

# **Sustaining Timber Harvesting and Older Forest Conditions: A Harvest Scheduling Analysis for Koochiching County's 2010 Forest Plan**

by

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**Staff Paper Series No. 210**  
**Department of Forest Resources**

August 1, 2010

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**Technical Report  
Interagency Information Cooperative**

## **Acknowledgements**

This research was funded by the Interagency Information Cooperative, University of Minnesota, Department of Forest Resources, and the Minnesota Agricultural Experiment Station under project MIN 42-86. The authors wish to thank the staff of Koochiching County, Pro-West and Associates, and the Koochiching County Forest Planning Advisory Group for their guidance in developing scenarios and providing forest inventory data.

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## Summary

Analyses were developed to help support the forest planning effort of the Koochiching County Land Department. Emphasis was on comparing scenarios describing plausible management strategies for five forest cover types: (1) aspen, (2) Balm of Gilead, (3) lowland spruce, (4) spruce-fir, and (5) tamarack. These cover types were not analyzed independently, as it was assumed that the annual harvest area, across cover types, is limited by the county's forestry budget. A harvest-scheduling model was applied using a 100-year planning horizon and 5-year planning periods. Analyses used the county's most recent forest inventory information, with results providing scheduled management actions for individual stands. Growth projections to estimate yields for alternative rotation lengths utilized information from a recent Minnesota Department of Natural Resources (MNDNR) study that analyzed Minnesota's wood supply potentials. Average stumpage prices received by the county in late 2009 were used in the objective function of the model that estimated the net present value (NPV) from timber returns. Stumpage prices for aspen have been higher in 2010. NPV estimates were updated to examine impacts of these higher prices.

Initially, analyses examined all nine combinations of three alternatives describing general forest regulation policies by three alternative target levels for the area of the aspen cover type to sustain over time as older aspen (age 55 to 74 or age 55+ aspen). An Initial Benchmark run was developed to help understand the opportunity costs of the scenarios. Modeling results were reviewed by the county's Forest Planning Advisory Group, with that group requesting analysis of ten additional scenarios. Four of these scenarios (Regulation Alternative G scenarios) allowed 40-year rotations in the aspen cover type. Two unconstrained benchmark scenarios were also considered that included no management constraints. The benchmark runs varied only in terms of the minimum rotation age assumed for aspen (40 years or 45 years). Substantial effort was also placed on modeling a scenario developed earlier for the county by an outside consulting firm. Scenarios were also developed that produced more age 55+ aspen when such conditions are less costly to produce (Scenarios E and Gvariable).

Analyses emphasize learning. Findings include:

1. Koochiching County's forest-wide harvest levels and forest-wide NPV estimates are dominated by the management of the aspen cover type. With 123,000 acres, the aspen cover type is the largest cover type by far. Lowland spruce is the second largest type with less than 35,000 acres. The aspen type also has substantially shorter rotations, so in sustainable terms, a higher percentage of the aspen type can be cut each year. Stumpage prices are also highest for this cover type, pointing to its substantial impact on financial returns from harvesting.
2. For an unconstrained case under constant stumpage prices and a 4% discount rate and the growth and yield assumptions used in this study, the optimal rotation age is 40 years for the aspen cover type. This rotation age holds for all site index classes.

3. The initial age class distribution of the aspen cover type is imbalanced. It has nearly 32,000 acres that will be age 45 or older in the first planning period. However, it will have relatively few acres (23,600) that will reach age 40 in the next 15 years.
4. Sustainable harvest levels are sensitive to the order that aspen stands are harvested. Initial harvesting strategies proposed by the County emphasized shorter rotations for stands in the lowest site index and tended to harvest these stand earlier. This strategy resulted in relatively low NPV estimates of timber production.
5. Sustainable harvest levels are sensitive to the minimum rotation age assumed for aspen. Results are sensitive not only because of stand-level economics, but also because of the age class imbalance present in the initial inventory. For the county, if the minimum rotation age is 45 years rather than 40 years, then it will be 20 years rather than 15 years, before substantial area of younger aspen becomes available for harvest.
6. NPV estimates varied by as much as \$3.8 million between scenarios. With updated (higher) stumpage price assumptions, differences increased to \$7.5 million. NPV estimates for the forest are sensitive to the minimum rotation assumption for aspen.
7. Koochiching County has the potential to raise harvest levels in the short term without impacting long-term timber production substantially. Departures can be larger when shorter rotations are possible for aspen. Sustaining more age 55+ aspen reduces this potential.
8. Sustaining acres of the age 55+ aspen comes at a cost to timber production. The per unit (marginal) cost of sustaining more area of age 55+ aspen increases as this area increased.
9. The cost of sustaining acres of age 55+ aspen varies over time, with the marginal cost highest during and shortly after bottleneck periods when aspen supplies are tightest. Bottleneck periods tend to be in periods 3 to 5 and are later and more pronounced when the minimum rotation length for aspen is longer. The costs of supplying age 55+ aspen lags beyond the bottleneck periods because stands age 55+ in the periods following bottleneck period must be withheld from harvesting during the bottleneck period.
10. Scenarios were compared under varying assumptions regarding the value of age 55+ aspen. Increasing this value changed the ranking of scenarios based on combined (timber plus age 55+ aspen) NPV estimates. Of the scenarios considered, the scenario that maximizes combined value was always a scenario that allows at least some use 40-year rotations in the aspen cover type.

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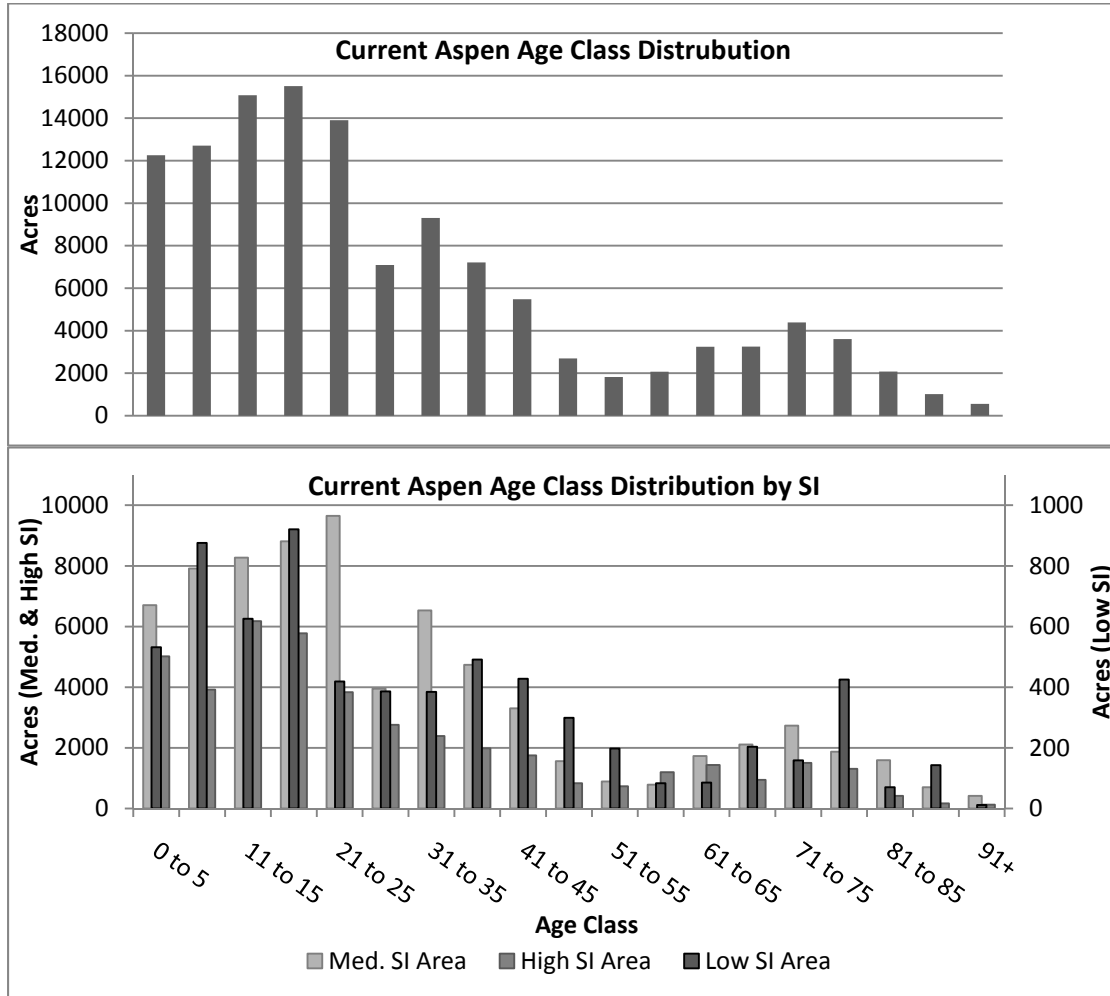
## Introduction

This report summarizes work by the University of Minnesota, Interagency Information Cooperative (IIC) to help support the ongoing forest planning process of the Koochiching County Land Department. At their October 20, 2009, meeting, the Koochiching County Forest Planning Advisory Group requested that the IIC help develop an analysis of forest management alternatives for Koochiching County. This report describes results of analyses developed to assist the advisory group. The process was iterative, with the group often requesting additional information after each monthly meeting. The committee selected a preferred alternative at their May 2010 meeting.

The Koochiching County Land Department manages approximately 123,200 acres of forest land in the aspen cover type. This cover type is, by far, the largest forest cover type in Koochiching County. It can be harvested on a shorter rotation than most other types, making it possible to cut a higher percentage of this cover type annually without damaging long-term sustainability. Stands in the aspen cover type typically contain a mixture of species with approximately 75% of the volume in the aspen product group. The aspen is also one of highest-valued product groups with major pulp mills in Minnesota all currently depending on its production. The age class distribution is currently imbalanced for lands in the aspen cover type that are managed by Koochiching County with large areas of both young and old aspen and fewer acres in intermediate age classes (Figure 1). Key planning questions concern the potential to harvest more from the older aspen age classes during the next 5 to 10 years, as a substantial area of the aspen cover type is beyond optimal economic rotation. Higher harvest volume would benefit the struggling local economy. Aspen is a relatively short-lived tree. There is concern over slow growth rates and tree mortality in older aspen stands. Harvesting and regenerating older aspen contributes to future timber productivity, as young aspen stands grow rapidly. Koochiching County has productive sites for growing aspen, with overall average potential productivity high compared to other Minnesota counties. Yet harvesting all aspen stands today that are currently beyond their age of financial maturity would cause a future temporary shortfall in harvest levels because of the imbalanced age class distribution. The current age class distribution of the aspen cover type shows that a less than desirable number of acres will reach economic maturity over the next 20 years (Figure 1). Maintaining some older aspen on the landscape is also important for sustaining environmental conditions that have occurred naturally for many years.

So why use a harvest scheduling model? Traditionally, public forest land management agencies have relied on simple formulas or computer simulation models to help set forest-wide harvest levels. Such approaches assume that priorities for sequencing stands for harvesting are known. They basically project (simulate) forest conditions forward through time based on an assumed forest management strategy. In contrast, computer optimization models make it possible to explore forest management options in much greater detail. Priorities for sequencing stands for harvest need not be specified *a priori*. Instead, harvest sequencing can be an output of the analysis. Optimization models can search through an almost limitless numbers of possible management combinations to help find “best” solutions. Best is defined by the user through a specified objective function. For modeling purposes in this study, the objective is assumed to be to maximize net discounted returns from timber sales (4% annual interest rate) subject to a set of overriding forest management constraints that define Koochiching County forest management

policies. Multiple scenarios are analyzed to help estimate and compare impacts of alternative forest management policies and strategies.



**Figure 1. The current age class distribution of aspen.** The top graph is a total for all site index classes. The bottom graph breaks out the site index (SI) classes. Medium and high site indices use the left vertical axis and the low site index uses the right vertical axis.

## Methods

Koochiching County's forest management planning process was well underway before this study began in the fall of 2009. Koochiching County contracted with Pro West & Associates (PWA) to help develop much of the plan. Prior to IIC involvement, PWA completed area control simulation analyses to address potential harvest levels for each forest cover type. Their work also addressed forest cover types not addressed in this study. This study focused on the aspen, lowland spruce, Balm of Gilead, spruce-fir and tamarack cover types. The aspen and lowland spruce cover types are by far the two largest cover types managed by the county. Jack pine, red pine, ash, lowland hardwoods, northern hardwoods and birch are cover types not included in the analyses. These cover types were addressed by PWA in their earlier analysis.

The basic modeling units (analysis areas) recognized were the 16,850 individual stands represented in Koochiching County's stand level inventory. That data was provided by PWA in a GIS format, with updating done by the IIC to recognize recent timber sales. Modeling results can easily be linked back to stand level data for potential use in plan implementation. As with many county inventories in Minnesota, the Koochiching County inventory is old, with much of the data dating back to the 1980s, especially for stands currently of harvestable age. Because of the age of the data, relatively few inventory fields could be considered reliable. Only the forest cover type, stand age, and site index estimates were considered reliable at the stand level. Typically, one would also like to recognize stand-level information on species mix and stocking (basal area), but that was not feasible with the available data.

Adjustments were made to the Koochiching Inventory Data to help overcome some of its shortcomings. In recent years, older stands in the spruce-fir cover type have suffered large losses from spruce-budworm damage. PWA estimated that 60% to 80% of the stands in this type that currently would be of harvestable age have suffered major disturbance and are thus not currently harvestable. For our analysis, stands over age 60 in the spruce-fir cover type were selected randomly such that approximately 30% of these stands were assumed to have suffered a major stand disturbance (age set back to ages 0) at a time randomly selected between years 1993 and 2009. Adjustments were also made to the inventory to recognize additional variation in the lowland spruce (black spruce) cover type. For this type, stocking levels were assumed to vary by as much as 30% from the average stocking level reflected in the yield data. Specifically, stocking level factors (multipliers) for stands in the lowland spruce cover type were randomly generated from a triangular distribution with a minimum value of 0.7, a mean value of 1.0, and a maximum value of 1.3. Adjusting stocking levels made some on the lowland spruce stands nonmarketable in the model, with the lowest site index stands most likely nonmarketable.

The only management costs recognized in the model were those associated with sale administration. Sale administration costs for regeneration harvests were assumed to be \$100/acre plus \$50/stand. These costs make some low-volume stands nonmarketable, especially if a stand contains low-valued products. Estimates of future stumpage price estimates (\$/cord) were obtained from the Koochiching County Land Department and were \$19, \$15, \$10, \$5, and \$5 for aspen, spruce and fir, pine pulp, tamarack and other hardwoods. Red pine and jack pine sawlog price estimates were \$35/cord and \$25/cord. All timber prices were assumed to remain constant over time.

All scenarios and the Initial Benchmark constrained the maximum area harvested in any period. Specifically, because of assumed limits on county staffing, it was assumed that the county cannot harvest more than 5,000 acres/year. For modeling purposes, this limit was translated to 4,300 acres/year, assuming that 700 acres/year would be harvested from forest cover types not modeled. During years 2005 to 2009, harvesting averaged less than 500 acres/year from these other forest types. PWA estimated that approximately 760 acres/year should be harvested from these other types in the next five years, with approximately 440 acres of that harvesting from the ash lowland cover type.

Considerable effort went into developing growth and yield estimates. The process developed empirical yield tables using recent FIA inventory data along with short-term projections of that

data using growth model projections developed for a 2006 Environmental Impact Statement for a recently proposed mill expansion in northern Minnesota (MNDNR 2006). The yield estimates are based on plots located in 15 northern Minnesota counties. In developing the tables, data was weighted based on the length of the growth projection, with longer projections receiving less weight. No growth projections were used that projected stand growth for more than 14 years. Projections were also not used for older stands, as tree mortality estimates are questionable. Table 1 shows total volume estimates by age for the aspen cover type for a range of site index levels.

**Table 1.** Average volume yield (all species) by site index and stand age for the aspen cover type (cords/acre). These estimates were reduced in analyses to recognize site level guidelines for leaving residual trees after harvest.

Age (years)	Site Index								
	45	50	55	60	65	70	75	80	85
40	8.3	11.0	13.7	16.4	19.1	21.4	23.7	25.9	28.2
45	11.3	13.8	16.2	18.7	21.1	23.3	25.5	27.7	29.9
50	11.7	14.3	17.0	19.6	22.3	25.2	28.0	30.9	33.8
55	12.9	15.7	18.4	21.2	24.0	27.1	30.1	33.2	36.2
60	15.8	18.1	20.5	22.9	25.3	28.3	31.4	34.4	37.5
65	16.5	19.2	22.0	24.7	27.4	29.4	31.4	33.4	35.3
70	14.7	17.1	19.5	21.9	24.4	26.1	27.9	29.6	31.4
75	12.9	15.0	17.1	19.2	21.3	22.9	24.4	25.9	27.5
80	11.0	12.8	14.6	16.5	18.3	19.6	20.9	22.2	23.6
85	9.2	10.7	12.2	13.7	15.2	16.3	17.4	18.5	19.6
90	7.3	8.6	9.8	11.0	12.2	13.1	13.9	14.8	15.7

All scenarios analyzed followed statewide voluntary site level management guidelines assuming, that on average, 4 square feet of basal area of otherwise merchantable timber would be left onsite for environmental purposes. Tree species left as residuals were pro-rated based on species basal area estimated present on the site. Inventory information was not available describing forest land in riparian areas. Forest area potentially lost because of road impacts were not considered.

## Scenarios

Analyses focused on multiple runs of a forest management scheduling model. Emphasis was on learning more about impacts of alternative forest management strategies for Koochiching County's forest lands. Initially, assumptions about two key facets of the forest management situation were varied between model runs, with the intent of later comparing results to better understand the potential impact of these facets. An initial benchmark model run was also done to help provide a baseline for comparing the nine initial scenarios.

Specific scenarios modeled initially were characterized by variations in: (1) the specific forest regulation policy to implement for sustaining harvest levels over time, and (2) the targeted amount of aspen between ages 55 to age 75 to sustain on the landscape in the aspen cover type over time. For each of these two factors, three alternatives were considered. All nine combinations (3 x 3) of these alternatives were modeled separately. Scenarios are named A1, A2, A3, B1, B2, B3, C1, C2, and C3 with the A, B, and C referring to one of the three forest



regulation alternatives and the 1, 2, and 3 referring to one of the three alternative target levels for the area of age 55+ stands in the aspen forest cover type between ages 55-74 years (age 55+).

### **Initial Benchmark**

The Initial Benchmark included fewer constraints than any of the scenarios modeled. It serves as a run for comparison purposes to help better understand the costs of the “package of constraints” included for each scenario. The Initial Benchmark requires an age class distribution at the end of the 100-year planning horizon that is representative of a fully regulated forest. It targets sustaining 2,500 acres of age 55+ aspen (as low as all other scenarios). It limits annual harvest from all cover types to 4,300 acres. It uses a minimum harvest age of 45 years for stands in the aspen cover type. Only for the aspen cover type do minimum rotation age assumptions vary by scenario. Minimum rotation age limits for lowland spruce ranged from 70 years on high quality sites to 120 years on low quality sites. For Balm of Gilead, the minimum rotation age was 50 years. For the spruce-fir cover type, the minimum rotation age was 60 years. For tamarack minimum rotation ages ranges from 90 years on low quality sites to 60 years on high quality sites.

### **Regulation Alternative A**

This alternative emphasizes area control. It targets harvesting at least 2,300 acres of the aspen forest cover type each year. This harvesting is assumed to help support the local economy at the time of harvest while also improving future timber productivity by replacing slow-growing, shorter-lived, older aspen with regenerated faster-growing young stands that can help meet future timber demands. The minimum annual area of the aspen cover type to harvest and regenerate is approximately the same area of the aspen forest cover type targeted by PWA in their area control analysis. Alternative A also follows closely the minimum harvest age assumptions used in the PWA analysis. Specifically, for the aspen forest cover type, stands with site index less than 55 feet are assumed to have a minimum rotation age of 45 years. For aspen stands with a site index exceeding 55 feet, the minimum rotation age is 50 years. Alternative A contains no regulation constraints for specific cover types other than those for the aspen cover type.

### **Regulation Alternative B**

This alternative emphasizes area control and includes some bounds on volume harvested. It prevents large fluctuations in areas harvested by targeting to harvest annually at least 2080 acres from the aspen cover type and 250 acres from the lowland spruce cover type. It partially overcomes problems associated with the initial imbalanced age class distribution of the aspen forest cover type by harvesting more from the lowland spruce cover type during times when aspen harvest levels would otherwise be low. Specifically, it targets to keep the combined annual volume harvested from the aspen and lowland spruce cover types between 54,000 and 70,000 cords. Like Alternative A, Alternative B also follows the minimum rotation age assumptions used by PWA for their analysis. For the aspen forest cover type, stands with site index less than 55 feet are assumed to have a minimum rotation age of 45 years. For aspen stands with a site index exceeding 55 feet, the minimum rotation age is 50 years.

### **Regulation Alternative C**

This alternative emphasizes volume control. It targets harvesting at least 41,000 cords annually of aspen product volume from all the modeled forest cover types. Identical to Alternative B,

Alternative C targets harvesting at least 2,080 acres annually from the aspen cover type. It also constrains the volume of spruce-fir product volume to at least 10,000 cords annually. Alternative C differs from Alternative A and Alternative B in that the minimum harvest age is not as restrictive for the aspen cover type; all site index classes in the aspen cover type are considered harvestable at age 45 years.

### **Age 55+ Aspen Alternatives 1, 2, & 3**

These three alternatives are each defined by a targeted amount (area) of age 55+ stands to sustain in the aspen cover type. Age 55+ stands are between the ages of 55 and 74 years. Alternative 1 targets maintaining 2500 acres of age 55+. Alternative 2 targets 3750 acres and Alternative 3 targets 5000 acres. An upper age limit was used in defining age 55+ aspen to discourage holding acres beyond age 74.

## **Background on Shadow Prices**

Shadow prices are a valuable model output from a linear programming (LP) model. In the results section that follows, shadow prices (marginal costs) are presented to help readers better understand the opportunity costs associated with the constraints used in modeling. In this section we provide background information on shadow prices from LP so that readers unfamiliar with LP can gain a basic understanding. Readers familiar with LP and shadow prices can skip this section.

Typically, in solving LP formulations of a problem, a shadow price estimate is available to help better understand the marginal impact of each constraint used in the model. Shadow price estimates are often referred to as marginal cost estimates because they are an estimate, at the margin, of the impact of changing the level of the associated constraint by one unit. The impact is in terms of the impact on the objective function, the function (value) being maximized or minimized. Marginal costs are measured in the same units used for defining the objective function and the associated constraint. For example, if the objective function is maximizing the NPV of the forest in dollars, and a constraint sets a specific limit on the number of acres that can be harvested in a specific planning period, then the shadow price for that constraint is measured in dollars per acre. In effect, for this example, the shadow price is estimating the dollar change in the objective function for a 1-acre change in the level of the constraint. Specifically, if the objective is to maximize NPV and the constraint is relaxed, then the absolute value of the shadow price is an estimate of the rate of improvement in NPV for each unit change in the level of the constraint. Similarly, if one were to tighten the constraint, then the absolute value of the shadow price is an estimate of the rate of decline in NPV for each unit change in the level of the constraint. Constraints that are not binding in the optimal solution do not have an impact on the solution. Thus those constraints each have a shadow price estimate equal to zero.

Shadow prices from a forest-wide planning model can be thought of as internal price to use in evaluating management options at the stand level. Specifically, shadow prices can be interpreted as either a credit or penalty to apply consistently in all stand-level analyses so that forest-wide considerations are achieved when stand-level results are accumulated to a forest-wide level. For example, with an older forest, and if one were to conduct a stand-level analyses to maximize

NPV, results without using shadow prices would likely suggest that many stands should be harvested in the first planning period. Typically, forest-wide models include constraints to require a more balanced flow of harvest over time. These constraints could be in terms of either the volume or area harvested. Shadow prices associated with such constraints are estimates of internal credits (or penalties) that are needed to include system-wide (forest-wide) so harvest levels, when summed from stand-level analyses, are balanced adequately over time. “Balanced adequately” is as defined by the forest regulation constraints used. Essentially, the LP model works to identify the best credits/penalties to apply to account for each forest-wide constraint so that the forest-wide constraints are satisfied and the forest-wide objective function is optimized. Solutions with large shadow prices (penalties or credits) indicate that large adjustments are needed in stand-level analysis, suggesting stand-level management will shift away from options that would otherwise maximize the objective function when constraints are not included in the model.

