
the study showing 2-3/4% cost increase

<u>Period</u>	<u>Stumpage cost for Price Policies I and III</u>	<u>Stumpage cost for Price Policies II and IV</u>
1967-1968	\$6.16 per cord	\$8.22 per cord
1969-1970	6.51 per cord	8.68 per cord
1971-1972	6.87 per cord	9.16 per cord
1973-1974	7.25 per cord	9.67 per cord
1975-1976	7.66 per cord	10.21 per cord
1977-1978	8.09 per cord	10.78 per cord
1979-1980	8.54 per cord	11.38 per cord
1981-1982	9.01 per cord	12.00 per cord
1983-1984	9.51 per cord	12.68 per cord
1985-1986	10.02 per cord	13.36 per cord

Note: All costs used by the firm at the beginning of the
study were compounded 1, 3, 5, . . . , 19 years
respectively for 1st, 2nd, 3rd, . . . , 10th periods.

Appendix Table 8. Land costs in the study
showing 5% cost increase

<u>Period</u>	<u>Land cost per acre for Price Policies I and II</u>	<u>Land cost per acre for Price Policies III and IV</u>
1967-1968	\$42.00	\$63.00
1969-1970	46.28	69.42
1971-1972	51.04	76.56
1973-1974	56.28	84.42
1975-1976	62.04	93.06
1977-1978	68.40	102.60
1979-1980	75.40	113.10
1981-1982	83.12	124.68
1983-1984	91.68	137.52
1985-1986	101.04	151.56

Appendix Table 9. Planting cost used for
all price policies showing 4% cost increase

<u>Period</u>	<u>Planting cost per acre</u>
1967-1968	\$15.60
1969-1970	16.87
1971-1972	18.24
1973-1974	19.74
1975-1976	21.34
1977-1978	23.09
1979-1980	24.98
1981-1982	27.00
1983-1984	29.22
1985-1986	31.50

Appendix Table 10. Accumulated property taxes
for one acre of land compounded at 6%

Number of years tax paid	Accumulated total at 6%
1	\$.25
3	.80
5	1.41
7	2.10
9	2.87
11	3.74
13	4.72
15	5.82
17	7.05
19	8.44

Appendix Table 11. Quantity of each alternative
available each period for all price policies

Maximum amount of alternative available	I	Price Policies		
		II	III	IV
open market pine, zone 1	5,000	5,000	5,000	5,000
open market pine, zone 2	15,000	15,000	15,000	15,000
open market pine, zone 3	25,000	25,000	25,000	25,000
open market pine beyond zone 3	35,000	35,000	35,000	35,000
open market pine shipped by rail	45,000	45,000	45,000	45,000
open market soft hardwood roundwood, zone 1	3,000	3,000	3,000	3,000
open market soft hardwood roundwood, zone 2	7,000	7,000	7,000	7,000
open market soft hardwood roundwood, zone 3	11,000	11,000	11,000	11,000
soft hardwood roundwood from beyond zone 3	16,000	16,000	16,000	16,000
soft hardwood roundwood shipped by rail	20,000	20,000	20,000	20,000
slabs from the open market	31,200	31,200	31,200	31,200
chips from the open market	10,400	10,400	10,400	10,400
shavings from the open market	11,960	11,960	11,960	11,960
bare land	7,500	7,500	11,250	11,250

Appendix Table 11. (Continued)

Maximum Amount of Alternative Available	I	Price Policies		IV
		II	III	
land with timber, zone 1	1,000	1,300	1,350	1,650
land with timber, zone 2	3,000	3,900	4,050	4,950
land with timber, zone 3	5,000	6,500	6,750	8,250
land with timber beyond zone 3	7,000	9,100	9,450	11,550
land with timber from areas which supply the mill with rail wood	9,000	11,700	12,150	14,850

Appendix Table 12. Linear equations forming the wood procurement cost minimization matrix

Plant Capacity, Period One: $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} + X_{14} + 1.05X_{16} + 1.05X_{26} + 1.05X_{36} + 1.05X_{46} + 1.05X_{56} = 240,000$

Minimum Pine Requirement, Period One: $X_1 + X_2 + X_3 + X_4 + X_5 + 1.05X_{26} + 1.05X_{36} + 1.05X_{46} + 1.05X_{56} = 72,000$

Maximum Oak Requirement, Period One: $X_{11} = 36,000$

Maximum Slab Requirement, Period One: $X_{12} = 40,800$

Maximum Chip Requirement, Period One: $X_{13} = 48,000$

Maximum Shaving Requirement, Period One: $X_{14} = 24,000$

Maximum Slab, Chip, and Shaving Combination Requirement, Period One: $X_{12} + X_{13} + X_{14} = 64,800$

Amount of Open Market Pine Available, Zone 1, Period One: $X_1 + X_{16} = 5,000$

Amount of Open Market Pine Available, Zone 2, Period One: $X_2 + X_{26} = 15,000$

Amount of Open Market Pine Available, Zone 3, Period One: $X_3 + X_{36} = 25,000$

Amount of Open Market Pine Available Beyond Zone 3, Period One: $X_4 + X_{46} = 35,000$

Amount of Open Market Pine Available to be Shipped by Rail, Period One: $X_5 + X_{56} = 45,000$

Appendix Table 12. (Continued)

Amount of Soft Hardwood Available, Zone 1, Period One:

$$X_6 = 3,000$$

Amount of Soft Hardwood Available, Zone 2, Period One:

$$X_7 = 7,000$$

Amount of Soft Hardwood Available, Zone 3, Period One:

$$X_8 = 11,000$$

Amount of Soft Hardwood Available Beyond Zone 3, Period

$$\text{One: } X_9 = 16,000$$

Amount of Soft Hardwood Available to be Shipped by Rail,

$$\text{Period One: } X_{10} = 20,000$$

Amount of Slabs Available, Period One: $X_{12} = 31,200$

Amount of Chips Available, Period One: $X_{13} = 10,400$

Amount of Shavings Available, Period One: $X_{14} = 11,960$

Amount of Bare Land Available, Period One: $X_{15} = 7,500$

Amount of Land with Timber Available, Zone 1, Period One:

$$X_{16} + X_{17} + X_{18} + X_{19} + X_{20} + X_{21} + X_{22} + X_{23} + X_{24} + X_{25} = 1,000$$

Amount of Land with Timber Available, Zone 2, Period One:

$$X_{26} + X_{27} + X_{28} + X_{29} + X_{30} + X_{31} + X_{32} + X_{33} + X_{34} + X_{35} = 3,000$$

Amount of Land with Timber Available, Zone 3, Period One:

$$X_{36} + X_{37} + X_{38} + X_{39} + X_{40} + X_{41} + X_{42} + X_{43} + X_{44} + X_{45} = 5,000$$

Amount of Land with Timber Available Beyond Zone 3, Period

$$\text{One: } X_{46} + X_{47} + X_{48} + X_{49} + X_{50} + X_{51} + X_{52} + X_{53} + X_{54} + X_{55} = 7,000$$

Amount of Land with Timber Available, with Wood to be Shipped

$$\text{by Rail, Period One: } X_{56} + X_{57} + X_{58} + X_{59} + X_{60} + X_{61} + X_{62} + X_{63} +$$

$$X_{64} + X_{65} = 9,000$$

Appendix Table 12. (Continued)

Plant Pine Requirement, Period One: $X_{15} + .1X_{16} + .1X_{26} + .1X_{36} + .1X_{46} + .1X_{56} = 6,000$

Plant Capacity, Period Two: $1.15X_{17} + 1.15X_{27} + 1.15X_{37} + 1.15X_{47} + 1.15X_{57} + X_{66} + X_{67} + X_{68} + X_{69} + X_{70} + X_{71} + X_{72} + X_{73} + X_{74} + X_{75} + X_{76} + X_{77} + X_{78} + X_{79} + 1.05X_{81} + 1.05X_{90} + 1.05X_{99} + 1.05X_{108} + 1.05X_{117} = 240,000$

Minimum Pine Requirement, Period Two: $1.15X_{17} + 1.15X_{27} + 1.15X_{37} + 1.15X_{47} + 1.15X_{57} + X_{66} + X_{67} + X_{68} + X_{69} + X_{70} + 1.05X_{81} + 1.05X_{90} + 1.05X_{99} + 1.05X_{108} + 1.05X_{117} = 72,000$

Maximum Oak Requirement, Period Two: $X_{76} = 36,000$

Maximum Slab Requirement, Period Two: $X_{77} = 40,800$

Maximum Chip Requirement, Period Two: $X_{78} = 48,000$

Maximum Shaving Requirement, Period Two: $X_{79} = 24,000$

Maximum Slab, Chip, and Shaving Combination Requirement, Period Two: $X_{77} + X_{78} + X_{79} = 64,800$

Amount of Open Market Pine Available, Zone 1, Period Two: $X_{66} + X_{81} = 5,000$

Amount of Open Market Pine Available, Zone 1, Period Two: $X_{67} + X_{90} = 15,000$

Amount of Open Market Pine Available, Zone 3, Period Two: $X_{68} + X_{99} = 25,000$

Amount of Open Market Pine Available Beyond Zone 3, Period Two: $X_{69} + X_{108} = 35,000$

Appendix Table 12. (Continued)

Amount of Open Market Pine Available to be Shipped by Rail,

$$\text{Period Two: } X_{70} + X_{117} = 45,000$$

Amount of Soft Hardwood Available, Zone 1, Period Two:

$$X_{71} = 3,000$$

Amount of Soft Hardwood Available, Zone 2, Period Two:

$$X_{72} = 7,000$$

Amount of Soft Hardwood Available, Zone 3, Period Two:.

$$X_{73} = 11,000$$

Amount of Soft Hardwood Available Beyond Zone 3, Period Two:

$$X_{74} = 16,000$$

Amount of Soft Hardwood Available to be Shipped by Rail,

$$\text{Period Two: } X_{75} = 20,000$$

Amount of Slabs Available, Period Two: $X_{77} = 31,200$

Amount of Chips Available, Period Two: $X_{78} = 10,400$

Amount of Shavings Available, Period Two: $X_{79} = 11,960$

Amount of Bare Land Available, Period Two: $X_{80} = 7,500$

Amount of Land with Timber Available, Zone 1, Period Two:

$$X_{81} + X_{82} + X_{83} + X_{84} + X_{85} + X_{86} + X_{87} + X_{88} + X_{89} = 1,000$$

Amount of Land with Timber Available, Zone 2, Period Two:

$$X_{90} + X_{91} + X_{92} + X_{93} + X_{94} + X_{95} + X_{96} + X_{97} + X_{98} = 3,000$$

Amount of Land with Timber Available, Zone 3, Period Two:

$$X_{99} + X_{100} + X_{102} + X_{103} + X_{104} + X_{105} + X_{106} + X_{107} = 5,000$$

Amount of Land with Timber Available Beyond Zone 3, Period Two:

$$X_{108} + X_{109} + X_{110} + X_{111} + X_{112} + X_{113} + X_{114} + X_{115} + X_{116} = 7,000$$

Appendix Table 12. (Continued)

Amount of Land with Timber Available, with Wood to be Shipped

by Rail, Period Two: $X_{117} + X_{118} + X_{119} + X_{120} + X_{121} + X_{222} + X_{123} +$

$$X_{124} + X_{125} = 9,000$$

Plant Pine Requirement, Period Two: $X_{15} + .1X_{16} + .1X_{26} + .1X_{36} +$

$.1X_{46} + .1X_{56} + .1X_{17} + .1X_{27} + .1X_{37} + .1X_{47} + .1X_{57} + X_{80} + .1X_{81} +$

$$.1X_{90} + .1X_{99} + .1X_{107} + .1X_{117} = 12,000$$

Plant Capacity, Period Three: $1.25X_{18} + 1.25X_{28} + 1.25X_{38} + 1.25X_{48} +$

