Forest Management Plan Implementation: The Economic Implications of Straying from the Optimal Strategy

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Abstract

Increasingly investors are using sophisticated computer modeling techniques to formulate forest management plans. Optimization modeling techniques are gaining in popularity because they allow the exploration of management alternatives and provide an optimal solution. As investor sophistication grows models incorporate more and more detailed geographic information system (GIS) data, inventory data, and biometric assumptions. Biometric models, that provide growth and yield assumptions for optimization models, now include treatment responses allowing the ability to model intensive silviculture directly represented by data rather than simple multipliers (as was common in the past). The goal of these sophisticated models is to improve financial returns for investors. Improved financial returns, however, may be compromised if an optimal plan is not implemented.

To examine the sensitivity of financial returns, three common forest management plan implementation methods were investigated. Impacts on financial returns were calculated using 1) 'rules of thumb' to guide implementation, 2) current harvesting practices even while silviculture intensity is increasing, and 3) implementation rules addressing only the broadest intent of a plan. It is shown that varying from the optimal plan can have significant consequences in future volumes, revenues and net present value.

Keywords: forest management plan, modeling, optimization, financial return.

1 Introduction

The process of harvest scheduling has changed significantly over the past 20 years. Early planning processes involved area based or volume based calculations of harvest information dealing with timber objectives only. It was not uncommon to conduct a harvest scheduling exercise for very large forest tracts using aggregated strata and yield tables to represent the range of forest types and silviculture in current practice. Little effort was made to look at alternative management regimes or ranges of silvicultural intensity beyond those regimes that were currently in practice. The harvest scheduling exercise produced an allowable cut figure and with such averaged input information, it was reasonable that foresters would use the resulting harvest schedule only as a rough guide during implementation.

More complex planning requirements, the availability of highly detailed GIS and inventory systems, and the advent of fast computers and more robust planning tools have led to comprehensive forest plans that go beyond just calculating harvest levels. Forest management plans now involve managing for multiple objectives including wood flow, cash flow, ecological, and wildlife objectives. Far greater detail goes into the models, often employing stand-level inventory and yield information. These models evaluate a large variety of alternatives in selecting the appropriate silvicultural intensity and set of management regimes that maximize present net value or other management objectives.

With improvements in data and planning models over the recent past, one would expect forest managers would have increased trust in the results of these models. However, many continue to follow historic rules of thumb, or continue to use current practices, even when models indicate otherwise. Others follow the very broadest intent of the forest plan by using aggregated information on harvest volumes and/or cash flows to guide their implementation. This paper will demonstrate how deviation from calculated planning results can lead to reduction in financial returns from managing forest land. We will investigate common implementation methods used by forest managers and illustrate that significant reduction in volume and financial returns can occur as a result of failures to implement the optimal forest management plan.

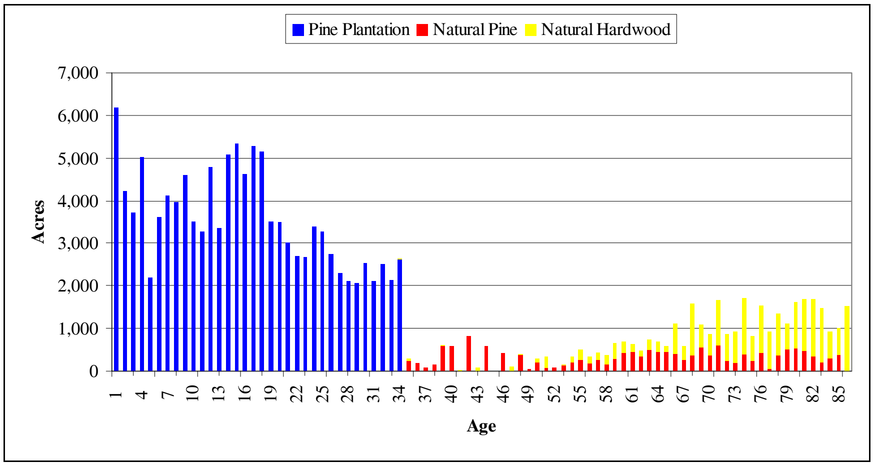
2 Methodology

2.1 Forest Dataset

A South Carolina National Forest database served as the foundation for the simulated forest used in this analysis. Significant alterations to the National Forest database, totaling 158,971 acres in size, were made so that it would better represent a managed industrial forest.