Forest management is characterized by long planning horizons. Typically, separate constraints are used for each planning period. For example, one might use 20 forest-wide constraints to reflect a desire to harvest at least 2,000 acres in each of 20 planning periods in the planning horizon. Shadow price estimates are provided by the model for each of these 20 periods. These estimates often have a temporal pattern that reflects the initial conditions of the forest. For example, with a forest that is initially older than a regulated forest, credits (shadow prices) are often needed to delay harvest until period 2. And with period 2 harvest options receiving a credit, then even higher credits are likely needed for period 3, so that enough stands are held until period 3. Typically, harvest timings for individual stands can be adjusted by several periods, and the LP model will pick to harvest the stand in the period that maximizes returns based on the internal valuing system, considering all penalties/credits as reflected in the shadow price estimates for the constraints.

When considering shadow prices as an internal pricing system for evaluating stand level treatment options, any shadow price for a “greater-than-or-equal-to” constraint is an internal per unit credit. It is a credit needed to raise the associated production level to the level of the constraint. In contrast, a shadow price for a “less-than-or-equal-to” constraint is an internal per unit penalty to keep the associated production level below the constraint level. For an equality constraint, the shadow price can be either a penalty or a credit. The penalties and credits are essentially applied in the modeling process when evaluating management options for individual stands. When these shadow prices are relatively large, they can cause substantial change in terms of the management option selected for an individual stand as compared to the option that maximizes net benefits if only stand-level values are considered.

Typically, in examining model results, one is interested in identifying the constraints that are having a large impact. When interpreting shadow price estimates, it is critical to take into account the units used in the shadow price estimates. For example, shadow prices for volume constraints are often reported in dollars per cord. In contrast, shadow prices for area constraints are often reported in dollars per acre. When harvested, one acre often yields 20 or more cords.

Additional information on shadow prices can be found in most any introductory management science text. Hillier and Lieberman (2009) is one of the most widely used texts. Descriptions of

using shadow prices to coordinate stand-level management to achieve forest wide constraints can be found in Hoganson and Rose (1984), Paredes and Brodie (1987), and Paredes and Brodie (1988).

## **Initial Results**

This section provides an overview of the initial modeling results. Intent is to describe the results and not judge which scenario is best. In this section, information is first presented to compare the initial nine scenarios and Initial Benchmark in terms of the total area and total volume harvested over all of the forest cover types that were modeled. Then, similar comparisons follow for just the aspen forest cover type. Age class distributions for the aspen cover type over time are also presented. These distributions help identify “bottleneck” time periods when timber supplies will potentially be tightest under each scenario. Scenarios are also compared in terms of the estimated NPV of each scenario. In developing management schedules, the model attempts to maximize NPV while satisfying all of the constraints that define each scenario.

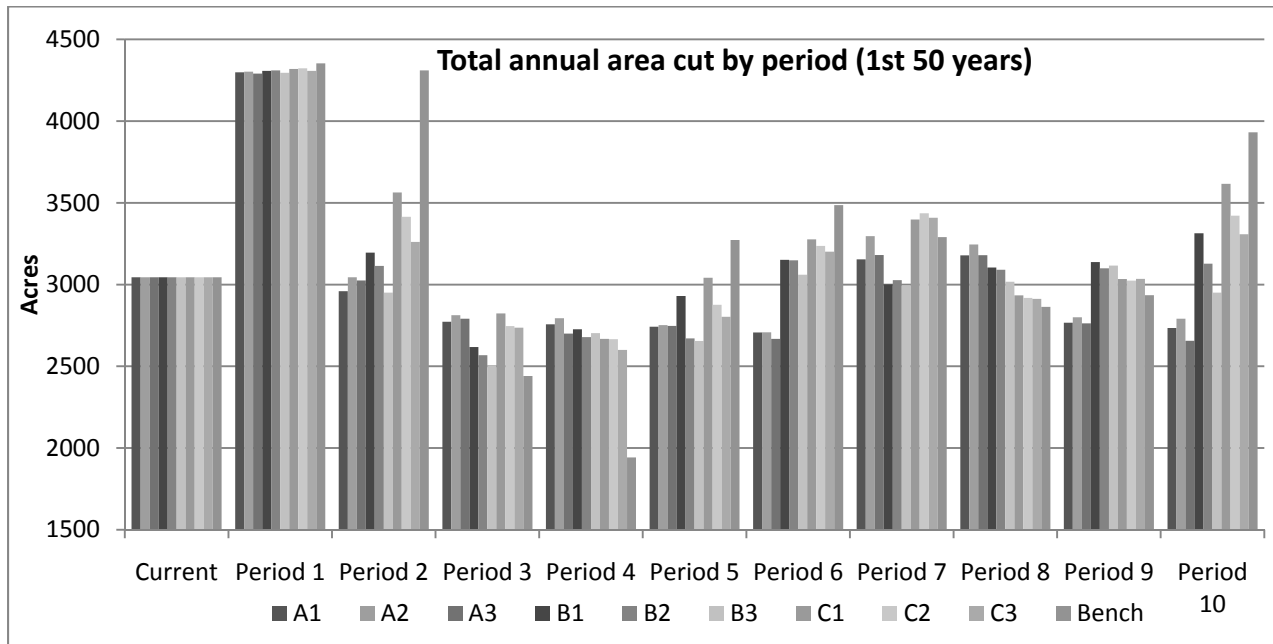
In the next section of this report, similar information on modeling results will be presented for additional scenarios requested by the Koochiching County Forest Planning Committee after reviewing the results summarized in this section. Detailed appendices are included at the end of this report that include information on the nine initial scenarios modeled and the additional scenarios described in the next section. Specifically, Appendix A provides detailed information on the age class distributions over time. Appendix B shows details on area harvested during each 5-year planning period. Appendix C shows similar details by period in terms of volume harvested. Appendix D shows specific shadow price estimates for the age 55+ constraints for the aspen forest cover type. The remainder of this section summarizes results for the initial modeling results.

### **Area Harvested - All Forest Cover Types**

Only the spruce-fir, aspen, black spruce, tamarack and Balm of Gilead cover types were modeled. For all other cover types combined, it was assumed that annual area harvest levels could be up to 700 acres. For the cover types modeled, it was assumed that the average annual harvest level could not exceed 4,300 acres in any of the five-year planning periods. Figure 2 shows the total acres harvested from all modeled cover types for each planning period. Only in the first period is the 4,300-acre limit a binding constraint—all scenarios harvest at this level in the first period. In all other periods, average annual harvest levels per period range from approximately 2,500 to 3,500 acres for all scenarios. In the second period, harvest levels are substantially higher for Alternative C than for Alternative B or Alternative A. The Area harvested for the Initial Benchmark fluctuates widely with a high harvest in period 1 and a low harvest in period 4.

For all model runs the shadow price estimates are zero for the 4,300-acre harvest limits for all periods except for period 1. For scenarios A1, A2, and A3, the marginal cost estimates for the 4,300-acre constraint limit for period 1 are \$31.47/acre, \$20.94/acre and \$16.73/acre respectively. Essentially, the differences reflect that the 4300 acre maximum harvest level constraint has less of an impact when management is also required to produce more age 55+ Aspen (A3 has the highest age 55+ Aspen requirement of these three scenarios). For scenarios

B1, B2, and B3, the shadow price estimate for the 4,300-acre constraint for period 1 are \$51.51/acre \$43.03/acre and \$31.08/acre respectively. These are of larger in magnitude and follow the same general trend as those for A1, A2, and A3. The magnitude of these shadow prices are informative. For example for Scenario B1, the shadow price corresponding with period 1 indicates that the model delays harvesting a stand until at least period 2 if the corresponding reduction in NPV from such a delay is less than \$51.51/acre.

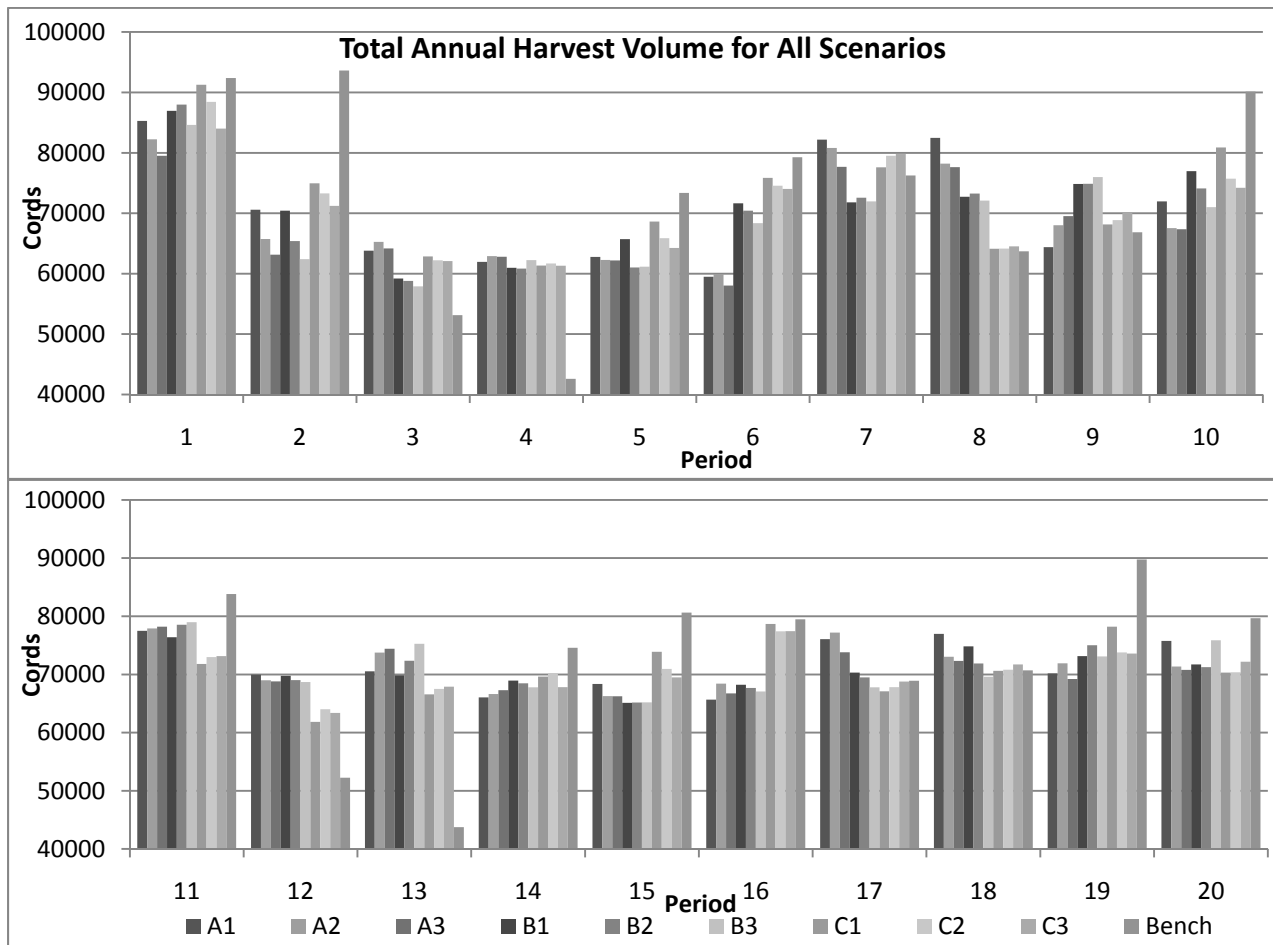


**Figure 2.** Total annual area cut by period for the first 50 years in the modeled forest cover types for all scenarios (acres/year). Note: Bench represents the Initial Benchmark scenario.

The shadow price estimates for the 4,300-acre constraint for period 1 follow a similar pattern for the C1, C2, and C3 scenarios. Values are \$80.03/acre \$59.89/acre and \$37.28/acre respectively. The somewhat higher shadow prices for Alternative C reflect the potential to otherwise harvest more under Alternative C during period 1.

### Volume Harvested - All Forest Cover Types

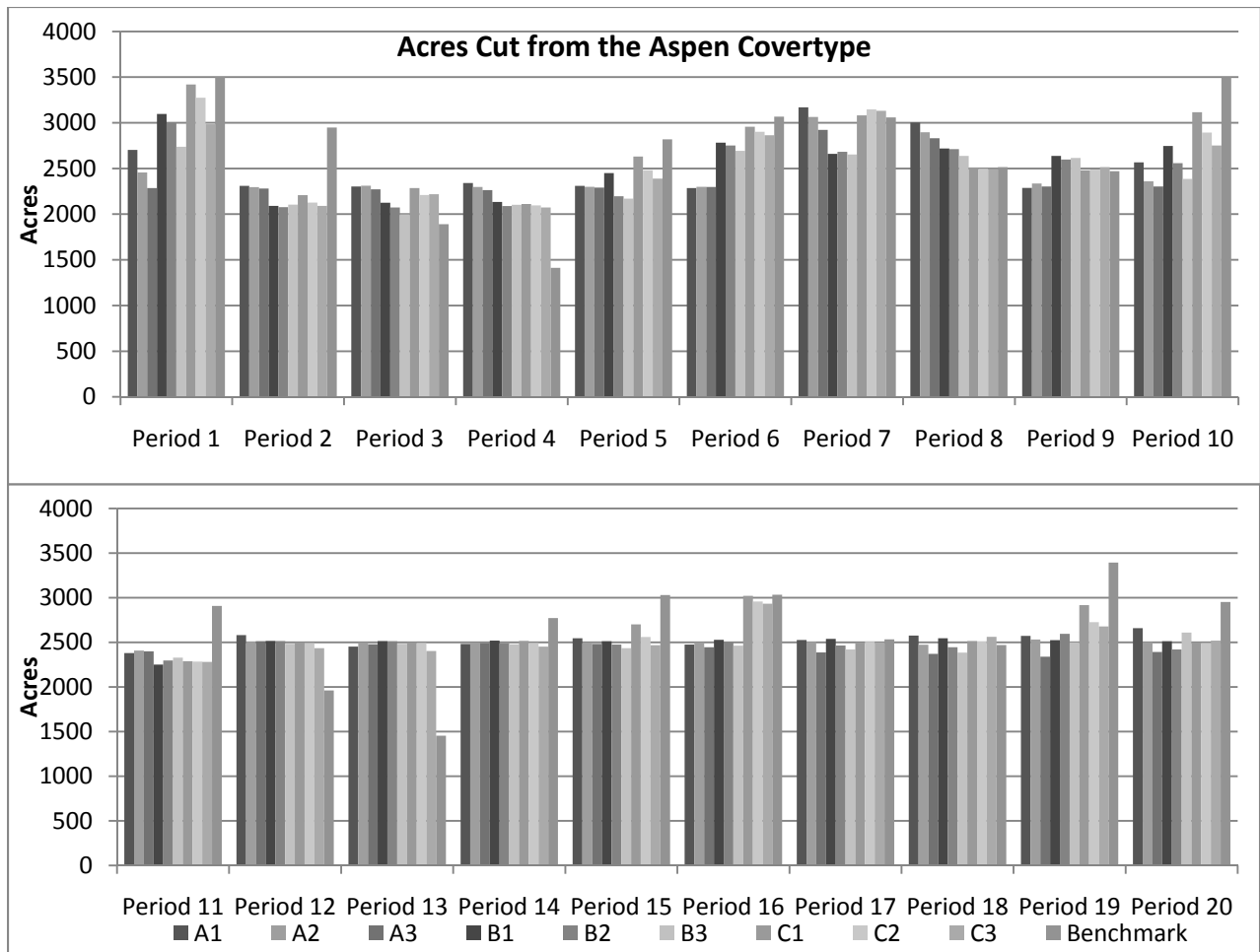
Figure 3 compares the volume harvested for each scenario over the 20 periods in the planning horizon. All of the scenarios have higher harvest levels in period 1, taking advantage of having more financially mature stands available at the start of the planning horizon than would be present over the remainder of the planning horizon. Not all financially mature stands are harvested in period 1 for any scenario except for the Initial Benchmark. For all scenarios except the Initial Benchmark, harvest levels are maintained at nearly 60,000 cords in all periods. Harvest levels tend to be lowest in periods 3 and 4 and higher again in periods 6 to 8. This reflects large areas of young stands in the aspen cover type in the initial inventory that will become available for harvest at that time. Also evident from Figure 3, if a larger area of age 55+ aspen is required then the volumes harvested are lower in early periods. The Initial Benchmark has large fluctuations in harvest volumes compared to any scenario, as harvest levels drop to nearly 40,000 cords in period 4 and period 13.



**Figure 3.** Total annual harvest volume for each scenario and the Benchmark Run by 5-year period (cords/year). Note: Bench represents the Initial Benchmark scenario.

### Area Harvested -- Aspen Cover Type

In terms of the acres harvested annually from the aspen cover type, all scenarios in the first period have at least some departure from what would be considered a long-term steady state. All scenarios are harvesting more acres of the aspen type in the first period (Figure 4) because of the age imbalance of this cover type at the start of the planning horizon (Figure 1). Aspen also has a high price relative to most other species and growth rates for older aspen are low, thus making aspen a priority cover type to harvest in the model in period 1. The model is limited to the total area harvested in period 1 over all cover types so the model is suggesting delaying harvest is better suited in cover types other than aspen under the objective of maximizing net present value (NPV). In periods 2, 3, and 4, all scenarios have lower harvest levels, but maintain requirements as defined by each scenario. In contrast, the Initial Benchmark has substantially more variation in aspen harvest levels over time. Once current age 10 to 24 year old aspen stands reach harvestable age in periods 5, 6, and 7, scenarios are able to cut more acres (Figure 4). Alternative C can harvest more sooner, as it allows for harvesting all productivity site classes at age 45. Following period 7, scenarios harvest at a fairly regular level, cutting between 2,400 and 2,500 acres per year.

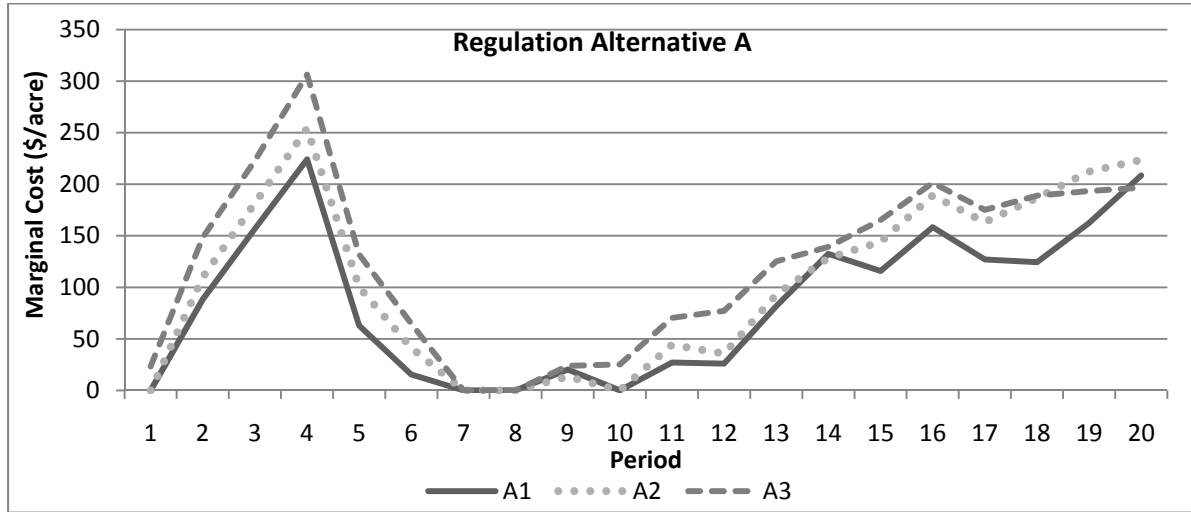


**Figure 4.** Annual area cut from the aspen cover type for all scenarios and the benchmark scenario.  
 Note: Benchmark represents the Initial Benchmark scenario.

Regulation Alternative A is based on controlling the acres harvested in the aspen cover type. It requires 2,300 annual aspen acres harvested at a minimum for each period. Alternative A meets this requirement every period.

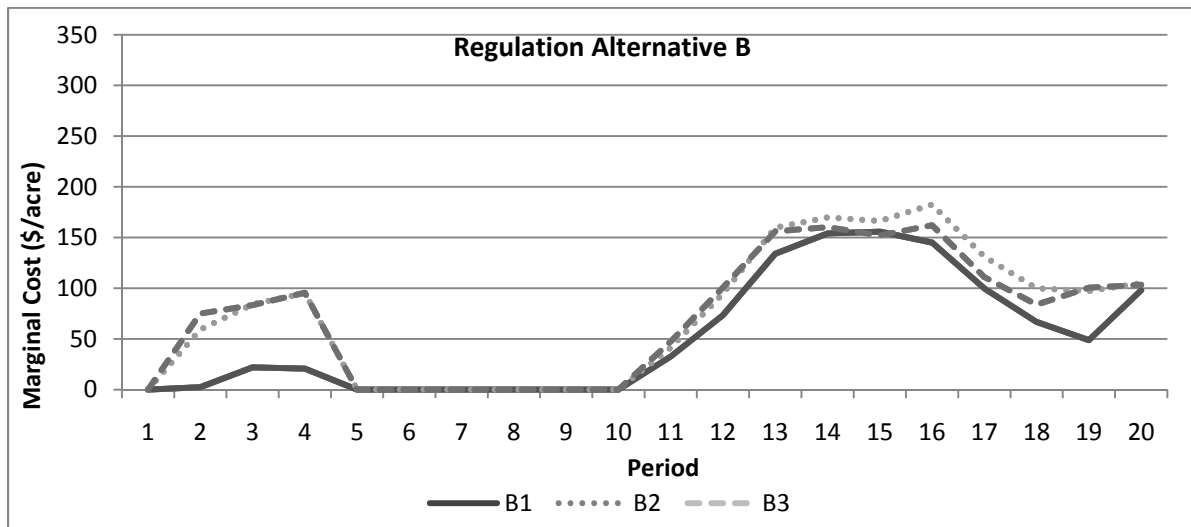
Shadow price (marginal cost) estimates help in interpreting the impact of the constraints that regulate the area of the harvest in the aspen type. These marginal costs reflect the opportunity cost of needing to delay harvests when a stand is otherwise financially mature. One would expect that these marginal costs might fluctuate substantially over time because of the imbalance in the age class distribution of the aspen cover type at the start of the planning horizon. Figure 5 shows the marginal cost (shadow price) estimates for the aspen harvest-level area constraints of Alternative A. The graph shows that it is expensive to delay harvests of stands financially mature in earlier periods to achieve the targeted levels for periods 2 to 5. The marginal cost is close to zero in period 1 and periods 6 to 9 because there is an abundant area of financially mature wood in these periods compared to the 2,300-acre requirement. As one might expect, the marginal costs are higher when more age 55+ aspen stands are required. Higher marginal cost estimates for later periods reflect the difficulty of cutting at a 2,500 acre/yr target level while still

maintaining old forest. Lowering these acreage targets a small amount would likely lower these marginal costs substantially in the later periods.



**Figure 5.** Marginal cost estimates for the constraints used to regulate the area of aspen harvested for Regulation Alternative A.

Regulation Alternative B considered combined impacts of harvesting from the aspen and black spruce cover types. This alternative requires that, together, these cover types produce between 56 and 70 thousand cords per year. However, it also requires a 2,080 annual acre minimum aspen harvest each period. These constraints on aspen harvest are not as restrictive as for Regulation Alternative A, and as expected, the marginal cost of achieving these levels are much less than those for Regulation Alternative A (Figure 6).