$1.25X_{58} + 1.15X_{82} + 1.15X_{91} + 1.15X_{100} + 1.15X_{109} + 1.15X_{118} +$

$X_{126} + X_{127} + X_{128} + X_{129} + X_{130} + X_{131} + X_{132} + X_{133} + X_{134} + X_{135} + X_{136} +$

$X_{137} + X_{138} + X_{139} + 1.05X_{141} + 1.05X_{149} + 1.05X_{157} + 1.05X_{165} +$

$$1.05X_{173} = 240,000$$

Minimum Pine Requirement, Period Three: $1.25X_{18} + 1.25X_{28} +$

$1.25X_{38} + 1.25X_{48} + 1.25X_{58} + 1.15X_{82} + 1.15X_{91} + 1.15X_{100} +$

$1.15X_{109} + 1.15X_{118} + X_{126} + X_{127} + X_{128} + X_{129} + X_{130} + 1.05X_{141} +$

$$1.05X_{149} + 1.05X_{157} + 1.05X_{165} + 1.05X_{173} = 72,000$$

Maximum Oak Requirement, Period Three: $X_{136} = 36,000$

Maximum Slab Requirement, Period Three: $X_{137} = 40,800$

Maximum Chip Requirement, Period Three: $X_{138} = 48,000$

Maximum Shaving Requirement, Period Three: $X_{139} = 24,000$

Maximum Slab, Chip, and Shaving Combination Requirement,

$$\text{Period Three: } X_{136} + X_{138} + X_{139} = 64,800$$

Amount of Open Market Pine Available, Zone 1, Period Three:

$$X_{126} + X_{141} = 5,000$$

Appendix Table 12. (Continued)

Amount of Open Market Pine Available, Zone 2, Period Three:

$$X_{127} + X_{149} = 15,000$$

Amount of Open Market Pine Available, Zone 3, Period Three:

$$X_{128} + X_{157} = 25,000$$

Amount of Open Market Pine Available Beyond Zone 3, Period

Three: $X_{129} + X_{165} = 35,000$

Amount of Open Market Pine Available to be Shipped by Rail,

Period Three: $X_{130} + X_{173} = 45,000$

Amount of Soft Hardwood Available, Zone 1, Period Three:

$$X_{131} = 3,000$$

Amount of Soft Hardwood Available, Zone 2, Period Three:

$$X_{132} = 7,000$$

Amount of Soft Hardwood Available, Zone 3, Period Three:

$$X_{133} = 11,000$$

Amount of Soft Hardwood Available Beyond Zone 3, Period Three:

$$X_{134} = 16,000$$

Amount of Soft Hardwood Available to be Shipped by Rail,

Period Three: $X_{135} = 20,000$

Amount of Slabs Available, Period Three: $X_{137} = 31,200$

Amount of Chips Available, Period Three: $X_{138} = 10,400$

Amount of Shavings Available, Period Three: $X_{139} = 11,960$

Amount of Bare Land Available, Period Three: $X_{140} = 7,500$

Amount of Land with Timber Available, Zone 1, Period Three:

$$X_{141} + X_{142} + X_{143} + X_{144} + X_{145} + X_{146} + X_{147} + X_{148} = 1,000$$

Appendix Table 12. (Continued)

Amount of Land with Timber Available, Zone 2, Period Three:

$$X_{149} + X_{150} + X_{151} + X_{152} + X_{153} + X_{154} + X_{155} + X_{156} = 3,000$$

Amount of Land with Timber Available, Zone 3, Period Three:

$$X_{157} + X_{158} + X_{159} + X_{160} + X_{161} + X_{162} + X_{163} + X_{164} = 5,000$$

Amount of Land with Timber Available Beyond Zone 3, Period

$$\text{Three: } X_{165} + X_{166} + X_{167} + X_{168} + X_{169} + X_{170} + X_{171} + X_{172} = 7,000$$

Amount of Land with Timber Available, with Wood to be Shipped

$$\text{by Rail, Period Three: } X_{173} + X_{174} + X_{175} + X_{176} + X_{177} + X_{178} +$$

$$X_{179} + X_{180} = 9,000$$

Plant Pine Requirement, Period Three: $X_{15} + .1X_{16} + .1X_{26} + .1X_{36} +$

$$.1X_{46} + .1X_{56} + .1X_{17} + .1X_{27} + .1X_{37} + .1X_{47} + .1X_{57} + X_{80} + .1X_{81} +$$

$$.1X_{90} + .1X_{99} + .1X_{108} + .1X_{117} + .1X_{18} + .1X_{28} + .1X_{38} + .1X_{48} + .1X_{58} +$$

$$.1X_{82} + .1X_{91} + .1X_{100} + .1X_{109} + .1X_{118} + X_{140} + .1X_{141} + .1X_{149} +$$

$$.1X_{157} + .1X_{165} + .1X_{173} = 18,000$$

Plant Capacity, Period Four: $1.35X_{19} + 1.35X_{29} + 1.35X_{39} +$

$$1.35X_{49} + 1.35X_{59} + 1.25X_{83} + 1.25X_{92} + 1.25X_{101} + 1.25X_{119} +$$

$$1.15X_{142} + 1.15X_{150} + 1.15X_{158} + 1.15X_{166} + 1.15X_{174} + X_{181} +$$

$$X_{182} + X_{183} + X_{184} + X_{185} + X_{186} + X_{187} + X_{188} + X_{189} + X_{190} + X_{191} + X_{192} +$$

$$X_{193} + X_{194} + 1.05X_{196} + 1.05X_{203} + 1.05X_{210} + 1.05X_{217} + 1.05X_{224}$$

$$= 240,000$$

Minimum Pine Requirement, Period Four: $1.35X_{19} + 1.35X_{29} +$

$$1.35X_{39} + 1.35X_{49} + 1.35X_{59} + 1.25X_{83} + 1.25X_{92} + 1.25X_{101} +$$

$$1.25X_{110} + 1.25X_{119} + 1.15X_{142} + 1.15X_{150} + 1.15X_{158} + 1.15X_{166} +$$

Appendix Table 12. (Continued)

$$1.15X_{174} + X_{181} + X_{182} + X_{183} + X_{184} + X_{185} + 1.05X_{196} + 1.05X_{203} + 1.05X_{210} + 1.05X_{217} + 1.05X_{224} = 72,000$$

Maximum Oak Requirement, Period Four: $X_{191} = 36,000$

Maximum Slab Requirement, Period Four: $X_{192} = 40,800$

Maximum Chip Requirement, Period Four: $X_{193} = 48,000$

Maximum Shaving Requirement, Period Four: $X_{194} = 24,000$

Maximum Slab, Chip, and Shaving Combination Requirement,

$$\text{Period Four: } X_{192} + X_{193} + X_{194} = 64,800$$

Amount of Open Market Pine Available, Zone 1, Period Four:

$$X_{181} + X_{196} = 5,000$$

Amount of Open Market Pine Available, Zone 2, Period Four:

$$X_{182} + X_{203} = 15,000$$

Amount of Open Market Pine Available, Zone 3, Period Four:

$$X_{183} + X_{210} = 25,000$$

Amount of Open Market Pine Available Beyond Zone 3, Period

$$\text{Four: } X_{184} + X_{217} = 35,000$$

Amount of Open Market Pine Available to be Shipped by Rail,

$$\text{Period Four: } X_{185} + X_{224} = 45,000$$

Amount of Soft Hardwood Available, Zone 1, Period Four:

$$X_{186} = 3,000$$

Amount of Soft Hardwood Available, Zone 2, Period Four:

$$X_{187} = 7,000$$

Amount of Soft Hardwood Available, Zone 3, Period Four:

$$X_{188} = 11,000$$

Appendix Table 12. (Continued)

Amount of Soft Hardwood Available Beyond Zone 3, Period

Four: $X_{189} = 16,000$

Amount of Soft Hardwood Available to be Shipped by Rail,

Period Four: $X_{190} = 20,000$

Amount of Slabs Available, Period Four: $X_{192} = 31,200$

Amount of Chips Available, Period Four: $X_{193} = 10,400$

Amount of Shavings Available, Period Four: $X_{194} = 11,960$

Amount of Bare Land Available, Period Four: $X_{195} = 7,500$

Amount of Land with Timber Available, Zone 1, Period Four:

$$X_{196} + X_{197} + X_{198} + X_{199} + X_{200} + X_{201} + X_{202} = 1,000$$

Amount of Land with Timber Available, Zone 2, Period Four:

$$X_{203} + X_{204} + X_{205} + X_{206} + X_{207} + X_{208} + X_{209} = 3,000$$

Amount of Land with Timber Available, Zone 3, Period Four:

$$X_{210} + X_{211} + X_{212} + X_{213} + X_{214} + X_{215} + X_{216} = 5,000$$

Amount of Land with Timber Available Beyond Zone 3, Period

Four: $+X_{217} + X_{218} + X_{219} + X_{220} + X_{221} + X_{222} + X_{223} = 7,000$

Amount of Land with Timber Available, with Wood to be

Shipped by Rail, Period Four: $X_{224} + X_{225} + X_{226} + X_{227} +$

$$X_{228} + X_{229} + X_{230} = 9,000$$

Plant Pine Requirement, Period Four: $X_{15} + .1X_{16} + .1X_{26} + .1X_{36} +$

$$.1X_{46} + .1X_{56} + .1X_{17} + .1X_{27} + .1X_{37} + .1X_{47} + .1X_{57} + X_{80} + .1X_{81} +$$

$$.1X_{90} + .1X_{99} + .1X_{108} + .1X_{117} + .1X_{18} + .1X_{28} + .1X_{38} + .1X_{48} + .1X_{58} +$$

$$.1X_{82} + .1X_{91} + .1X_{100} + .1X_{109} + .1X_{118} + X_{140} + .1X_{141} + .1X_{149} +$$

$$.1X_{157} + .1X_{165} + .1X_{173} + .1X_{19} + .1X_{29} + .1X_{39} + .1X_{49} + .1X_{59} +$$

Appendix Table 12. (Continued)

$$\begin{aligned}
 &.1X_{83}+.1X_{92}+.1X_{101}+.1X_{110}+.1X_{119}+.1X_{142}+.1X_{150}+.1X_{158}+ \\
 &.1X_{166}+.1X_{174}+X_{195}+.1X_{196}+.1X_{203}+.1X_{210}+.1X_{217}+.1X_{224} \\
 &= 24,000
 \end{aligned}$$

$$\begin{aligned}
 \text{Plant Capacity, Period Five: } &1.45X_{20}+1.45X_{30}+1.45X_{50}+1.45X_{60} \\
 &+1.35X_{84}+1.35X_{93}+1.35X_{102}+1.35X_{111}+1.35X_{120}+1.25X_{143}+ \\
 &1.25X_{151}+1.25X_{159}+1.25X_{167}+1.25X_{175}+1.15X_{197}+1.15X_{204}+ \\
 &1.15X_{211}+1.15X_{218}+1.15X_{225}+X_{231}+X_{232}+X_{233}+X_{234}+X_{235}+ \\
 &X_{236}+X_{237}+X_{238}+X_{239}+X_{240}+X_{241}+X_{242}+X_{243}+X_{244}+1.05X_{246}+ \\
 &1.05X_{252}+1.05X_{258}+1.05X_{264}+1.05X_{270} = 240,000
 \end{aligned}$$

$$\begin{aligned}
 \text{Minimum Pine Requirement, Period Five: } &1.45X_{20}+1.45X_{30}+ \\
 &1.45X_{40}+1.45X_{50}+1.45X_{60}+1.35X_{84}+1.35X_{93}+1.35X_{102}+ \\
 &1.35X_{111}+1.35X_{120}+1.25X_{143}+1.25X_{151}+1.25X_{159}+1.25X_{167}+ \\
 &1.25X_{175}+1.15X_{197}+1.15X_{204}+1.15X_{211}+1.15X_{218}+1.15X_{225}+ \\
 &X_{231}+X_{232}+X_{233}+X_{234}+X_{235}+1.05X_{246}+1.05X_{252}+1.05X_{258}+ \\
 &1.05X_{264}+1.05X_{270} = 72,000
 \end{aligned}$$

$$\text{Maximum Oak Requirement, Period Five: } X_{241} = 36,000$$

$$\text{Maximum Slab Requirement, Period Five: } X_{242} = 40,800$$

$$\text{Maximum Chip Requirement, Period Five: } X_{243} = 48,000$$

$$\text{Maximum Shaving Requirement, Period Five: } X_{244} = 24,000$$

Maximum Slab, Chip, and Shaving Combination Requirement,

$$\text{Period Five: } X_{242}+X_{243}+X_{244} = 64,800$$

Amount of Open Market Pine Available, Zone 1, Period Five:

$$X_{231}+X_{246} = 5,000$$

Amount of Open Market Pine Available, Zone 2, Period Five:

