Harvest Scheduling as a Timber Appraisal Tool

By Christopher N. Singleton and Thomas J. Straka

Abstract

Appraisers often value a forest that contains many different timber stands that can vary due to factors such as age, stocking, species, and site index. Many assumptions are possible on how the various stands will be harvested and what subsequent cash flows might be generated. We describe harvest scheduling methodology that is widely used to obtain the net present value of such a forest under optimal conditions. We illustrate how a popular software package can be used by appraisers to obtain optimal discounted cash flows using harvest scheduling and resulting timber stand values.

Background

Appraisers often value a forest that contains many different timber stands that can vary due to factors such as age, stocking, species, and site index. If the objective is to obtain the value of the entire forest many assumptions are possible on how the various stands will be harvested and what subsequent cash flows might be generated (Boykin, 2001). We describe a widely-utilized forestry optimization technique that can be used to obtain the value of such a forest under optimal conditions.

Even more challenging is valuing such a forest subject to harvesting constraints, cash flow constraints, or other operational constraints. For example, what is the value of the forest if a contract requires harvesting timber sufficient to generate $100,000 annually? This technique is ideally suited to operational constraints that often confront an appraiser in forestry situations.

How Does Harvest Scheduling Work?

Harvest scheduling is the use of optimization techniques to obtain a temporal sequence of timber harvesting options that will produce a maximum or minimum value for an objective function. It usually involves mathematical programming, specifically linear programming, and an objective that is optimized in terms of a production or financial criterion. The objective function is a mathematical expression of the thing being optimized. Four common objectives that are optimized relative to timber are: 1) maximize net present value; 2) maximize bare land value; (3) maximize timber production; and (4) minimize timber cost.

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The harvesting decision in timber management involves a huge number of variables that impact cash flow and eventually forest value (e.g., age at harvest, planting density, timing of thinnings, spatial pattern of the forest, and silvicultural treatments). These variables ultimately result in forest structure and age class distributions that produce a flow of timber products and, thus, a cash flow (Klemperer, 1996). Variable manipulation is complex and any serious effort to maximize or minimize an objective function requires the use of mathematical programming.

When an appraiser considers the valuation of a forest, he or she converts the forest output into a cash flow series. That is, the basis of timber valuation is discounted cash flow analysis. Simply speaking, the appraiser needs to know the timing of forest costs and revenues and, if optimal value is the goal, also the pattern of these cash flows under optimal conditions. Short-term requirements involve knowing how to manage and harvest the existing forest. What is the best sequence of management actions and the best age to harvest the existing forest? Long-term requirements involve managing the future forest under the best yielding management regime (sequence of management actions).

Optimality then means identifying the management pattern (operational, silvicultural, spatial, and temporal) that will produce the highest (maximum) net present value or bare land value. Bare land value (or land expectation value) is the net present value of all future timber rotations on a bare area of forest land. Since it considers all future timber rotations, it is considered the proper discounted cash flow technique to use in harvest scheduling (Clutter, et al., 1983).

There is a second major component that involves using linear programming (LP) to determine the optimum value of a forest. LP allows the user to solve for the optimal value subject to a set of constraints. This allows for a more realistic estimate of value since few forests in the real world are not subject to constraints. Examples of timber harvesting related constraints are: (1) specified revenue requirements over time, (2) specified timber flow over time, (3) specified cash flow over time, and (4) acre distribution over time.

LP offers the opportunity to express the constraints in flexible terms. They do not have to be absolute (e.g., cubic foot output of the forest must exceed 100,000 cubic feet per year,) but can be a range, like output should be between 100,000 and 300,000 cubic feet per year or the first thinning should occur between ages 14 and 20. Constraints are generally operational criteria and appraisers should ensure that all constraints are market-based.

The objective function should also be market-based. The usual harvest scheduling problem involves some sort of maximization of discounted cash flow resulting from permanent timber production measured in terms of maximizing bare land value (which is nothing more than maximizing the net present value of all timber rotations in perpetuity). However, the appraiser's client may be an institutional investor with a 10- to 15-year planning horizon. The LP model then would use a 10- to 15-year planning horizon and a residual value would be calculated and included in the analysis to account for timber harvests past the planning horizon.