The simulated forest was categorized into 117,496 acres of pine plantation, 22,055 acres natural hardwood, 15,758 acres of natural pine, 2,181 acres of site preparation, and 1,481 acres of cutover stand conditions. A portion of the forest was also categorized a having been thinned, 19,080 acres or 12% of the total area. Each of the 3,588 forest stands was assigned an age, with the initial age-class distribution (Figure 1) representing conditions common to the industrially managed timberlands in the SE USA.

Figure 1: Initial age-class distribution, by forest type, assigned to the simulated forest.



The simulated forest was categorized into 9 site index classes ranging from 50 to 100 feet at 25 years. The distribution of site classes by acreage is detailed in Table 1.

Table 1: Distribution of site class by acreage.

Site Index (@25 years)	Acres	% Acres
50	146	0.1%
60	7,660	4.8%
65	10,580	6.7%
70	59,553	37.5%
75	27,774	17.5%
80	32,776	20.6%
85	10,669	6.7%
90	7,685	4.8%
100	2,127	1.3%
Total	**158,971**	

Ten categories of trees per acre (TPA) were assigned, with 49.6% or 78,850 acres having TPA's equal to or greater than 300. The distribution of TPA by acreage is detailed in Table 2.

Table 2: Distribution of trees per acre (TPA) by acreage.

TPA	Acres	% Acres
<100	32,404	20.4%
100-149	9,279	5.8%
150-199	422	0.3%
200-299	38,032	23.9%
300-399	15,666	9.9%
400-499	11,670	7.3%
500-544	5,309	3.3%
545-599	34,023	21.4%
600-699	9,372	5.9%
700+	2,794	1.8%
Total	**158,971**	

A biometrics analysis divided the simulated forest into 588 strata. These strata were then grown using a propriety growth and yield model specific to the Southeast USA. This analysis included growth and yield responses for mid-rotation fertilization with and without thinning.

Products merchandised for this analysis included pine pulpwood, pine topwood, pine Chip 'n' Saw, pine sawtimber, hardwood pulpwood, and hardwood sawtimber. The starting inventory for this analysis is detailed in Table 3. On average the volume of pine stands was 70.7 tons/acre and the volume of hardwood stands was 117.6 tons/acre.

Table 3: Starting inventory of the simulated forest (tons).

Product	Volume (tons)
Pine pulpwood	2,781,312
Pine topwood	95,047
Pine Chip 'n' Saw	3,231,356
Pine Sawtimber	3,310,441
Pine Sub-Total	**9,418,156**
Hardwood pulpwood	753,380
Hardwood sawtimber	1,839,189
Hardwood Sub-Total	**2,592,569**
Pine + Hardwood Total	**12,010,725**

2.2 Base Model (Base)

A strategic model was formulated utilizing the *Woodstock* forest modeling system (utilizing Model-II linear-programming optimization techniques) for the simulated forest. This *Base* model was also used to derive four alternative model formulations representing various strategic plan implementation techniques. The Base model included a number of assumptions, including;

1. Only even-aged forest management was employed.
2. Silviculture included site preparation, plantation establishment, and fertilization.

3. Harvesting included thinning and final harvest (clearcut). All thinnings received a post thinning fertilization application. Thinning was permitted between the ages of 14 and 20. Final harvest was permitted on stands 20 years of age and greater.
4. An 8% real discount rate was used for financial analysis (net of inflation).
5. Financial assumptions were considered pre-tax.
6. An objective function maximized NPV over a 100-year model horizon, with 1-year period intervals. Only the first 50-years of the planning horizon were used for reporting, with longer planning horizons used in the model to eliminate artifacts due to "end of planning horizon effects" that are common to all planning models.
7. A sequential flow constraint (+/- 20%) was placed on the pine volume (top wood, pulpwood, Chip 'n' Saw, and saw timber) harvested. The amount of pine harvested could increase or decrease by as much as 20% from one period (year) to another.
8. A sequential flow constraint (+/- 20%) for acreage 30 years or greater cut in years 1 to 8. The amount of final harvest acres could increase or decrease by as much as 20% from one period (year) to another.

2.3 Alternative Models (HYld, Rule 1, Budget, and Rule 2)

Four alternative models were developed to represent implementation of the Base model 'on the ground' or operationally. These alternatives quantify the consequences of deviating from an optimal solution through various implementation techniques. To mimic various implementation techniques, several Base model assumptions were altered, the model re-run and results reported. Each alternative model is described below, including the implementation technique each represents.