Appendix Table 12. (Continued)

$$X_{232} + X_{252} = 15,000$$

Amount of Open Market Pine Available, Zone 3, Period Five:

$$X_{233} + X_{258} = 25,000$$

Amount of Open Market Pine Available Beyond Zone 3, Period

Five: $X_{234} + X_{264} = 35,000$

Amount of Open Market Pine Available to be Shipped by Rail,

Period Five: $X_{235} + X_{270} = 45,000$

Amount of Soft Hardwood Available, Zone 1, Period Five:

$$X_{236} = 3,000$$

Amount of Soft Hardwood Available, Zone 2, Period Five:

$$X_{237} = 7,000$$

Amount of Soft Hardwood Available, Zone 3, Period Five:

$$X_{238} = 11,000$$

Amount of Soft Hardwood Available Beyond Zone 3, Period

Five: $X_{239} = 16,000$

Amount of Soft Hardwood Available to be Shipped by Rail,

Period Five: $X_{240} = 20,000$

Amount of Slabs Available, Period Five: $X_{242} = 31,200$

Amount of Chips Available, Period Five: $X_{243} = 10,400$

Amount of Shavings Available, Period Five: $X_{244} = 11,960$

Amount of Bare Land Available, Period Five: $X_{245} = 7,500$

Amount of Land with Timber Available, Zone 1, Period Five:

$$X_{246} + X_{247} + X_{248} + X_{249} + X_{250} + X_{251} = 1,000$$

Amount of Land with Timber Available, Zone 2, Period Five:

Appendix Table 12. (Continued)

$$X_{252} + X_{253} + X_{254} + X_{255} + X_{256} + X_{257} = 3,000$$

Amount of Land with Timber Available, Zone 3, Period Five:

$$X_{258} + X_{259} + X_{260} + X_{261} + X_{262} + X_{263} = 5,000$$

Amount of Land with Timber Available Beyond Zone 3, Period

$$\text{Five: } X_{264} + X_{265} + X_{266} + X_{267} + X_{268} + X_{269} = 7,000$$

Amount of Land with Timber Available, with Wood to be

$$\begin{aligned} &\text{Shipped by Rail, Period Five: } X_{270} + X_{271} + X_{272} + X_{273} + X_{274} \\ &+ X_{275} = 9,000 \end{aligned}$$

$$\begin{aligned} \text{Plant Pine Requirement, Period Five: } &X_{15} + .1X_{16} + .1X_{26} + .1X_{36} + \\ &.1X_{46} + .1X_{56} + .1X_{17} + .1X_{27} + .1X_{37} + .1X_{47} + .1X_{57} + X_{80} + .1X_{81} + \\ &.1X_{90} + .1X_{99} + .1X_{108} + .1X_{117} + .1X_{18} + .1X_{28} + .1X_{38} + .1X_{48} + .1X_{58} + \\ &.1X_{82} + .1X_{91} + .1X_{100} + .1X_{109} + .1X_{118} + X_{140} + .1X_{141} + .1X_{149} + \\ &.1X_{157} + .1X_{165} + .1X_{173} + .1X_{19} + .1X_{29} + .1X_{39} + .1X_{49} + .1X_{59} + \\ &.1X_{83} + .1X_{92} + .1X_{101} + .1X_{110} + .1X_{119} + .1X_{142} + .1X_{150} + .1X_{158} + \\ &.1X_{166} + .1X_{174} + X_{195} + .1X_{196} + .1X_{203} + .1X_{210} + .1X_{217} + .1X_{224} + \\ &.1X_{20} + .1X_{40} + .1X_{50} + .1X_{60} + .1X_{84} + .1X_{93} + .1X_{102} + .1X_{111} + \\ &.1X_{120} + .1X_{143} + .1X_{151} + .1X_{159} + .1X_{167} + .1X_{175} + .1X_{197} + .1X_{204} \\ &+ .1X_{211} + .1X_{218} + .1X_{225} + .1X_{245} + .1X_{246} + .1X_{252} + .1X_{258} + \\ &.1X_{264} + .1X_{270} = 30,000 \end{aligned}$$

$$\text{Plant Capacity, Period Six: } 1.55X_{21} + 1.55X_{31} + 1.55X_{41} +$$

$$1.55X_{51} + 1.55X_{61} + 1.45X_{85} + 1.45X_{94} + .145X_{103} + 1.45X_{112} +$$

$$1.45X_{121} + 1.35X_{144} + 1.35X_{152} + 1.35X_{160} + 1.35X_{168} + 1.35X_{176}$$

$$+ 1.25X_{198} + 1.25X_{205} + 1.25X_{212} + 1.25X_{219} + 1.25X_{226} + 1.15X_{247}$$

$$+ 1.15X_{253} + 1.15X_{259} + 1.15X_{265} + 1.15X_{271} + X_{276} + X_{277} + X_{278} +$$

Appendix Table 12. (Continued)

$$X_{279} + X_{280} + X_{281} + X_{282} + X_{283} + X_{284} + X_{285} + X_{286} + X_{287} + X_{288} + X_{289}$$

$$+ 1.05X_{291} + 1.05X_{296} + 1.05X_{301} + 1.05X_{306} + 1.05X_{311} = 240,000$$

$$\begin{aligned} \text{Minimum Pine Requirement, Period Six: } & 1.55X_{21} + 1.55X_{31} + \\ & 1.55X_{41} + 1.55X_{51} + 1.55X_{61} + 1.45X_{85} + 1.45X_{94} + 1.45X_{103} + \\ & 1.45X_{112} + 1.45X_{121} + 1.35X_{144} + 1.35X_{152} + 1.35X_{160} + 1.35X_{168} + \\ & 1.35X_{176} + 1.25X_{198} + 1.25X_{205} + 1.25X_{212} + 1.25X_{219} + 1.25X_{226} \\ & + 1.15X_{247} + 1.15X_{253} + 1.15X_{259} + 1.15X_{265} + 1.15X_{271} + X_{276} + X_{277} \\ & + X_{278} + X_{279} + X_{280} + 1.05X_{291} + 1.05X_{296} + 1.05X_{301} + 1.05X_{306} + \\ & 1.05X_{311} = 72,000 \end{aligned}$$

$$\text{Maximum Oak Requirement, Period Six: } X_{286} = 36,000$$

$$\text{Maximum Slab Requirement, Period Six: } X_{287} = 40,800$$

$$\text{Maximum Chip Requirement, Period Six: } X_{288} = 48,000$$

$$\text{Maximum Shaving Requirement, Period Six: } X_{289} = 24,000$$

Maximum Slab, Chip, and Shaving Combination Requirement,

$$\text{Period Six: } X_{287} + X_{288} + X_{289} = 64,800$$

Amount of Open Market Pine Available, Zone 1, Period Six:

$$X_{276} + X_{291} = 5,000$$

Amount of Open Market Pine Available, Zone 2, Period Six:

$$X_{277} + X_{296} = 15,000$$

Amount of Open Market Pine Available, Zone 3, Period Six:

$$X_{278} + X_{301} = 25,000$$

Amount of Open Market Pine Available Beyond Zone 3, Period

$$\text{Six: } X_{279} + X_{306} = 35,000$$

Appendix Table 12. (Continued)

Amount of Open Market Pine Available to be Shipped by Rail,

$$\text{Period Six: } X_{280} + X_{311} = 45,000$$

Amount of Soft Hardwood Available, Zone 1, Period Six:

$$X_{281} = 3,000$$

Amount of Soft Hardwood Available, Zone 2, Period Six:

$$X_{282} = 7,000$$

Amount of Soft Hardwood Available, Zone 3, Period Six:

$$X_{283} = 11,000$$

Amount of Soft Hardwood Available Beyond Zone 3, Period

$$\text{Six: } X_{284} = 16,000$$

Amount of Soft Hardwood Available to be Shipped by Rail,

$$\text{Period Six: } X_{285} = 20,000$$

Amount of Slabs Available, Period Six: $X_{287} = 31,200$

Amount of Chips Available, Period Six: $X_{288} = 10,400$

Amount of Shavings Available, Period Six: $X_{289} = 11,960$

Amount of Bare Land Available, Period Six: $X_{290} = 7,500$

Amount of Land with Timber Available, Zone 1, Period Six:

$$X_{291} + X_{292} + X_{293} + X_{294} + X_{295} = 1,000$$

Amount of Land with Timber Available, Zone 2, Period Six:

$$X_{296} + X_{297} + X_{298} + X_{299} + X_{300} = 3,000$$

Amount of Land with Timber Available, Zone 3, Period Six:

$$X_{301} + X_{302} + X_{303} + X_{304} + X_{305} = 5,000$$

Amount of Land with Timber Available Beyond Zone 3, Period

$$\text{Six: } X_{306} + X_{307} + X_{308} + X_{309} + X_{310} = 7,000$$

Appendix Table 12. (Continued)

Amount of Land with Timber Available, with Wood to be

$$\text{Shipped by Rail, Period Six: } X_{311} + X_{312} + X_{313} + X_{314} + X_{315} \\ = 9,000$$

$$\begin{aligned} \text{Plant Pine Requirement, Period Six: } & X_{15} + .1X_{16} + .1X_{26} + .1X_{36} + \\ & .1X_{46} + .1X_{56} + .1X_{17} + .1X_{27} + .1X_{37} + .1X_{47} + .1X_{57} + X_{80} + .1X_{81} + \\ & .1X_{90} + .1X_{99} + .1X_{108} + .1X_{117} + .1X_{18} + .1X_{28} + .1X_{38} + .1X_{48} + .1X_{58} \\ & + .1X_{82} + .1X_{91} + .1X_{100} + .1X_{109} + .1X_{118} + X_{140} + .1X_{141} + .1X_{149} + \\ & .1X_{157} + .1X_{165} + .1X_{173} + .1X_{19} + .1X_{29} + .1X_{39} + .1X_{49} + .1X_{59} + \\ & .1X_{83} + .1X_{92} + .1X_{101} + .1X_{110} + .1X_{119} + .1X_{142} + .1X_{150} + .1X_{158} + \\ & .1X_{166} + .1X_{174} + X_{195} + .1X_{196} + .1X_{203} + .1X_{210} + .1X_{217} + .1X_{224} + \\ & .1X_{20} + .1X_{30} + .1X_{40} + .1X_{50} + .1X_{60} + .1X_{84} + .1X_{93} + .1X_{102} + .1X_{111} \\ & + .1X_{120} + .1X_{143} + .1X_{151} + .1X_{159} + .1X_{167} + .1X_{175} + .1X_{197} + \\ & .1X_{204} + .1X_{211} + .1X_{218} + .1X_{225} + X_{225} + X_{245} + .1X_{246} + .1X_{252} + \\ & .1X_{258} + .1X_{264} + .1X_{270} + .1X_{21} + .1X_{31} + .1X_{41} + .1X_{51} + .1X_{61} + \\ & .1X_{85} + .1X_{94} + .1X_{103} + .1X_{112} + .1X_{121} + .1X_{144} + .1X_{152} + .1X_{160} + \\ & .1X_{168} + .1X_{176} + .1X_{198} + .1X_{205} + .1X_{212} + .1X_{219} + .1X_{226} + \\ & .1X_{247} + .1X_{253} + .1X_{259} + .1X_{265} + .1X_{271} + .1X_{290} + .1X_{291} + \\ & .1X_{296} + .1X_{301} + .1X_{306} + .1X_{311} = 36,000 \end{aligned}$$

$$\begin{aligned} \text{Plant Capacity, Period Seven: } & 1.65X_{22} + 1.65X_{32} + 1.55X_{42} + 1.65X_{52} \\ & + 1.65X_{62} + 1.55X_{86} + 1.55X_{95} + 1.55X_{104} + 1.55X_{113} + 1.55X_{122} + \\ & 1.45X_{145} + 1.45X_{153} + 1.45X_{161} + 1.45X_{169} + 1.45X_{177} + 1.35X_{199} + \\ & 1.35X_{206} + 1.35X_{213} + 1.35X_{220} + 1.35X_{227} + 1.25X_{248} + 1.25X_{254} + \\ & 1.25X_{260} + 1.25X_{266} + 1.25X_{272} + 1.15X_{292} + 1.15X_{297} + 1.15X_{302} + \end{aligned}$$

Appendix Table 12. (Continued)

$$1.15X_{307} + 1.15X_{312} + X_{316} + X_{317} + X_{318} + X_{319} + X_{320} + X_{321} + X_{322} + \\ X_{323} + X_{324} + X_{325} + X_{326} + X_{327} + X_{328} + X_{329} + 1.05X_{335} + 1.05X_{339} + \\ 1.05X_{343} + 1.05X_{347} = 240,000$$