Likewise, constraints can easily approximate real world limitations. For example, the land might have been purchased from a timber company and be subject to a long-term cutting arrangement that specifies wood flow for a fixed number of years. The land could be subject to a conservation easement that specifies harvest age limitations, maximum harvest block sizes, or time limits for adjacent stands to be harvested (Davis, et al., 2001).

A Simple Harvest Scheduling Example

This description is based on the MAX-MILLION harvest scheduling model. It is the classic harvest scheduling model and the easiest to understand. First, four terms must be defined: 1) planning horizon; 2) cutting period; (3) cutting unit; and (4) management regime (Bullard and Straka, 1998).

Planning horizon is the time period over which the harvests will be scheduled. This limits the size of the problem. Two or three timber rotation lengths is a common planning horizon. In the South, 50 to 60 years is often used. For an institutional investor with a short investment length, 10 to 15 years would be more common (with a discounted reversion value of harvests extending past the planning horizon).

The planning horizon is broken into cutting periods as short as a year or of several years in length. Cutting period length depends on how accurately harvests need to be determined. Often longer periods are used to limit problem size. Perhaps annual harvests are used for the first few years where accurate forecasts are needed and longer cutting periods are used later in the planning horizon. Factors like weather and tree species may make precise harvest schedules impracticable, so annual cutting periods may not make sense. Multi-year cutting periods are common for northern hardwoods, for example. For an institutional investor with a short 10- to 15-year planning horizon, annual cutting periods would make sense. By the time the planning horizon ends, the forest's cash flows have developed a pattern that can easily be discounted to include a residual value. So, perpetual cash flows are part of the model.

Cutting units are the areas of the forest to be scheduled for harvest. These might be timber stands or age classes of trees. A management regime is the schedule of planned activities on a particular cutting unit. For example, a management regime might be to perform site preparation at year 1, plant trees at year 2, thin the stand at year 17, and harvest the stand at year 25. Each management regime represents a management option for a cutting unit and the model allocates acres from each cutting unit to the optimal management regime to achieve the objective. Note that each management regime represents a cash flow series. All thinnings and harvests have known yields in the model and are converted into cash flows. All other activities represent costs and revenues. The model is ideally suited to produce discounted cash flows that can be maximized. That is what an appraiser is often seeking.

An example problem will illustrate these concepts. Consider a short planning horizon of 20 years, with four 5-year cutting periods. Current age of the timber is 20 years. The owner does not want timber age to exceed 40 years. One thinning is allowed between the ages of 20 and 40, and at least 10 years must separate a thinning and a harvest. These simple limitations keep the number of management regimes down to seven. All activities are assumed to occur at the midpoint of the cutting period.

Figure 1 shows the seven management regimes. In regime one, harvest at cutting period 1 (age 22.5), and do not harvest or thin again as the timber will not be old enough. Since harvest with no thinning is allowed until age 40, management regimes 2, 3, and 4 give the other options of later harvests. Regimes 5, 6, and 7 show the options of thinning and then harvesting later. The harvests and thinnings in the table are converted into timber yields and then equivalent cash flows. All other activities (like prescribed fire, fertilizer, herbicide, property taxes, and management fee) are included in the discounted cash flow for each regime.

How are an objective function and constraints developed? Consider a second example of a 600-acre forest consisting of a low quality pine-hardwood forest type. The forest currently has two stands, mainly differentiated from each other on the basis of site productivity. Stand 1 has 250 acres and stand 2 has 350 acres. The owner's goal is to maximize discounted cash flow over a 30-year planning horizon. Cutting periods will be ten years to keep things simple. The owner desires an equal number of acres be cut over the 30 years in each cutting period so that he ends up with three stands ten years apart in age. Table 1 gives the yield of the stands in cubic feet for each of the cutting periods. If we assume wood is worth \$0.50 cents a cubic foot and that the discount rate is six percent, yields can be reduced to discounted cash flows (using the midpoint assumption, discounted for 5, 15, and 25 years). Table 2 shows the results of this process.