**Figure 6.** Marginal cost (shadow price) estimates for the constraints used to regulate the area of aspen harvested for Regulation Alternative B.



Regulation Alternative C focuses on producing a minimum of 41,000 cords of aspen volume each period. Like Regulation Alternative B, it requires a 2,080 annual acre minimum aspen harvest each period. These constraints on aspen harvest area are not as restrictive as for Alternative A and, as expected, the marginal cost of achieving these levels (Figure 7) are less than those for Alternative A (Figure 5). At a maximum, Regulation Alternative C harvests almost 3,200 acres per year. This occurs during periods of surplus wood that results from the age class imbalance in the aspen type.

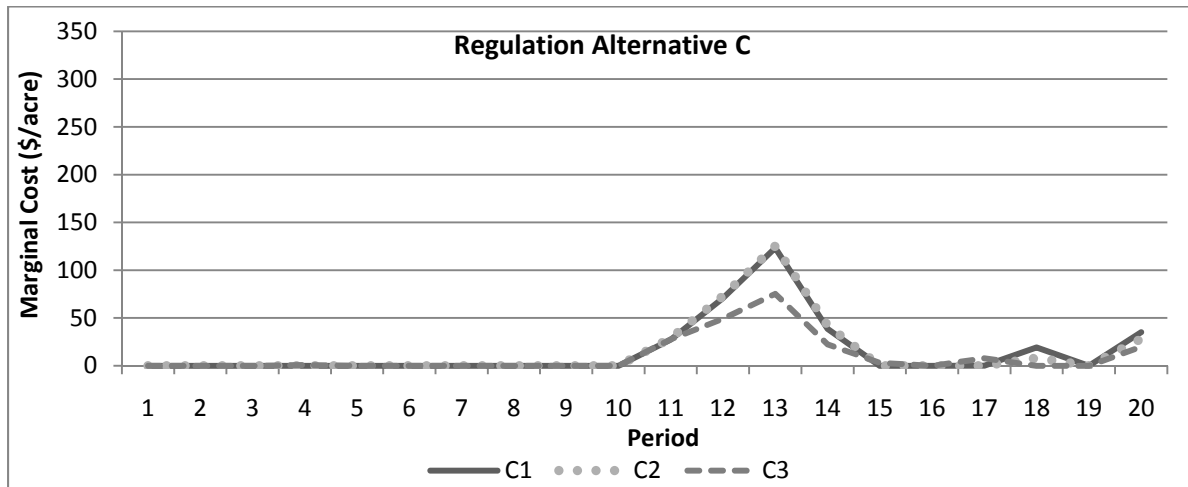
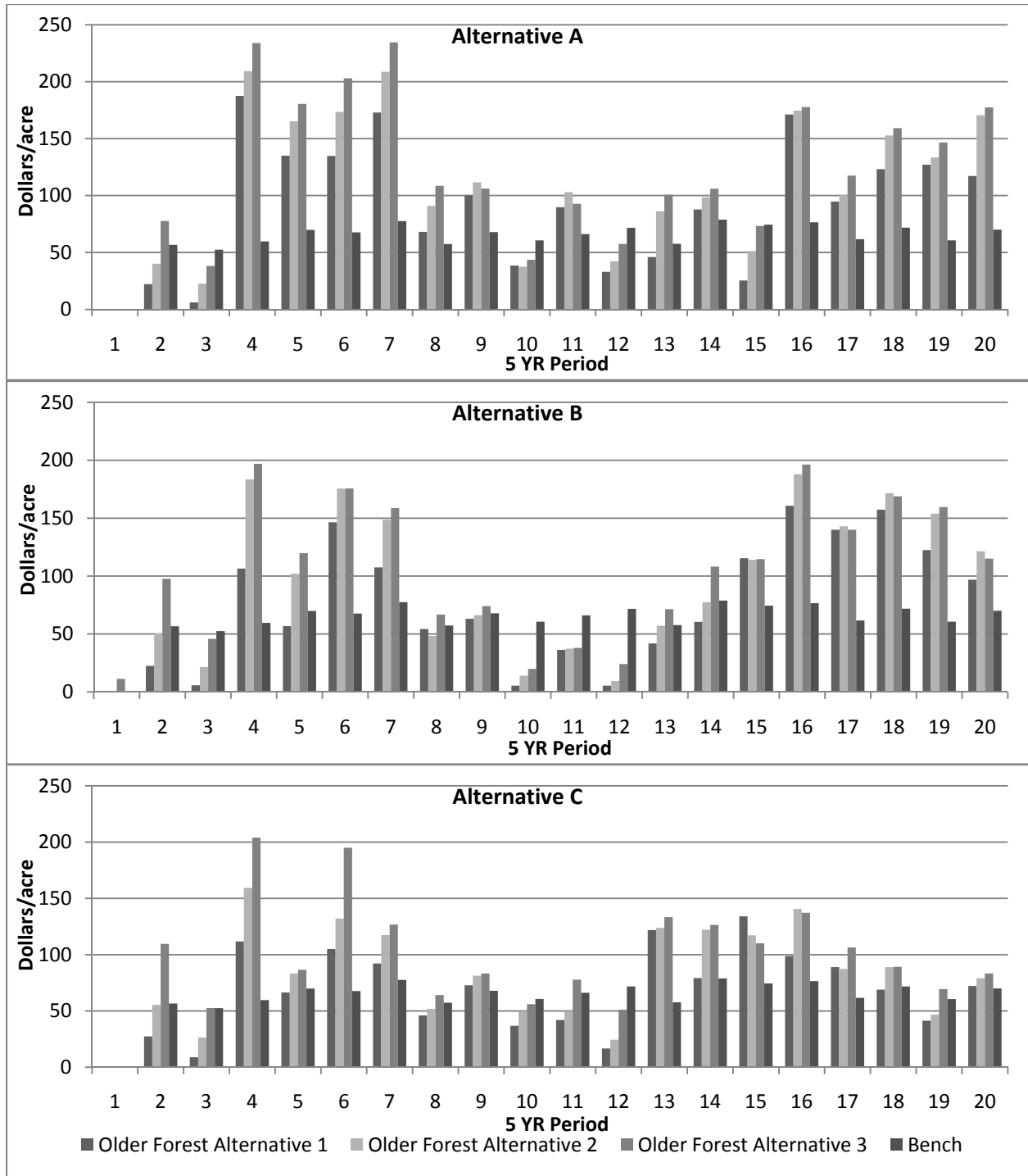


Figure 7. Marginal cost (shadow price) estimates for the constraints used to regulate the area of aspen harvested for Regulation Alternative C.

### Forest Condition - Area of Aspen Cover Type Age 55-74 Years

Generally, each scenario has no more area of age 55+ aspen than is required by the assumptions of the scenario. The exception is period 1 because of the abundance of age 55+ aspen in the existing inventory. Of interest is the cost of sustaining alternative levels of these levels of age 55+ aspen (2,500 acres, 3,750 acres, or 5,000 acres). Figure 8 shows that the shadow prices (marginal cost) of producing age 55+ aspen varies substantially by period. The fluctuations over time are a result of the age class imbalance in the aspen type. In the first three periods the model has less trouble finding acres to satisfy the age 55+ aspen requirements. In periods 4 to 7 it struggles to do so, particularly under Alternative A. When looking at these shadow prices and comparing them to shadow prices for area control or volume constraints on harvesting, there are some clear interrelationships. Essentially there is competition between the need to sustain age 55+ aspen and the need to harvest a minimum level in periods of relative low aspen supply. This is especially true in the later periods when area control constraints are allowing more acres to be harvested. Important to note is the difference in time between the points at which a stand is financially mature and when it counts as age 55+ aspen. This difference helps explain the lag between the peaks of maximum shadow prices when comparing shadow prices for age 55+ aspen constraints to shadow prices for harvest level constraints. These lags are generally 2 to 4 periods long. For example, the age 55+ aspen requirement in period 7 (Figure 8) is competing with the Regulation Alternative A requirement to harvest acres in the aspen cover type in periods 4 and 5 (Figure 5). Higher shadow prices for age 55+ aspen force stands that could be harvested when financially mature in period 5 to be held until through period 7 to satisfy the age 55+ aspen requirement for period 7.

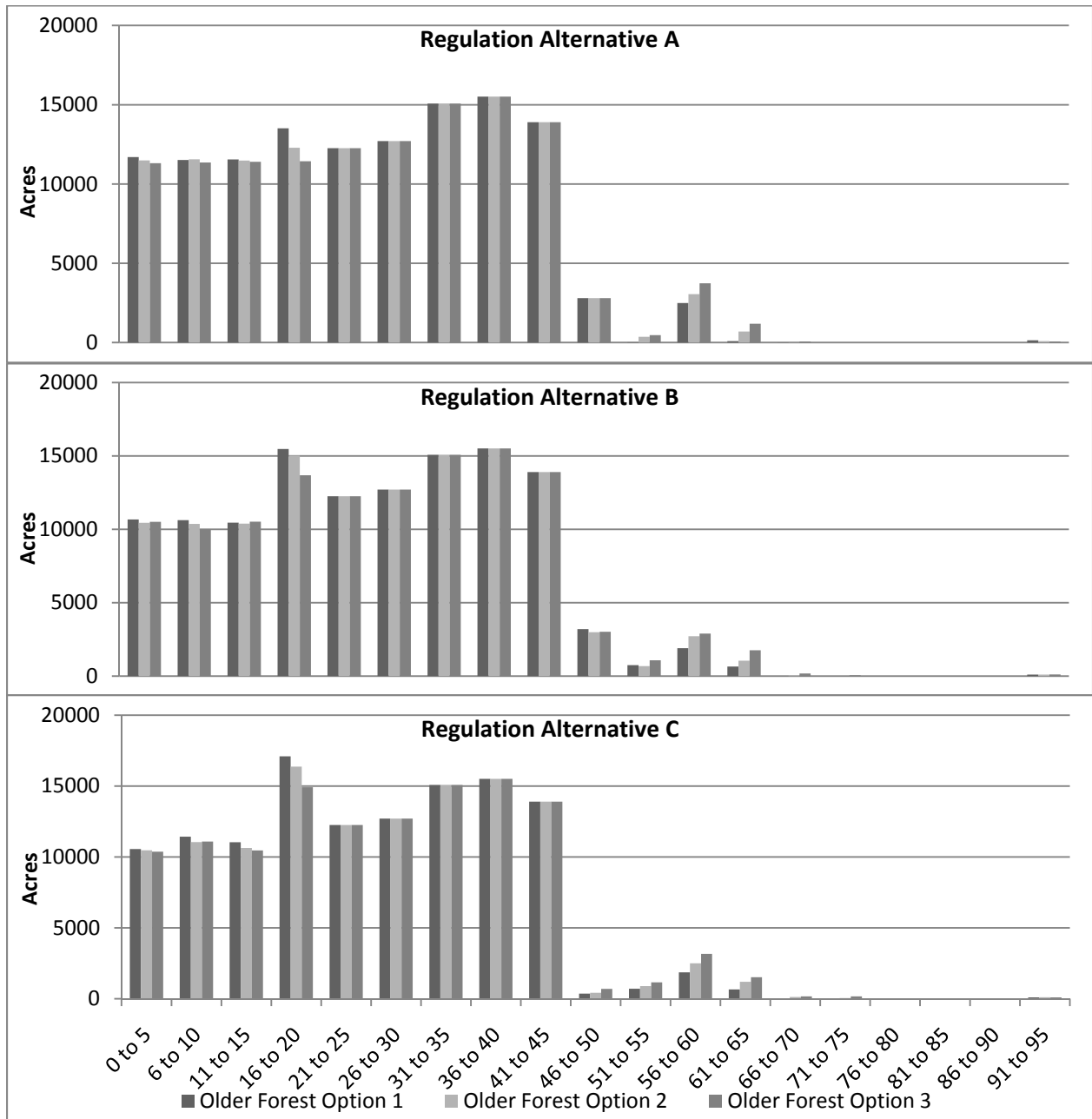


**Figure 8.** Marginal cost (shadow price) estimates for the age 55+ aspen constraints for all periods and scenarios (\$/acre). Note: Bench represents the Initial Benchmark scenario.

### Forest Condition -- Aspen Cover Type Age Class Distribution

Tables in Appendix A summarize the aspen age class distribution for each scenario. In any of these tables, by comparing changes in these distributions between successive periods, one can identify the specific area of each age class scheduled for harvest each period for the

corresponding scenario. Figure 9 shows the age class distribution for the aspen cover type at the end of period 4 for each Regulation Alternative. The end of period 4 is highlighted, as period 4 is when the aspen wood supply tends to be the tightest. At the end of period 4 the area of age 55+ aspen does not exceed the targeted amount substantially. By the end of period 4, the aspen cover type is closer to a fully regulated condition than at the start of the planning horizon (figure 9). Alternatives A and B have substantially more area in the 45-50 age class, as these scenarios assume a minimum rotation age of 50 years for aspen stands with site index greater than 55 feet.

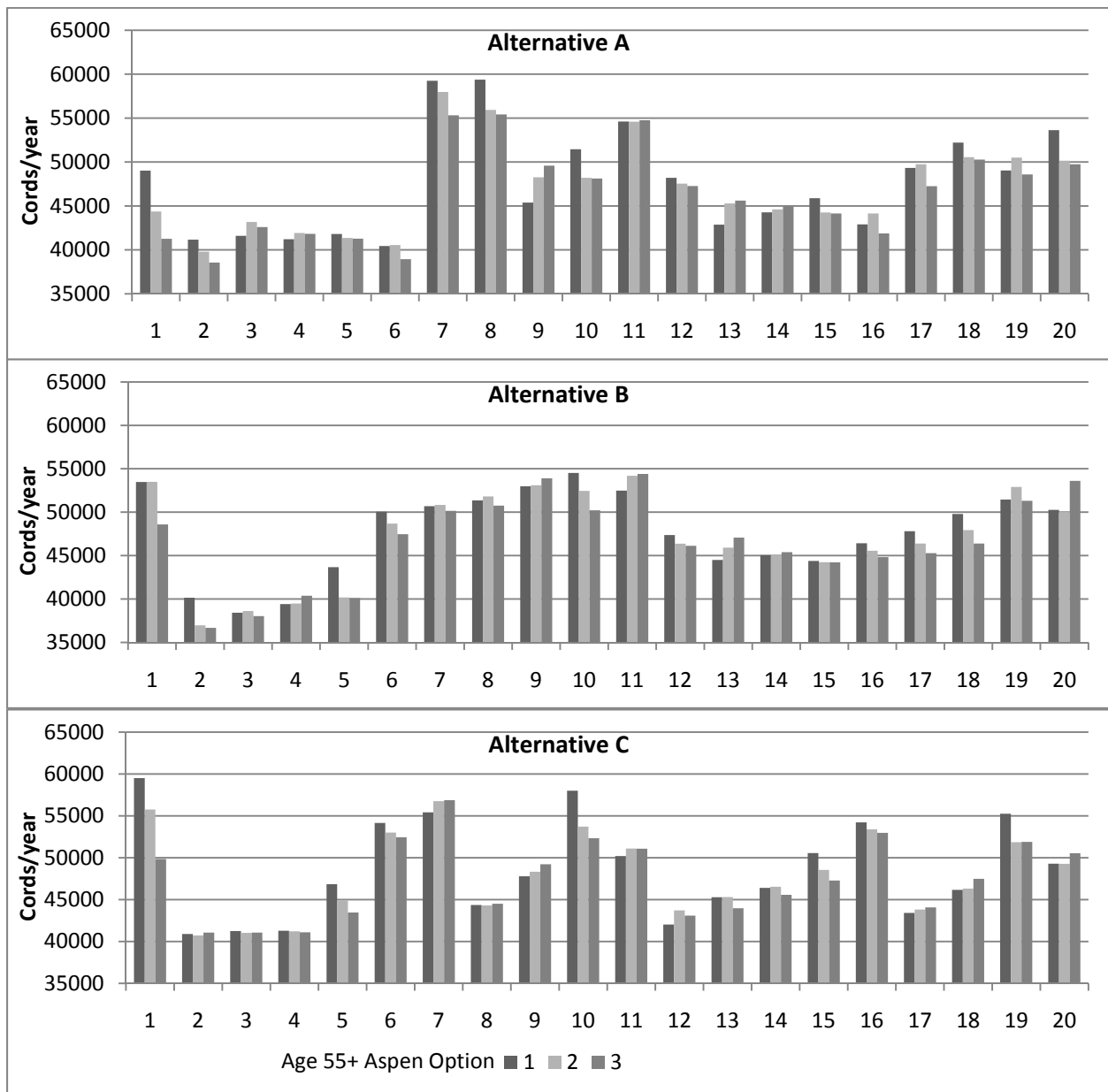


**Figure 9.** Projected age-class distribution of the aspen cover type at the end of period 4 for all scenarios.

All nine of the initial scenarios (Figure 3) have substantial area in the age 41 to 45 age class—approximately 14,000 acres. One might interpret these acres as potential “safety stock,” as aspen stands on at least the higher quality sites, are likely financially mature at age 40.

### Volume Harvested - Aspen Product - All Cover Types

The pattern of aspen product volume (all modeled cover types) from Regulation Alternative A (Figure 10) follows a pattern similar to the annual area harvested in each period from the aspen cover type (Figure 4). Yields are slightly higher in period one, but average just above 40,000 cords for periods 2 to 6. As the area harvested in the aspen cover type rebounds in periods 7 and 8, so too does volume.



**Figure 10.** Volume of aspen harvested from all forest cover types by scenario and 5-year planning period (cords/year).

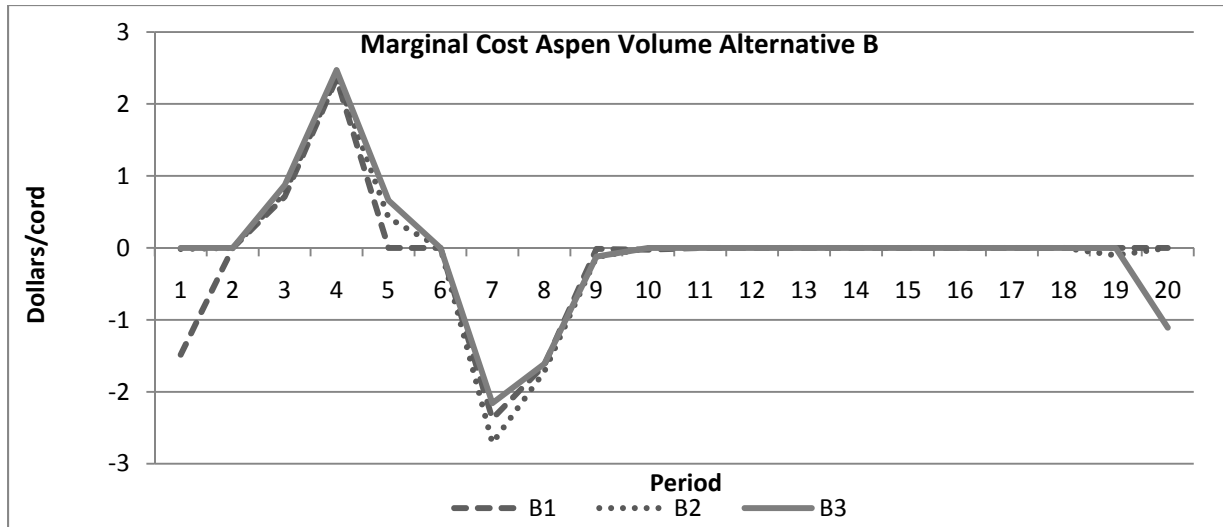
Compared to Alternative A, Alternative B shows more fluctuations over time in the volume of aspen harvested. It has higher aspen volumes than Alternative A in period 1 and lower volumes in periods 2 to 4.

When looking at volumes harvested for a specific series of scenarios with the same Regulation Alternative assumptions (any one of the three graphs in Figure 10), a stepladder pattern within a period indicates that the age 55+ aspen constraints are limiting the volume harvested in that period. Other flatter patterns indicate regulation constraints are the driving factor impacting all scenarios in the series. For example, for scenarios C1, C2, and C3, a stepladder pattern is present in period 1, reflecting a substantial impact of requiring more age 55+ aspen. In contrast, all three of these scenarios have similar volumes in periods 2 to 4, suggesting that the constraints controlling volume harvested under Alternative C are likely driving harvest volume levels in these three periods.

Aspen harvest volumes are greater in period 1 for Regulation Alternative C than for Alternatives A and B. For Alternative C, aspen volume is constrained to be at least 41,000 cords/year in each period. For Alternatives A & B, aspen harvest volume drops below this level in at least two of the first six planning periods (Figure 10). Under Alternative C, the impact of the age class imbalance is not as long or pronounced because under Alternative C, more stands can be harvested when reaching age 45. Alternatives A and B force holding aspen stands until age 50 for all but the low site index site class.

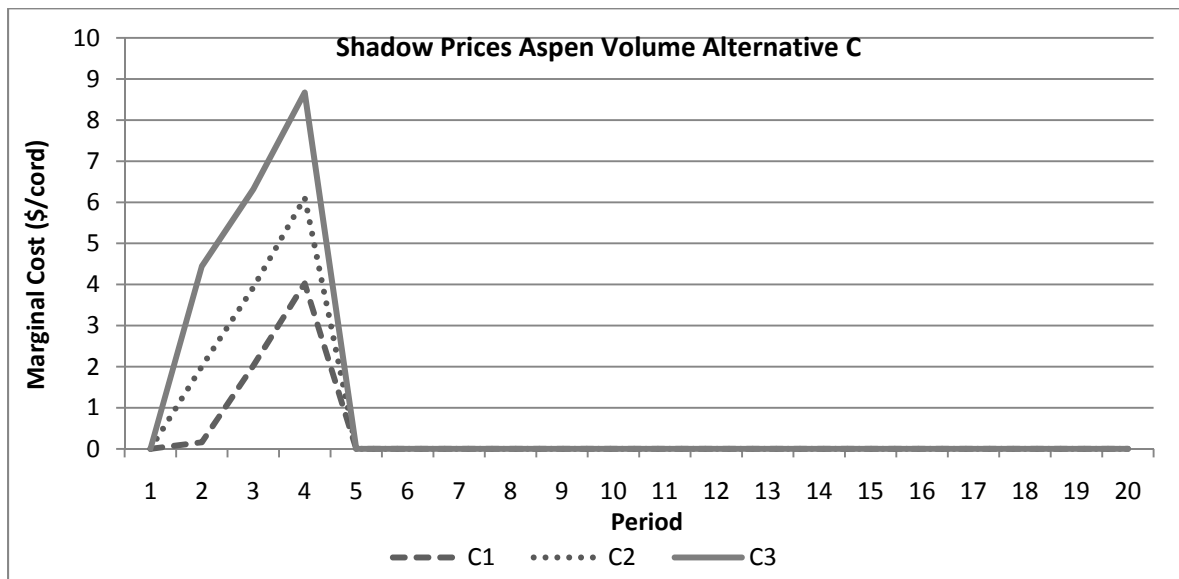
Age 55+ aspen requirements impact aspen harvest volumes substantially (Figure 10). In most planning periods, for scenarios that share the same regulation alternative, aspen harvest volumes are lower for scenarios targeting more age 55+ aspen. For example in period 1, Regulation Alternatives A and C exhibit a stepladder pattern across the modeled age 55+ aspen levels in numerous periods simply because requiring more age 55+ aspen makes fewer acres available for to harvest. In periods when acres becomes scarce both as a source of age 55+ aspen and as a source for meeting harvest requirements, associated shadow prices of the constraints are high. The highest shadow prices are almost always associated with age 55+ aspen Alternative 3, as these scenarios require more age 55+ aspen. In general, higher age 55+ aspen requirements will lower aspen volumes in the first period. Higher age 55+ aspen requirements also have higher associated shadow prices because more of the acres being held tend to older and growing slow if even growing at all.