Minimum Pine Requirement, Period Seven: $1.65_{22} + 1.65_{32} +$
 $1.65_{42} + 1.65X_{52} + 1.65X_{62} + 1.55X_{86} + 1.55X_{95} + 1.55X_{104} +$
 $1.55X_{113} + 1.55X_{122} + 1.45X_{145} + 1.45X_{153} + 1.45X_{161} + 1.45X_{169}$
 $+ 1.45X_{177} + 1.35X_{199} + 1.35X_{206} + 1.35X_{213} + 1.35X_{220} + 1.35X_{227}$
 $+ 1.25X_{248} + 1.25X_{254} + 1.25X_{260} + 1.25X_{266} + 1.25X_{272} + 1.15X_{292}$
 $+ 1.15X_{297} + 1.15X_{302} + 1.15X_{307} + 1.15X_{312} + X_{316} + X_{317} + X_{318} +$
 $X_{319} + X_{320} + 1.05X_{331} + 1.05X_{335} + 1.05X_{339} + 1.05X_{343} + 1.05X_{347}$
 $= 72,000$

Maximum Oak Requirement, Period Seven: $X_{326} = 36,000$

Maximum Slab Requirement, Period Seven: $X_{327} = 40,800$

Maximum Chip Requirement, Period Seven: $X_{328} = 48,000$

Maximum Shaving Requirement, Period Seven: $X_{329} = 24,000$

Maximum Slab, Chip, and Shaving Combination Requirement,

Period Seven: $X_{327} + X_{328} + X_{329} = 64,800$

Amount of Open Market Pine Available, Zone 1, Period Seven:

$$X_{316} + X_{331} = 5,000$$

Amount of Open Market Pine Available, Zone 2, Period Seven:

$$X_{317} + X_{335} = 15,000$$

Amount of Open Market Pine Available, Zone 3, Period Seven:

$$X_{318} + X_{339} = 25,000$$

Amount of Open Market Pine Available Beyond Zone 3, Period

Appendix Table 12. (Continued)

$$\text{Seven: } X_{319} + X_{343}$$

Amount of Open Market Pine Available to be Shipped by Rail,

$$\text{Period Seven: } X_{320} + X_{347} = 45,000$$

Amount of Soft Hardwood Available, Zone 1, Period Seven:

$$X_{321} = 3,000$$

Amount of Soft Hardwood Available, Zone 2, Period Seven:

$$X_{322} = 7,000$$

Amount of Soft Hardwood Available, Zone 3, Period Seven:

$$X_{323} = 11,000$$

Amount of Soft Hardwood Available Beyond Zone 3, Period

$$\text{Seven: } X_{324} = 16,000$$

Amount of Soft Hardwood Available to be Shipped by Rail,

$$\text{Period Seven: } X_{325} = 20,000$$

Amount of Slabs Available, Period Seven: $X_{327} = 31,200$

Amount of Chips Available, Period Seven: $X_{328} = 10,400$

Amount of Shavings Available, Period Seven: $X_{329} = 11,960$

Amount of Bare Land Available, Period Seven: $X_{330} = 7,500$

Amount of Land with Timber Available, Zone 1, Period Seven:

$$X_{331} + X_{332} + X_{333} + X_{334} = 1,000$$

Amount of Land with Timber Available, Zone 2, Period Seven:

$$X_{335} + X_{336} + X_{337} + X_{338} = 3,000$$

Amount of Land with Timber Available, Zone 3, Period Seven:

$$X_{339} + X_{340} + X_{341} + X_{342} = 5,000$$

Amount of Land with Timber Available Beyond Zone 3, Period

Appendix Table 12. (Continued)

Seven: $X_{343} + X_{344} + X_{345} + X_{346} = 7,000$

Amount of Land with Timber Available, with Wood to be

Shipped by Rail, Period Seven: $X_{347} + X_{348} + X_{349} + X_{350}$
 $= 9,000$

Plant Pine Requirement, Period Seven: $X_{15} + .1X_{16} + .1X_{26} +$
 $.1X_{36} + .1X_{46} + .1X_{56} + .1X_{17} + .1X_{27} + .1X_{37} + .1X_{47} + .1X_{57} + X_{80}$
 $+ .1X_{81} + .1X_{90} + .1X_{99} + .1X_{108} + .1X_{117} + .1X_{18} + .1X_{28} + .1X_{38} +$
 $.1X_{48} + .1X_{58} + .1X_{82} + .1X_{91} + .1X_{100} + .1X_{109} + .1X_{118} + X_{140} +$
 $.1X_{141} + .1X_{149} + .1X_{157} + .1X_{165} + .1X_{173} + .1X_{19} + .1X_{29} + .1X_{39}$
 $+ .1X_{49} + .1X_{59} + .1X_{83} + .1X_{92} + .1X_{101} + .1X_{110} + .1X_{119} + .1X_{142}$
 $+ .1X_{150} + .1X_{158} + .1X_{166} + .1X_{174} + X_{195} + .1X_{196} + .1X_{203} + .1X_{210}$
 $+ .1X_{217} + .1X_{224} + .1X_{20} + .1X_{30} + .1X_{40} + .1X_{50} + .1X_{60} + .1X_{84} +$
 $.1X_{93} + .1X_{102} + .1X_{111} + .1X_{120} + .1X_{143} + .1X_{151} + .1X_{159} + .1X_{167}$
 $+ .1X_{175} + .1X_{197} + .1X_{204} + .1X_{211} + .1X_{218} + .1X_{255} + X_{245} + .1X_{246}$
 $+ .1X_{252} + .1X_{258} + .1X_{264} + .1X_{270} + .1X_{21} + .1X_{31} + .1X_{41} + .1X_{51} +$
 $.1X_{61} + .1X_{85} + .1X_{94} + .1X_{103} + .1X_{112} + .1X_{121} + .1X_{144} + .1X_{152} +$
 $.1X_{160} + .1X_{168} + .1X_{176} + .1X_{198} + .1X_{205} + .1X_{212} + .1X_{219} +$
 $.1X_{226} + .1X_{247} + .1X_{253} + .1X_{259} + .1X_{265} + .1X_{271} + X_{290} + .1X_{291} +$
 $.1X_{296} + .1X_{301} + .1X_{306} + .1X_{311} + .1X_{22} + .1X_{32} + .1X_{42} + .1X_{52} +$
 $.1X_{62} + .1X_{86} + .1X_{95} + .1X_{104} + .1X_{113} + .1X_{122} + .1X_{145} + .1X_{153} +$
 $.1X_{161} + .1X_{169} + .1X_{177} + .1X_{199} + .1X_{206} + .1X_{213} + .1X_{220} +$
 $.1X_{227} + .1X_{248} + .1X_{254} + .1X_{260} + .1X_{266} + .1X_{272} + .1X_{292} +$
 $.1X_{302} + .1X_{307} + .1X_{312} + .1X_{330} + .1X_{331} + .1X_{335} + .1X_{339} +$
 $.1X_{343} + .1X_{347} = 42,000$

Appendix Table 12. (Continued)

Plant Capacity, Period Eight: $1.75X_{23} + 1.75X_{33} + 1.75X_{43} +$
 $1.75X_{53} + 1.75X_{63} + 1.65X_{87} + 1.65X_{96} + 1.65X_{105} + 1.65X_{114} +$
 $1.65X_{123} + 1.55X_{146} + 1.55X_{154} + 1.55X_{162} + 1.55X_{170} + 1.55X_{178}$
 $+ 1.45X_{200} + 1.45X_{207} + 1.45X_{214} + 1.45X_{221} + 1.45X_{228} + 1.35X_{249}$
 $+ 1.35X_{255} + 1.35X_{261} + 1.35X_{267} + 1.35X_{273} + 1.25X_{293} + 1.25X_{298}$
 $+ 1.25X_{303} + 1.25X_{308} + 1.25X_{313} + 1.15X_{332} + 1.15X_{336} + 1.15X_{340}$
 $+ 1.15X_{344} + 1.15X_{348} + X_{351} + X_{352} + X_{353} + X_{354} + X_{355} + X_{356} + X_{357} +$
 $+ X_{358} + X_{359} + X_{360} + X_{361} + X_{362} + X_{363} + X_{364} + 1.05X_{366} + 1.05X_{369} + 1.05X_{372}$
 $+ 1.05X_{375} + 1.05X_{378} = 240,000$

Minimum Pine Requirement, Period Eight: $1.75X_{23} + 1.75X_{33} +$
 $1.75X_{43} + 1.75X_{53} + 1.75X_{63} + 1.65X_{87} + 1.65X_{96} + 1.65X_{105} +$
 $1.65X_{114} + 1.65X_{123} + 1.65X_{146} + 1.55X_{154} + 1.55X_{162} + 1.55X_{170}$
 $+ 1.55X_{178} + 1.45X_{200} + 1.45X_{207} + 1.45X_{214} + 1.45X_{221} + 1.45X_{228}$
 $+ 1.35X_{249} + 1.35X_{255} + 1.35X_{261} + 1.35X_{267} + 1.35X_{273} + 1.25X_{293}$
 $+ 1.25X_{298} + 1.25X_{303} + 1.25X_{308} + 1.25X_{313} + 1.15X_{332} + 1.15X_{336}$
 $+ 1.15X_{340} + 1.15X_{344} + 1.15X_{348} + X_{351} + X_{352} + X_{353} + X_{354} + X_{355} +$
 $1.05X_{366} + 1.05X_{369} + 1.05X_{372} + 1.05X_{372} + 1.05X_{375} + 1.05X_{378}$
 $= 72,000$

Maximum Oak Requirement, Period Eight: $X_{361} = 36,000$

Maximum Slab Requirement, Period Eight: $X_{362} = 40,800$

Maximum Chip Requirement, Period Eight: $X_{363} = 48,000$

Maximum Shaving Requirement, Period Eight: $X_{364} = 24,000$

Maximum Slab, Chip, and Shaving Combination Requirement,

Period Eight: $X_{362} + X_{363} + X_{364} = 64,800$

Appendix Table 12. (Continued)

Amount of Open Market Pine Available, Zone 1, Period Eight:

$$X_{351} + X_{366} = 5,000$$

Amount of Open Market Pine Available, Zone 2, Period Eight:

$$X_{352} + X_{369} = 15,000$$

Amount of Open Market Pine Available, Zone 3, Period Eight:

$$X_{353} + X_{372} = 25,000$$

Amount of Open Market Pine Available Beyond Zone 3, Period

Eight: $X_{354} + X_{375} = 35,000$

Amount of Open Market Pine Available to be Shipped by Rail,

Period Eight: $X_{355} + X_{379} = 45,000$

Amount of Soft Hardwood Available, Zone 1, Period Eight:

$$X_{356} = 3,000$$

Amount of Soft Hardwood Available, Zone 2, Period Eight:

$$X_{357} = 7,000$$

Amount of Soft Hardwood Available, Zone 3, Period Eight:

$$X_{358} = 11,000$$

Amount of Soft Hardwood Available Beyond Zone 3, Period

Eight: $X_{359} = 16,000$

Amount of Soft Hardwood Available to be Shipped by Rail,

Period Eight: $X_{360} = 20,000$

Amount of Slabs Available, Period Eight: $X_{362} = 31,200$

Amount of Chips Available, Period Eight: $X_{363} = 10,400$

Amount of Shavings Available, Period Eight: $X_{364} = 11,960$

Amount of Bare Land Available, Period Eight: $X_{365} = 7,500$

Appendix Table 12. (Continued)