Our LP problem is how many acres to harvest from each of the two stands in each of the three cutting periods. LP models usually define decision variables as X_{ij} where this equals the acres harvested from stand "I" in cutting period "j." In this example, "i" equals 1 or 2 and "j" equals 1, 2, or 3. The problem then has six decision variables: X_{11}, X_{12}, X_{13}, X_{21}, X_{22}, and X_{23}. Note that the last variable in the series is the number of acres harvested from stand 2 in cutting period 3. Our objective (usually defined as Z) is to maximize discounted cash flow and we calculated those values in Table 2, so the objective function can be stated as:

$$\text{Maximize } Z = 205.12 X_{11} + 542.44X_{12} + 454.81X_{13} + 310.86X_{21} + 816.80X_{22} + 640.16X_{23}$$

The first set of constraints deals with acreage restrictions. Stand 1 has 250 acres and stand 2 has 350 acres. This requires two constraints:

$$X11 + X12 + X13 \leq 250 \text{ acres}$$
$$X21 + X22 + X23 \leq 350 \text{ acres}$$

The owner also requires that one-third of the acreage be harvested during each 10-year cutting period. This will lead to what is called a fully-regulated forest with three 200-acre stands (one stand 1 to 10 years old, one stand 11 to 20 years old, and one stand 21 to 30 years old). The set of constraints to accomplish this are:

$$X11 + X21 = 200 \text{ acres}$$
$$X12 + X22 = 200 \text{ acres}$$
$$X13 + X23 = 200 \text{ acres}$$

There is one other implied constraint LP models handle automatically and that is all decision variables have to be greater than zero. That is, for example, there can't be negative acres in one cutting unit. The full LP model is shown in Figure 2 and was solved using the EXCEL add-in program Solver.

When the problem is solved, Z = $323,148.50 and the optimal solution is shown in Table 3. The optimal solution is to cut 200 acres of stand 1 in cutting period 1, 200 acres of stand 2 in cutting period 2, and to cut 50 acres of stand 1 and 150 acres of stand 2 in cutting period 3. Note that 250 acres are cut from stand 1 and 350 acres from stand 2.

Also, 200 acres are cut in each time period. All constraints are satisfied. Figure 3 illustrates actual computer output for this problem using Solver type software.

Without constraints the solution to this problem would be to cut all of stand 1 in cutting period 2 and all of stand 2 in cutting period 2, since cutting period 2 had the highest discounted cash flows in both cases. The objective function value without the constraints would have been Z = $421,490.00. Thus, the incremental cost of the constraints was $421,490.00 - $323, 148.50 = $98,341.50. This is a common problem posed to appraisers: restrictions on current harvests, but the requirement to appraise properties as long-term going concern situations (perpetual forest production). Restrictions reduce bare land values and current stand values. Harvest scheduling is an excellent tool to handle this appraisal problem.

Modern LP software packages are set up to handle timber harvest scheduling problems with a minimum of actual computer programming. There are software packages specifically developed for timber applications. One such package is the Remsoft Spatial Planning System, a software package designed to handle these types of timber valuation problems.

The Remsoft Spatial Planning System

According to standard appraisal theory, the Income Capitalization Approach, or Income Approach, is based on the principle of anticipation, whereby value is determined by the present value of a series of anticipated future benefits. The two primary methods for developing an income approach are direct capitalization and yield capitalization, of which discounted cash flow analysis (DCF) is one technique and the most appropriate method for timberland properties (Appraisal Institute, 2001).

Direct capitalization, which is based on the relationship of one year's income to value, is suited to many types of properties with stabilized income streams or where the income stream can be reasonably stabilized, such as single or multi-family rental properties and cropland. When this is available and can be paired with a market-derived capitalization rate, the estimated market value of a property can be determined relatively easily (Appraisal Institute, 2001).

However, for property types that do not lend themselves to stabilized cash flows it is necessary to use DCF techniques in order to develop a reasonable and credible income approach value. A number of highly sophisticated computer programs are available to assist in the development of a DCF for these types of properties. However, they are primarily focused on commercial and industrial properties and, because they are not designed to project biological growth and yield, are not suited to the development of a DCF for an appraisal of timberland. We will explain the components involved in a timberland DCF and then present a commercially available software model that has been designed for this purpose.