2.3.1 Alternative 1 – Harvest Highest Yielding First (HYld).

This model alternative involved two modeling steps. First, the Base model solution was used as input to a simulation model. This simulation model forced harvesting of the highest yielding strata for the first 20 years, while at the same time maintaining the annual harvest volume reported by the Base model. Second, the 20-year solution provided by the simulation model was incorporated into the Base model and re-run to obtain the balance of the solution for years 21-100. This alternative was meant to mimic the implementation of a strategic plan where the 'best' or highest yielding harvest blocks are favored over lower yielding harvest blocks.

2.3.2 Alternative 2 – Applying a 'rule of thumb' (Rule1)

This model alternative applied a 'rule of thumb' to harvest implementation. The Base model allows final harvest at 20 years of age and greater. In this alternative, the following 'rule of thumb' was applied: final harvesting was only allowed between 23-25 years of age from year 9 to the end of the 100-year planning horizon. In addition, while the Base model stipulates thinning between 14-20 years of age, the 'rule of thumb' for this alternative allows a narrower thinning window of 14-16 years of age. This alternative is meant to mimic management where the foresters believe that similar management should occur regardless of other important stand conditions such as site index, basal area, or trees per acre.

2.3.3 Alternative 3 – Silviculture Budget Constrained (Budget)

This model alternative restricted silviculture expenditures in order to represent real world budget constraints. Only 75% of the silviculture expenditure per year in the Base model was permitted for the first 20-years. Silviculture expenditures were applied at 100% of the Base model levels beyond 20 years. This is meant to mimic the somewhat common situation where silviculture budgets were reduced for a period of time.

2.3.4 Alternative 4 – Applying a 'rule of thumb' (Rule2)

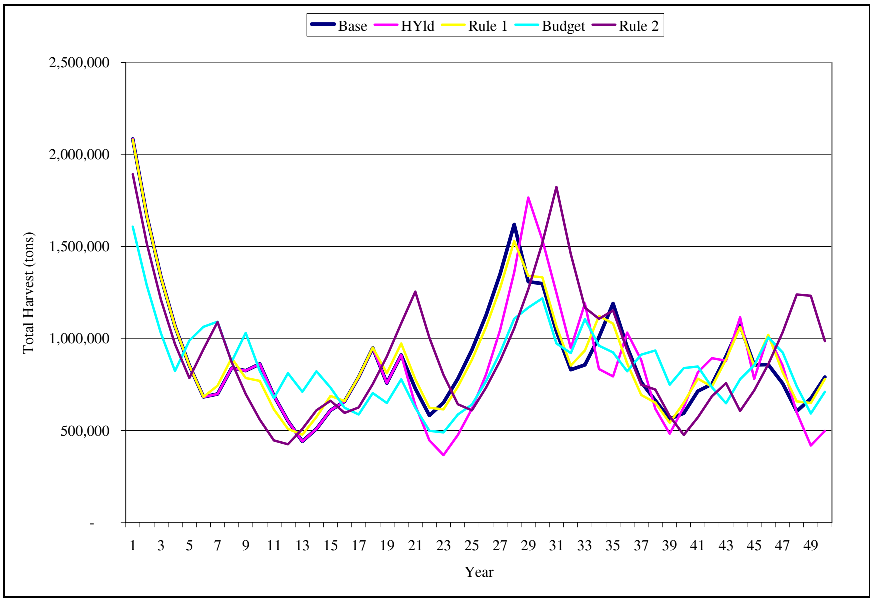
This model alternative applied a 'rule of thumb' to harvest implementation. The Base model allows final harvest at 20 years of age and greater. In this alternative, the following 'rule of thumb' was applied: final harvesting was only allowed between 26-28 years of age from year 9 to the end of the 100-year planning horizon. In addition, while the Base model stipulates thinning between 14-20 years of age, the 'rule of thumb' for this alternative only allows a thinning window of 16-18 years of age. These thinning and final harvest timings are outside the optimal range in the base model. This alternative is meant to mimic management where foresters continue to manage the way they historically have even while planting better genetic material and use improved silvicultural practices.

For clarity and ease of understanding each model has been provided a name. The Base model will simply be referred to as *Base*. The alternative models are named according to their implementation technique; Alternative 1 is named *HYld***,** Alternative 2 is named *Rule 1*, Alternative 3 is named *Budget*, and Alternative 4 is named *Rule 2*.

3 Results and Discussion

Harvest volumes over 50 years for the Base model and the four alternative models are illustrated in Figure 2. Variations in harvest volume are evident when comparing the four alternative models to the Base model. The total harvest volume over 50 years for the Base model was 44.6 million tons; the alternative models varied in totals from 42.7 to 45.8 million tons, a -1.9 to +1.2 million tons variation range. If distributed equally over 50 years, this variation equates to -37,976 to 23,270 tons per year.