Amount of Land with Timber Available, Zone 1, Period Eight:

$$X_{366} + X_{367} + X_{368} = 1,000$$

Amount of Land with Timber Available, Zone 2, Period Eight:

$$X_{369} + X_{370} + X_{371} = 3,000$$

Amount of Land with Timber Available, Zone 3, Period Eight:

$$X_{372} + X_{373} + X_{374} = 5,000$$

Amount of Land with Timber Available Beyond Zone 3, Period

$$\text{Eight: } X_{375} + X_{376} + X_{377} = 7,000$$

Amount of Land with Timber Available, with Wood to be Shipped

$$\text{by Rail, Period Eight: } X_{378} + X_{379} + X_{380} = 9,000$$

$$\begin{aligned} \text{Plant Pine Requirement, Period Eight: } & X_{15} + .1X_{16} + .1X_{26} + .1X_{36} \\ & + .1X_{46} + .1X_{56} + .1X_{17} + .1X_{27} + .1X_{37} + .1X_{47} + .1X_{57} + X_{80} + .1X_{81} + \\ & .1X_{90} + .1X_{99} + .1X_{108} + .1X_{117} + .1X_{18} + .1X_{28} + .1X_{38} + .1X_{48} + .1X_{58} \\ & + .1X_{82} + .1X_{91} + .1X_{100} + .1X_{109} + .1X_{118} + X_{140} + .1X_{141} + .1X_{149} + \\ & .1X_{157} + .1X_{165} + .1X_{173} + .1X_{19} + .1X_{29} + .1X_{39} + .1X_{49} + .1X_{59} + .1X_{83} \\ & + .1X_{92} + .1X_{101} + .1X_{110} + .1X_{119} + .1X_{142} + .1X_{150} + .1X_{158} + .1X_{166} \\ & + .1X_{174} + X_{195} + .1X_{196} + .1X_{203} + .1X_{210} + .1X_{217} + .1X_{224} + .1X_{20} + \\ & .1X_{30} + .1X_{40} + .1X_{50} + .1X_{60} + .1X_{84} + .1X_{93} + .1X_{102} + .1X_{111} + \\ & .1X_{120} + .1X_{143} + .1X_{151} + .1X_{159} + .1X_{167} + .1X_{175} + .1X_{197} + \\ & .1X_{204} + .1X_{211} + .1X_{218} + .1X_{255} + X_{245} + .1X_{246} + .1X_{252} + .1X_{258} \\ & + .1X_{264} + .1X_{270} + .1X_{21} + .1X_{31} + .1X_{41} + .1X_{51} + .1X_{61} + .1X_{85} + \\ & .1X_{94} + .1X_{103} + .1X_{112} + .1X_{121} + .1X_{144} + .1X_{152} + .1X_{160} + .1X_{168} \\ & + .1X_{176} + .1X_{198} + .1X_{205} + .1X_{212} + .1X_{219} + .1X_{226} + .1X_{247} + \\ & .1X_{253} + .1X_{259} + .1X_{265} + .1X_{271} + X_{290} + .1X_{291} + .1X_{296} + .1X_{301} \end{aligned}$$

Appendix Table 12. (Continued)

$$\begin{aligned}
&+.1X_{306}+.1X_{311}+.1X_{22}+.1X_{32}+.1X_{42}+.1X_{52}+.1X_{62}+.1X_{86}+ \\
&.1X_{95}+.1X_{104}+.1X_{113}+.1X_{122}+.1X_{145}+.1X_{153}+.1X_{161}+.1X_{169} \\
&+.1X_{177}+.1X_{199}+.1X_{206}+.1X_{213}+.1X_{220}+.1X_{227}+.1X_{248}+ \\
&.1X_{254}+.1X_{260}+.1X_{266}+.1X_{272}+.1X_{292}+.1X_{302}+.1X_{307}+.1X_{312} \\
&+.1X_{330}+.1X_{331}+.1X_{335}+.1X_{339}+.1X_{343}+.1X_{347}+.1X_{23}+.1X_{33}+ \\
&.1X_{43}+.1X_{53}+.1X_{63}+.1X_{87}+.1X_{96}+.1X_{105}+.1X_{114}+.1X_{123}+ \\
&.1X_{146}+.1X_{154}+.1X_{162}+.1X_{170}+.1X_{200}+.1X_{207}+.1X_{214}+ \\
&.1X_{221}+.1X_{228}+.1X_{249}+.1X_{255}+.1X_{261}+.1X_{267}+.1X_{273}+ \\
&.1X_{293}+.1X_{298}+.1X_{303}+.1X_{308}+.1X_{313}+.1X_{332}+.1X_{336}+ \\
&.1X_{340}+.1X_{344}+.1X_{348}+.1X_{365}+.1X_{366}+.1X_{369}+.1X_{372}+.1X_{375} \\
&+.1X_{378} = 48,000
\end{aligned}$$

$$\begin{aligned}
\text{Plant Capacity, Period Nine: } &1.85X_{24}+1.85X_{34}+1.85X_{44}+1.85X_{54} \\
&+1.85X_{64}+1.75X_{88}+1.75X_{97}+1.75X_{106}+1.75X_{115}+1.75X_{124}+ \\
&1.65X_{147}+1.65X_{155}+1.65X_{163}+1.65X_{171}+1.65X_{179}+1.55X_{201}+ \\
&+1.55X_{208}+1.55X_{215}+1.55X_{232}+1.55X_{229}+1.45X_{250}+1.45X_{256} \\
&+1.45X_{262}+1.45X_{268}+1.45X_{274}+1.35X_{294}+1.35X_{299}+1.35X_{304} \\
&+1.35X_{309}+1.35X_{314}+1.25X_{333}+1.25X_{337}+1.25X_{341}+1.25X_{345} \\
&+1.25X_{349}+1.15X_{367}+1.15X_{370}+1.15X_{373}+1.15X_{376}+1.15X_{379} \\
&+.1X_{381}+.1X_{382}+.1X_{383}+.1X_{384}+.1X_{385}+.1X_{386}+.1X_{387}+.1X_{388}+.1X_{389}+.1X_{390}+.1X_{391} \\
&+.1X_{392}+.1X_{393}+.1X_{394}+1.05X_{396}+1.05X_{398}+1.05X_{400}+1.05X_{402}+ \\
&1.05X_{404} = 240,000
\end{aligned}$$

$$\begin{aligned}
\text{Minimum Pine Requirement, Period Nine: } &1.85X_{24}+1.85X_{34}+ \\
&1.85X_{44}+1.85X_{54}+1.85X_{64}+1.75X_{88}+1.75X_{97}+1.75X_{106}+ \\
&1.75X_{115}+1.75X_{124}+1.65X_{147}+1.65X_{155}+1.65X_{163}+1.65X_{171}
\end{aligned}$$

Appendix Table 12. (Continued)

$$\begin{aligned}
&+1.65X_{179}+1.55X_{201}+1.55X_{208}+1.55X_{215}+1.55X_{232}+1.55X_{229} \\
&+1.45X_{250}+1.45X_{256}+1.45X_{262}+1.45X_{268}+1.45X_{274}+1.35X_{294} \\
&+1.35X_{299}+1.35X_{304}+1.35X_{309}+1.35X_{314}+1.25X_{333}+1.25X_{337} \\
&+1.25X_{341}+1.25X_{345}+1.25X_{349}+1.15X_{367}+1.15X_{370}+1.15X_{373} \\
&+1.15X_{376}+1.15X_{379}+X_{381}+X_{382}+X_{383}+X_{384}+X_{385}+1.05X_{396}+ \\
&1.05X_{398}+1.05X_{400}+1.05X_{402}+1.05X_{404} = 72,000
\end{aligned}$$

Maximum Oak Requirement, Period Nine: $X_{391} = 36,000$

Maximum Slab Requirement, Period Nine: $X_{392} = 40,800$

Maximum Chip Requirement, Period Nine: $X_{393} = 48,000$

Maximum Shaving Requirement, Period Nine: $X_{394} = 24,000$

Maximum Slab, Chip, and Shaving Combination Requirement,

$$\text{Period Nine: } X_{392}+X_{393}+X_{394} = 64,800$$

Amount of Open Market Pine Available, Zone 1, Period Nine:

$$X_{381}+X_{396} = 5,000$$

Amount of Open Market Pine Available, Zone 2, Period Nine:

$$X_{382}+X_{389} = 15,000$$

Amount of Open Market Pine Available, Zone 3, Period Nine:

$$X_{383}+X_{400} = 25,000$$

Amount of Open Market Pine Available Beyond Zone 3, Period

$$\text{Nine: } X_{384}+X_{402} = 35,000$$

Amount of Open Market Pine Available to be Shipped by Rail,

$$\text{Period Nine: } X_{385}+X_{404} = 45,000$$

Amount of Soft Hardwood Available, Zone 1, Period Nine:

$$X_{386} = 3,000$$

Appendix Table 12. (Continued)

Amount of Soft Hardwood Available, Zone 2, Period Nine:

$$X_{387} = 7,000$$

Amount of Soft Hardwood Available, Zone 3, Period Nine:

$$X_{388} = 11,000$$

Amount of Soft Hardwood Available Beyond Zone 3, Period Nine:

$$X_{389} = 16,000$$

Amount of Soft Hardwood Available to be Shipped by Rail,

Period Nine: $X_{390} = 20,000$

Amount of Slabs Available, Period Nine: $X_{392} = 31,200$

Amount of Chips Available, Period Nine: $X_{393} = 10,400$

Amount of Shavings Available, Period Nine: $X_{394} = 11,960$

Amount of Bare Land Available, Period Nine: $X_{395} = 7,500$

Amount of Land with Timber Available, Zone 1, Period Nine:

$$X_{396} + X_{397} = 1,000$$

Amount of Land with Timber Available, Zone 2, Period Nine:

$$X_{398} + X_{399} = 3,000$$

Amount of Land with Timber Available, Zone 3, Period Nine:

$$X_{400} + X_{401} = 5,000$$

Amount of Land with Timber Available Beyond Zone 3, Period

Nine: $X_{402} + X_{403} = 7,000$

Amount of Land with Timber Available, with Wood to be Shipped

by Rail, Period Nine: $X_{404} + X_{405} = 9,000$

Plant Pine Requirement, Period Nine: $X_{15} + .1X_{16} + .1X_{26} + .1X_{36}$
 $+ .1X_{46} + .1X_{56} + .1X_{17} + .1X_{27} + .1X_{37} + .1X_{47} + .1X_{57} + X_{80} + .1X_{81} +$

Appendix Table 12. (Continued)

$\cdot LX_{90}^+ \cdot LX_{99}^+ \cdot LX_{108}^+ \cdot LX_{117}^+ \cdot LX_{18}^+ \cdot LX_{28}^+ \cdot LX_{38}^+ \cdot LX_{48}^+ \cdot LX_{58}$
 $+ \cdot LX_{82}^+ \cdot LX_{91}^+ \cdot LX_{100}^+ \cdot LX_{109}^+ \cdot LX_{118}^+ \cdot LX_{140}^+ \cdot LX_{141}^+ \cdot LX_{149}^+$
 $\cdot LX_{157}^+ \cdot LX_{165}^+ \cdot LX_{173}^+ \cdot LX_{19}^+ \cdot LX_{29}^+ \cdot LX_{39}^+ \cdot LX_{49}^+ \cdot LX_{59}^+ \cdot LX_{83}$
 $+ \cdot LX_{92}^+ \cdot LX_{101}^+ \cdot LX_{110}^+ \cdot LX_{119}^+ \cdot LX_{142}^+ \cdot LX_{150}^+ \cdot LX_{158}^+ \cdot LX_{166}$
 $+ \cdot LX_{174}^+ \cdot LX_{195}^+ \cdot LX_{196}^+ \cdot LX_{203}^+ \cdot LX_{210}^+ \cdot LX_{217}^+ \cdot LX_{224}^+ \cdot LX_{20}^+$
 $\cdot LX_{30}^+ \cdot LX_{40}^+ \cdot LX_{50}^+ \cdot LX_{60}^+ \cdot LX_{84}^+ \cdot LX_{93}^+ \cdot LX_{102}^+ \cdot LX_{111}^+ \cdot LX_{120}$
 $+ \cdot LX_{143}^+ \cdot LX_{151}^+ \cdot LX_{159}^+ \cdot LX_{167}^+ \cdot LX_{175}^+ \cdot LX_{197}^+ \cdot LX_{204}^+ \cdot LX_{211}$
 $+ \cdot LX_{218}^+ \cdot LX_{255}^+ \cdot LX_{245}^+ \cdot LX_{246}^+ \cdot LX_{252}^+ \cdot LX_{258}^+ \cdot LX_{264}^+ \cdot LX_{270}$
 $+ \cdot LX_{21}^+ \cdot LX_{31}^+ \cdot LX_{41}^+ \cdot LX_{51}^+ \cdot LX_{61}^+ \cdot LX_{85}^+ \cdot LX_{94}^+ \cdot LX_{103}^+$
 $\cdot LX_{112}^+ \cdot LX_{121}^+ \cdot LX_{144}^+ \cdot LX_{152}^+ \cdot LX_{160}^+ \cdot LX_{168}^+ \cdot LX_{176}^+ \cdot LX_{198}$
 $+ \cdot LX_{205}^+ \cdot LX_{212}^+ \cdot LX_{219}^+ \cdot LX_{226}^+ \cdot LX_{247}^+ \cdot LX_{253}^+ \cdot LX_{259}^+$
 $\cdot LX_{265}^+ \cdot LX_{271}^+ \cdot LX_{290}^+ \cdot LX_{291}^+ \cdot LX_{296}^+ \cdot LX_{301}^+ \cdot LX_{306}^+ \cdot LX_{311}$
 $+ \cdot LX_{22}^+ \cdot LX_{32}^+ \cdot LX_{42}^+ \cdot LX_{52}^+ \cdot LX_{62}^+ \cdot LX_{86}^+ \cdot LX_{95}^+ \cdot LX_{104}^+$
 $\cdot LX_{113}^+ \cdot LX_{122}^+ \cdot LX_{145}^+ \cdot LX_{153}^+ \cdot LX_{161}^+ \cdot LX_{169}^+ \cdot LX_{177}^+$
 $\cdot LX_{199}^+ \cdot LX_{206}^+ \cdot LX_{213}^+ \cdot LX_{220}^+ \cdot LX_{227}^+ \cdot LX_{248}^+ \cdot LX_{254}^+$
 $\cdot LX_{260}^+ \cdot LX_{266}^+ \cdot LX_{272}^+ \cdot LX_{292}^+ \cdot LX_{302}^+ \cdot LX_{307}^+ \cdot LX_{312}^+$
 $\cdot LX_{330}^+ \cdot LX_{331}^+ \cdot LX_{335}^+ \cdot LX_{339}^+ \cdot LX_{343}^+ \cdot LX_{347}^+ \cdot LX_{23}^+ \cdot LX_{33}^+$
 $\cdot LX_{43}^+ \cdot LX_{53}^+ \cdot LX_{63}^+ \cdot LX_{87}^+ \cdot LX_{96}^+ \cdot LX_{105}^+ \cdot LX_{114}^+ \cdot LX_{123}^+$
 $\cdot LX_{146}^+ \cdot LX_{154}^+ \cdot LX_{162}^+ \cdot LX_{170}^+ \cdot LX_{178}^+ \cdot LX_{200}^+ \cdot LX_{207}^+$
 $\cdot LX_{214}^+ \cdot LX_{221}^+ \cdot LX_{228}^+ \cdot LX_{249}^+ \cdot LX_{225}^+ \cdot LX_{261}^+ \cdot LX_{267}^+$
 $\cdot LX_{273}^+ \cdot LX_{293}^+ \cdot LX_{298}^+ \cdot LX_{303}^+ \cdot LX_{308}^+ \cdot LX_{313}^+ \cdot LX_{332}^+$
 $\cdot LX_{336}^+ \cdot LX_{340}^+ \cdot LX_{344}^+ \cdot LX_{348}^+ \cdot LX_{365}^+ \cdot LX_{366}^+ \cdot LX_{369}^+ \cdot LX_{372}$
 $+ \cdot LX_{375}^+ \cdot LX_{378}^+ \cdot LX_{24}^+ \cdot LX_{34}^+ \cdot LX_{44}^+ \cdot LX_{54}^+ \cdot LX_{64}^+ \cdot LX_{88}^+$
 $\cdot LX_{97}^+ \cdot LX_{106}^+ \cdot LX_{115}^+ \cdot LX_{124}^+ \cdot LX_{147}^+ \cdot LX_{155}^+ \cdot LX_{163}^+ \cdot LX_{171}$