As stated previously, the primary difference that sets timberland DCFs apart from commercial, industrial, residential, or even annual rotational agricultural DCFs is that timbered properties grow physically over much longer periods of time and have periodic, rather than annual, revenues. Through the years, forest industry, consultants and researchers have developed a number of software programs capable of growing and valuing timber at a uniform stand or development type level. However, this meant that, for large properties with multiple stands and development types, either each stand had to be modeled individually or the property had to be very broadly stratified and each development type calculated separately and then summed to the property level. In either case, this could prove to be not only very time consuming, but also made it difficult to optimize the property value in the presence of constraints. The Remsoft Spatial Planning System (RSPS) is a commercially available software program that integrates growth and yield with the standard financial calculations while allowing the user to load multiple stands or development types and run them all at the same time, thereby allowing the user to optimize and constrain cash flows at the property level, while also reducing hands-on time (Remsoft, 2009). In addition, RSPS also has the spatial functionality to allow the user to adjust and constrain the location and timing of individual parcels, an important function in the appraisal of large timberland tracts that have been sold with the continued use of spatial constraints, such as those imposed by the Sustainable Forestry Initiative[1] as a condition of sale.

As the old saying goes, "time is money." This is certainly true in the appraisal world, where appraisers primarily earn fixed fees for their projects, meaning that the more time they spend on a particular project, the fewer projects they can complete and the less they are able to earn. The focus here will be primarily on the speed and efficiency with which the RSPS can handle four key components of a timberland DCF: data input, biological growth and yield, linear programming objectives and constraints, and reporting.

Data Input

In timberland appraisal, the client generally provides the data used in the property valuation. Because clients manage their data differently, it is necessary to be able to quickly convert that data into a standard format that can be used by RSPS. RSPS provides two primary options for inputting property data into the model. The first is to format the data directly in MS Excel© and then paste it into the model. The second, which is available only when the data is provided as a shape file, is to format the data directly in the shape file and then have RSPS create the input file from the shape file itself. This also allows the user to perform a variety of spatial analyses, the results of which can also be stored in the shape file, recognized by the model, and applied to the DCF when necessary (Remsoft, 2006). This flexibility allows the user to decide which method best serves his or her needs on a particular project rather than forcing one particular input process.

It is also necessary to efficiently enter the various model parameters and financial inputs required for a DCF. Southern pine timber properties typically have five different products, each of which may have different pricing for thinnings and clearcuts, as well as a variety of management and property costs and revenues, such as stand establishment, fertilization, property taxes, hunting lease revenue, and harvest commissions to name a few. Other input parameters may include product specifications[2], the age at which trees become merchantable, and age ranges for particular harvest and management activities. If these variables were hard-coded into the model it could take quite a bit of time to search out and change each one. However, RSPS is designed so that the user is able to treat variables such as these as constants that can be grouped in one section and changed as needed, thereby providing for a much more efficient means to change pricing, discount and appreciation rates, harvest age ranges, etc. This functionality also makes it much easier to run sensitivity analyses on product pricing, product appreciation rates, discount rates, and a variety of other model inputs.

Biological Growth and Yield

As was mentioned previously, timberland properties differ from most other types of properties, even other agricultural properties, by virtue of the fact that many timberland costs and revenues are periodic rather than annual. In order to accurately assess these revenues, it is necessary to have accurate growth and yield[3] estimates. Due to the vast amount of research performed by universities and the timber industry over the years, there are a number of growth and yield equations and tables available for use in the RSPS model. This growth and yield can be used by the model in two different forms: yield tables and dynamic link libraries (DLLs).

Yield tables are simply tables indicating the volume per acre by product that a particular harvest can be expected to yield at a particular age. For example, Table 4 shows a yield table based on USDA Forest Service research for natural loblolly pine in the U.S. Southeast. Based on this yield table, a 35-year-old natural loblolly stand clearcut in the model would yield 33.1 tons of pine pulpwood per acre, 35 tons of chip-n-saw per acre, 18.3 tons of pine sawtimber per acre, 5.6 tons of hardwood pulpwood per acre, and 2.7 tons of hardwood sawtimber per acre. The correct prices per ton would then be applied to each of these volume numbers, and then multiplied by the total number of acres harvested, to develop the total revenue from a clearcut harvest of this particular stand of timber.

In order to adequately model growth and yield, a series of yield tables can be used, each for a different timber type on the property. This approach works well for small timberland properties and properties that have very few timber types, all planted pine of the same species, for example. However, large timber properties typically have a variety of timber types. This requires that the appraiser make a choice between two options: either aggregate the timber types in order to reduce the number of yield tables needed; or produce a large number of yield tables to accommodate each current, and potential, timber type on the property. The first option can reduce the accuracy of the model by lumping similar but not identical timber types together, while the second can be very time consuming.