Regulation Alternative B included constraints on the combined volume harvested from the aspen and lowland spruce cover types. Constraints forced this combined harvest volume to be between 54,000 and 70,000 cords/year. Figure 11 shows the marginal cost estimates for these constraints. Negative values refer to periods where the upper bound on harvesting is limiting. Positive values refer to periods where the lower bound on harvesting is limiting. Negative values can be thought of as an internal penalty necessary on stand-level management options to keep the forest-wide harvest level below the upper bound. Positive values can be thought of as internal subsidies in valuing management alternatives to push harvest levels up to the minimum acceptable level. Note that these values are in dollars per cord. For comparison purposes, note that aspen prices were assumed to be \$19/cord and spruce-fir prices \$15/cord.



**Figure 11.** Marginal cost (shadow price) estimates for the maximum and minimum harvest volume requirements for Regulation Alternative B.

Regulation Alternative C included constraints on the volume of aspen product harvested from all forest cover types. Harvest levels needed to be 41,000 cords/year. Figure 12 shows the marginal cost estimates for these constraints. These values can be thought of as an internal subsidy needed for stand-level management options. High subsidies are needed for aspen product volumes in periods 2 to 4 to compensate for the slow growth rates associated with stands in the initial inventory that are financially mature but need to be held for harvest during these periods. Marginal costs are increasing in nature over the first four periods, as relatively few acres are growing into the minimum harvestable age during these periods. By period 5, more acres are growing into this age, making internal subsidies unnecessary to meet minimum harvest levels. Note that marginal costs are in terms of dollars per cord, and that the assumed price for aspen is \$19/cord.

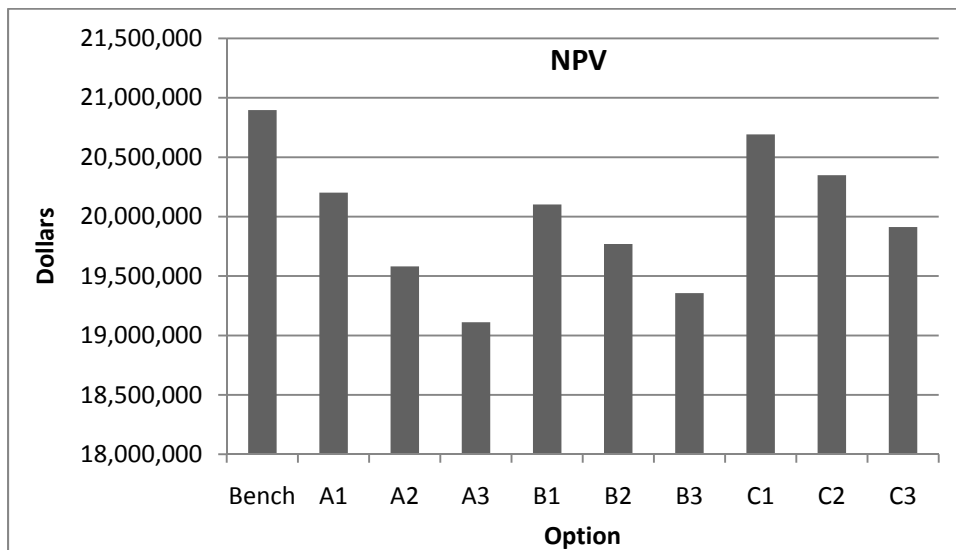


**Figure 12.** Marginal cost estimates for the harvest volume requirements for Regulation Alternative C.

## Net Present Value

All of the model applications used NPV as the objective function to maximize. Included in the NPV estimates are estimates of the returns from stumpage sales (benefits) and estimates of sale administration costs. Maximum NPV estimates differed by scenario because of the different constraints and different assumptions associated with each scenario. Results for the Initial Benchmark can be used as one basis for comparison, realizing that the Initial Benchmark included no constraints for forest regulation and constraints to sustain only 2,500 acres of age 55+ aspen.

The NPV estimates vary substantially between scenarios (Figure 13). Scenario C1, with an estimate of NPV of more than \$20.5 million, comes the closest to achieving the NPV of the Initial Benchmark. Scenario C1 differs from the Initial Benchmark only in that it also includes constraints to harvest at least 41,000 cords of aspen each year. Therefore the drop in NPV between the Initial Benchmark and Scenario C1 must be due to these volume control constraints (Figure 13). Scenario C2 differs from C1 only in terms of an increase in the old forest target from 2,500 acres to 3,750 acres. Therefore, the drop in NPV between the Scenario C1 and Scenario C2 must be due to the increase in age 55+ aspen requirement. Similarly, Scenario C3 differs from C2 only in terms of an increase in the old forest target from 3,750 acres to 5,000 acres. Therefore, the drop in NPV between the Scenario C2 and Scenario C3 must be due to the increase in age 55+ aspen requirement.

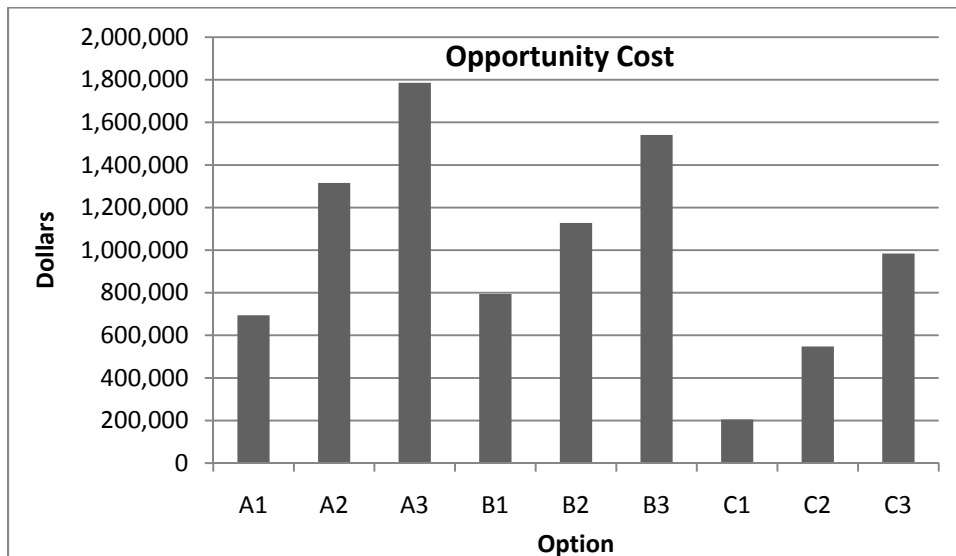


**Figure 13.** Net Present Value (NPV) estimates for the initial scenarios. Note: Bench represents the Initial Benchmark scenario.

Scenario A1 differs from the Initial Benchmark in that it includes a minimum area to harvest from the aspen cover type each period, and it does not allow harvesting the more productive sites in the aspen cover type until age 50. The drop in NPV between the Initial Benchmark and Scenario A1 must be due to these added requirements for Scenario A1. Similarly, the drop in NPV estimates between Scenarios A1 and A2 and between Scenarios A2 and A3 reflect the added cost of producing more age 55+ aspen.

Scenario B1 differs from the Initial Benchmark in that it includes forest regulation constraints and it does not allow harvesting the more productive sites in the aspen cover type until age 50. The drop in NPV between the Initial Benchmark and Scenario B1 must be due to these added requirements for Scenario B1. Similarly, the drop in NPV estimates between Scenarios B1 and B2 and between Scenarios B2 and B3 reflect the added cost of producing more age 55+ aspen under Regulation Alternative B.

Figure 14 shows the difference between the NPV estimate for the Initial Benchmark and the NPV estimate for each alternative. These comparisons provide insight on the overall opportunity cost of the additional forest-wide constraints included in a scenario as compared to the Initial Benchmark. The actual dollar amount of the NPV estimates are heavily dependent on the stumpage prices assumed and the assumed sale administration costs. Stumpage price estimates used were the county's estimate of current stumpage prices. Currently these levels are relatively low compared to recent years. If stumpage prices rebound, NPV estimates would also increase along with the differences in NPV estimates between scenarios. Understanding the relative impacts is likely more important, rather than the specific dollar amounts.



**Figure 14.** Opportunity costs of scenarios. Opportunity costs reflect the reduction in the NPV estimates from the NPV estimate from the Initial Benchmark .

## Additional Scenarios

After reviewing the preliminary results described above, the Koochiching County Forest Planning Committee requested additional scenarios to be modeled. These scenarios were not requested all at once. Generally, the letter describing each scenario indicates the order that the requests were made.

A key question that developed concerned the assumed minimum rotation age for the aspen cover type. Table 2 compares NPV estimates of an infinite series of rotations (soil expectation value or SEV) based on the timber yield estimates used in this study for the aspen cover type (Table 1).



For the estimates shown in Table 2 it was assumed that the stumpage price is \$25/cord for all species, and that the annual interest rate is 4% in real terms. For all site index levels and for rotation lengths greater than 40 years, longer rotation lengths result in lower NPV estimates (Table 2). Some have suggested that rotation lengths for the aspen cover type should be longer than 40 years to promote aspen saw log production. Table 2 also shows the stumpage price that would be needed for aspen if the NPV estimate for the corresponding rotation length is to equal the NPV estimate of a 40-year rotation. Table values show that a much higher average price is needed. Even long rotations for aspen may yield only 10% sawlogs so a real premium would be needed to raise average stumpage price to these higher values. For example, if at age 50, 10% of the volume is sawlogs, then the sawlog price must be \$115/cord to raise the overall stumpage price average to \$34. Currently in Koochiching County there is little if any premium paid for sawlog quality aspen.

**Table 2.** Impact of rotation length on harvest yield and the NPV of an infinite series of rotations (SEV) for the aspen cover type.

Rotation age (years)	Harvest volume (cords)	Mean annual increment (cords/year)	Average annual growth rate for prior 5 years (%/year)	SEV (\$/acre)	Average stumpage price needed for SEV to equal SEV for age 40 (\$/cord)	Average annual value growth rate for prior 5 years including land value set at max SEV (%/year)
<b>Site Index = 85</b>						
40	28.2	0.71		<b>185</b>	<b>25.0</b>	
45	29.9	0.66	1.2	<b>154</b>	<b>30.0</b>	0.9
50	33.8	0.68	2.5	<b>138</b>	<b>33.5</b>	2.0
55	36.2	0.66	1.4	<b>118</b>	<b>39.2</b>	1.1
60	37.5	0.63	0.7	<b>98</b>	<b>47.1</b>	0.6
65	35.3	0.54	-1.2	<b>75</b>	<b>62.0</b>	-1.0
<b>Site Index = 75</b>						
40	23.7	0.59		<b>156</b>	<b>25.0</b>	
45	25.5	0.57	1.5	<b>132</b>	<b>29.6</b>	1.2
50	28.0	0.56	1.9	<b>115</b>	<b>34.0</b>	1.5
55	30.1	0.55	1.5	<b>98</b>	<b>39.6</b>	1.2
60	31.4	0.52	0.8	<b>82</b>	<b>47.3</b>	0.7
65	31.4	0.48	0.0	<b>67</b>	<b>58.6</b>	0.0
<b>Site Index = 65</b>						
40	19.1	0.48		<b>126</b>	<b>25.0</b>	
45	21.1	0.47	2.0	<b>109</b>	<b>28.8</b>	1.6
50	22.3	0.45	1.1	<b>91</b>	<b>34.4</b>	0.9
55	24.0	0.44	1.5	<b>78</b>	<b>40.0</b>	1.2
60	25.1	0.42	0.9	<b>66</b>	<b>47.6</b>	0.7
65	27.4	0.42	1.8	<b>58</b>	<b>54.1</b>	1.5

### Bench40 and Bench45

Two additional benchmark runs were requested. Intent was to include fewer constraints than for the Initial Benchmark. These two additional benchmarks varied from each other only in the minimum harvest age for the aspen cover type. One assumed that this minimum harvest age was 40 years and the other assumed 45 years. For both of these benchmarks, constraints were dropped from the Initial Benchmark that: (1) targeted sustaining 2500 acres of age 55+ aspen and (2) limited annual harvest to 4300 acres.

## **Scenario C0**

This is similar to the other scenarios, but with no constraints included to require production of age 55+ aspen over time.

## **Scenario D**

Scenario D was designed to mimic the PWA Alternative 1-C. To help with this match, for Scenario D the site index class ranges for the aspen cover type were adjusted to match those used by PWA for modeling Alternative 1-C. Scenario D is similar to Scenario A3, but with one key difference: rather than set minimum area harvest levels for the aspen cover type each period, 2,315 acres are targeted for harvesting each period. The targeted amount of age 55+ aspen by period was the amount reported by PWA for Alternative 1-C. This targeted amount was approximately 5,000 acres every period in the long term. It was lower in periods 3 to 7 because of the imbalance in the age class distribution at the start of the planning horizon. The minimum harvest age for the aspen cover type is: (1) 50 years for stands with site index at least 70 feet and (2) 45 years for stands with site index less than 70 feet.

Modeling efforts for Scenario D using 5-year planning periods found it impossible to achieve both the targeted harvest levels and targeted areas of age 55+ aspen for Scenario D. This outcome flagged concerns with the PWA simulations of Alternative 1-C. For example, PWA results for Alternative 1-C call for harvesting 30,913 acres of the aspen low site index class in the first 30 years. But the inventory data indicates only 24,050 acres in this site class will reach the minimum rotation age (45 years) in the next 30 years. Discrepancies like this explain why modeling results for Scenario D fell short of harvesting the targeted 2,313 acres in the aspen cover type while still sustaining areas of age 55+ aspen as targeted under Scenario D. The PWA simulations were based on 10-year planning periods (time steps) with 10-year age classes. Precision concerning alternative rotation ages differing by 5 years are difficult to address accurately without recognizing more detail.

## **Scenario D\***

As described above, initial analysis of Scenario D found that with the assumptions of Scenario D, all of the constraints of Scenario D could not be satisfied. As a result, Scenario D\* was developed. Compared to Scenario D, Scenario D\* relaxes the “older aspen” requirements in two ways. First, it changes the age break point to define “older” aspen to focus on the area in the aspen cover type that is over age 50 rather than age 55 to 75. Second, it allows departures from the targeted amount of older forest during periods 3, 4, 5, and 6. In all other 5-year periods it is assumed that 8% of the aspen cover type (9,860 of 123,260 acres) must be age 50+ aspen.

## **Scenario E**

Scenario E is constrained to produce more age 55+ aspen in the long term than for any of the initial scenarios. Longer term, for periods 10 to 20 the age 55+ aspen target is 7,500 acres. For periods 1 to 3 it is 5,000 acres, for periods 4 to 7 it is 3,750 acres, and for periods 8 to 9, it is 5,000 acres. Targets for older aspen were varied over time to recognize the initial age class imbalance, with higher opportunity costs of producing age 55+ aspen when timber supplies are tightest. Scenario E also requires more acres of the aspen type to be managed on at least a 50-year rotation, requiring at least 8,000 acres of the aspen cover type to be in the 45 to 49 year age class in periods 10 to 20. Scenario E uses the same minimum harvest ages as used in Regulation

Alternative A and Regulation Alternative B. It also includes volume control constraints requiring at least 41,000 cords of aspen product volume and 10,000 cords of spruce-fir produced each year. These volume control constraints are identical to the volume constraints of Regulation Alternative C. Scenario E differs from Alternative C scenarios in that it does not allow rotations less than 50 years on the higher site index stands in the aspen cover type.

### **Scenario F**

Scenario F emphasizes sustaining the level of older forest close to what is present in the initial inventory. Modeling of this scenario was stopped after it became clear that harvest levels would be substantially lower for this scenario compared to all other scenarios.

### **Scenarios G0, G1, G3**

These scenarios are similar to Scenarios C0, C1, and C3 except the minimum rotation age for aspen was reduced to 40 years. Scenario G3 requires sustaining 5000 acres of ages 55+ aspen at the end of each 5-year planning period. Scenario G1 requires this level to be 2500 acres. Scenario G0 has no requirement for providing age 55+ aspen. These scenarios also increased the minimum acceptable harvest volume of aspen product (from all cover types) to 46,000 cords. For the Regulation Alternative C scenarios, this floor is 41,000 cords. A higher floor was used for because the impact of the initial age class imbalance is not as large during the bottleneck periods if age 40 stands can be harvested during those periods.

### **Scenario Gvariable (Gvar)**

This Regulation Alternative G scenario is similar to Scenario E in that the quantity of age 55+ aspen was allowed to fluctuate based on the opportunity cost of producing it. Gvar differs from Scenario E in that it uses a downward sloping demand curve to adjust the age 55+ aspen levels. As with Scenario E, the intent was to produce more age 55+ aspen than the other Regulation Alternative G scenarios, at least in the long term.

### **Compromise Scenario**

This scenario was developed by a small subcommittee of the Koochiching County Planning Committee as the last scenario to be considered. It was similar to scenario D\* but with four key differences:

1. The minimum harvest age for all aspen stands is 45 years ( Scenario D\* only allowed harvesting the lowest site index class used a 45-year rotation).
2. The targeted annual harvest level for the aspen cover type was increased to 13,276 acres in the first 5-year period (3,000 acres over the first 2 years, 2,650 acres in the 3rd year, and 2,313 acres in the 4th and 5th years).
3. The targeted annual harvest level for the aspen cover type was decreased to 11,000 acres for the second 5-year period 2
4. The targeted harvest levels for the aspen cover type for periods 3 to 20 depend on the amount of age 50+ aspen. Specifically, the level is as targeted in Scenario D\* (2,314 acres) unless the area of age 50+ aspen is less than 8% of the area in the aspen cover type. Then, then the annual harvest area for the period is reduced to 2,000 acres.

## Results for Additional Scenarios

### Area Harvested - All Forest Cover Types

Table 3 shows the total harvest area by scenario and by period. In all runs except the benchmarks, the harvest area per year is constrained to be no more than 4,300 acres/year. For all scenarios, this constraint is binding for the first 5-year period. In other words, under each scenario, the NPV of the forest could be increased if this constraint is relaxed for period 1. For Scenario G0 the 4,300 acre limit is also binding in each of the first 3 periods. For Scenario G1, it is binding for the first two periods. Scenario D and Scenario D\* harvest the least area in most periods. Scenario E tends to harvest less area than the Regulation Alternative C Scenarios. Not surprising, the Alternative Regulation G scenarios harvest the greatest area in most periods. Requiring more age 55+ aspen also lowers the total area harvested (Table 3).

**Table 3.** Area harvested from all modeled cover types (acres/year) .

5 Yr Period	Bench 40	G0	G1	G3	Gvar	C0	C1	C3	D	D*	E	Comp.
1	10210	4308	4310	4309	4285	4316	4319	4307	4309	3790	4301	4123
2	2240	4302	4310	4177	3593	4071	3563	3261	3140	3628	3205	3475
3	1876	4301	3419	2791	2794	2890	2823	2736	2720	2654	2679	2631
4	3324	3383	3267	3140	3085	2782	2668	2600	2862	2621	2615	2602
5	3412	3360	3542	3529	3200	3140	3042	2803	2601	2522	2647	2468
6	3375	3063	3119	3258	3434	3371	3277	3201	2598	2385	2689	2711
7	2743	3249	3158	3064	2954	3317	3398	3409	2583	2583	3196	2592
8	2928	3295	3146	3025	3006	3024	2934	2912	2582	2663	2925	2668
9	7535	4064	3986	3693	3054	3030	3034	3035	2742	2786	2713	2794
10	2656	4172	3981	3507	3370	3894	3616	3308	2724	2743	3008	2749
12	3231	3467	3187	3119	2981	2991	2912	2879	2696	2913	2555	2901
14	3274	3042	3147	3086	2942	3294	3108	2925	2654	3009	2614	3016
16	3441	3310	3157	3111	3155	3420	3480	3425	2974	2930	3328	2908
18	2244	4064	4083	3328	3254	3114	3140	3130	2805	2928	3143	2929
20	3348	3470	3278	3205	3127	3042	3049	3081	2723	2847	2654	2837

### Volume Harvested - All Forest Cover Types

Table 4 shows the total volume harvested by 5-year period for all modeled cover types. It was assumed that residual volumes after harvest would be left on site as described in the Minnesota state guidelines. Values in Table 4 do not include the residual volumes left on site. Those residual volumes were pro-rated based on the specific product volumes prior to harvest, assuming 4 square feet of standing basal area should remain on site after harvest.

Similar to area harvested, Regulation Alternative G scenarios have the highest volumes harvested, both in the short term and in the bottleneck periods when harvest volumes are lowest (Table 4). Regulation Alternative C scenarios tend to harvest more volume than Scenario E and Scenario E tends to harvest more than Scenario D. Volumes are generally between 60,000 and 80,000 cords/year with lowest volumes in period 3 thru to period 6.

**Table 4.** Total volume harvested from all modeled cover types (cords/year).

5 Yr Period	Bench 40	G0	G1	G3	Gvar	C0	C1	C3	D	D*	E	Comp.
1	205812	95203	94247	89390	80091	91648	95455	84017	72435	72464	80872	81046
2	43870	100608	98009	88580	76263	86388	74655	71209	60876	76619	69655	75764
3	38090	84503	72087	67948	67683	62641	62454	62082	60986	62155	61603	60689
4	67523	68688	68377	67909	67989	60386	63777	61324	70515	61577	61167	61068
5	71556	71248	76344	78434	73041	69566	67924	64244	62059	55103	61148	56583
6	69772	64649	66809	69947	76113	76501	75977	74028	58547	58350	61929	64591
7	55733	64781	65102	65383	65456	74892	78217	79808	62567	67072	78031	64312
8	59833	64538	64947	65112	65304	64316	64035	64511	61281	68932	72144	64973
9	157631	86316	85973	81211	69207	66393	68554	70075	65933	70591	63536	68236
10	51118	87732	84753	74998	74915	88024	82812	74205	66529	70470	72113	68191
12	66063	69505	67128	67649	66264	65193	61656	63377	65493	73392	61318	73815
14	69549	66967	70611	70700	67313	72539	72367	67805	68817	76369	64120	77785
16	68480	66815	66920	67793	69131	77283	79391	77451	69381	67537	77954	71969
18	44335	85738	86274	72462	72641	68935	68798	71721	69335	71648	82253	70801
20	67948	69655	68298	66985	66036	66308	70051	72190	65759	72087	66818	68029

### Area Harvested - Aspen Cover Type

Table 5 shows the harvest area by scenario and period for the aspen cover type. Of the modeled forest cover types, the aspen cover type dominates the area harvested, as its overall area is large and its rotation ages are short. The area harvested in the aspen cover type varies substantially between scenarios, especially in early periods of the planning horizon. The Regulation Alternative G Scenarios can harvest more in early periods, as these scenarios use 40-year rotations to help overcome the age class imbalance of the initial inventory.

In terms of the acres harvested annually from the aspen cover type, Scenario D, by design, maintains a near constant area over time. This level is below that of Scenario C3 for all periods except periods 2 to 4. Scenario E harvest areas are notably lower for periods 11 to 15 as during those periods there is an increase in the area of area 55+ aspen. The Regulation Alternative G scenarios have fluctuations in the area of aspen harvested for at least two reasons. First, emphasis for these scenarios is on volume control, not area control. Second, the volume control process considers Balm of Gilead in the aspen product group with harvest area in the aspen cover type lower in periods when the area of harvest in the Balm of Gilead is higher. The Balm of Gilead harvest is generally high in period 1 and then again 50 years later (period 11).

### Volume Harvested - Aspen Product - All Cover Types

Table 6 shows the volume harvested for the aspen product group from all modeled cover types. Most of this volume comes from the aspen cover type with approximately 75% of the harvest volume from in the aspen cover type being aspen product volume. The aspen product group includes Balm of Gilead.