Figure 2: 50-Year harvest volumes for the Base model and four alternative models (HYld, Rule 1, Budget, and Rule 2).



When harvest volume is examined over years 1-25 versus 26-50 it is evident that variation in total harvest volume over the total 50-years is influenced by timing of harvest (Table 4). Alternatives HYld, Rule1, and Budget show considerably more variation in years 1-25 than 26-50.

Table 4: Total harvest volume (tons) for years 1-25 and 26-50. Variation from Base and the variation of harvest volume per year (distributed evenly over 25 years) are calculated.

	Years 1-25			Years 26-50		
Model	**Harvest Volume**	**Variation from Base**	**Variation Per Year**	**Harvest Volume**	**Variation from Base**	**Variation Per Year**
Base	***21,460,124***			***23,146,039***		
HYld	20,322,176	-1,137,948	-45,518 (-5.3%)	23,030,722	-115,317	-2,306 (-0.2%)
Rule 1	21,556,402	1,234,226	49,369 (5.8%)	23,241,047	210,325	4,207 (0.5%)
Budget	20,549,685	-1,006,717	-40,269 (-4.7%)	22,157,700	-1,083,347	-21,667 (-2.3%)
Rule2	21,458,998	909,312	36,372 (4.2%)	24,310,650	2,152,951	43,059 (4.7%)

Variance of harvest volume from the Base is illustrated in Figure 3 for years 1-25. Harvest volumes vary significantly year to year from the Base depending on the alternative. The Budget model alternative variance peaks at year 7 at 392 thousand tons more than Base. The Rule 2 model alternative peaks at year 21 at 526 thousand tons more than Base. The HYld model alternative variance is negligible until year 20 beyond which harvest volume decreases 319 thousand tons by year 25. This is not unexpected considering the HYld alternative focused on matching the Base model harvest volumes over the initial 20 years.

Figure 3: Harvest volume variance of four alternative models (HYld, Rule 1, Budget, and Rule 2) from Base harvest volume for years 1-25.

Final harvest acres over 50 years for the Base model and the four alternative models are illustrated in Figure 4. Acres of final harvest vary from year to year as the different implementation techniques are employed in each alternative model. The HYld and Rule 2 alternative models show the greatest one year variance, +3,844 acres at year 7 and -4,733 acres at year 9 respectively (Figure 5).

Figure 4: Acres of final harvest for Base and four alternative models (HYld, Rule 1, Budget, and Rule 2) for years 1-50.

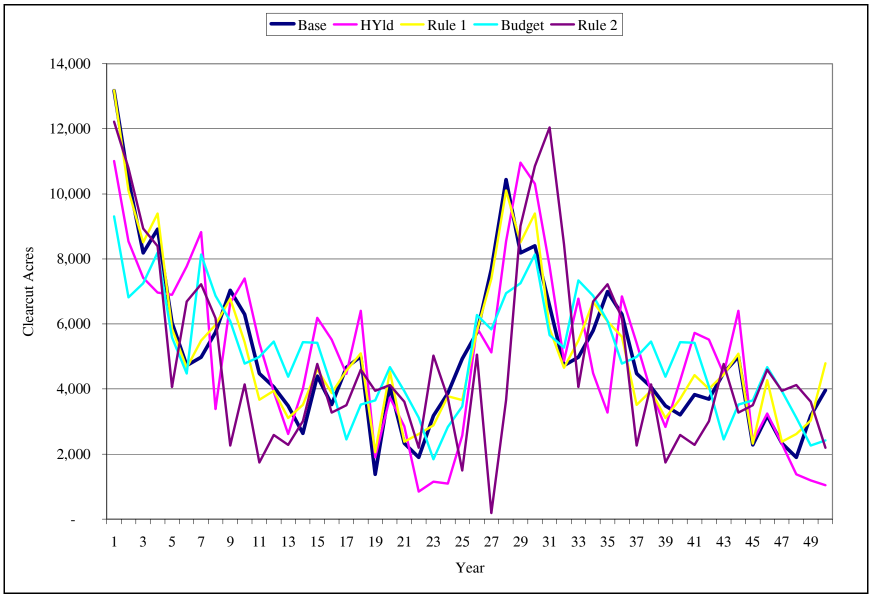
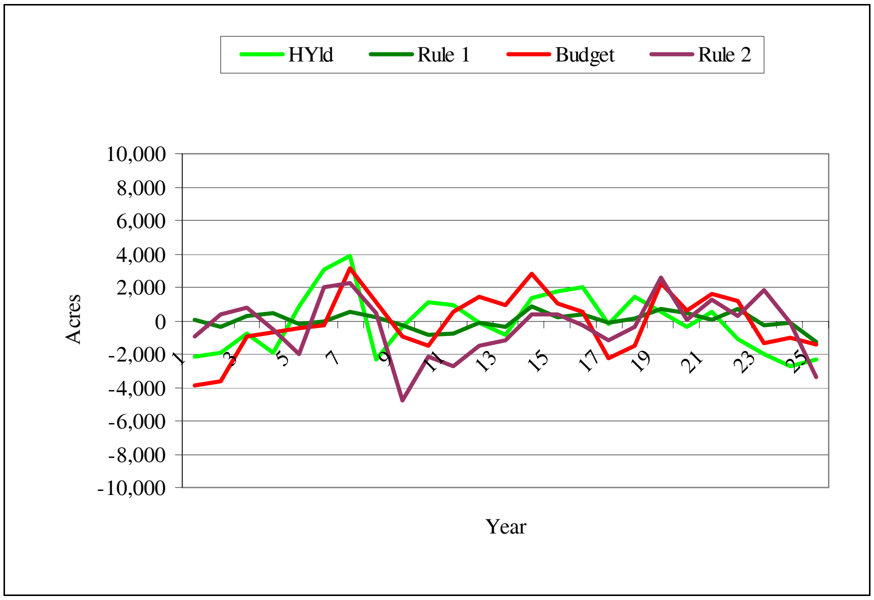