Another option that exists to calculate timber growth and yield is the DLL. Simply put, a DLL is a way to pass information from the model to an outside growth and yield equation and then return the calculated results back to the model. This format reduces, or even eliminates, the need to generate yield tables since unique stand information can be passed from the model to the equation and back in a matter of seconds or minutes, depending on the size of the property being modeled. Because individual stand information can be passed to the growth and yield equation, as well as other information such as product specifications, it is possible to account for each unique stand of timber without having to invest time in the production of a large quantity of yield tables, allowing the appraiser to produce a more accurate DCF more quickly.

LP Objectives and Constraints

As mentioned previously, two primary components of any linear programming model are the objective function and constraints. These can be quite cumbersome inputs for those who are not familiar with the mathematical concepts underlying LP, as well as the standard input conventions used in many models. The RSPS allows the user to build complex multi-period LP models, with complex objective functions and multiple constraints, without having to have more than a beginning level understanding of LP theory and formulation.

RSPS objective functions and constraints are based on user named and defined outputs, so rather than having an objective function like the one shown in Figure 2, with Z's and X-sub-somethings, the user can simply state the objective function using a few keywords and outputs. For example, if the user wishes to maximize the present value of total harvest revenue over a twenty-five-year period, he could create a series of outputs to define harvest revenue, such as "totpstrev" for total pine sawtimber revenue, "totppwrev" for total pine pulpwood revenue, and so on, until each timber product has been defined. (There is no need to define these by year, ala, X11, X12, and so forth, because the software is designed to handle this.) These can then be summed to create a "totharvestrev" output for total timber harvest revenue. The discount rate selected by the appraiser can then be applied to the "totharvestrev" output to create a discounted harvest revenue output, "discharvestrev," which can then be used in the objective function. The objective function will read simply "_MAX discharvestrev 1.._LENGTH," where _MAX is the model keyword for "maximize" and _LENGTH is a user defined variable indicating how long the model run will be, twenty-five years in this case. There is no need to manually enter an equation summing each individual year's discounted harvest revenue because the software automatically does this when the 1.._LENGTH convention is used. Also, by changing the value assigned to the _LENGTH keyword the user easily modifies the model run length while at the same time modifying the objective function. The _LENGTH keyword does not have to be used and the time period applied to the objective function can be less than the length of the model run, if so desired. Although maximization is the most widely used objective, particularly for appraisals, the software also allows for minimization (Remsoft, 2006).

User-defined outputs, in addition to being used in the objective function, are also used in the formulation of constraints. The RSPS software provides a number of ways to constrain a model beyond the traditional "greater than" or "less than." Options include sequential flow (both proportional and fixed), non-declining/increasing, even-flow, summary, and average constraints. For example, suppose that an appraiser is performing an acquisition appraisal on a property that has, as a condition of sale, a fiber supply agreement requiring the property owner to supply a minimum of 10,000 tons of pine pulpwood each year over a ten-year period. This can be handled by the standard ">=" constraint, which in the RSPS model would look like "totppwharv >= 10,000 1..10," where "totppwharv" is an output defined as the total annual pine pulpwood volume harvested and "1..10" indicates years one through ten. However, suppose that in addition to the minimum supply requirement, there is also a requirement that the pulpwood supply cannot vary by more than 10 percent from one year to the next. Modeling this condition in most standard LP programs would be difficult and require a great many lines of constraints. However, in RSPS it can be handled easily via the use of the sequential flow keyword "SEQ." This constraint would be easily written as "_SEQ(totppwharv,0.1,0.1) 1..10." This is but one example of the flexibility that the RSPS provides in modeling constraints.

Reporting

In appraisal, as well as every other client-driven field, it is imperative that the results of the analysis be communicated clearly to the client in a manner that they can easily understand. No analytical tool, no matter how robust and easy to use, is worth much if the results cannot be output easily into a readily usable format. The RSPS allows the user to define each report and tailor it to his or her own needs and the needs of his or her clients. Model reports can be output as .DBF and as .CSV files, both of which can be easily pasted into a pre-formatted spreadsheet to produce a standard report with multiple tables and graphs. Figures 4 and 5 are examples of two tables showing results of an Income Approach on an investment-grade timberland property. Both of these tables were linked to an input page into which the raw data from an RSPS report was pasted, automatically populating them. In addition to tabular reports like these, the RSPS is also capable of exporting results with spatial data attached as shape files that are easily loaded into many GIS products and used to modify harvest blocks and produce maps, among other things. These shape files can also be loaded back into RSPS and re-run with the modifications to produce an updated DCF.