**Table 5.** Annual aspen harvest (acres/year).

5 Yr Period	Benc40	G0	G1	G3	Gvar	C0	C1	C3	D	D*	E	Comp.
1	7372	3677	3589	3316	2760	3453	3420	2985	2308	2323	2783	2656
2	1867	3622	3394	2831	2476	2701	2208	2091	2239	2354	2152	2201
3	1422	3291	2543	2263	2264	2353	2286	2218	2250	2016	2181	1993
4	2751	2783	2697	2579	2508	2228	2112	2074	2274	2039	2099	2020
5	2994	2920	3108	3111	2785	2730	2630	2389	2152	2053	2254	1999
6	2996	2632	2707	2884	3146	3063	2957	2863	2219	2003	2304	2329
7	2469	2815	2730	2654	2554	2969	3082	3131	2310	2310	2918	2319
8	2581	2803	2658	2557	2545	2586	2511	2495	2235	2316	2524	2321
9	7063	3579	3512	3208	2502	2452	2480	2515	2270	2314	2164	2322
10	2228	3666	3468	2933	2823	3415	3115	2751	2296	2315	2427	2321
12	2800	3056	2772	2717	2588	2552	2500	2435	2247	2319	2075	2306
14	2956	2536	2672	2527	2446	2730	2516	2453	2286	2290	2121	2298
16	2493	2832	2678	2635	2626	2962	3021	2934	2334	2308	2759	2285
18	1855	3521	3369	2770	2717	2490	2514	2563	2269	2300	2651	2301
20	2840	2921	2712	2641	2568	2501	2501	2520	2196	2306	2099	2296

**Table 6.** Total aspen product volume harvested (cords/year).

5 Yr Period	Bench 40	G0	G1	G3	Gvar	C0	C1	C3	D	D*	E	Comp.
1	128311	63831	62439	56784	45885	60137	59504	49841	35787	40569	45512	46452
2	30042	67959	63507	52755	46013	49010	40886	41057	34461	43953	41006	44077
3	24497	53237	45665	46154	45846	41190	41250	41051	39857	39044	40789	38462
4	46291	46796	46623	46084	45851	40701	41280	41083	45892	38636	40818	38421
5	51574	50789	54420	55806	51618	47655	46826	43459	41197	35933	40996	37423
6	50724	46008	47704	50200	54828	54869	54142	52435	39473	39176	42400	44732
7	40856	45999	46050	46065	45870	53482	55414	56864	44606	47351	55578	45039
8	43550	45996	46065	45929	46072	44705	44354	44497	43051	48032	50844	44505
9	120624	64614	64178	59803	49147	46461	47788	49221	45529	49004	43786	47206
10	37029	65716	62981	54352	53867	63979	58002	52326	46820	49390	50700	47551
12	46714	49671	47536	47599	46038	44762	42026	43082	43866	49011	41240	49594
14	51362	46042	48582	46796	45985	48889	46389	45573	46887	44666	41866	45920
16	42669	46068	45971	45883	46240	53402	54217	52973	43819	42912	51294	46241
18	31012	62018	59954	50202	50034	45115	46166	47475	46349	46972	56046	45880
20	49636	50511	48938	47497	45977	46168	49277	50534	45642	49971	45969	46790

Some have suggested that our harvest yield table estimates are low for the aspen cover type. This is likely for ages over 65 in Koochiching County. Aspen mortality is difficult to model and quantify, especially when utilization standards are also considered. Aspen mortality tends to be

lower in Minnesota in areas farther north. Yield estimates for age 65+ aspen are generally used in this study only for early periods of the planning horizon, as few acres are managed in later periods based on rotation lengths longer than 65 years. Assuming management schedules are implemented based on areas scheduled for harvest rather than on specific target volumes, then harvesting may result in greater yields in the early periods when age 65+ aspen is harvested. Monitoring of harvest yields will be important.

It is important to realize that all scenarios used the same growth and yield information. To the extent possible, comparisons should emphasize the differences between scenarios rather than the absolute magnitude of specific yield estimates for any one scenario.

### Forest Condition - Area of Aspen Cover Type - Age 55+ and Age 50+Years

Table 7 compares scenarios in terms of the area of the aspen cover type between ages 55 and 74 at the end of most 5-year planning periods. Most scenarios were required to meet minimum area requirements for age 55+ aspen. Most scenarios do not produce more than the minimum required unless other constraints prevent harvesting. Scenario D and Scenario D\* produce lower levels of age 55+ aspen in periods 5 and 6 because of the imbalanced age class distribution for the aspen cover type at the start of the planning horizon.

**Table 7.** Area of the aspen cover type between ages 55 and 74 (acres).

5 Yr Period	Bench 40	G0	G1	G3	Gvar	C0	C1	C3	D	D*	E	Comp.
1	69	3650	4090	5453	8870	4767	4455	7161	11320	10420	8117	8755
2	78	1072	2572	5082	8275	961	2582	5119	7238	3822	5097	3881
3	25	156	2633	5060	7099	1303	2618	5164	5033	3620	5100	4358
4	54	110	2617	5140	7916	99	2555	5199	3885	2411	3875	3420
5	38	116	2599	5059	8709	99	2462	5192	903	1849	3849	4331
6	137	340	2599	5098	6246	140	2504	5136	903	3007	3865	4488
7	297	418	2597	5103	6407	386	2531	5080	4590	1769	3865	4552
8	164	214	2596	5119	7905	293	2605	5078	8304	4018	5140	4111
9	261	306	2582	5053	8330	342	2584	4951	8548	4237	5100	4619
10	126	133	2574	5155	7888	257	2582	5067	9197	5312	7425	5154
12	74	98	2572	5112	7367	582	2580	4995	9726	5026	7587	5707
14	22	156	2695	5103	8058	99	2596	5098	7916	3183	7632	2426
16	39	95	2558	4991	7346	99	2581	4933	8947	6188	8152	3505
18	103	87	2591	5100	8263	106	2596	5097	8625	4266	7512	3589
20	109	165	2591	5110	8017	164	2513	5132	9006	4648	7672	4047

Table 8 compares scenarios in terms of the area of the aspen cover type over age 50. Most scenarios were not required to meet minimum levels for these age classes. This metric was used by PWA to report results for Alternative 1-C. Scenario Gvar (Gvariable) compares favorably to Scenario D and Scenario D\* in terms of this metric, especially if one considers its relative stability in earlier periods as compared to Scenario D and Scenario D\*.

**Table 8.** Area of the aspen cover type over age 50 (acres).

5 Yr Period	Bench 40	G0	G1	G3	Gvar	C0	C1	C3	D	D*	E	Comp.
1	134	6346	6786	8149	11566	7463	7631	9805	13190	13116	10813	11451
2	90	3170	4642	8411	12527	2945	4770	8642	10462	8595	8471	8633
3	54	185	3666	6767	10147	2332	4502	8273	7377	5981	7662	8655
4	64	130	4083	7766	11349	99	3323	6279	3885	4314	4658	6092
5	163	370	3652	7431	11447	140	2966	5803	903	3098	4546	6130
6	387	611	4062	7729	9839	392	4076	8244	4983	5017	6151	9851
7	448	610	4049	7763	10629	576	3689	6954	9220	8950	6297	9857
8	358	385	3646	7412	11924	481	3748	7692	13263	12111	7511	10047
9	334	318	4026	7816	12102	455	3844	7200	13722	12379	8618	11598
10	212	213	3617	7269	10272	390	3597	7408	15798	13058	10262	10867
12	130	172	3657	7262	9846	1528	4175	6766	14374	13409	11125	11963
14	22	168	3765	7177	11428	99	2627	5156	13719	10980	11463	9882
16	64	115	3822	7675	11745	125	3881	7052	13836	10925	11680	9933
18	353	464	3671	7048	10343	351	3930	6895	12668	11012	10322	9838
20	317	350	4038	7478	11340	362	4491	7201	14102	11014	10666	9812

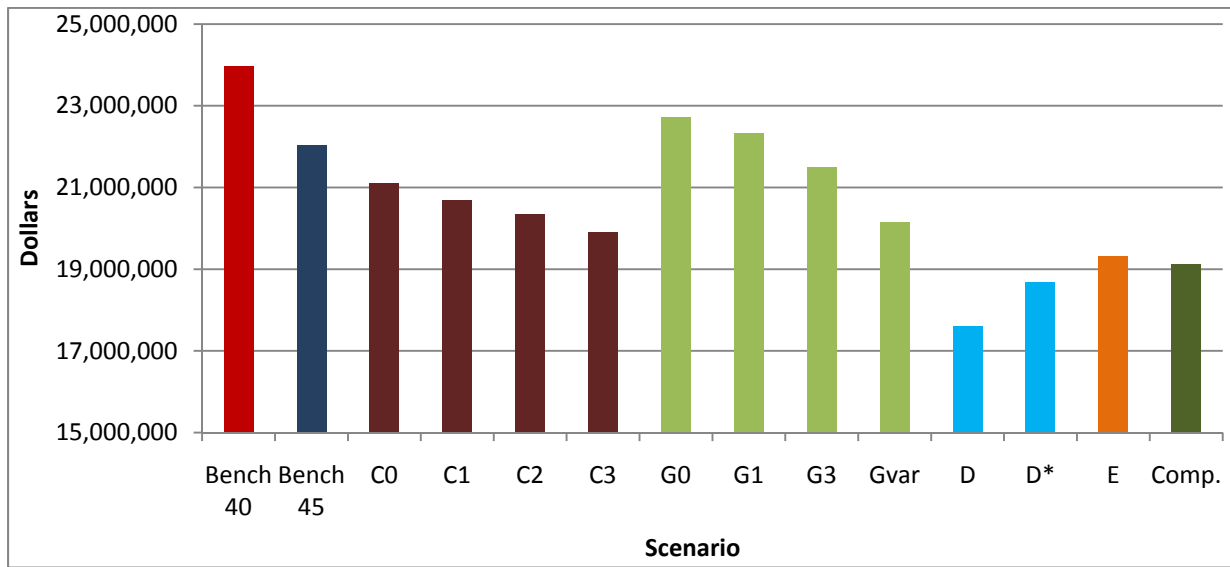
### Net Present Value

Figure 15 compares scenarios in terms of the NPV estimates maximized in the objective function. These values include all costs and market values over the 100-year planning horizon. Costs included only sale administration costs. These costs varied roughly in proportion to the area harvested each period with a small adjustment based on the size of each individual stand harvested. Other than for the benchmark runs, the net present value of all administration costs ranged from \$7,820,000 (Scenario D) to \$9,660,000 (Scenario G0). In terms of the objective function, these values are negative values reflecting that they are costs.

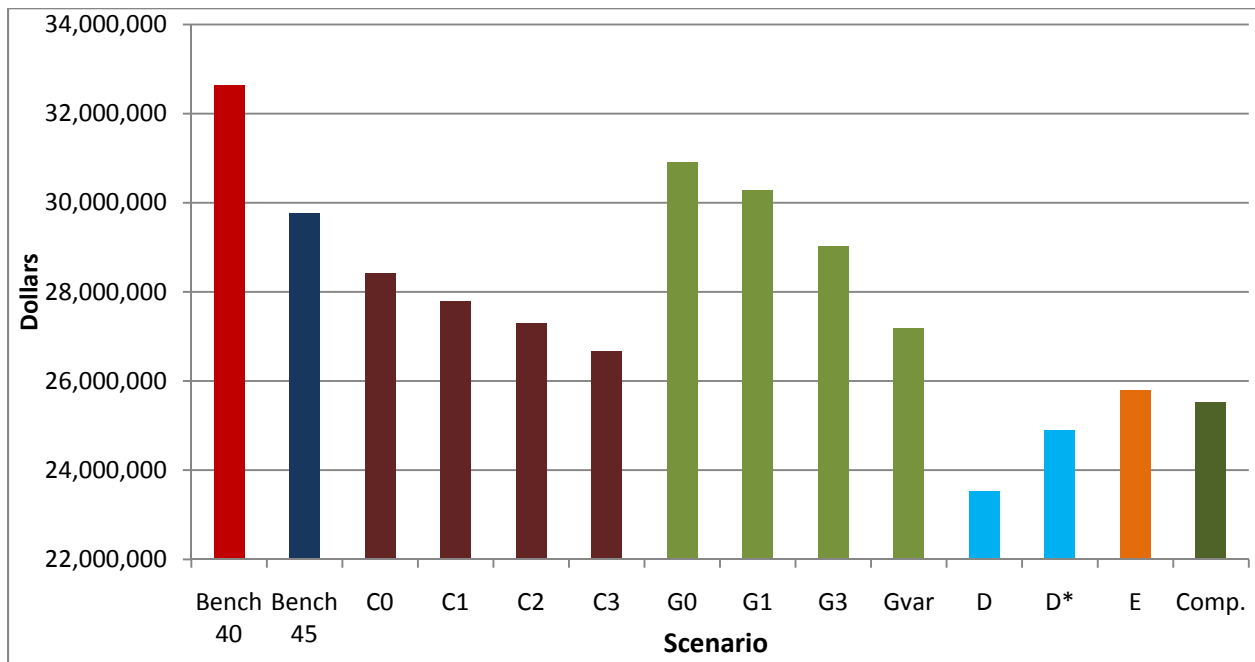
Scenario D holds acres of the aspen cover type in the medium and high site index classes until at least age 50. This shifts emphasis in harvesting to low productivity sites in early periods. This emphasis explains both the relatively low aspen harvest volume estimates for Scenario D for early periods (Table 2) and the overall low NPV estimates for the planning horizon (Figure 15). Scenario D needs this emphasis on low productivity stands to get past period 6 (year 30) if it is to harvest 2313 acres per year and not harvest aspen stands in the medium and high site index classes before age 50.

Questions were raised about the price used for valuing timber products. Modeling efforts assumed stumpage prices of \$19/cord for aspen product volumes. This estimate was based on current stumpage prices at the time analyses began in late 2009. Stumpage prices for aspen in prior years were substantially higher than this value and aspen stumpage prices in the spring of 2010 rebounded to approximately \$25/cord. Figure 16 shows the estimate NPV from timber production for each scenario based on a \$25/cord stumpage price for aspen. These estimates did not involve rerunning the models with the new prices. Rather, the value of solutions developed based on the \$19/cord price are re-estimated using the higher price for aspen product volume.





**Figure 15.** Comparison of net present value (NPV) estimates for selected scenarios assuming a \$19/cord price for aspen stumpage.



**Figure 16.** Comparison of net present value (NPV) estimates for selected scenarios assuming a \$25/cord price for aspen stumpage.

## Short-term Revenues

One benefit for the county is the revenue generated from timber sales. Koochiching County has been concerned about revenue flows to the county over the short-term. Timber sale revenues to the county have been lower in recent years, as timber prices have been substantially lower in recent years. Table 9 compares the revenues flows for the scenarios over the first 10 years of the plan. These flows do not include administrative costs. The Compromise scenario emphasized higher harvest levels in the first 5-years.

**Table 9.** Comparison of alternatives in terms of estimated revenue generated from annual stumpage sales from all timber species over the first six 5-year planning periods (thousands of dollars per year). Values have not been discounted. Values are based on the initial stumpage price estimates with aspen = \$19/cord.

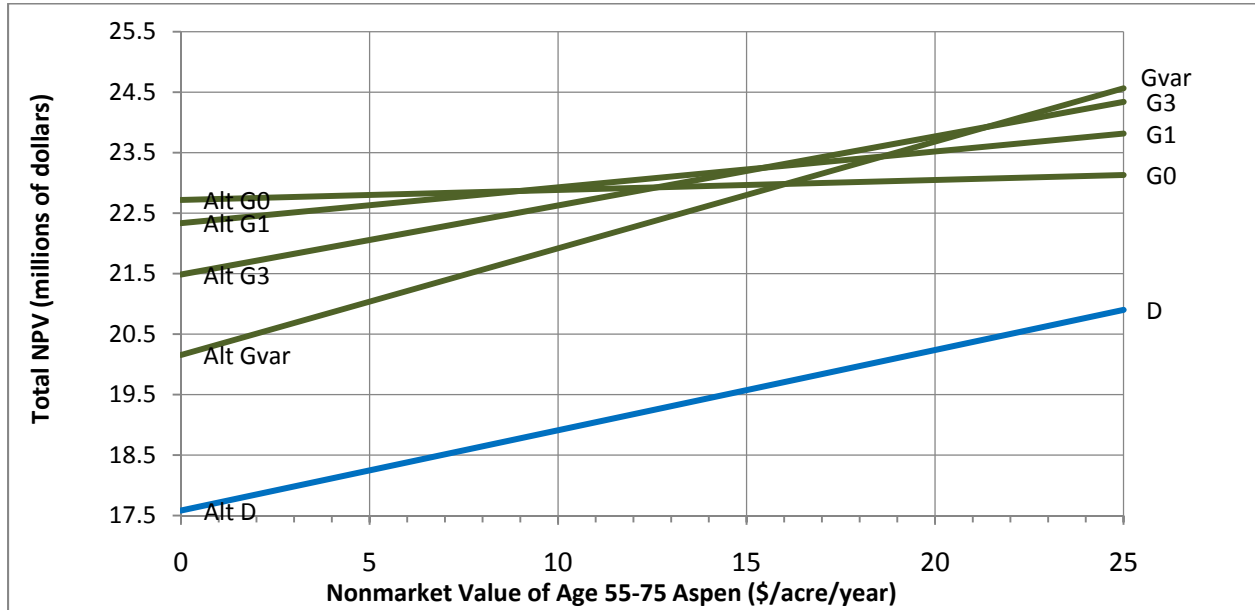
Alternative	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
<b>C0</b>	1500	1374	1009	979	1119	1252
<b>C1</b>	1492	1188	1013	994	1104	1241
<b>C3</b>	1352	1143	1001	992	1032	1209
<b>G0</b>	1515	1626	1361	1114	1177	1072
<b>G1</b>	1496	1574	1161	1110	1260	1107
<b>G3</b>	1406	1403	1107	1101	1293	1159
<b>Gvar</b>	1234	1213	1100	1100	1202	1257
<b>D*</b>	1115	1177	998	979	890	948
<b>E</b>	1294	1120	994	990	981	1009
<b>Compromise</b>	1252	1169	975	971	914	1054

## Nonmarket Values

Questions were raised about emphasizing only the values of timber (market) returns in comparing the values of scenarios. Figure 17 compares scenarios over a range of possible nonmarket values for age 55+ aspen (acres the aspen cover type in the 55-75 age range.) Age 55+ aspen was used in defining the scenarios. The area harvested was reported earlier by 5-year period in Table 7. Figure 17 combines those flows with NPV estimates for timber production. Clearly, the appropriate value to assume for age 55+ aspen is subjective and would vary by stakeholder (x-axis values in Figure 17). Possible nonmarket values to assume for this metric are expressed as a price per year, recognizing that stands produce this value only over part of its rotation. The y-axis in Figure 17 represents a total NPV for a scenario, assuming the nonmarket value for age 55+ aspen is added to the NPV estimate for timber production. All NPV calculations assume a 4% discount rate net of inflation. The y-intercept (x-axis = 0, no nonmarket value) is simply the value of the market NPV corresponding with each scenario as shown earlier in Figure 15.

The slope of the lines in Figure 17 reflect the amount of age 55+ aspen produced. For example, the slope of the line for Scenario G0 are low (flat) because these scenarios produce relatively little area of age 55+ aspen. The slope of the lines for Scenario Gvar and Scenario D are steepest because they produce the most age 55+ aspen. The line for Scenario Gvar is steeper than that for Scenario D. Stakeholders are unlikely to agree as to the appropriate value to assume for valuing

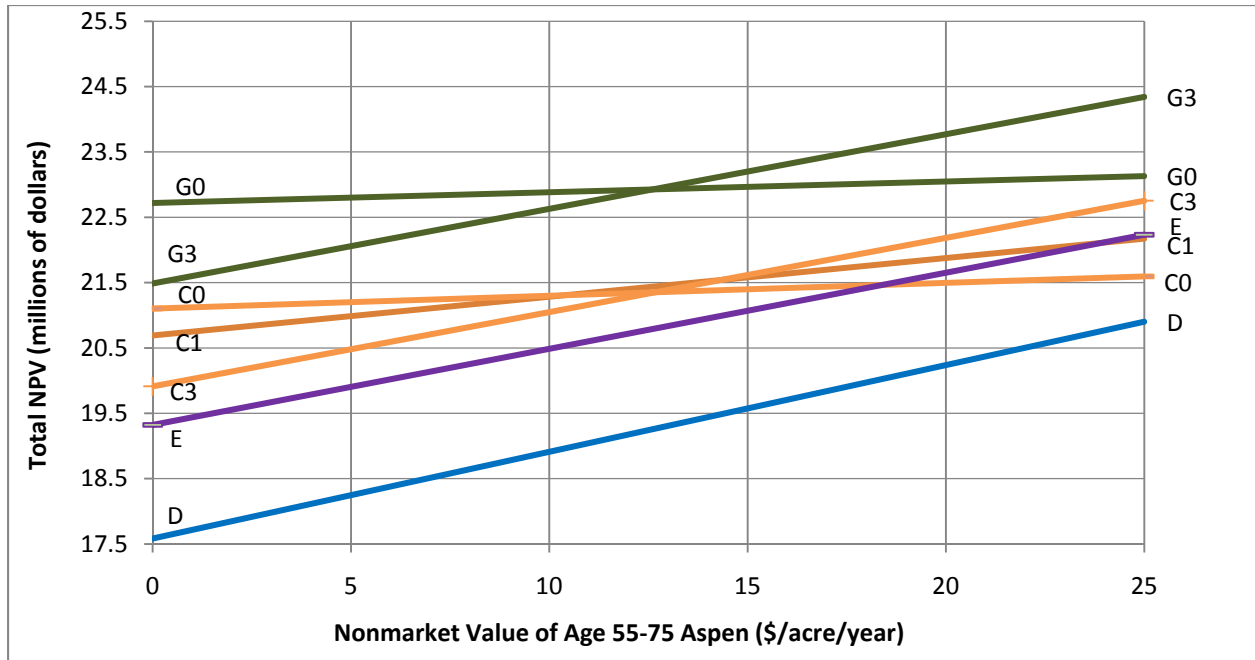
nonmarket values, yet the graph provides insight as to how scenarios compare over a range of assumed values for age 55+ aspen.



**Figure 17.** Impact of alternative nonmarket values for age 55-75 aspen on Total Net Present Value (NPV) over a 100-year planning horizon: G scenarios and Alt D.

Figure 18 is similar to the Figure 17, bringing into comparison the Regulation Alternative C scenarios. The total NPV estimate for one of the Regulation Alternative G scenarios has the highest total NPV estimate at every nonmarket price level shown (Figure 18). This would be true for even higher nonmarket values than those shown in the graph, as the line for Scenario Gvar is steeper than that for any of the other modeled scenario.

It is important to note that NPV estimates are simplified. Modeled NPV estimates from timber production are based only in terms of revenue generated from stumpage sales and assumed sale administration costs. These NPV estimates are just part of the overall market benefits. It is important to recognize that additional values include more than any assumed value for age 55+ aspen. Timber production supports employment throughout the local economy, with considerable value added through forest products produced by local industry. Forest industries are undoubtedly key components of the local tax base. There is clearly a multiplier effect from timber production that is not captured in the simple timber NPV estimates developed in this study.



**Figure 18.** Impact of alternative nonmarket values for age 55-75 aspen on Total Net Present Value (NPV) over a 100-year planning horizon: adding C scenarios and Alt E.