Figure 5: Final harvest acres variance of four alternative models (HYld, Rule 1, Budget, and Rule 2) from Base final harvest acres.



Acres of thinning vary significantly from year to year as the different implementation techniques are employed in each alternative model (Figure 6). The Budget and HYld alternative models show the greatest one year variance, -8,148 acre at year 2 and +8,540 acres at year 8 respectively (Figure 7).

Figure 6: Thinning acres of four alternative models (HYld, Rule 1, Budget, and Rule 2) from Base thinning acres.

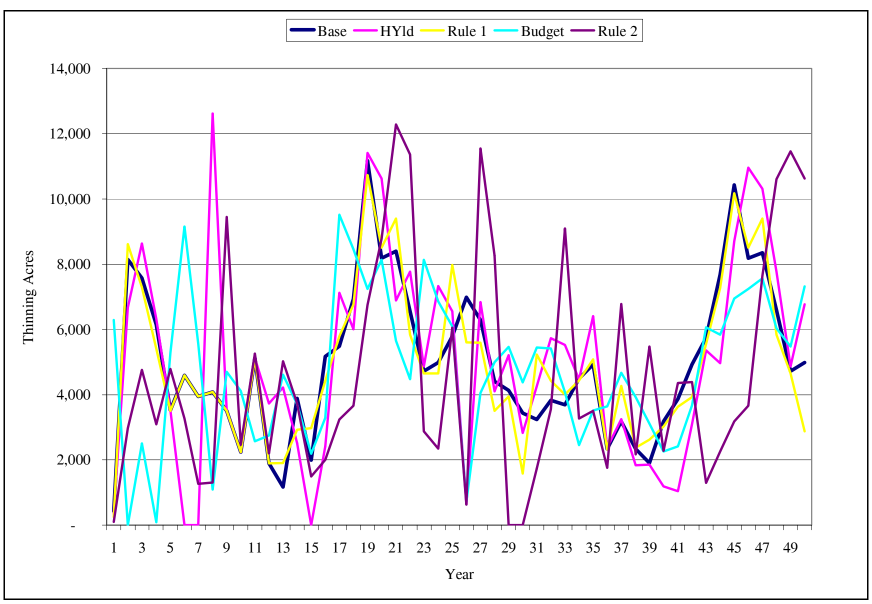
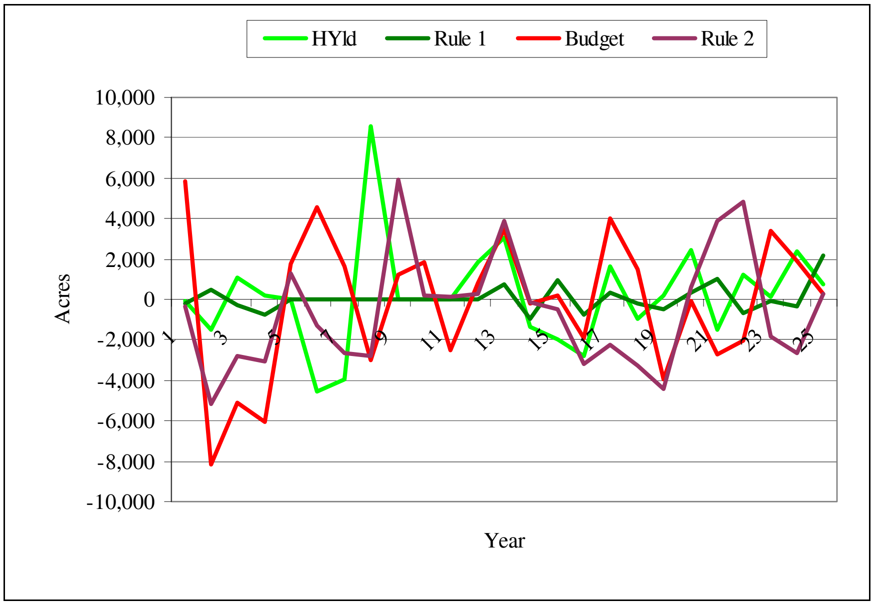