Conclusion

For DCFs on commercial timberland, costs and revenues are irregular and vary greatly based on a number of factors, including tree species and origin (planted or naturally regenerated), the current age-class distribution of the trees on the subject property, the quality of the site, the appropriate market-derived harvest regime, and the distribution of products at the time of harvest. All of these factors, when viewed in conjunction with cost estimates for various management activities, various product prices used to calculate harvest revenues, discount rates, and a variety of potential constraints, create a very complex DCF analysis. The Remsoft Spatial Planning System provides a flexible framework that allows timberland appraisers to accurately and efficiently produce and report discounted cash flows on a variety of timberland properties.

Footnotes

1 The Sustainable Forestry Initiative (SFI) is a voluntary program that attempts to ensure responsible, sustainable management of timberlands by placing limits on average harvest block size and timing across an ownership, among other things. Though voluntary, it was seen by many forest industry companies as necessary for public relations; some lumber dealers also would only buy lumber from certified sustainable forests. Many of the large blocks of industry land that have been sold to institutional investors over the last decade have been sold with the condition that the land will continue to be managed under SFI constraints.

2 Diameter and length limits on portions of trees indicating when they move from one product to another, such as pulpwood that can be used for paper, to another, higher value product, or sawtimber that can be used for lumber.

3 Yield refers to the total amount of timber volume by product that can be harvested and merchandised for a particular type of harvest at a given age and site index.

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Figure 1. Example management regimes

Cutting Period	Stand Age (Midpoint)	Management Regimes*						
		1	2	3	4	5	6	7
1	22.5	H				T	T	
2	27.5		H					T
3	32.5			H		H		
4	37.5				H		H	H

*Where H=harvest and T=thinning

Figure 2. The complete linear programming problem

Max. Z = 205.12 X 11 + 542.44 X 12 + 454.81 X 13 + 310.86 X 21 + 816.80 X 22 + 640.16 X 23

Subject to:

$X_{11} + X_{12} + X_{13} \leq 250$

$X_{21} + X_{22} + X_{23} \leq 350$

$X_{11} + X_{21} = 200$

$X_{12} + X_{22} = 200$

$X_{13} + X_{23} = 200$

All $X_{ij} \geq 0$ for all i and j

Figure 3. Computer output for the example problem

Program: Linear Programming

Problem Title : Example for ACF Spring Meeting

***** Input Data *****

Max. Z = 205.12x1 + 542.44x2 + 454.81x3 + 310.86x4 + 816.80x5 + 640.16x6

Subject to

```
C1   1x1 + 1x2 + 1x3 <= 250
C2   1x4 + 1x5 + 1x6 <= 350
C3   1x1 + 1x4 = 200
C4   1x2 + 1x5 = 200
C5   1x3 + 1x6 = 200
```

***** Program Output *****

Final Optimal Solution At Simplex Tableau : 4

Z = 323148.500

Variable	Value	Reduced Cost
x 1	200.000	0.000
x 2	0.000	88.982
x 3	50.000	0.000
x 4	0.000	79.609
x 5	200.000	0.000
x 6	150.000	0.000

Constraint	Slack/Surplus	Shadow Price
C 1	0.000	10000000205.000
C 2	0.000	10000000390.000

Objective Coefficient Ranges

Variables	Lower Limit	Current Values	Upper Limit	Allowable Increase	Allowable Decrease
x 1	125.511	205.120	No limit	No limit	79.609
x 2	No limit	542.440	631.422	88.982	No limit
x 3	365.828	454.810	534.419	79.609	88.982
x 4	No limit	310.860	390.469	79.609	No limit
x 5	727.818	816.800	No limit	No limit	88.982
x 6	560.551	640.160	729.142	88.982	79.609

Right Hand Side Ranges

Constraints	Lower Limit	Current Values	Upper Limit	Allowable Increase	Allowable Decrease
C 1	50.000	250.000	250.000	0.000	200.000
C 2	200.000	350.000	350.000	0.000	150.000
C 3	200.000	200.000	No limit	No limit	0.000
C 4	200.000	200.000	350.000	150.000	0.000
C 5	200.000	200.000	400.000	200.000	0.000