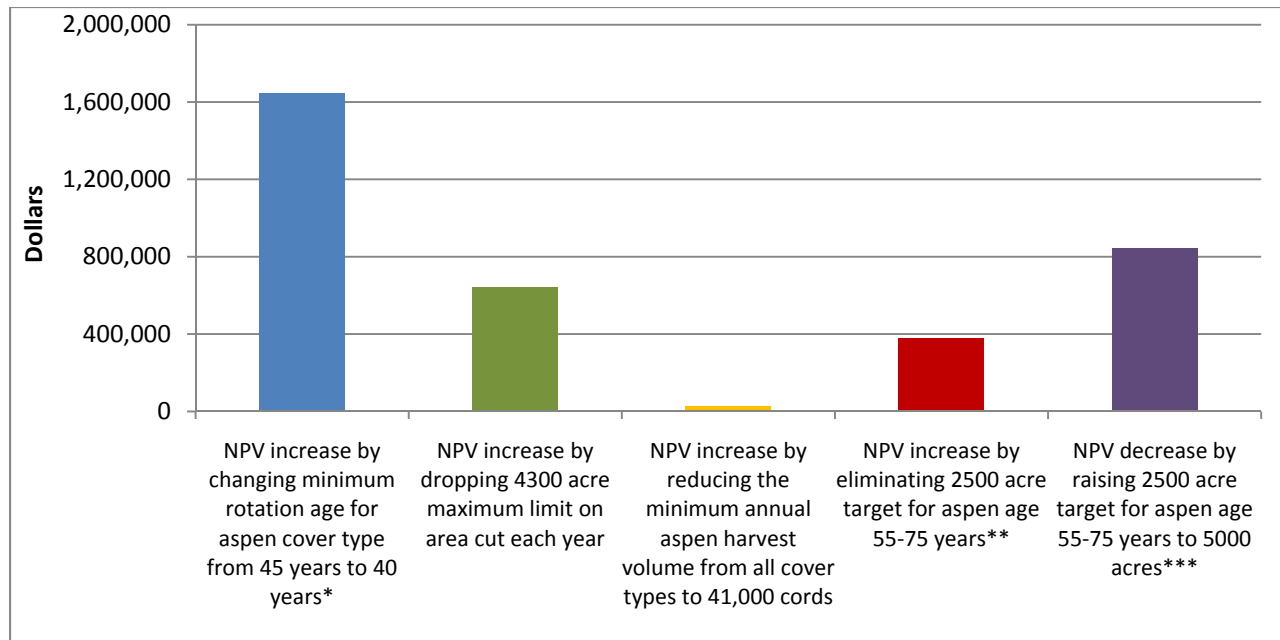
### Additional Sensitivity Analysis

Questions were raised about the impact of imposing a 4,300 acre limit on the area harvested annually. Scenario G1 was rerun without this constraint. The area harvested in the first 5-year period increased to 7,430 acres per year. The NPV estimate increased by \$642,000. This net increase in NPV includes an increase in sale administration cost of \$785,000. Total volume harvested (all products) increased from approximately 94,250 cords in period 1 (Alt G1 in Table 3) to 145,250 cords. The total harvest volume in period 2 dropped from approximately 98,000 cords (Alt G1, Table 3) to 66,610 cords. The harvest of aspen volume from all cover types increased from approximately 62,400 cords in period 1 (Alt G1, Table 4) to 82,860 cords in period 1. The harvest of aspen volume (all cover types) in period 2 decreased from 63,500 to 46,150 cords. The lower limit (floor) on annual aspen product harvest volume for all the Regulation Alternative G scenarios was 46,000 cords.

Questions were also asked about the impact of including a minimum level (floor) for the volume of aspen product harvested each period. Regulation Alternative G requires harvesting at least 46,000 cords of aspen product (all cover types) in each 5-year period. Scenario G1 was rerun to examine the impact of lowering this floor to 41,000 cords. The estimated NPV increased by only \$28,400.

The Regulation Alternative G scenarios can also be compared to the Regulation Alternative C scenarios to identify the potential increase in value by allowing 40-year rotations for the aspen cover type. This was a primary reason for modeling the Regulation Alternative G scenarios. Regulation Alternative G was designed to be similar to Regulation Alternative C, differing primarily in just the inclusion of options for harvesting stands in the aspen cover type at age 40.

Differences in NPV estimates between scenarios G0 and C0 and between G1 and C1 and between G3 and C3 are all approximately \$1,600,000. This difference is approximately \$1,900,000 for the two benchmark runs that also differed only in terms of the minimum rotation age. All of these differences are quite sensitive to the price assumed for aspen. This comparison is based on an aspen produce price of \$19/cord for all cover types. Using a \$25/cord price for aspen increases the difference in NPV between the Regulation Alternative G scenarios and the Regulation Alternative C scenarios; to approximately \$2,500,000 for the comparisons of G0 to C0, G1 to C1, and G3 to C3. Figure 19 summarizes the sensitivity analysis comparisons for Scenario G1 for the analyses based on a \$19/cord aspen price.



**Figure 19.** Summary of sensitivity analyses based on Alternative G1. \*Difference between C1 and G1. \*\*Difference between G0 and G1. \*\*\*Difference between G1 and G3.

## Discussion

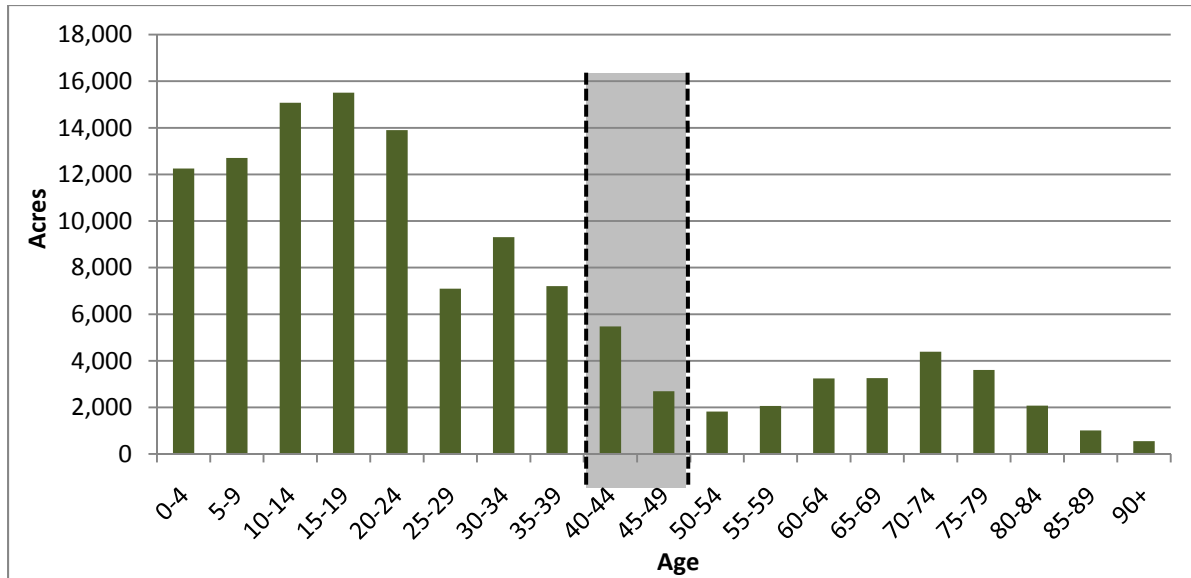
In comparing scenarios, differences in forest-wide harvest levels and differences in forest-wide NPV estimates are generally explained by the assumptions concerning the aspen cover type. Of the approximately 180,000 acres modeled, nearly 70% are in the aspen cover type. For all scenarios, of the total area harvested, substantially more than 70% is from the aspen type because rotation lengths are shorter for aspen than for other cover types. Stumpage prices are also higher for the aspen cover type. The initial age class distribution of the aspen cover type has over 22,000 acres that are at least age 50. This represents almost 10 years of harvesting in terms of area harvested. With many of these acres potentially losing harvest volume over time, it is understandable why many want to see increased harvesting now to utilize this resource and regenerate these acres to improve future timber productivity. Koochiching County has the potential to raise harvest levels in the short term without impacting long-term timber production substantially. The G series of scenarios have the greatest short-term departures and they also

sustain the highest harvest levels over time—even through bottleneck periods in the regulation process. Short-term departures can be larger when shorter rotations are possible for aspen. Sustaining more age 55+ aspen reduces the potential level of short-term departure.

Modeling results show that sustainable harvest levels are sensitive to the order that aspen stands are harvested. Initial harvesting strategies proposed by the county emphasized shorter rotations for stands in the lowest site index and tended to harvest these stand earlier. This strategy resulted in relatively low NPV estimates of timber production. With harvest scheduling models, it is important to use caution in imposing management constraints to achieve forest regulation. Simply hardwiring harvest levels to prespecified levels allows little flexibility for the model to find solutions with higher objective function values. Scenarios D\* and the Compromise Solution use the most restrictive constraints. It is not surprising that timber returns are lower for these scenarios. One might question why the Compromise Solution is more desirable than Scenario Gvariable. Scenario Gvariable has a higher NPV and it produces more age 55+ aspen. The Compromise Solution is appealing to some as it does not allow any harvesting in the aspen type below age 45.

Modeling results are sensitive to the minimum rotation length used for aspen. From a simple stand-level perspective, analyses shown in Table 2 suggest a 40-year rotation. The benefits of a 40-year year rotation increase when one also considers forest-wide impacts. Figure 20 shows the aspen age class distribution for aspen with bars (spikes) at two possible aspen rotation ages. One logger on the Advisory Committee summarized the forest-wide impact well when he stated that if a shorter rotation is used for regulation, then to balance the area in each age class fewer age classes below the rotation age will need “backfilling” and you’ll have more older age classes above the rotation age to use as backfill. Specifically for Koochiching County (Figure 20), with a rotation age of 40, only three 5-year age classes would need backfilling while with a 50-year rotation five 5-year age classes would need backfilling. And if the rotation age is 50 years then only acres older than age 50 can be used as backfill. Not all of the aspen type needs to be regulated on a single rotation age, yet it’s clear that if age 40 stands can be harvested then those stands can potentially help overcome timber harvesting needs during bottleneck periods. Future work should look at average tree size for age 40 aspen. County forestry staff is not convinced that most aspen stands are of marketable size by age 40.

The planning process for the Koochiching County 2010 Forest Plan has drawn out for almost a year. Many scenarios were considered and the group met monthly. It was not difficult to model multiple scenarios after the model was up and running. Yet none of the scenarios were developed in great detail as the Advisory Group had difficulty in making decisions concerning specific assumptions that define a scenario. The Advisory Group members represented a wide range of interests. Interactions were respectful, yet most members were fairly set in their views as how county lands should be managed. Reaching a compromise solution (Compromise Scenario) was not easy for them. The Compromise Scenario includes high harvest levels in the first two years. This was critical for Advisory Committee members representing local timber industry. One might expect that the adequacy of the Compromise Scenario will be questioned in even 5-years, as harvest levels drop substantially in the compromise solution after the first 5 years. Within that time frame, the county has the potential to improve their inventory and potentially continue refining analyses. As many suggest, forest planning needs to be a continuous learning process. Results here have shown that forest is valuable with much at stake.



**Figure 20.** The current age class distribution for aspen. The bars represent two potential rotation ages for aspen.

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## Appendix A: Age Class Distributions -- Aspen Cover Type

**Table A. 1.** Scenario A1: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

Age	Current	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
<b>0-4</b>	12256	13514	11550	11511	11702	11545	11424	15851	15013	11435	12836
<b>5-9</b>	12708	12256	13514	11550	11511	11702	11545	11424	15851	15013	11435
<b>10-14</b>	15076	12708	12256	13514	11550	11511	11702	11545	11424	15851	15013
<b>15-19</b>	15510	15076	12708	12256	13514	11550	11511	11702	11545	11424	15851
<b>20-24</b>	13901	15510	15076	12708	12256	13514	11550	11511	11702	11545	11424
<b>25-29</b>	7094	13901	15510	15076	12708	12256	13514	11550	11511	11702	11545
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	13514	11550	11511	11702
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	13514	11550	11511
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	13514	11550
<b>45-49</b>	2696	5477	7096	4972	2798	4926	6605	7404	5058	5896	6892
<b>50-54</b>	1822	2696	2635	2529	20	228	2587	828	1227	1140	880
<b>55-59</b>	2066	1762	1709	1895	2487	20	228	2587	828	1227	1140
<b>60-64</b>	3247	1254	668	612	87	2487	20	228	1609	828	1227
<b>65-69</b>	3255	302	30	0	8	87	2402	20	41	492	122
<b>70-74</b>	4391	992	76	0	0	8	0	0	0	0	0
<b>75-79</b>	3605	4073	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	138	138	138	138	138	138	138	138	138	138



Table A.1 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	11900	12906	12265	12414	12735	12380	12631	12883	12858	13301
5-9	12836	11900	12906	12265	12414	12735	12380	12631	12883	12858
10-14	11435	12836	11900	12906	12265	12414	12735	12380	12631	12883
15-19	15013	11435	12836	11900	12906	12265	12414	12735	12380	12631
20-24	15851	15013	11435	12836	11900	12906	12265	12414	12735	12380
25-29	11424	15851	15013	11435	12836	11900	12906	12265	12414	12735
30-34	11545	11424	15851	15013	11435	12836	11900	12906	12265	12414
35-39	11702	11545	11424	15851	15013	11435	12836	11900	12906	12265
40-44	11511	11702	11545	11424	15851	15013	11435	12836	11900	12906
45-49	5904	4962	3757	3113	2649	6087	8209	5747	5666	5542
50-54	1472	1055	1549	1366	543	309	869	1455	1312	650
55-59	880	1472	1055	1549	1366	543	309	869	1455	1312
60-64	1140	880	1472	1055	1171	1366	543	309	869	867
65-69	515	148	120	0	43	896	1254	543	309	154
70-74	0	0	0	0	0	43	441	1254	543	230
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	138	138	138	138	138	138	138	138	138	138

**Table A. 2.** Scenario A2: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	12287	11479	11558	11492	11500	11495	15319	14482	11679	11800
<b>5-9</b>	12708	12256	12287	11479	11558	11492	11500	11495	15319	14482	11679
<b>10-14</b>	15076	12708	12256	12287	11479	11558	11492	11500	11495	15319	14482
<b>15-19</b>	15510	15076	12708	12256	12287	11479	11558	11492	11500	11495	15319
<b>20-24</b>	13901	15510	15076	12708	12256	12287	11479	11558	11492	11500	11495
<b>25-29</b>	7094	13901	15510	15076	12708	12256	12287	11479	11558	11492	11500
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	12287	11479	11558	11492
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	12287	11479	11558
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	12287	11479
<b>45-49</b>	2696	5477	6951	4529	2798	4989	6742	8306	5290	6732	6794
<b>50-54</b>	1822	2696	2842	3054	358	568	2824	1021	2129	1372	1815
<b>55-59</b>	2066	1817	2629	2816	3054	358	568	2824	1021	2129	1372
<b>60-64</b>	3247	1618	887	850	690	3054	358	568	2824	1021	2129
<b>65-69</b>	3255	453	132	50	8	332	2831	358	41	628	258
<b>70-74</b>	4391	1421	119	8	0	8	0	4	0	0	0
<b>75-79</b>	3605	4347	0	0	0	0	0	0	4	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	4	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	4
<b>90+</b>	554	90	90	90	90	90	90	90	90	90	90

Table A.2 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	12041	12536	12502	12485	12464	12507	12531	12363	12658	12513
5-9	11800	12041	12536	12502	12485	12464	12507	12531	12363	12658
10-14	11679	11800	12041	12536	12502	12485	12464	12507	12531	12363
15-19	14482	11679	11800	12041	12536	12502	12485	12464	12507	12531
20-24	15319	14482	11679	11800	12041	12536	12502	12485	12464	12507
25-29	11495	15319	14482	11679	11800	12041	12536	12502	12485	12464
30-34	11500	11495	15319	14482	11679	11800	12041	12536	12502	12485
35-39	11492	11500	11495	15319	14482	11679	11800	12041	12536	12502
40-44	11558	11492	11500	11495	15319	14482	11679	11800	12041	12536
45-49	6233	5591	3846	3629	2670	6360	8235	6659	6270	5566
50-54	1827	1507	2235	1455	1399	505	645	1530	1074	1298
55-59	1815	1827	1507	2235	1455	1399	505	645	1530	1074
60-64	1372	1727	1827	1507	2235	1455	1399	505	645	1530
65-69	558	174	403	8	98	858	1369	1232	505	639
70-74	0	0	0	0	8	98	472	1369	1059	505
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	94	94	94	94	94	94	94	94	94	94

**Table A. 3.** Scenario A3: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	11432	11404	11356	11317	11457	11488	14613	14154	11513	11514
<b>5-9</b>	12708	12256	11432	11404	11356	11317	11457	11488	14613	14154	11513
<b>10-14</b>	15076	12708	12256	11432	11404	11356	11317	11457	11488	14613	14154
<b>15-19</b>	15510	15076	12708	12256	11432	11404	11356	11317	11457	11488	14613
<b>20-24</b>	13901	15510	15076	12708	12256	11432	11404	11356	11317	11457	11488
<b>25-29</b>	7094	13901	15510	15076	12708	12256	11432	11404	11356	11317	11457
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	11432	11404	11356	11317
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	11432	11404	11356
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	11432	11404
<b>45-49</b>	2696	5477	6052	3733	2798	4872	6395	8841	6001	7331	6967
<b>50-54</b>	1822	2696	3465	3739	464	843	3374	1371	2689	2084	2374
<b>55-59</b>	2066	1817	2679	3465	3739	464	843	3374	1371	2689	2084
<b>60-64</b>	3247	1723	1486	1419	1180	3739	464	843	3374	1371	2666
<b>65-69</b>	3255	840	252	75	65	707	3635	464	228	925	226
<b>70-74</b>	4391	1770	586	38	0	65	0	282	0	6	0
<b>75-79</b>	3605	4391	0	0	0	0	0	0	65	0	6
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	65	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	65
<b>90+</b>	554	61	61	61	61	61	61	61	61	61	61

Table A.3 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	11996	12564	12394	12455	12416	12226	11936	11856	11702	11965
5-9	11514	11996	12564	12394	12455	12416	12226	11936	11856	11702
10-14	11513	11514	11996	12564	12394	12455	12416	12226	11936	11856
15-19	14154	11513	11514	11996	12564	12394	12455	12416	12226	11936
20-24	14613	14154	11513	11514	11996	12564	12394	12455	12416	12226
25-29	11488	14613	14154	11513	11514	11996	12564	12394	12455	12416
30-34	11457	11488	14613	14154	11513	11514	11996	12564	12394	12455
35-39	11317	11457	11488	14613	14154	11513	11514	11996	12564	12394
40-44	11356	11317	11457	11488	14613	14154	11513	11514	11996	12564
45-49	6475	5492	3940	3841	2675	5668	8456	7297	7050	6905
50-54	2269	2009	2501	1548	1885	1177	644	1473	1607	1814
55-59	2374	2269	2009	2501	1548	1885	1177	644	1473	1607
60-64	2084	2374	2269	2009	2501	1548	1885	1177	644	1473
65-69	523	372	722	543	362	1260	1548	1637	1177	644
70-74	0	0	0	0	543	362	408	1548	1637	1177
75-79	0	0	0	0	0	0	0	0	0	0
80-84	6	0	0	0	0	0	0	0	0	0
85-89	0	6	0	0	0	0	0	0	0	0
90+	126	126	132	132	132	132	132	132	132	132

**Table A. 4.** Scenario B1: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	15479	10453	10623	10669	12251	13911	13298	13593	13184	13737
<b>5-9</b>	12708	12256	15479	10453	10623	10669	12251	13911	13298	13593	13184
<b>10-14</b>	15076	12708	12256	15479	10453	10623	10669	12251	13911	13298	13593
<b>15-19</b>	15510	15076	12708	12256	15479	10453	10623	10669	12251	13911	13298
<b>20-24</b>	13901	15510	15076	12708	12256	15479	10453	10623	10669	12251	13911
<b>25-29</b>	7094	13901	15510	15076	12708	12256	15479	10453	10623	10669	12251
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	15479	10453	10623	10669
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	15479	10453	10623
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	15479	10453
<b>45-49</b>	2696	5477	6556	5490	3198	4806	6234	7835	5641	5999	7981
<b>50-54</b>	1822	2696	2295	2086	746	814	972	1152	2494	1239	983
<b>55-59</b>	2066	1817	1850	1945	1900	746	814	972	1152	1790	1239
<b>60-64</b>	3247	1612	672	546	648	1764	746	814	972	456	1216
<b>65-69</b>	3255	252	0	0	0	12	975	746	374	220	28
<b>70-74</b>	4391	534	12	0	0	0	0	0	0	0	0
<b>75-79</b>	3605	2240	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	99	99	99	99	99	99	99	99	99	99

Table A.4 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	11262	12584	12572	12598	12560	12645	12697	12732	12626	12562
5-9	13737	11262	12584	12572	12598	12560	12645	12697	12732	12626
10-14	13184	13737	11262	12584	12572	12598	12560	12645	12697	12732
15-19	13593	13184	13737	11262	12584	12572	12598	12560	12645	12697
20-24	13298	13593	13184	13737	11262	12584	12572	12598	12560	12645
25-29	13911	13298	13593	13184	13737	11262	12584	12572	12598	12560
30-34	12251	13911	13298	13593	13184	13737	11262	12584	12572	12598
35-39	10669	12251	13911	13298	13593	13184	13737	11262	12584	12572
40-44	10623	10669	12251	13911	13298	13593	13184	13737	11262	12584
45-49	6446	4986	2866	3473	4277	5392	6235	6687	6903	5314
50-54	1732	1206	1425	475	1088	443	565	520	1370	1754
55-59	983	1732	1196	1425	475	1088	443	565	520	1370
60-64	1239	752	1284	1054	1425	475	1088	443	565	520
65-69	237	0	2	0	511	520	475	1088	443	190
70-74	0	0	0	0	0	511	520	475	1088	442
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	99	99	99	99	99	99	99	99	99	99

**Table A. 5.** Scenario B2: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	15021	10386	10367	10441	10976	13757	13408	13561	12989	12794
<b>5-9</b>	12708	12256	15021	10386	10367	10441	10976	13757	13408	13561	12989
<b>10-14</b>	15076	12708	12256	15021	10386	10367	10441	10976	13757	13408	13561
<b>15-19</b>	15510	15076	12708	12256	15021	10386	10367	10441	10976	13757	13408
<b>20-24</b>	13901	15510	15076	12708	12256	15021	10386	10367	10441	10976	13757
<b>25-29</b>	7094	13901	15510	15076	12708	12256	15021	10386	10367	10441	10976
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	15021	10386	10367	10441
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	15021	10386	10367
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	15021	10386
<b>45-49</b>	2696	5477	5357	4371	2992	5538	6169	8621	5750	6761	9033
<b>50-54</b>	1822	2696	2783	2716	674	969	2185	1392	3517	1733	1751
<b>55-59</b>	2066	1762	2629	2783	2716	674	969	2185	1392	2723	1733
<b>60-64</b>	3247	1110	961	971	1048	2716	674	969	2185	808	1884
<b>65-69</b>	3255	254	87	0	65	458	2175	674	144	229	79
<b>70-74</b>	4391	610	88	0	0	65	0	0	0	0	0
<b>75-79</b>	3605	3173	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	104	104	104	104	104	104	104	104	104	104



Table A.5 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	11487	12573	12565	12449	12377	12496	12327	12227	12980	12100
5-9	12794	11487	12573	12565	12449	12377	12496	12327	12227	12980
10-14	12989	12794	11487	12573	12565	12449	12377	12496	12327	12227
15-19	13561	12989	12794	11487	12573	12565	12449	12377	12496	12327
20-24	13408	13561	12989	12794	11487	12573	12565	12449	12377	12496
25-29	13757	13408	13561	12989	12794	11487	12573	12565	12449	12377
30-34	10976	13757	13408	13561	12989	12794	11487	12573	12565	12449
35-39	10441	10976	13757	13408	13561	12989	12794	11487	12573	12565
40-44	10367	10441	10976	13757	13408	13561	12989	12794	11487	12573
45-49	6952	5379	3401	2870	4470	5115	6695	7024	6601	6366
50-54	2675	2023	1863	1010	847	1118	763	1103	1247	896
55-59	1751	2617	1794	1863	1010	847	1118	763	1103	1247
60-64	1733	1155	1991	1794	1863	1010	847	1118	763	1103
65-69	268	0	2	41	726	1053	1010	847	1118	337
70-74	0	0	0	0	41	726	670	1010	847	1118
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	104	104	104	104	104	104	104	104	104	104