Figure 7: Thinning acres variance of four alternative models (HYld, Rule 1, Budget, and Rule 2) from Base thinning acres.



The average annual pine harvest volume (tons) for years 1-20 and years 1-50 for the Base and the four alternative models are listed in Table 5.

Table 5: Average annual pine harvest volume (tons) for years 1-20 and years 1-50 for Base and four alternative models.

		Years 1..20			
tons	***Base***	**HYld**	**Rule 1**	**Budget**	**Rule 2**
Pine Sawtimber	***334,853***	301,316	338,295	361,133	339,296
Pine Chip 'n' Saw	***285,400***	307,130	287,390	273,141	272,418
Pine Pulpwood	***268,692***	280,495	270,243	251,300	245,466
Total	***888,945***	888,940	895,929	885,575	857,180

		Years 1..50			
tons	***Base***	**HYld**	**Rule 1**	**Budget**	**Rule 2**
Pine Sawtimber	***409,121***	373,979	412,271	356,327	433,444
Pine Chip 'n' Saw	***212,472***	223,487	214,307	246,790	210,149
Pine Pulpwood	***270,530***	269,592	269,370	251,031	271,800
Total	***892,123***	867,058	895,949	854,148	915,393

Some relevant observations of the average annual pine harvest volumes when compared to the Base include:

1. HYld shows a loss in harvest volume of 4.4% in years 21-50, and 2.8% across years 1-50.

2. HYld shows less sawtimber with a 10.0% reduction over years 1-20 and an 8.6% reduction over years 1-50.
3. Rule1 shows a very similar harvest and product mix to the Base model.
4. Budget shows a loss in harvest volume over years 1-50 with a 4.3% reduction in total harvest and a 12.9% reduction in sawtimber. The reduction in silviculture spending causes a reduction in volume in later years, especially sawtimber volume.
5. Rule 2 shows slightly lower harvest volumes for years 1-20 with a 3.6% reduction, and slightly higher volumes across years 1-50 with a 2.6% increase.

The average annual harvest acres for years 1-20 and years 1-50 for the Base and the four alternative models are listed in Table 6.

Table 6: Average annual harvest acres for years 1-20 and years 1-50.

		Years 1..20			
acres	***Base***	**HYld**	**Rule 1**	**Budget**	**Rule 2**
Thinning	***4,762***	4,854	4,725	4,566	3,784
Final Harvest	***5,662***	5,952	5,719	5,580	5,237
Total	***10,424***	10,805	10,443	10,146	9,021

		Years 1..50			
acres	***Base***	**HYld**	**Rule 1**	**Budget**	**Rule 2**
Thinning	***4,992***	5,018	4,940	4,786	4,604
Final Harvest	***5,087***	5,050	5,138	5,060	4,805
Total	***10,079***	10,068	10,078	9,846	9,409

Some relevant observations of the average annual harvest acres when compared to the Base include:

1. HYld shows slightly more harvest acres for years 1-20; however, total harvest acreage is almost identical over years 1-50.
2. Rule 1 shows almost identical harvest acres and harvest timing over years 1-50.
3. Budget shows lower harvest acres during years 1-20 with a 2.7% reduction. Harvest acres are also lower over years 1-50 with a 2.3% reduction.
4. Rule 2 shows less harvest acres over years 1-20 with a 13.5% reduction. Thinning acres are reduced by 20.5%, and final harvest acres are reduced by 7.5% over years 1-20.
5. Rule 2 shows less harvest acres over years 1-50 with a 6.6% reduction. Thinning acres are reduced by 7.8%, and final harvest acres are reduced by 5.5% over years 1-50.