***** End of Output *****

Figure 4. Example Remsoft project cash flow report

Table 5
Client A
Property B
County, State
PROJECTED FUTURE CASHFLOWS
January 1, 2010

		COSTS		REVENUES					
				Timber Sales			Land	NET	PRESENT
YEAR	PERIOD	Operating	Silviculture	Clearcuts	Thinnings	Leases	Sales	REVENUE	VALUE
2010	1	40,581	65,277	8,995	404,497	24,714	0	332,349	315,022
2011	2	40,581	2,291	9,823	355,994	24,961	0	347,906	312,577
2012	3	40,581	0	820,406	279,400	25,211	0	1,084,435	923,520
2013	4	40,581	208,145	1,034,305	111,735	25,463	0	922,776	744,880
2014	5	40,581	206,250	1,200,563	37,545	25,717	0	1,016,994	778,137
2015	6	40,581	206,250	1,345,754	353,825	25,975	0	1,478,722	1,072,437
2016	7	40,581	206,250	311,677	335,923	26,234	0	427,003	293,537
2017	8	40,581	42,955	0	384,855	26,497	0	327,815	213,604
2018	9	40,581	10,742	0	177,788	26,762	0	153,227	94,637
2019	10	40,581	0	6,940	66,928	27,029	0	60,316	35,311
2020	11	40,581	0	638,781	0	27,300	0	625,499	347,096
2021	12	40,581	2,079	415,485	0	27,573	0	400,397	210,601
2022	13	40,581	182,149	540,215	0	27,848	0	345,333	172,169
2023	14	40,581	115,838	320,368	0	28,127	0	192,075	90,769
2024	15	40,581	158,213	0	86,086	28,408	18,796,908 *	18,712,608	8,381,996

5.50% DISCOUNT RATE
5.50% DISCOUNT RATE, REVERSION
0.00% COST INFLATION
1.50% PINE PULPWOOD PRICE INFLATION
0.50% PINE CHIP-N-SAW PRICE INFLATION
0.50% BLENDED PINE SAWTIMBER PRICE INFLATION
0.00% BLENDED HDWD/CYPRESS PW PRICE INFLATION
0.00% BLENDED HDWD/CYPRESS ST PRICE INFLATION
1.50% BARE LAND PRICE INFLATION
1.00% HUNTING LEASE PRICE INFLATION