**Table A. 6.** Scenario B3: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	13687	10521	9992	10516	10850	13463	13267	13184	13073	11926
<b>5-9</b>	12708	12256	13687	10521	9992	10516	10850	13463	13267	13184	13073
<b>10-14</b>	15076	12708	12256	13687	10521	9992	10516	10850	13463	13267	13184
<b>15-19</b>	15510	15076	12708	12256	13687	10521	9992	10516	10850	13463	13267
<b>20-24</b>	13901	15510	15076	12708	12256	13687	10521	9992	10516	10850	13463
<b>25-29</b>	7094	13901	15510	15076	12708	12256	13687	10521	9992	10516	10850
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	13687	10521	9992	10516
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	13687	10521	9992
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	13687	10521
<b>45-49</b>	2696	5477	4874	4519	3023	6080	6401	9037	6183	7332	8959
<b>50-54</b>	1822	2696	3305	2892	1081	1100	2750	1931	4210	2248	2430
<b>55-59</b>	2066	1817	2679	3305	2892	1081	1100	2750	1931	3569	2248
<b>60-64</b>	3247	1612	1544	1603	1761	2892	1081	1100	2750	1115	2606
<b>65-69</b>	3255	458	275	56	178	711	2758	1081	349	341	122
<b>70-74</b>	4391	1118	426	38	56	178	0	0	0	0	0
<b>75-79</b>	3605	3235	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	106	106	106	106	106	106	106	106	106	106

Table A.6 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	11647	12424	12427	12402	12175	12317	12103	11926	12504	13052
5-9	11926	11647	12424	12427	12402	12175	12317	12103	11926	12504
10-14	13073	11926	11647	12424	12427	12402	12175	12317	12103	11926
15-19	13184	13073	11926	11647	12424	12427	12402	12175	12317	12103
20-24	13267	13184	13073	11926	11647	12424	12427	12402	12175	12317
25-29	13463	13267	13184	13073	11926	11647	12424	12427	12402	12175
30-34	10850	13463	13267	13184	13073	11926	11647	12424	12427	12402
35-39	10516	10850	13463	13267	13184	13073	11926	11647	12424	12427
40-44	9992	10516	10850	13463	13267	13184	13073	11926	11647	12424
45-49	7034	5315	3946	2786	4809	5064	6620	7311	6940	6053
50-54	3174	2453	2033	1555	863	1479	1087	1517	1348	838
55-59	2430	3174	2453	2033	1555	863	1479	1087	1517	1348
60-64	2248	1857	2449	2453	2033	1555	863	1479	1087	1517
65-69	354	9	17	520	854	1769	1555	863	1479	594
70-74	0	0	0	0	520	854	1061	1555	863	1479
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	106	106	106	106	106	106	106	106	106	106

**Table A. 7.** Scenario C0: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

Age	Current	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
<b>0-4</b>	13917	17267	13504	11764	11140	13649	15316	14846	12930	12262	17075
<b>5-9</b>	12256	12256	17267	13504	11764	11140	13649	15316	14846	12930	12262
<b>10-14</b>	12708	12708	12256	17267	13504	11764	11140	13649	15316	14846	12930
<b>15-19</b>	15076	15076	12708	12256	17267	13504	11764	11140	13649	15316	14846
<b>20-24</b>	15510	15510	15076	12708	12256	17267	13504	11764	11140	13649	15316
<b>25-29</b>	13901	13901	15510	15076	12708	12256	17267	13504	11764	11140	13649
<b>30-34</b>	7094	7094	13901	15510	15076	12708	12256	17267	13504	11764	11140
<b>35-39</b>	9305	9305	7094	13901	15510	15076	12708	12256	17267	13504	11764
<b>40-44</b>	7209	7209	9305	7094	13901	15510	15076	12708	12256	17267	13504
<b>45-49</b>	5477	5477	3700	1853	41	252	194	240	112	133	390
<b>50-54</b>	2696	2696	1985	1030	0	41	252	190	189	112	133
<b>55-59</b>	1822	1581	697	1020	0	0	41	252	190	189	112
<b>60-64</b>	2031	817	164	183	0	0	0	34	3	54	45
<b>65-69</b>	1176	178	0	0	0	0	0	0	0	0	0
<b>70-74</b>	761	356	0	0	0	0	0	0	0	0	0
<b>75-79</b>	2228	1736	0	0	0	0	0	0	0	0	0
<b>80-84</b>	0	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	0	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	99	99	99	99	99	99	99	99	99	99	99

**Table A.7 continued.**

<b>Age</b>	<b>55 Years</b>	<b>60 Years</b>	<b>65 Years</b>	<b>70 Years</b>	<b>75 Years</b>	<b>80 Years</b>	<b>85 Years</b>	<b>90 Years</b>	<b>95 Years</b>	<b>100 Years</b>
<b>0-4</b>	11664	12760	12665	13649	15290	14809	12488	12451	16236	12506
<b>5-9</b>	17075	11664	12760	12665	13649	15290	14809	12488	12451	16236
<b>10-14</b>	12262	17075	11664	12760	12665	13649	15290	14809	12488	12451
<b>15-19</b>	12930	12262	17075	11664	12760	12665	13649	15290	14809	12488
<b>20-24</b>	14846	12930	12262	17075	11664	12760	12665	13649	15290	14809
<b>25-29</b>	15316	14846	12930	12262	17075	11664	12760	12665	13649	15290
<b>30-34</b>	13649	15316	14846	12930	12262	17075	11664	12760	12665	13649
<b>35-39</b>	11140	13649	15316	14846	12930	12262	17075	11664	12760	12665
<b>40-44</b>	11764	11140	13649	15316	14846	12930	12262	17075	11664	12760
<b>45-49</b>	1891	96	0	0	26	37	442	65	839	51
<b>50-54</b>	390	946	0	0	0	26	37	245	65	198
<b>55-59</b>	133	390	0	0	0	0	26	6	245	65
<b>60-64</b>	103	92	0	0	0	0	0	0	6	0
<b>65-69</b>	4	0	0	0	0	0	0	0	0	0
<b>70-74</b>	0	0	0	0	0	0	0	0	0	0
<b>75-79</b>	0	0	0	0	0	0	0	0	0	0
<b>80-84</b>	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	99	99	99	99	99	99	99	99	99	99

**Table A. 8.** Scenario C1: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	17099	11038	11431	10561	13148	14784	15412	12553	12399	15573
<b>5-9</b>	12708	12256	17099	11038	11431	10561	13148	14784	15412	12553	12399
<b>10-14</b>	15076	12708	12256	17099	11038	11431	10561	13148	14784	15412	12553
<b>15-19</b>	15510	15076	12708	12256	17099	11038	11431	10561	13148	14784	15412
<b>20-24</b>	13901	15510	15076	12708	12256	17099	11038	11431	10561	13148	14784
<b>25-29</b>	7094	13901	15510	15076	12708	12256	17099	11038	11431	10561	13148
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	17099	11038	11431	10561
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	17099	11038	11431
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	17099	11038
<b>45-49</b>	2696	5477	4508	2650	363	1473	1089	1140	1236	997	2771
<b>50-54</b>	1822	2696	2171	1867	702	363	1473	1089	1140	1236	997
<b>55-59</b>	2066	1647	1908	1988	1862	702	363	1473	1089	1140	1236
<b>60-64</b>	3247	847	590	549	653	1784	702	363	1380	1089	1134
<b>65-69</b>	3255	191	0	0	8	12	1441	666	41	280	131
<b>70-74</b>	4391	400	3	0	0	8	0	0	0	0	0
<b>75-79</b>	3605	1752	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	98	98	98	98	98	98	98	98	98	98

**Table A.8 continued.**

<b>Age</b>	<b>55 Years</b>	<b>60 Years</b>	<b>65 Years</b>	<b>70 Years</b>	<b>75 Years</b>	<b>80 Years</b>	<b>85 Years</b>	<b>90 Years</b>	<b>95 Years</b>	<b>100 Years</b>
<b>0-4</b>	11441	12499	12501	12579	13505	15106	12475	12571	14592	12506
<b>5-9</b>	15573	11441	12499	12501	12579	13505	15106	12475	12571	14592
<b>10-14</b>	12399	15573	11441	12499	12501	12579	13505	15106	12475	12571
<b>15-19</b>	12553	12399	15573	11441	12499	12501	12579	13505	15106	12475
<b>20-24</b>	15412	12553	12399	15573	11441	12499	12501	12579	13505	15106
<b>25-29</b>	14784	15412	12553	12399	15573	11441	12499	12501	12579	13505
<b>30-34</b>	13148	14784	15412	12553	12399	15573	11441	12499	12501	12579
<b>35-39</b>	10561	13148	14784	15412	12553	12399	15573	11441	12499	12501
<b>40-44</b>	11431	10561	13148	14784	15412	12553	12399	15573	11441	12499
<b>45-49</b>	1693	721	0	897	1279	1228	1325	1086	2239	441
<b>50-54</b>	1672	1581	360	0	897	1279	1228	1325	1086	1886
<b>55-59</b>	997	1672	1581	360	0	897	1279	1228	1325	1086
<b>60-64</b>	1236	815	916	1581	360	0	897	1279	1228	1325
<b>65-69</b>	268	9	2	588	1581	360	0	0	20	76
<b>70-74</b>	0	0	0	0	588	1247	360	0	0	20
<b>75-79</b>	0	0	0	0	0	0	0	0	0	0
<b>80-84</b>	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	98	98	98	98	98	98	98	98	98	98

**Table A. 9.** Scenario C2: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

Age	Current	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
<b>0-4</b>	12256	16370	10633	11052	10473	12399	14511	15730	12485	12434	14465
<b>5-9</b>	12708	12256	16370	10633	11052	10473	12399	14511	15730	12485	12434
<b>10-14</b>	15076	12708	12256	16370	10633	11052	10473	12399	14511	15730	12485
<b>15-19</b>	15510	15076	12708	12256	16370	10633	11052	10473	12399	14511	15730
<b>20-24</b>	13901	15510	15076	12708	12256	16370	10633	11052	10473	12399	14511
<b>25-29</b>	7094	13901	15510	15076	12708	12256	16370	10633	11052	10473	12399
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	16370	10633	11052	10473
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	16370	10633	11052
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	16370	10633
<b>45-49</b>	2696	5477	3828	2282	421	2453	1420	1847	1639	1691	3543
<b>50-54</b>	1822	2696	2715	2502	888	421	2453	1420	1847	1639	1691
<b>55-59</b>	2066	1817	2679	2715	2501	888	421	2453	1420	1847	1639
<b>60-64</b>	3247	1540	998	1012	1196	2501	888	421	2274	1420	1847
<b>65-69</b>	3255	221	30	50	127	294	2501	888	72	476	258
<b>70-74</b>	4391	413	59	0	50	127	0	0	0	0	0
<b>75-79</b>	3605	1568	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	104	104	104	104	104	104	104	104	104	104



Table A.9 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	11422	12454	12464	12471	12800	14797	12541	12548	13637	12453
5-9	14465	11422	12454	12464	12471	12800	14797	12541	12548	13637
10-14	12434	14465	11422	12454	12464	12471	12800	14797	12541	12548
15-19	12485	12434	14465	11422	12454	12464	12471	12800	14797	12541
20-24	15730	12485	12434	14465	11422	12454	12464	12471	12800	14797
25-29	14511	15730	12485	12434	14465	11422	12454	12464	12471	12800
30-34	12399	14511	15730	12485	12434	14465	11422	12454	12464	12471
35-39	10473	12399	14511	15730	12485	12434	14465	11422	12454	12464
40-44	11052	10473	12399	14511	15730	12485	12434	14465	11422	12454
45-49	2127	1333	0	1032	1711	1930	1601	1839	2391	861
50-54	2303	1646	1049	0	1032	1711	1930	1601	1839	2391
55-59	1691	2303	1646	1049	0	1032	1711	1930	1601	1839
60-64	1639	1494	2099	1646	1049	0	1032	1711	1930	1601
65-69	429	11	2	997	1646	1049	0	117	148	156
70-74	0	0	0	0	997	1646	1038	0	117	148
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	104	104	104	104	104	104	104	104	104	104

**Table A. 10.** Scenario C3: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	14924	10457	11091	10370	11945	14317	15655	12476	12575	13757
<b>5-9</b>	12708	12256	14924	10457	11091	10370	11945	14317	15655	12476	12575
<b>10-14</b>	15076	12708	12256	14924	10457	11091	10370	11945	14317	15655	12476
<b>15-19</b>	15510	15076	12708	12256	14924	10457	11091	10370	11945	14317	15655
<b>20-24</b>	13901	15510	15076	12708	12256	14924	10457	11091	10370	11945	14317
<b>25-29</b>	7094	13901	15510	15076	12708	12256	14924	10457	11091	10370	11945
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	14924	10457	11091	10370
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	14924	10457	11091
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	14924	10457
<b>45-49</b>	2696	5477	3392	1975	693	3126	1878	2590	2084	2256	3216
<b>50-54</b>	1822	2696	3553	3168	1158	693	3126	1878	2590	2084	2256
<b>55-59</b>	2066	1822	2696	3553	3168	1158	693	3126	1878	2590	2084
<b>60-64</b>	3247	1978	1688	1290	1523	3168	1158	693	2998	1878	2590
<b>65-69</b>	3255	674	274	164	168	517	3168	1158	128	550	380
<b>70-74</b>	4391	634	333	0	164	168	0	0	0	0	0
<b>75-79</b>	3605	1903	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	99	99	99	99	99	99	99	99	99	99

Table A.10 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	11411	12174	12017	12265	12342	14668	12499	12817	13392	12602
5-9	13757	11411	12174	12017	12265	12342	14668	12499	12817	13392
10-14	12575	13757	11411	12174	12017	12265	12342	14668	12499	12817
15-19	12476	12575	13757	11411	12174	12017	12265	12342	14668	12499
20-24	15655	12476	12575	13757	11411	12174	12017	12265	12342	14668
25-29	14317	15655	12476	12575	13757	11411	12174	12017	12265	12342
30-34	11945	14317	15655	12476	12575	13757	11411	12174	12017	12265
35-39	10370	11945	14317	15655	12476	12575	13757	11411	12174	12017
40-44	11091	10370	11945	14317	15655	12476	12575	13757	11411	12174
45-49	1601	1820	94	1463	2093	2528	1862	2420	2121	1288
50-54	2951	1601	1820	94	1463	2093	2528	1862	2420	2121
55-59	2256	2951	1601	1820	94	1463	2093	2528	1862	2420
60-64	2084	2089	2951	1601	1820	94	1463	2093	2528	1862
65-69	679	27	374	1542	1482	1820	69	244	406	293
70-74	0	0	0	0	1542	1482	1443	69	244	406
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	99	99	99	99	99	99	99	99	99	99

**Table A. 11.** Scenario G0: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

Age	Current	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
<b>0-4</b>	12256	18384	18112	16457	13914	14600	13158	14073	14013	17894	18329
<b>5-9</b>	12708	12256	18384	18112	16457	13914	14600	13158	14073	14013	17894
<b>10-14</b>	15076	12708	12256	18384	18112	16457	13914	14600	13158	14073	14013
<b>15-19</b>	15510	15076	12708	12256	18384	18112	16457	13914	14600	13158	14073
<b>20-24</b>	13901	15510	15076	12708	12256	18384	18112	16457	13914	14600	13158
<b>25-29</b>	7094	13901	15510	15076	12708	12256	18384	18112	16457	13914	14600
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	18384	18112	16457	13914
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	18384	18112	16457
<b>40-44</b>	5477	7209	4343	636	464	1096	2664	1461	157	645	614
<b>45-49</b>	2696	5477	2711	41	254	292	401	240	11	81	0
<b>50-54</b>	1822	2696	2098	29	20	254	271	193	171	11	80
<b>55-59</b>	2066	1468	760	75	29	20	254	271	133	171	11
<b>60-64</b>	3247	783	229	0	0	15	5	66	0	54	41
<b>65-69</b>	3255	178	0	0	0	0	0	0	0	0	0
<b>70-74</b>	4391	356	3	0	0	0	0	0	0	0	0
<b>75-79</b>	3605	784	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	81	81	81	81	81	81	81	81	81	81

Table A.11 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	15445	15279	14604	12679	13966	14162	18141	17603	15511	14604
5-9	18329	15445	15279	14604	12679	13966	14162	18141	17603	15511
10-14	17894	18329	15445	15279	14604	12679	13966	14162	18141	17603
15-19	14013	17894	18329	15445	15279	14604	12679	13966	14162	18141
20-24	14073	14013	17894	18329	15445	15279	14604	12679	13966	14162
25-29	13158	14073	14013	17894	18329	15445	15279	14604	12679	13966
30-34	14600	13158	14073	14013	17894	18329	15445	15279	14604	12679
35-39	13914	14600	13158	14073	14013	17894	18329	15445	15279	14604
40-44	1605	227	228	767	929	786	175	837	593	1592
45-49	74	76	12	14	20	6	377	85	184	53
50-54	0	74	76	12	14	20	6	377	85	184
55-59	80	0	74	76	12	14	20	6	377	85
60-64	0	17	0	0	0	0	0	0	0	0
65-69	0	0	0	0	0	0	0	0	0	0
70-74	0	0	0	0	0	0	0	0	0	0
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	81	81	81	81	81	81	81	81	81	81

**Table A. 12.** Scenario G1: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

Age	Current	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
<b>0-4</b>	12256	17944	16971	12716	13486	15541	13535	13648	13292	17558	17338
<b>5-9</b>	12708	12256	17944	16971	12716	13486	15541	13535	13648	13292	17558
<b>10-14</b>	15076	12708	12256	17944	16971	12716	13486	15541	13535	13648	13292
<b>15-19</b>	15510	15076	12708	12256	17944	16971	12716	13486	15541	13535	13648
<b>20-24</b>	13901	15510	15076	12708	12256	17944	16971	12716	13486	15541	13535
<b>25-29</b>	7094	13901	15510	15076	12708	12256	17944	16971	12716	13486	15541
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	17944	16971	12716	13486
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	17944	16971	12716
<b>40-44</b>	5477	7209	4237	1052	1464	1452	2594	2070	1043	1449	1085
<b>45-49</b>	2696	5477	2927	1466	1052	1464	1452	1050	1444	1043	1449
<b>50-54</b>	1822	2696	2070	1033	1466	1052	1464	1452	1050	1444	1043
<b>55-59</b>	2066	1603	1741	1882	1033	1466	1052	1464	1452	1050	1444
<b>60-64</b>	3247	847	672	621	1446	1033	1466	1052	1063	1452	1050
<b>65-69</b>	3255	212	19	50	8	12	0	0	0	0	0
<b>70-74</b>	4391	404	59	0	50	8	0	0	0	0	0
<b>75-79</b>	3605	944	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	81	81	81	81	81	81	81	81	81	81

Table A.12 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	12593	13860	15398	13362	13911	13390	17595	16847	12672	13560
5-9	17338	12593	13860	15398	13362	13911	13390	17595	16847	12672
10-14	17558	17338	12593	13860	15398	13362	13911	13390	17595	16847
15-19	13292	17558	17338	12593	13860	15398	13362	13911	13390	17595
20-24	13648	13292	17558	17338	12593	13860	15398	13362	13911	13390
25-29	13535	13648	13292	17558	17338	12593	13860	15398	13362	13911
30-34	15541	13535	13648	13292	17558	17338	12593	13860	15398	13362
35-39	13486	15541	13535	13648	13292	17558	17338	12593	13860	15398
40-44	1172	1070	1187	1264	954	1079	1192	1447	1050	1444
45-49	1085	1172	1070	1187	1264	954	1079	1192	1447	1050
50-54	1449	1085	1172	1070	1187	1264	954	1079	1192	1447
55-59	1043	1449	1085	1172	1070	1187	1264	954	1079	1192
60-64	1444	1043	1449	1085	1172	1070	1187	1264	954	1079
65-69	0	0	0	357	225	220	61	292	428	239
70-74	0	0	0	0	0	0	0	0	0	0
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	81	81	81	81	81	81	81	81	81	81

**Table A. 13.** Scenario G3: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	16446	14667	10501	13018	15891	14375	13250	12802	16262	14808
<b>5-9</b>	12708	12256	16446	14667	10501	13018	15891	14375	13250	12802	16262
<b>10-14</b>	15076	12708	12256	16446	14667	10501	13018	15891	14375	13250	12802
<b>15-19</b>	15510	15076	12708	12256	16446	14667	10501	13018	15891	14375	13250
<b>20-24</b>	13901	15510	15076	12708	12256	16446	14667	10501	13018	15891	14375
<b>25-29</b>	7094	13901	15510	15076	12708	12256	16446	14667	10501	13018	15891
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	16446	14667	10501	13018
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	16446	14667	10501
<b>40-44</b>	5477	7209	3583	2630	2465	2611	2942	2720	2084	2649	2470
<b>45-49</b>	2696	5477	3646	2664	2630	2465	2611	2345	2720	2084	2649
<b>50-54</b>	1822	2696	3329	1910	2664	2630	2465	2611	2345	2720	2084
<b>55-59</b>	2066	1817	2696	3327	1910	2664	2630	2465	2611	2345	2720
<b>60-64</b>	3247	1612	1696	1372	2871	1910	2664	2630	2465	2611	2345
<b>65-69</b>	3255	469	247	198	283	182	29	0	0	0	0
<b>70-74</b>	4391	1170	347	38	198	178	0	29	0	0	0
<b>75-79</b>	3605	456	0	0	0	0	0	0	29	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	29	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	29
<b>90+</b>	554	63	63	63	63	63	63	63	63	63	63



Table A.13 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	12056	13792	15592	12982	13374	13394	16479	14019	11868	13790
5-9	14808	12056	13792	15592	12982	13374	13394	16479	14019	11868
10-14	16262	14808	12056	13792	15592	12982	13374	13394	16479	14019
15-19	12802	16262	14808	12056	13792	15592	12982	13374	13394	16479
20-24	13250	12802	16262	14808	12056	13792	15592	12982	13374	13394
25-29	14375	13250	12802	16262	14808	12056	13792	15592	12982	13374
30-34	15891	14375	13250	12802	16262	14808	12056	13792	15592	12982
35-39	13018	15891	14375	13250	12802	16262	14808	12056	13792	15592
40-44	790	1945	2383	2332	1677	1929	2115	2361	2034	2300
45-49	2470	790	1945	2383	2332	1677	1929	2115	2361	2034
50-54	2649	2470	790	1945	2383	2332	1677	1929	2115	2361
55-59	2084	2649	2470	790	1945	2383	2332	1677	1929	2115
60-64	2720	2084	2649	2470	790	1945	2383	2332	1677	1929
65-69	0	0	0	1710	2379	647	259	1068	1554	933
70-74	0	0	0	0	0	0	0	0	0	0
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	92	92	92	92	92	92	92	92	92	92

**Table A. 14.** Scenario Gvar: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

Age	Current	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
<b>0-4</b>	12256	13800	12378	11321	12538	13927	15729	12768	12725	12508	14113
<b>5-9</b>	12708	12256	13800	12378	11321	12538	13927	15729	12768	12725	12508
<b>10-14</b>	15076	12708	12256	13800	12378	11321	12538	13927	15729	12768	12725
<b>15-19</b>	15510	15076	12708	12256	13800	12378	11321	12538	13927	15729	12768
<b>20-24</b>	13901	15510	15076	12708	12256	13800	12378	11321	12538	13927	15729
<b>25-29</b>	7094	13901	15510	15076	12708	12256	13800	12378	11321	12538	13927
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	13800	12378	11321	12538
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	13800	12378	11321
<b>40-44</b>	5477	6573	3799	2737	3594	4222	4548	3901	2384	4885	2479
<b>45-49</b>	2696	5477	4217	3432	2737	3594	4222	4019	3772	2384	4885
<b>50-54</b>	1822	2696	4252	3048	3432	2737	3594	4222	4019	3772	2384
<b>55-59</b>	2066	1822	2696	4252	3048	3432	2737	3594	4222	4019	3772
<b>60-64</b>	3247	2031	1822	1897	3731	3048	3432	2737	3594	4222	4019
<b>65-69</b>	3255	2645	1896	336	849	1481	29	0	13	0	8
<b>70-74</b>	4391	2311	1815	566	241	701	0	29	0	13	0
<b>75-79</b>	3605	15	0	0	0	0	0	0	29	0	13
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	29	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	29
<b>90+</b>	554	47	47	47	47	47	47	47	47	47	47