The total and per acre net revenues for years 1-20 and years 1-50 for the Base and the four alternative models are listed in Table 7.

Table 7: Total and per acre net revenues for years 1-20 and years 1-50.

Years 1..20	*Base*	HYld	Rule 1	Budget	Rule 2
Net Revenue (millions)	***$391***	$376	$396	$420	$389
Net Revenue/Acre	***$2,462***	$2,368	$2,489	$2,640	$2,444
Percent Loss		3.8%	-1.1%	-7.2%	0.7%

Years 1..50	*Base*	HYld	Rule 1	Budget	Rule 2
Net Revenue (millions)	***$1,024***	$969	$1,033	$979	$1,069
Net Revenue/Acre	***$6,444***	$6,098	$6,497	$6,155	$6,724
Percent Loss		5.4%	-0.8%	4.5%	-4.3%

Some relevant observations of the total and per acre net revenues when compared to the Base include:

1. HYld shows lower revenue in years 1-20 with a 3.8% reduction. Lower revenue is also evident over years 1-50 with a 5.4% reduction. Both of these reductions are due to less favorable product mix.
2. Rule 1 shows a net revenue increase over years 1-50 of 0.8%.
3. Budget shows net revenues increase 7.2% in years 1-20 due to lower spending on silviculture, however, net revenues decrease 4.5% over years 1-50 as a consequence of not spending as much on silviculture in the early years.
4. Rule 2 shows net revenue marginally lower in years 1-20 by 0.7%, however, over years 1-50 net revenue increases 4.3%. This increase is due to longer rotations yielding an improved product mix in the later periods.

The total and per acre Net Present Value (NPV) for years 1-20 and years 1-50 for the Base and the four alternative models are listed in Table 8.

Table 8: Total and per acre NPV for years 1-20 and years 1-50.

Years 1..20	*Base*	HYld	Rule 1	Budget	Rule 2
NPV (millions)	***$235***	$228	$235	$239	$229
NPV/AC	***$1,477***	$1,432	$1,480	$1,503	$1,438
Percent Loss		3.0%	-0.2%	-1.8%	2.6%

Years 1..50	*Base*	HYld	Rule 1	Budget	Rule 2
NPV (millions)	***$287***	$275	$287	$282	$283
NPV/AC	***$1,808***	$1,727	$1,808	$1,773	$1,782
Percent Loss		4.5%	0.0%	1.9%	1.4%

Some relevant observations of the total and per acre NPV when compared to the Base include:

1. HYld shows a 3% decrease in NPV over years 1-20, and a 4.5% decrease over years 1-50.
2. Rule 1 shows a 0.2% decrease in NPV over years 1-20 and no net loss over years 1-50.
3. Budget shows a 1.8% increase in NPV over years 1-20, however, NPV decreases 1.9% over years 1-50. This is due to not obtaining the gains from advanced silviculture at the time of harvest of future stands.
4. Rule 2 shows a decrease in NPV of 2.6% over years 1-20, and a 1.4% loss over years 1-50. This shows the negative impact of missing the optimal thinning and timing windows by even a small margin.

4 Conclusions

This analysis attempted to mimic implementation of an optimal strategic plan in a modeling environment. The modeling environment enabled quantifiable variables to be reported, thus demonstrating the implications of deviating from an optimal strategic plan. The results have provided interesting insight into strategic plan implementation.

A predominant observation of this analysis is the sensitivity of a strategic plan to change because all activities in an optimal solution are inherently linked and small deviations in implementing a plan have widespread implications. The various alternative models demonstrated these implications when harvest volumes and acres, revenues and NPV are compared year to year with the Base model. Each alternative model showed significantly different solutions in terms of treatment acreage scheduled each period.

More specifically, some significant conclusions can be draw from the solution results of each specific alternative model.

The HYld alternative model showed a reduction in NPV of 3% over years 1-20 and 4.5% over years 1-50. When implementing a strategic plan scheduling the highest yielding blocks first, the short-term benefits are given very high priority. This implementation technique may result in short-term operational efficiencies (logistical and economic) but the long-term negative implications are evident as indicated in the results. At some point in the future a high concentration of lower yielding harvest blocks will have to be scheduled for harvest. This will result in a reduction of future revenues and may also result in higher harvesting and silviculture costs in the future. Acceptance of this implementation technique depends on the management philosophy of the land manager. One manger may prefer to schedule lower yielding blocks with the higher yielding blocks to distribute the associated higher operating costs over time. Another manager may prefer to harvest the higher yielding blocks first and simply deal with the lower yielding blocks at some point in the future. Either approach may be acceptable if the land manager's long-term goals are achieved. It is when the long-term goals are not achieved that this implementation technique comes into question.