Appendix Table 12. (Continued)

$$\begin{aligned}
&+.1X_{179}+.1X_{201}+.1X_{208}+.1X_{215}+.1X_{222}+.1X_{229}+.1X_{250}+ \\
&.1X_{256}+.1X_{262}+.1X_{268}+.1X_{274}+.1X_{294}+.1X_{299}+.1X_{304}+.1X_{309} \\
&+.1X_{314}+.1X_{333}+.1X_{337}+.1X_{341}+.1X_{345}+.1X_{349}+.1X_{367}+ \\
&.1X_{370}+.1X_{373}+.1X_{375}+.1X_{379}+.1X_{395}+.1X_{396}+.1X_{398}+.1X_{400} \\
&+.1X_{402}+.1X_{404} = 54,000
\end{aligned}$$

$$\begin{aligned}
\text{Plant Capacity, Period Ten: } &1.95X_{25}+1.95X_{35}+1.95X_{45}+1.95X_{55} \\
&+1.95X_{65}+1.85X_{89}+1.85X_{98}+1.85X_{107}+1.85X_{116}+1.85X_{125}+ \\
&1.75X_{148}+1.75X_{156}+1.75X_{164}+1.75X_{172}+1.75X_{180}+1.65X_{202} \\
&+1.65X_{209}+1.65X_{216}+1.65X_{223}+1.65X_{230}+1.55X_{251}+1.55X_{257} \\
&+1.55X_{263}+1.55X_{269}+1.55X_{275}+1.45X_{295}+1.45X_{300}+1.45X_{305} \\
&+1.45X_{310}+1.45X_{315}+1.35X_{334}+1.35X_{338}+1.35X_{342}+1.35X_{346} \\
&+1.35X_{350}+1.25X_{368}+1.25X_{371}+1.25X_{374}+1.25X_{377}+1.25X_{380} \\
&+1.15X_{397}+1.15X_{399}+1.15X_{401}+1.15X_{403}+1.15X_{405}+.X_{406}+ \\
&.X_{407}+.X_{408}+.X_{409}+.X_{410}+.X_{411}+.X_{412}+.X_{413}+.X_{414}+.X_{415}+.X_{416}+.X_{417} \\
&+.X_{418}+.X_{419}+1.05X_{421}+1.05X_{422}+1.05X_{423}+1.05X_{424}+1.05X_{425} \\
&= 240,000
\end{aligned}$$

$$\begin{aligned}
\text{Minimum Pine Requirement, Period Ten: } &1.95X_{25}+1.95X_{35}+1.95X_{45} \\
&+1.95X_{55}+1.95X_{65}+1.85X_{89}+1.85X_{98}+1.85X_{107}+1.85X_{116}+ \\
&1.85X_{125}+1.75X_{148}+1.75X_{156}+1.75X_{164}+1.75X_{172}+1.75X_{180}+ \\
&1.65X_{202}+1.65X_{209}+1.65X_{216}+1.65X_{223}+1.65X_{230}+1.55X_{251}+ \\
&1.55X_{257}+1.55X_{263}+1.55X_{269}+1.55X_{275}+1.45X_{295}+1.45X_{300}+ \\
&1.45X_{305}+1.45X_{310}+1.45X_{315}+1.35X_{334}+1.35X_{338}+1.35X_{342}+ \\
&1.35X_{346}+1.35X_{350}+1.25X_{368}+1.25X_{371}+1.25X_{374}+1.25X_{377}+ \\
&1.25X_{380}+1.15X_{397}+1.15X_{399}+1.15X_{401}+1.15X_{403}+1.15X_{405}+
\end{aligned}$$

Appendix Table 12. (Continued)

$$X_{406} + X_{407} + X_{408} + X_{409} + X_{410} = 72,000$$

Maximum Oak Requirement, Period Ten: $X_{416} = 36,000$

Maximum Slab Requirement, Period Ten: $X_{417} = 40,800$

Maximum Chip Requirement, Period Ten: $X_{418} = 48,000$

Maximum Shaving Requirement, Period Ten: $X_{419} = 24,000$

Maximum Slab, Chip, and Shaving Combination Requirement,

$$\text{Period Ten: } X_{417} + X_{418} + X_{419} = 64,800$$

Amount of Open Market Pine Available, Zone 1, Period Ten:

$$X_{406} + X_{421} = 5,000$$

Amount of Open Market Pine Available, Zone 2, Period Ten:

$$X_{407} + X_{422} = 15,000$$

Amount of Open Market Pine Available, Zone 3, Period Ten:

$$X_{408} + X_{423} = 25,000$$

Amount of Open Market Pine Available Beyond Zone 3, Period

$$\text{Ten: } X_{409} + X_{424} = 35,000$$

Amount of Open Market Pine Available to be Shipped by Rail,

$$\text{Period Ten: } X_{410} + X_{425} = 45,000$$

Amount of Soft Hardwood Available, Zone 1, Period Ten: $X_{411} = 3,000$

Amount of Soft Hardwood Available, Zone 2, Period Ten:

$$X_{412} = 7,000$$

Amount of Soft Hardwood Available, Zone 3, Period Ten:

$$X_{413} = 11,000$$

Amount of Soft Hardwood Available Beyond Zone 3, Period Ten:

Appendix Table 12. (Continued)

$$X_{414} = 16,000$$

Amount of Soft Hardwood Available to be Shipped by Rail,

Period Ten: $X_{415} = 20,000$

Amount of Slabs Available, Period Ten: $X_{417} = 31,200$

Amount of Chips Available, Period Ten: $X_{418} = 10,400$

Amount of Shavings Available, Period Ten: $X_{419} = 11,960$

Amount of Bare Land Available, Period Ten: $X_{420} = 7,500$

Amount of Land with Timber Available, Zone 1, Period Ten:

$$X_{421} = 1,000$$

Amount of Land with Timber Available, Zone 2, Period Ten:

$$X_{422} = 3,000$$

Amount of Land with Timber Available, Zone 3, Period Ten:

$$X_{423} = 5,000$$

Amount of Land with Timber Available Beyond Zone 3, Period

Ten: $X_{424} = 7,000$

Amount of Land with Timber Available, with Wood to be Shipped
by Rail, Period Ten: $X_{425} = 9,000$

Plant Pine Requirement, Period Ten: $X_{15} + .1X_{16} + .1X_{26} + .1X_{36} +$
 $.1X_{46} + .1X_{56} + .1X_{17} + .1X_{27} + .1X_{37} + .1X_{47} + .1X_{57} + X_{80} + .1X_{81} +$
 $.1X_{90} + .1X_{99} + .1X_{108} + .1X_{117} + .1X_{18} + .1X_{28} + .1X_{38} + .1X_{48} + .1X_{58}$
 $+ .1X_{82} + .1X_{91} + .1X_{100} + .1X_{109} + .1X_{118} + X_{140} + .1X_{141} + .1X_{149} +$
 $.1X_{157} + .1X_{165} + .1X_{173} + .1X_{19} + .1X_{29} + .1X_{39} + .1X_{49} + .1X_{59} + .1X_{83}$
 $+ .1X_{92} + .1X_{101} + .1X_{110} + .1X_{119} + .1X_{142} + .1X_{150} + .1X_{158} + .1X_{166}$
 $+ .1X_{174} + X_{195} + .1X_{196} + .1X_{203} + .1X_{210} + .1X_{217} + .1X_{224} + .1X_{20} +$

Appendix Table 12. (Continued)

$.1X_{30}+.1X_{40}+.1X_{50}+.1X_{60}+.1X_{84}+.1X_{93}+.1X_{102}+.1X_{111}+$
 $.1X_{120}+.1X_{143}+.1X_{151}+.1X_{159}+.1X_{167}+.1X_{175}+.1X_{197}+.1X_{204}$
 $+.1X_{211}+.1X_{218}+.1X_{255}+.1X_{245}+.1X_{246}+.1X_{252}+.1X_{258}+.1X_{264}$
 $+.1X_{270}+.1X_{21}+.1X_{31}+.1X_{41}+.1X_{51}+.1X_{61}+.1X_{85}+.1X_{94}+$
 $.1X_{103}+.1X_{112}+.1X_{121}+.1X_{144}+.1X_{152}+.1X_{160}+.1X_{168}+.1X_{176}$
 $+.1X_{198}+.1X_{205}+.1X_{212}+.1X_{219}+.1X_{226}+.1X_{247}+.1X_{253}+$
 $.1X_{259}+.1X_{265}+.1X_{271}+.1X_{290}+.1X_{291}+.1X_{296}+.1X_{301}+.1X_{306}$
 $+.1X_{311}+.1X_{22}+.1X_{32}+.1X_{42}+.1X_{52}+.1X_{62}+.1X_{86}+.1X_{95}+$
 $.1X_{104}+.1X_{113}+.1X_{122}+.1X_{145}+.1X_{153}+.1X_{161}+.1X_{169}+$
 $.1X_{177}+.1X_{199}+.1X_{206}+.1X_{213}+.1X_{220}+.1X_{227}+.1X_{248}+$
 $.1X_{254}+.1X_{260}+.1X_{266}+.1X_{272}+.1X_{292}+.1X_{302}+.1X_{307}+$
 $.1X_{312}+.1X_{330}+.1X_{331}+.1X_{335}+.1X_{339}+.1X_{343}+.1X_{347}+.1X_{23}$
 $+.1X_{33}+.1X_{43}+.1X_{53}+.1X_{63}+.1X_{87}+.1X_{96}+.1X_{105}+.1X_{114}+$
 $.1X_{123}+.1X_{146}+.1X_{154}+.1X_{162}+.1X_{170}+.1X_{178}+.1X_{200}+$
 $.1X_{207}+.1X_{214}+.1X_{221}+.1X_{228}+.1X_{249}+.1X_{225}+.1X_{261}+$
 $.1X_{267}+.1X_{273}+.1X_{293}+.1X_{298}+.1X_{303}+.1X_{308}+.1X_{313}+$
 $.1X_{332}+.1X_{336}+.1X_{340}+.1X_{344}+.1X_{348}+.1X_{365}+.1X_{366}+.1X_{369}$
 $+.1X_{372}+.1X_{375}+.1X_{378}+.1X_{24}+.1X_{34}+.1X_{44}+.1X_{54}+.1X_{64}+$
 $.1X_{88}+.1X_{97}+.1X_{106}+.1X_{115}+.1X_{124}+.1X_{147}+.1X_{155}+.1X_{163}$
 $+.1X_{171}+.1X_{179}+.1X_{201}+.1X_{208}+.1X_{215}+.1X_{222}+.1X_{229}+$
 $.1X_{250}+.1X_{256}+.1X_{262}+.1X_{268}+.1X_{274}+.1X_{294}+.1X_{299}+$
 $.1X_{304}+.1X_{309}+.1X_{314}+.1X_{333}+.1X_{337}+.1X_{341}+.1X_{345}+$
 $.1X_{349}+.1X_{367}+.1X_{370}+.1X_{373}+.1X_{376}+.1X_{379}+.1X_{395}+$
 $.1X_{396}+.1X_{398}+.1X_{400}+.1X_{402}+.1X_{404}+.1X_{25}+.1X_{35}+.1X_{45}$