NET PRESENT VALUE =	$13,986,296
ACRES	7,529
ROUNDED VALUE =	$14,000,000
VALUE PER ACRE =	$1,859.48

* SALE OF ALL LAND & TIMBER IN 2023
NO OTHER LAND SALES PROJECTED

Figure 5. Example Remsoft timber harvest plan, tons harvested per year

Client A; Property B

REGENERATION HARVEST	2010	2011	2012	2013	2014	2015	2016	2017	2018
PINE									
Plantation									
Acres	-	-	-	-	97	17	-	-	-
PST tons	-	-	-	-	5,165	352	-	-	-
CNS tons	-	-	-	-	4,282	1,050	-	-	-
PPWD tons	-	-	-	-	1,529	504	-	-	-
Total tons	-	-	-	-	10,976	1,906	-	-	-
Natural									
Acres	250	121	-	-	-	-	8	-	-
PST tons	-	-	-	-	-	-	295	-	-
CNS tons	-	-	-	-	-	-	256	-	-
PPWD tons	-	-	-	-	-	-	30	-	-
Total tons	-	-	-	-	-	-	581	-	-
Total									
Acres	250	121	-	-	97	17	8	-	-
PST tons	-	-	-	-	5,165	352	295	-	-
CNS tons	-	-	-	-	4,282	1,050	256	-	-
PPWD tons	-	-	-	-	1,529	504	30	-	-
Total tons	-	-	-	-	10,976	1,906	581	-	-
HARDWOOD									
Sawtimber tons	8,190	3,827	-	-	-	-	-	-	-
Pulpwood tons	19,716	9,697	-	-	-	-	-	-	-
THIN HARVEST	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
PINE									
First Thin									
Acres	-	-	17	-	33	-	126	-	-
PST tons	-	-	-	-	-	-	-	-	-
CNS tons	-	-	37	-	77	-	227	-	-
PPWD tons	-	-	748	-	1,425	-	5,038	-	-
Total tons	-	-	785	-	1,503	-	5,266	-	-
Second Thin									
Acres	-	-	-	-	-	-	-	17	-
PST tons	-	-	-	-	-	-	-	14	-
CNS tons	-	-	-	-	-	-	-	319	-
PPWD tons	-	-	-	-	-	-	-	438	-
Total tons	-	-	-	-	-	-	-	770	-
Total									
Acres	-	-	17	-	33	-	126	17	-
PST tons	-	-	-	-	-	-	-	14	-
CNS tons	-	-	37	-	77	-	227	319	-
PPWD tons	-	-	748	-	1,425	-	5,038	438	-
Total tons	-	-	785	-	1,503	-	5,266	770	-
TOTALS	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Harvest Acres	250	121	17	-	131	17	134	17	-
Annual land sale acres	-	-	-	-	-	-	-	-	-
Plantation area	420	420	420	420	323	403	420	428	428
Total forested area	1,897	1,897	1,897	1,897	1,897	1,897	1,897	1,897	1,897
Average Regen Harvest Age	39.00	41.29	-	-	28.10	25.00	35.00	-	-
Average First Thin Age	-	-	16.00	-	16.00	-	15.34	-	-
Average Second Thin Age	20.00	-	-	-	-	-	-	21.00	-
Average Thin Age	20.00	-	16.00	-	16.00	-	15.34	21.00	-
Volume									
Pine									
PST tons	-	-	-	-	5,165	352	295	14	-
CNS tons	-	-	37	-	4,359	1,050	483	319	-
PST/CNS total tons	-	-	37	-	9,524	1,402	778	332	-
PPWD harvest tons	-	-	748	-	2,955	504	5,068	438	-
Topwood	-	-	4	-	952	140	78	33	-
PPWD total tons	-	-	751	-	3,907	645	5,146	471	-
%PPW	0%	0%	95%	0%	29%	31%	87%	59%	0%
Total Pine tons	-	-	789	-	13,431	2,046	5,924	803	-
Hardwood									
HST	8,190	3,827	-	-	-	-	-	-	-
HPW	19,716	9,697	-	-	-	-	-	-	-
%HPW	71%	72%	0%	0%	0%	0%	0%	0%	0%
Total Hardwood tons	27,906	13,524	-	-	-	-	-	-	-
Total Volume, all products	27,906	13,524	789	-	13,431	2,046	5,924	803	-

Table 1. Projected yields during the conversion period for the example

	Yield (cubic feet per acre)		
Stand	Cutting Period 1	Cutting Period 2	Cutting Period 3
1	549	2,600	3,904
2	832	3,915	5,495

Table 2. Discounted cash flows for the example

	Discounted Cash Flow @ 6%		
Stand	Cutting Period 1	Cutting Period 2	Cutting Period 3
1	$205.12	$542.44	$454.81
2	310.86	816.80	640.16

Table 3. Solution to the linear programming problem

	Acre Cut		
Stand	Cutting Period 1	Cutting Period 2	Cutting Period 3
1	200	0	50
2	0	200	150

Table 4. Empirical yield table for natural loblolly in the U.S. Southeast, tons per acre

AGE	PPW*	CNS*	PST*	HPW*	HST*
10	8.5	0	0	0	0
15	24.5	2.4	0	3.8	0
20	33.6	11.6	0	6.0	0
25	37.2	20.4	4.3	7.5	0
30	36.6	28.3	10.3	6.7	1.6
35	33.1	35.0	18.3	5.6	2.7
40	28.0	40.0	27.0	5.6	2.7
45	22.6	43.0	35.6	5.6	2.7
50	18.3	43.4	42.7	5.6	2.7
55	16.3	41.0	47.4	5.6	2.7
60	16.0	35.2	48.5	5.6	2.7
65	15.7	29.4	49.6	5.6	2.7
70	15.4	23.6	50.7	5.6	2.7
75	15.1	17.8	51.8	5.6	2.7
80	14.8	12.0	53.0	5.6	2.7
85	14.5	6.2	54.1	5.6	2.7

*PPW = pine pulpwood, CNS = pine chin-n-saw, PST = pine sawtimber, HPW = hardwood pulpwood, HST =hardwood sawtimber.