The Rule 1 alternative model showed no impact on NPV over 1-50 years. This suggests there is some flexibility in implementing an optimal strategic plan and that a set of harvest scheduling rules obtained from a robust planning model works well. However, NPV is sensitive to changes in prices, costs, discount rates, and merchandising specifications. As changes occur, this implementation method may be compromised and have greater than expected consequences. This is a primary reason for the periodic nature of strategic plan formulation. Typically, strategic plans are prepared every 3-5 years in order to adjust to changing prices, costs, discount rates, and management regimes. Significant changes to these or other assumptions or parameters may require strategic plans to be updated more frequently.

The Budget alternative model showed a reduction in NPV of 1.9% over 50 years when compared to the Base model. Decreased revenues are a direct result of reduced silvicultural expenditures and lower intensity silviculture, thus negatively impacting the achievement of future financial returns. The short-term gain in revenues in years 1-20, a 1.8% increase in NPV, is simply a result of less spending as harvest levels have essentially remained the same. However, over the long-term, as missed silviculture opportunities would have produced a return on the initial investment, the NPV is reduced.

The Rule 2 alternative model showed that if timing of harvesting is not optimal, NPV can be negatively impacted, in this case a 2.6% reduction over years 1-20 and a 1.5% reduction over years 1-50. For the Rule 2 model, the average final harvest age was only 2 years later and the average thinning age 1 year later than the Base model averages. The alterations to harvest timing and reductions in NPV may seem small; however, when managing a large landbase this may represent a significant dollar amount. For the simulated forest used in this analysis, the reduction in NPV over 25 years was 6 million dollars. The later thinning ages lead to a reduction in thinning as a preferred management activity. On a positive note, these slightly longer rotations actually increase net revenue in later periods. This increase in revenue is a consequence of a change in product mix, as time allows for more high valued products to be produced.

Forest planners who formulate strategic plans do not expect forest managers to follow the plans exactly. Many factors can influence implementation of a strategic plan. Perhaps the most important factor is that the data used as input into strategic models may not be perfect. As a result, some areas scheduled for management may not be viable when the forest manager evaluates the strategic plan. In addition, all strategic plans incorporate many assumptions on revenues and costs which can abruptly change as conditions change. Lastly, markets, weather, and even road access can influence implementation of a strategic plan.

Though some changes are expected and unavoidable in implementing an optimal strategic plan, all changes have consequences. As expected, the more changes one makes the greater the consequences. The HYld alternative model demonstrated this, as it clearly illustrated that selecting choices which have higher short term gains may have unintended future consequences. These consequences create a ‘snowball effect’ impacting harvest flows, harvest acres, and silvicultural activities.

Another risk associated with implementing a strategic plan is being too selective in what to implement. Forest management plans should not be considered a basket of choices from which one chooses only certain activities to implement; all the parts go together as a set. For example, cutting at a level that assumes a given investment in silviculture, but not making that silvicultural investment violates the basic assumptions of the model. The results projected by the model can be significantly impacted by these types of arbitrary deviations, thus leading to considerable financial impact.

Forest managers are using much more sophisticated planning tools than in the past. GIS and inventory data are much more detailed and as data improves model solutions are becoming more and more accurate. Forest managers also have a wide range of silviculture activities at their disposal. Various high intensity silvicultural alternatives are being readily adopted and represented in strategic planning models. Biometrics now involves complicated growth and yield models that can derive site specific responses based on sophisticated stand specific data.

Using sophisticated forest management tools can lead to increased returns to timberland investors. However, the underlying assumptions of these models must not be violated unless truly justified. Arbitrary deviations from an optimal strategic plan, through various implementation techniques, may result in significant loss in NPV, harvest volume, or other forest values.

This analysis has only touched upon the non-spatial consequences of deviating from an optimal strategic plan. Spatial restrictions also have a large impact on optimal harvest allocation. Many spatial, geographically referenced factors, such as adjacency and green-up requirements, can significantly impact what can actually be implemented from a non-spatial strategic plan. The scale of the impact is further influenced by the manner in which a strategic plan is spatially implemented. Results can vary whether spatial resolution is accomplished manually or with the use of computer assisted allocation. Further research is planned to analyze the impact of failing to follow a computer assisted spatial allocation.