Appendix Table 12. (Continued)

$+ .1X_{55} + .1X_{65} + .1X_{89} + .1X_{98} + .1X_{107} + .1X_{116} + .1X_{125} + .1X_{148} +$
 $.1X_{156} + .1X_{164} + .1X_{172} + .1X_{180} + .1X_{202} + .1X_{209} + .1X_{216} +$
 $.1X_{223} + .1X_{230} + .1X_{251} + .1X_{257} + .1X_{263} + .1X_{269} + .1X_{275} + .1X_{295}$
 $+ .1X_{300} + .1X_{305} + .1X_{310} + .1X_{315} + .1X_{334} + .1X_{338} + .1X_{342} +$
 $.1X_{346} + .1X_{350} + .1X_{368} + .1X_{371} + .1X_{374} + .1X_{377} + .1X_{380} + .1X_{397}$
 $+ .1X_{399} + .1X_{401} + .1X_{403} + .1X_{405} + .1X_{420} + .1X_{421} + .1X_{422} + .1X_{423}$
 $+ .1X_{424} + .1X_{425} = 60,000$

Appendix Table 13. Results of
Study for Price Policy I

Period Purchased	Period Used	Alternative	Amount of Alternative Used	
1967-1968	1967-1968	X ₁	4,000	Cords
"	1967-1968	X ₂	12,000	Cords
"	1967-1968	X ₃	20,000	Cords
"	1967-1968	X ₄	28,000	Cords
"	1967-1968	X ₅	36,000	Cords
"	1967-1968	X ₆	3,000	Cords
"	1967-1968	X ₇	7,000	Cords
"	1967-1968	X ₈	11,000	Cords
"	1967-1968	X ₉	16,000	Cords
"	1967-1968	X ₁₀	20,000	Cords
"	1967-1968	X ₁₁	36,000	Cords
"	1967-1968	X ₁₂	31,200	Cords
"	1967-1968	X ₁₄	11,960	Cords
"	1967-1968	X ₁₅	5,634	Acres
"	1977-1978	X ₂₁	1,000	Cords
"	1977-1978	X ₃₁	3,000	Cords
"	1977-1978	X ₄₁	5,000	Cords
"	1975-1976	X ₅₀	7,000	Cords
"	1967-1968	X ₅₆	3,657	Cords
"	1973-1974	X ₅₉	5,342	Cords

Appendix Table 13. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used
1969-1970	1969-1970	X ₆₆	4,000 Cords
1969-1970	1969-1970	X ₆₇	12,000 Cords
"	1969-1970	X ₆₈	20,000 Cords
"	1969-1970	X ₆₉	28,000 Cords
"	1969-1970	X ₇₀	36,000 Cords
"	1969-1970	X ₇₁	3,000 Cords
"	1969-1970	X ₇₂	7,000 Cords
"	1969-1970	X ₇₃	11,000 Cords
"	1969-1970	X ₇₄	16,000 Cords
"	1969-1970	X ₇₅	20,000 Cords
"	1969-1970	X ₇₆	35,000 Cords
"	1969-1970	X ₇₇	31,200 Cords
"	1969-1970	X ₇₉	11,960 Cords
"	1969-1970	X ₈₀	5,634 Acres
"	1981-1982	X ₈₇	1,000 Cords
"	1977-1978	X ₉₄	3,000 Cords
"	1979-1980	X ₁₀₄	5,000 Cords
"	1975-1976	X ₁₁₁	7,000 Cords
"	1969-1970	X ₁₁₇	3,557 Cords
"	1975-1976	X ₁₂₀	3,502 Cords
"	1977-1978	X ₁₂₁	1,840 Cords

Appendix Table 13. (Continued)

Period Purchased	Period Used	Alternatives	Amount of Alternative Used	
1971-1972	1971-1972	X ₁₂₆	4,000	Cords
"	1971-1972	X ₁₂₇	12,000	Cords
"	1971-1972	X ₁₂₈	20,000	Cords
"	1971-1972	X ₁₂₉	28,000	Cords
"	1971-1972	X ₁₃₀	36,000	Cords
"	1971-1972	X ₁₃₁	3,000	Cords
"	1971-1972	X ₁₃₂	7,000	Cords
"	1971-1972	X ₁₃₃	11,000	Cords
"	1971-1972	X ₁₃₄	16,000	Cords
"	1971-1972	X ₁₃₅	20,000	Cords
"	1971-1972	X ₁₃₆	36,000	Cords
"	1971-1972	X ₁₃₇	31,200	Cords
"	1971-1972	X ₁₃₉	11,960	Cords
"	1971-1972	X ₁₄₀	5,364	Acres
"	1981-1982	X ₁₄₆	1,000	Cords
"	1979-1980	X ₁₅₃	3,000	Cords
"	1981-1982	X ₁₆₂	5,000	Cords
"	1979-1980	X ₁₆₉	7,000	Cords
"	1971-1972	X ₁₇₃	3,657	Cords
"	1977-1978	X ₁₇₆	1,690	Cords
"	1979-1980	X ₁₇₇	3,652	Cords

Appendix Table 13. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used
1973-1974	1973-1974	X ₁₈₁	4,000 Cords
"	1973-1974	X ₁₈₂	12,000 Cords
"	1973-1974	X ₁₈₃	20,000 Cords
"	1973-1974	X ₁₈₄	28,000 Cords
"	1973-1974	X ₁₈₅	23,177 Cords
"	1973-1974	X ₁₈₆	3,000 Cords
"	1973-1974	X ₁₈₇	7,000 Cords
"	1973-1974	X ₁₈₈	11,000 Cords
"	1973-1974	X ₁₈₉	16,000 Cords
"	1973-1974	X ₁₉₀	20,000 Cords
"	1973-1974	X ₁₉₁	36,000 Cords
"	1973-1974	X ₁₉₂	31,200 Cords
"	1973-1974	X ₁₉₄	11,960 Cords
"	1973-1974	X ₁₉₅	4,566 Acres
"	1983-1984	X ₂₀₁	1,000 Cords
"	1983-1984	X ₂₀₈	3,000 Cords
"	1981-1982	X ₂₁₄	5,000 Cords
"	1979-1980	X ₂₂₀	3,662 Cords
"	1981-1982	X ₂₂₁	3,338 Cords
"	1973-1974	X ₂₂₄	9,000 Cords

Appendix Table 13. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used	
1975-1976	1975-1976	X ₂₃₁	4,000	Cords
"	1975-1976	X ₂₃₂	12,000	Cords
"	1975-1976	X ₂₃₃	20,000	Cords
"	1975-1976	X ₂₃₄	28,000	Cords
"	1975-1976	X ₂₃₆	3,000	Cords
"	1975-1976	X ₂₃₇	7,000	Cords
"	1975-1976	X ₂₃₈	11,000	Cords
"	1975-1976	X ₂₃₉	16,000	Cords
"	1975-1976	X ₂₄₀	20,000	Cords
"	1975-1976	X ₂₄₁	36,000	Cords
"	1975-1976	X ₂₄₂	31,200	Cords
"	1975-1976	X ₂₄₄	11,960	Cords
"	1975-1976	X ₂₄₅	2,772	Acres
"	1983-1984	X ₂₅₀	1,000	Cords
"	1983-1984	X ₂₅₆	3,000	Cords
"	1983-1984	X ₂₆₂	5,000	Cords
"	1975-1976	X ₂₆₄	5,773	Cords
"	1983-1984	X ₂₆₈	1,226	Cords
"	1975-1976	X ₂₇₀	9,000	Cords
1977-1978	1977-1978	X ₂₇₆	4,000	Cords
"	1977-1978	X ₂₇₇	12,000	Cords
"	1977-1978	X ₂₇₈	20,000	Cords

Appendix Table 13. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used
1977-1978	1977-1978	X ₂₇₉	28,000 Cords
"	1977-1978	X ₂₈₁	3,000 Cords
"	1977-1978	X ₂₈₂	7,000 Cords
"	1977-1978	X ₂₈₃	11,000 Cords
"	1977-1978	X ₂₈₄	16,000 Cords
"	1977-1978	X ₂₈₅	20,000 Cords
"	1977-1978	X ₂₈₆	36,000 Cords
"	1977-1978	X ₂₈₇	31,200 Cords
"	1977-1978	X ₂₈₉	11,960 Cords
"	1977-1978	X ₂₉₀	2,867 Acres
"	1985-1986	X ₂₉₅	1,000 Cords
"	1985-1986	X ₃₀₀	3,000 Cords
"	1983-1984	X ₃₀₄	1,490 Cords
"	1985-1986	X ₃₀₅	3,510 Cords
"	1977-1978	X ₃₀₆	7,000 Cords
"	1977-1978	X ₃₁₁	8,799 Cords
1979-1980	1979-1980	X ₃₁₆	4,000 Cords
"	1979-1980	X ₃₁₇	12,000 Cords
"	1979-1980	X ₃₁₈	20,000 Cords
"	1979-1980	X ₃₁₉	28,000 Cords
"	1979-1980	X ₃₂₁	3,000 Cords
"	1979-1980	X ₃₂₂	7,000 Cords

Appendix Table 13. (Continued)

Period Purchased	Period Used	Alternatives	Amount of Alternative Used	
1979-1980	1979-1980	X ₃₂₃	11,000	Cords
"	1979-1980	X ₃₂₄	16,000	Cords
"	1979-1980	X ₃₂₅	20,000	Cords
"	1979-1980	X ₃₂₆	36,000	Cords
"	1979-1980	X ₃₂₇	31,200	Cords
"	1979-1980	X ₃₂₉	11,960	Cords
"	1979-1980	X ₃₃₀	3,069	Acres
"	1985-1986	X ₃₃₄	1,000	Cords
"	1985-1986	X ₃₃₈	3,000	Cords
"	1985-1986	X ₃₄₂	5,000	Cords
"	1979-1980	X ₃₄₃	7,000	Cords
1981-1982	1981-1982	X ₃₅₁	4,000	Cords
"	1981-1982	X ₃₅₂	12,000	Cords
"	1981-1982	X ₃₅₃	20,000	Cords
"	1981-1982	X ₃₅₄	28,000	Cords
"	1981-1982	X ₃₅₆	3,000	Cords
"	1981-1982	X ₃₅₇	7,000	Cords
"	1981-1982	X ₃₅₈	11,000	Cords
"	1981-1982	X ₃₅₉	16,000	Cords
"	1981-1982	X ₃₆₀	20,000	Cords
"	1981-1982	X ₃₆₁	36,000	Cords
"	1981-1982	X ₃₆₂	31,200	Cords

Appendix Table 13. (Continued)

Period Purchased	Period Used	Alternatives	Amount of Alternatives Used
1981-1982	1981-1982	X ₃₆₄	11,960 Cords
"	1981-1982	X ₃₆₅	2,866 Acres
"	1981-1982	X ₃₆₆	1,000 Cords
"	1981-1982	X ₃₆₉	3,000 Cords
"	1981-1982	X ₃₇₂	5,000 Cords
"	1981-1982	X ₃₇₅	7,000 Cords
1983-1984	1983-1984	X ₃₈₁	4,000 Cords
"	1983-1984	X ₃₈₂	12,000 Cords
"	1983-1984	X ₃₈₃	20,000 Cords
"	1983-1984	X ₃₈₄	28,000 Cords
"	1983-1984	X ₃₈₆	3,000 Cords
"	1983-1984	X ₃₈₇	7,000 Cords
"	1983-1984	X ₃₈₈	11,000 Cords
"	1983-1984	X ₃₈₉	16,000 Cords
"	1983-1984	X ₃₉₀	20,000 Cords
"	1983-1984	X ₃₉₁	36,000 Cords
"	1983-1984	X ₃₉₂	31,200 Cords
"	1983-1984	X ₃₉₄	11,960 Cords
"	1983-1984	X ₃₉₅	2,828 Acres
"	1983-1984	X ₃₉₆	1,000 Cords
"	1983-1984	X ₃₉₈	3,000 Cords
"	1983-1984	X ₄₀₀	5,000 Cords
"	1983-1984	X ₄₀₂	7,000 Cords

Appendix Table 13. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used
1985-1986	1985-1986	X ₄₀₆	4,000 Cords
"	1985-1986	X ₄₀₇	12,000 Cords
"	1985-1986	X ₄₀₈	20,000 Cords
"	1985-1986	X ₄₀₉	28,000 Cords
"	1985-1986	X ₄₁₁	3,000 Cords
"	1985-1986	X ₄₁₂	7,000 Cords
"	1985-1986	X ₄₁₃	11,000 Cords
"	1985-1986	X ₄₁₄	16,000 Cords
"	1985-1986	X ₄₁₅	20,000 Cords
"	1985-1986	X ₄₁₆	36,000 Cords
"	1985-1986	X ₄₁₇	31,200 Cords
"	1985-1986	X ₄₁₉	11,960 Cords
"	1985-1986	X ₄₂₀	2,749 Acres
"	1985-1986	X ₄₂₁	1,000 Cords
"	1985-1986	X ₄₂₂	3,000 Cords
"	1985-1986	X ₄₂₃	5,000 Cords
"	1985-1986	X ₄₂₄	7,000 Cords

Appendix Table 14. Results of study for
Bridge Policies II, III, and IV

Period Purchased	Period Used	Alternative	Amount of Alternative Used	
1967-1968	1967-1968	X ₁	5,000	Cords
"	1967-1968	X ₂	15,000	Cords
"	1967-1968	X ₃	25,000	Cords
"	1967-1968	X ₄	35,000	Cords
"	1967-1968	X ₅	23,840	Cords
"	1967-1968	X ₆	3,000	Cords
"	1967-1968	X ₇	7,000	Cords
"	1967-1968	X ₈	11,000	Cords
"	1967-1968	X ₉	16,000	Cords
"	1967-1968	X ₁₀	20,000	Cords
"	1967-1968	X ₁₁	36,000	Cords
"	1967-1968	X ₁₂	31,200	Cords
"	1967-1968	X ₁₄	11,960	Cords
"	1967-1968	X ₁₅	6,000	Aores
1969-1970	1969-1970	X ₆₆	5,000	Cords
"	1969-1970	X ₆₇	15,000	Cords
"	1969-1970	X ₆₈	25,000	Cords
"	1969-1970	X ₆₉	35,000	Cords
"	1969-1970	X ₇₀	23,840	Cords
"	1969-1970	X ₇₁	3,000	Cords
"	1969-1970	X ₇₂	7,000	Cords

Appendix Table 14. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used	
1969-1970	1969-1970	X ₇₃	11,000	Cords
"	1969-1970	X ₇₄	16,000	Cords
"	1969-1970	X ₇₅	20,000	Cords
"	1969-1970	X ₇₆	36,000	Cords
"	1969-1970	X ₇₇	31,200	Cords
"	1969-1970	X ₇₉	11,960	Cords
"	1969-1970	X ₈₀	6,000	Acres
1971-1972	1971-1972	X ₁₂₆	5,000	Cords
"	1971-1972	X ₁₂₇	15,000	Cords
"	1971-1972	X ₁₂₈	25,000	Cords
"	1971-1972	X ₁₂₉	35,000	Cords
"	1971-1972	X ₁₃₀	23,840	Cords
"	1971-1972	X ₁₃₁	3,000	Cords
"	1971-1972	X ₁₃₂	7,000	Cords
"	1971-1972	X ₁₃₃	11,000	Cords
"	1971-1972	X ₁₃₄	16,000	Cords
"	1971-1972	X ₁₃₅	20,000	Cords
"	1971-1972	X ₁₃₆	36,000	Cords
"	1971-1972	X ₁₃₇	31,200	Cords
"	1971-1972	X ₁₃₉	11,960	Cords
"	1971-1972	X ₁₄₀	6,000	Acres

Appendix Table 14. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used	
1973-1974	1973-1974	X ₁₈₁	5,000	Cords
"	1973-1974	X ₁₈₂	15,000	Cords
"	1973-1974	X ₁₈₃	25,000	Cords
"	1973-1974	X ₁₈₄	35,000	Cords
"	1973-1974	X ₁₈₅	23,840	Cords
"	1973-1974	X ₁₈₆	3,000	Cords
"	1973-1974	X ₁₈₇	7,000	Cords
"	1973-1974	X ₁₈₈	11,000	Cords
"	1973-1974	X ₁₈₉	16,000	Cords
"	1973-1974	X ₁₉₀	20,000	Cords
"	1973-1974	X ₁₉₁	36,000	Cords
"	1973-1974	X ₁₉₂	31,200	Cords
"	1973-1974	X ₁₉₄	11,960	Cords
"	1973-1974	X ₁₉₅	6,000	Acres
1975-1976	1975-1976	X ₂₃₁	5,000	Cords
"	1975-1976	X ₂₃₂	15,000	Cords
"	1975-1976	X ₂₃₃	25,000	Cords
"	1975-1976	X ₂₃₄	35,000	Cords
"	1975-1976	X ₂₃₅	23,840	Cords
"	1975-1976	X ₂₃₆	3,000	Cords
"	1975-1976	X ₂₃₇	7,000	Cords
"	1975-1976	X ₂₃₈	11,000	Cords
"	1975-1976	X ₂₃₉	16,000	Cords

Appendix Table 14. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used	
1975-1976	1975-1976	X ₂₄₀	20,000	Cords
"	1975-1976	X ₂₄₁	36,000	Cords
"	1975-1976	X ₂₄₂	31,200	Cords
"	1975-1976	X ₂₄₄	11,960	Cords
"	1975-1976	X ₂₄₅	6,000	Acres
1977-1978	1977-1978	X ₂₇₆	5,000	Cords
"	1977-1978	X ₂₇₇	15,000	Cords
"	1977-1978	X ₂₇₈	25,000	Cords
"	1977-1978	X ₂₇₉	35,000	Cords
"	1977-1978	X ₂₈₀	23,840	Cords
"	1977-1978	X ₂₈₁	3,000	Cords
"	1977-1978	X ₂₈₂	7,000	Cords
"	1977-1978	X ₂₈₃	11,000	Cords
"	1977-1978	X ₂₈₄	16,000	Cords
"	1977-1978	X ₂₈₅	20,000	Cords
"	1977-1978	X ₂₈₆	36,000	Cords
"	1977-1979	X ₂₈₇	31,200	Cords
"	1977-1978	X ₂₈₉	11,960	Cords
"	1977-1978	X ₂₉₀	6,000	Acres
1979-1980	1979-1980	X ₃₁₆	5,000	Cords
"	1979-1980	X ₃₁₇	15,000	Cords
"	1979-1980	X ₃₁₈	25,000	Cords

Appendix Table 14. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used	
1979-1980	1979-1980	X ₃₁₉	35,000	Cords
"	1979-1980	X ₃₂₀	23,840	Cords
"	1979-1980	X ₃₂₁	3,000	Cords
"	1979-1980	X ₃₂₂	7,000	Cords
"	1979-1980	X ₃₂₃	11,000	Cords
"	1979-1980	X ₃₂₄	16,000	Cords
"	1979-1980	X ₃₂₅	20,000	Cords
"	1979-1980	X ₃₂₆	36,000	Cords
"	1979-1980	X ₃₂₇	31,200	Cords
"	1979-1980	X ₃₂₉	11,960	Cords
"	1979-1980	X ₃₃₀	6,000	Acres
1981-1982	1981-1982	X ₃₅₁	5,000	Cords
"	1981-1982	X ₃₅₂	15,000	Cords
"	1981-1982	X ₃₅₃	25,000	Cords
"	1981-1982	X ₃₅₄	35,000	Cords
"	1981-1982	X ₃₅₅	23,840	Cords
"	1981-1982	X ₃₅₆	3,000	Cords
"	1981-1982	X ₃₅₇	7,000	Cords
"	1981-1982	X ₃₅₈	11,000	Cords
"	1981-1982	X ₃₅₉	16,000	Cords
"	1981-1982	X ₃₆₀	20,000	Cords
"	1981-1982	X ₃₆₁	36,000	Cords

Appendix Table 14. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used	
1981-1982	1981-1982	X ₃₆₂	31,200	Cords
"	1981-1982	X ₃₆₄	11,960	Cords
"	1981-1982	X ₃₆₅	6,000	Acres
1983-1984	1983-1984	X ₃₈₁	5,000	Cords
"	1983-1984	X ₃₈₂	15,000	Cords
"	1985-1984	X ₃₈₃	25,000	Cords
"	1985-1984	X ₃₈₄	35,000	Cords
"	1983-1984	X ₃₈₅	23,840	Cords
"	1983-1984	X ₃₈₆	3,000	Cords
"	1983-1984	X ₃₈₇	7,000	Cords
"	1983-1984	X ₃₈₈	11,000	Cords
"	1983-1984	X ₃₈₉	16,000	Cords
"	1983-1984	X ₃₉₀	20,000	Cords
"	1983-1984	X ₃₉₁	36,000	Cords
"	1983-1984	X ₃₉₂	31,200	Cords
"	1983-1984	X ₃₉₄	11,960	Cords
"	1983-1984	X ₃₉₅	6,000	Acres
1985-1986	1985-1986	X ₄₀₆	5,000	Cords
"	1985-1986	X ₄₀₇	15,000	Cords
"	1985-1986	X ₄₀₈	25,000	Cords
"	1985-1986	X ₄₀₉	35,000	Cords
"	1985-1986	X ₄₁₀	23,840	Cords

Appendix Table 14. (Continued)

Period Purchased	Period Used	Alternative	Amount of Alternative Used	
1985-1986	1985-1986	X ₄₁₁	3,000	Cords
"	1985-1986	X ₄₁₂	7,000	Cords
"	1985-1986	X ₄₁₃	11,000	Cords
"	1985-1986	X ₄₁₄	16,000	Cords
"	1985-1986	X ₄₁₅	20,000	Cords
"	1985-1986	X ₄₁₆	36,000	Cords
"	1985-1986	X ₄₁₇	31,200	Cords
"	1985-1986	X ₄₁₉	11,960	Cords
"	1985-1986	X ₄₂₀	6,000	Acres

Appendix Table 15. Present value cost
for the twenty year study

Price Policy	Total Present Value Cost
I (land \$40.00/acre, stumpage \$6.00/cord)	\$18,697,775.00
II (land \$40.00/acre, stumpage \$8.00/cord)	\$18,766,265.00
III (land \$60.00/acre, stumpage \$6.00/cord)	\$19,224,125.00
IV (land \$60.00/acre, stumpage \$8.00/cord)	\$19,224,125.00

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A LINEAR PROGRAMMING APPROACH TO MINIMIZING
WOOD PROCUREMENT COSTS FOR INTEGRATED
FOREST PRODUCTS FIRMS

by

Walter Bordley Tilghman

ABSTRACT

A linear programming cost minimization problem is presented to demonstrate the applicability of the technique to problems inherent in the forest management decision making process. A case study of an integrated forest products firm with the objective of minimizing the present value cost of wood procurement over a 20 year study is solved by a computer using the firm's present and three alternate price structures. The study is implemented with the product quality constraints and a managerial constraint of the firm and incorporates timber growth into the selection of procurement alternatives.

The minimum present value cost solutions of the four price structures studied are presented and discussed. Additional information regarding the stability of the solution to changes in future expectations, easily obtained by various computer agendums, is evaluated.