Table A.14 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	13845	12939	13921	12228	13683	13130	13502	13584	11747	12838
5-9	14113	13845	12939	13921	12228	13683	13130	13502	13584	11747
10-14	12508	14113	13845	12939	13921	12228	13683	13130	13502	13584
15-19	12725	12508	14113	13845	12939	13921	12228	13683	13130	13502
20-24	12768	12725	12508	14113	13845	12939	13921	12228	13683	13130
25-29	15729	12768	12725	12508	14113	13845	12939	13921	12228	13683
30-34	13927	15729	12768	12725	12508	14113	13845	12939	13921	12228
35-39	12538	13927	15729	12768	12725	12508	14113	13845	12939	13921
40-44	1495	3370	2390	4399	3073	2080	2768	3323	3807	3485
45-49	2479	1495	3370	2390	4399	3073	2080	2768	3323	3807
50-54	4885	2479	1495	3370	2390	4399	3073	2080	2768	3323
55-59	2384	4885	2479	1495	3370	2390	4399	3073	2080	2768
60-64	3772	2384	4885	2479	1495	3370	2390	4399	3073	2080
65-69	0	0	0	3987	2479	1488	1096	693	3382	3072
70-74	8	0	0	0	0	0	0	0	0	0
75-79	0	8	0	0	0	0	0	0	0	0
80-84	13	0	8	0	0	0	0	0	0	0
85-89	0	13	0	8	0	0	0	0	0	0
90+	76	76	90	90	97	97	97	97	97	97

**Table A. 15.** Scenario D: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	11539	11195	11248	11372	10760	11095	11548	11174	11348	11481
<b>5-9</b>	12708	12256	11539	11195	11248	11372	10760	11095	11548	11174	11348
<b>10-14</b>	15076	12708	12256	11539	11195	11248	11372	10760	11095	11548	11174
<b>15-19</b>	15510	15076	12708	12256	11539	11195	11248	11372	10760	11095	11548
<b>20-24</b>	13901	15510	15076	12708	12256	11539	11195	11248	11372	10760	11095
<b>25-29</b>	7094	13901	15510	15076	12708	12256	11539	11195	11248	11372	10760
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	11539	11195	11248	11372
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	11539	11195	11248
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	11539	11195
<b>45-49</b>	2696	5477	4220	5362	4575	10699	11035	10326	7817	8266	6248
<b>50-54</b>	1822	1871	3224	2343	0	0	4080	4630	4959	5174	6601
<b>55-59</b>	2066	1822	1662	3224	2343	0	0	4080	4630	4959	5174
<b>60-64</b>	3247	2032	1333	1514	1354	775	0	0	3546	3462	3895
<b>65-69</b>	3255	2424	1568	65	60	0	775	0	0	0	0
<b>70-74</b>	4391	2058	1474	103	0	0	0	382	0	0	0
<b>75-79</b>	3605	2855	1073	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0

**Table A.15 continued.**

<b>Age</b>	<b>55 Years</b>	<b>60 Years</b>	<b>65 Years</b>	<b>70 Years</b>	<b>75 Years</b>	<b>80 Years</b>	<b>85 Years</b>	<b>90 Years</b>	<b>95 Years</b>	<b>100 Years</b>
<b>0-4</b>	11464	11234	11286	11430	11476	11670	11823	11345	11437	10979
<b>5-9</b>	11481	11464	11234	11286	11430	11476	11670	11823	11345	11437
<b>10-14</b>	11348	11481	11464	11234	11286	11430	11476	11670	11823	11345
<b>15-19</b>	11174	11348	11481	11464	11234	11286	11430	11476	11670	11823
<b>20-24</b>	11548	11174	11348	11481	11464	11234	11286	11430	11476	11670
<b>25-29</b>	11095	11548	11174	11348	11481	11464	11234	11286	11430	11476
<b>30-34</b>	10760	11095	11548	11174	11348	11481	11464	11234	11286	11430
<b>35-39</b>	11372	10760	11095	11548	11174	11348	11481	11464	11234	11286
<b>40-44</b>	11248	11372	10760	11095	11548	11174	11348	11481	11464	11234
<b>45-49</b>	6832	7417	8775	7487	6717	6867	6283	7389	6190	6484
<b>50-54</b>	3847	4647	5138	5803	4551	4888	4512	4044	6420	5096
<b>55-59</b>	6601	3847	4517	5138	5803	4551	4888	3952	4044	6420
<b>60-64</b>	4369	5547	2888	2624	3532	4196	4242	4463	3191	2291
<b>65-69</b>	0	204	431	27	72	1	0	81	98	69
<b>70-74</b>	0	0	0	0	22	72	0	0	31	98
<b>75-79</b>	0	0	0	0	0	0	0	0	0	0
<b>80-84</b>	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	0	0	0	0	0	0	0	0	0	0

**Table A. 16.** Scenario D\*: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

Age	Current	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
<b>0-4</b>	12256	11614	11768	10078	10194	10266	10014	11550	11578	11571	11577
<b>5-9</b>	12708	12256	11614	11768	10078	10194	10266	10014	11550	11578	11571
<b>10-14</b>	15076	12708	12256	11614	11768	10078	10194	10266	10014	11550	11578
<b>15-19</b>	15510	15076	12708	12256	11614	11768	10078	10194	10266	10014	11550
<b>20-24</b>	13901	15510	15076	12708	12256	11614	11768	10078	10194	10266	10014
<b>25-29</b>	7094	13901	15510	15076	12708	12256	11614	11768	10078	10194	10266
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	11614	11768	10078	10194
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	11614	11768	10078
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	11614	11768
<b>45-49</b>	2696	5477	5439	7280	5848	10699	14277	13870	11838	12256	11614
<b>50-54</b>	1822	2696	4772	2361	1902	1249	2010	7181	8093	8142	7746
<b>55-59</b>	2066	1819	1850	2003	1173	831	1249	6	2985	3051	4137
<b>60-64</b>	3247	1783	733	621	246	25	765	770	0	192	182
<b>65-69</b>	3255	711	38	0	0	0	0	0	41	0	0
<b>70-74</b>	4391	1720	85	0	0	0	0	0	0	0	0
<b>75-79</b>	3605	3393	122	3	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	993	993	993	993	993	993	993	993	993	993

**Table A.16 continued.**

<b>Age</b>	<b>55 Years</b>	<b>60 Years</b>	<b>65 Years</b>	<b>70 Years</b>	<b>75 Years</b>	<b>80 Years</b>	<b>85 Years</b>	<b>90 Years</b>	<b>95 Years</b>	<b>100 Years</b>
<b>0-4</b>	11437	11593	11466	11450	11454	11541	11397	11499	11574	11531
<b>5-9</b>	11577	11437	11593	11466	11450	11454	11541	11397	11499	11574
<b>10-14</b>	11571	11577	11437	11593	11466	11450	11454	11541	11397	11499
<b>15-19</b>	11578	11571	11577	11437	11593	11466	11450	11454	11541	11397
<b>20-24</b>	11550	11578	11571	11577	11437	11593	11466	11450	11454	11541
<b>25-29</b>	10014	11550	11578	11571	11577	11437	11593	11466	11450	11454
<b>30-34</b>	10266	10014	11550	11578	11571	11577	11437	11593	11466	11450
<b>35-39</b>	10194	10266	10014	11550	11578	11571	11577	11437	11593	11466
<b>40-44</b>	10078	10194	10266	10014	11550	11578	11571	11577	11437	11593
<b>45-49</b>	11768	10078	10194	10050	8689	8673	8776	8840	8842	8747
<b>50-54</b>	6653	8383	7058	7796	6840	4737	5438	6746	6842	6366
<b>55-59</b>	5365	3858	3774	1981	2868	4984	4360	3063	2965	3645
<b>60-64</b>	218	176	195	210	200	212	213	0	2	11
<b>65-69</b>	6	0	2	0	0	0	0	211	0	0
<b>70-74</b>	0	0	0	0	0	0	0	0	211	0
<b>75-79</b>	0	0	0	0	0	0	0	0	0	0
<b>80-84</b>	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	993	993	993	993	993	993	993	993	993	993

**Table A. 17.** Scenario E: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	13917	10760	10904	10495	11269	11520	14592	12620	10818	12136
<b>5-9</b>	12708	12256	13917	10760	10904	10495	11269	11520	14592	12620	10818
<b>10-14</b>	15076	12708	12256	13917	10760	10904	10495	11269	11520	14592	12620
<b>15-19</b>	15510	15076	12708	12256	13917	10760	10904	10495	11269	11520	14592
<b>20-24</b>	13901	15510	15076	12708	12256	13917	10760	10904	10495	11269	11520
<b>25-29</b>	7094	13901	15510	15076	12708	12256	13917	10760	10904	10495	11269
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	13917	10760	10904	10495
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	13917	10760	10904
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	13917	10760
<b>45-49</b>	2696	5477	4268	3478	3081	5825	8209	8548	7423	7752	7889
<b>50-54</b>	1822	2696	3374	2562	783	697	2286	2432	2371	3518	2838
<b>55-59</b>	2066	1822	2696	3374	2286	783	697	2286	2432	2371	3518
<b>60-64</b>	3247	2031	1696	1455	1084	2286	783	697	2286	2424	2371
<b>65-69</b>	3255	1176	273	164	242	439	2286	783	323	207	1437
<b>70-74</b>	4391	761	333	8	164	242	0	0	0	0	0
<b>75-79</b>	3605	2228	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	99	99	99	99	99	99	99	99	99	99



**Table A.17 continued.**

<b>Age</b>	<b>55 Years</b>	<b>60 Years</b>	<b>65 Years</b>	<b>70 Years</b>	<b>75 Years</b>	<b>80 Years</b>	<b>85 Years</b>	<b>90 Years</b>	<b>95 Years</b>	<b>100 Years</b>
<b>0-4</b>	10158	10377	11020	10605	10675	13793	13052	13256	11226	10495
<b>5-9</b>	12136	10158	10377	11020	10605	10675	13793	13052	13256	11226
<b>10-14</b>	10818	12136	10158	10377	11020	10605	10675	13793	13052	13256
<b>15-19</b>	12620	10818	12136	10158	10377	11020	10605	10675	13793	13052
<b>20-24</b>	14592	12620	10818	12136	10158	10377	11020	10605	10675	13793
<b>25-29</b>	11520	14592	12620	10818	12136	10158	10377	11020	10605	10675
<b>30-34</b>	11269	11520	14592	12620	10818	12136	10158	10377	11020	10605
<b>35-39</b>	10495	11269	11520	14592	12620	10818	12136	10158	10377	11020
<b>40-44</b>	10904	10495	11269	11520	14592	12620	10818	12136	10158	10377
<b>45-49</b>	7893	8155	8205	7956	8693	9383	9300	7871	7908	8100
<b>50-54</b>	3559	3538	2830	3831	3858	3528	3607	2810	3671	2993
<b>55-59</b>	2838	3559	3538	2830	3831	3858	3528	3607	2810	3671
<b>60-64</b>	3518	2838	3559	3538	2830	3831	3858	3528	3607	2810
<b>65-69</b>	847	1092	525	1164	169	194	42	234	772	491
<b>70-74</b>	0	0	0	2	783	169	194	42	234	600
<b>75-79</b>	0	0	0	0	2	0	0	0	0	0
<b>80-84</b>	0	0	0	0	0	2	0	0	0	0
<b>85-89</b>	0	0	0	0	0	0	2	0	0	0
<b>90+</b>	99	99	99	99	99	99	99	100	100	100

**Table A. 18.** Compromise Scenario: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	13279	11003	9963	10098	9996	11643	11594	11607	11610	11605
<b>5-9</b>	12708	12256	13279	11003	9963	10098	9996	11643	11594	11607	11610
<b>10-14</b>	15076	12708	12256	13279	11003	9963	10098	9996	11643	11594	11607
<b>15-19</b>	15510	15076	12708	12256	13279	11003	9963	10098	9996	11643	11594
<b>20-24</b>	13901	15510	15076	12708	12256	13279	11003	9963	10098	9996	11643
<b>25-29</b>	7094	13901	15510	15076	12708	12256	13279	11003	9963	10098	9996
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	13279	11003	9963	10098
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	13279	11003	9963
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	13279	11003
<b>45-49</b>	2696	5477	4501	3821	3379	7246	7392	10868	11779	10874	13279
<b>50-54</b>	1822	2696	4751	4296	2672	1799	5363	5305	5935	6979	5712
<b>55-59</b>	2066	1817	1905	2630	1542	2237	1743	2373	2911	3417	3937
<b>60-64</b>	3247	1612	733	719	879	1097	1747	1181	169	204	219
<b>65-69</b>	3255	302	38	0	0	0	0	0	33	0	0
<b>70-74</b>	4391	1037	85	8	0	0	0	0	0	0	0
<b>75-79</b>	3605	2989	122	3	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	998	998	998	998	998	998	998	998	998	998

**Table A.18 continued.**

<b>Age</b>	<b>55 Years</b>	<b>60 Years</b>	<b>65 Years</b>	<b>70 Years</b>	<b>75 Years</b>	<b>80 Years</b>	<b>85 Years</b>	<b>90 Years</b>	<b>95 Years</b>	<b>100 Years</b>
<b>0-4</b>	11656	11530	11604	11489	11543	11426	11503	11507	11474	11482
<b>5-9</b>	11605	11656	11530	11604	11489	11543	11426	11503	11507	11474
<b>10-14</b>	11610	11605	11656	11530	11604	11489	11543	11426	11503	11507
<b>15-19</b>	11607	11610	11605	11656	11530	11604	11489	11543	11426	11503
<b>20-24</b>	11594	11607	11610	11605	11656	11530	11604	11489	11543	11426
<b>25-29</b>	11643	11594	11607	11610	11605	11656	11530	11604	11489	11543
<b>30-34</b>	9996	11643	11594	11607	11610	11605	11656	11530	11604	11489
<b>35-39</b>	10098	9996	11643	11594	11607	11610	11605	11656	11530	11604
<b>40-44</b>	9963	10098	9996	11643	11594	11607	11610	11605	11656	11530
<b>45-49</b>	11003	9963	10098	9046	9217	9261	9440	9564	9687	9896
<b>50-54</b>	7115	6255	6570	7455	5732	6429	6906	6248	5329	5765
<b>55-59</b>	4201	4504	2547	1230	2887	2308	1752	2387	3319	2842
<b>60-64</b>	170	205	206	199	194	200	204	205	200	207
<b>65-69</b>	6	0	2	0	0	0	0	0	0	0
<b>70-74</b>	0	0	0	0	0	0	0	0	0	0
<b>75-79</b>	0	0	0	0	0	0	0	0	0	0
<b>80-84</b>	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	998	998	998	998	998	998	998	998	998	998

**Table A. 19.** Benchmark 40: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	36859	9337	7111	13756	14968	14978	12347	12906	35316	11141
<b>5-9</b>	12708	12256	36859	9337	7111	13756	14968	14978	12347	12906	35316
<b>10-14</b>	15076	12708	12256	36859	9337	7111	13756	14968	14978	12347	12906
<b>15-19</b>	15510	15076	12708	12256	36859	9337	7111	13756	14968	14978	12347
<b>20-24</b>	13901	15510	15076	12708	12256	36859	9337	7111	13756	14968	14978
<b>25-29</b>	7094	13901	15510	15076	12708	12256	36859	9337	7111	13756	14968
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	36859	9337	7111	13756
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	36859	9337	7111
<b>40-44</b>	5477	411	406	444	464	782	750	974	571	2109	487
<b>45-49</b>	2696	12	29	10	125	250	155	233	75	104	44
<b>50-54</b>	1822	65	12	29	10	125	250	151	194	72	85
<b>55-59</b>	2066	56	65	12	29	10	125	250	151	194	72
<b>60-64</b>	3247	0	0	0	12	15	0	34	0	54	41
<b>65-69</b>	3255	0	0	0	0	0	0	0	0	0	0
<b>70-74</b>	4391	0	0	0	0	0	0	0	0	0	0
<b>75-79</b>	3605	0	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	13	13	13	13	13	13	13	13	13	13

**Table A.19 continued.**

<b>Age</b>	<b>55 Years</b>	<b>60 Years</b>	<b>65 Years</b>	<b>70 Years</b>	<b>75 Years</b>	<b>80 Years</b>	<b>85 Years</b>	<b>90 Years</b>	<b>95 Years</b>	<b>100 Years</b>
<b>0-4</b>	7234	13999	14877	14780	12290	12463	35608	9274	8863	14200
<b>5-9</b>	11141	7234	13999	14877	14780	12290	12463	35608	9274	8863
<b>10-14</b>	35316	11141	7234	13999	14877	14780	12290	12463	35608	9274
<b>15-19</b>	12906	35316	11141	7234	13999	14877	14780	12290	12463	35608
<b>20-24</b>	12347	12906	35316	11141	7234	13999	14877	14780	12290	12463
<b>25-29</b>	14978	12347	12906	35316	11141	7234	13999	14877	14780	12290
<b>30-34</b>	14968	14978	12347	12906	35316	11141	7234	13999	14877	14780
<b>35-39</b>	13756	14968	14978	12347	12906	35316	11141	7234	13999	14877
<b>40-44</b>	421	238	390	618	659	1012	495	2291	545	480
<b>45-49</b>	56	9	0	26	25	91	250	97	208	114
<b>50-54</b>	44	56	9	0	26	25	91	250	97	208
<b>55-59</b>	85	44	56	9	0	26	25	91	250	97
<b>60-64</b>	0	17	0	0	0	0	0	0	0	0
<b>65-69</b>	0	0	0	0	0	0	0	0	0	0
<b>70-74</b>	0	0	0	0	0	0	0	0	0	0
<b>75-79</b>	0	0	0	0	0	0	0	0	0	0
<b>80-84</b>	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	13	13	13	13	13	13	13	13	13	13

**Table A. 20.** Benchmark 45: Aspen cover type age-class distributions by 5-year planning period. The oldest age class below the minimum rotation age and the Older Forest age classes are darkly shaded.

<b>Age</b>	<b>Current</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>0-4</b>	12256	30061	7236	9360	6969	13677	15380	14938	12955	12251	30243
<b>5-9</b>	12708	12256	30061	7236	9360	6969	13677	15380	14938	12955	12251
<b>10-14</b>	15076	12708	12256	30061	7236	9360	6969	13677	15380	14938	12955
<b>15-19</b>	15510	15076	12708	12256	30061	7236	9360	6969	13677	15380	14938
<b>20-24</b>	13901	15510	15076	12708	12256	30061	7236	9360	6969	13677	15380
<b>25-29</b>	7094	13901	15510	15076	12708	12256	30061	7236	9360	6969	13677
<b>30-34</b>	9305	7094	13901	15510	15076	12708	12256	30061	7236	9360	6969
<b>35-39</b>	7209	9305	7094	13901	15510	15076	12708	12256	30061	7236	9360
<b>40-44</b>	5477	7209	9305	7094	13901	15510	15076	12708	12256	30061	7236
<b>45-49</b>	2696	12	29	10	125	250	155	233	75	104	44
<b>50-54</b>	1822	65	12	29	10	125	250	151	194	72	85
<b>55-59</b>	2066	56	65	12	29	10	125	250	151	194	72
<b>60-64</b>	3247	0	0	0	12	15	0	34	0	54	41
<b>65-69</b>	3255	0	0	0	0	0	0	0	0	0	0
<b>70-74</b>	4391	0	0	0	0	0	0	0	0	0	0
<b>75-79</b>	3605	0	0	0	0	0	0	0	0	0	0
<b>80-84</b>	2080	0	0	0	0	0	0	0	0	0	0
<b>85-89</b>	1015	0	0	0	0	0	0	0	0	0	0
<b>90+</b>	554	13	13	13	13	13	13	13	13	13	13

Table A.20 continued.

Age	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
0-4	7294	9419	7031	13707	15364	14847	12731	12179	30126	7430
5-9	30243	7294	9419	7031	13707	15364	14847	12731	12179	30126
10-14	12251	30243	7294	9419	7031	13707	15364	14847	12731	12179
15-19	12955	12251	30243	7294	9419	7031	13707	15364	14847	12731
20-24	14938	12955	12251	30243	7294	9419	7031	13707	15364	14847
25-29	15380	14938	12955	12251	30243	7294	9419	7031	13707	15364
30-34	13677	15380	14938	12955	12251	30243	7294	9419	7031	13707
35-39	6969	13677	15380	14938	12955	12251	30243	7294	9419	7031
40-44	9360	6969	13677	15380	14938	12955	12251	30243	7294	9419
45-49	56	9	0	26	25	91	250	97	208	114
50-54	44	56	9	0	26	25	91	250	97	208
55-59	85	44	56	9	0	26	25	91	250	97
60-64	0	17	0	0	0	0	0	0	0	0
65-69	0	0	0	0	0	0	0	0	0	0
70-74	0	0	0	0	0	0	0	0	0	0
75-79	0	0	0	0	0	0	0	0	0	0
80-84	0	0	0	0	0	0	0	0	0	0
85-89	0	0	0	0	0	0	0	0	0	0
90+	13	13	13	13	13	13	13	13	13	13

## Appendix B: Area Harvested -- By Forest Cover Type

**Table B. 1.** Scenario A1: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	597	91	95	211	177	104	66	66	77	119
Aspen	2028	2703	2310	2302	2340	2309	2285	3170	3003	2287	2567
Lowland Spruce	376	412	794	369	228	228	280	134	211	218	126
Tamarack	50	58	53	29	8	41	6	5	6	0	4
Balm of Gilead	228	523	43	26	60	12	10	22	63	178	195
<b>Total</b>	<b>3527</b>	<b>4292</b>	<b>3291</b>	<b>2821</b>	<b>2847</b>	<b>2768</b>	<b>2683</b>	<b>3398</b>	<b>3348</b>	<b>2760</b>	<b>3011</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	597	91	95	211	177	104	66	66
Aspen	2380	2581	2453	2483	2547	2476	2526	2577	2572	2660
Lowland Spruce	103	137	220	211	250	300	550	333	246	255
Tamarack	2	0	3	70	53	29	8	41	6	5
Balm of Gilead	506	41	43	61	12	9	22	66	178	190
<b>Total</b>	<b>3209</b>	<b>3011</b>	<b>3315</b>	<b>2916</b>	<b>2957</b>	<b>3025</b>	<b>3284</b>	<b>3121</b>	<b>3068</b>	<b>3176</b>



**Table B. 2.** Scenario A2: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	613	81	95	211	177	104	66	66	77	119
Aspen	2028	2457	2296	2312	2298	2300	2299	3064	2896	2336	2360
Lowland Spruce	376	637	583	357	219	221	287	138	214	210	112
Tamarack	50	62	51	24	8	41	6	5	6	0	4
Balm of Gilead	228	533	34	26	57	12	13	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>4302</b>	<b>3045</b>	<b>2813</b>	<b>2794</b>	<b>2752</b>	<b>2708</b>	<b>3296</b>	<b>3245</b>	<b>2800</b>	<b>2791</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	613	81	95	211	177	104	66	66
Aspen	2408	2507	2500	2497	2493	2501	2506	2473	2532	2503
Lowland Spruce	104	127	218	209	250	381	566	230	240	256
Tamarack	2	0	3	74	51	24	8	41	6	5
Balm of Gilead	514	33	45	58	12	9	22	69	178	190
<b>Total</b>	<b>3246</b>	<b>2918</b>	<b>3379</b>	<b>2919</b>	<b>2901</b>	<b>3126</b>	<b>3280</b>	<b>2917</b>	<b>3022</b>	<b>3020</b>

**Table B. 3.** Scenario A3: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	633	80	95	211	177	104	66	66	77	119
Aspen	2028	2286	2281	2271	2263	2291	2298	2923	2831	2303	2303
Lowland Spruce	376	771	520	357	217	220	287	138	214	210	112
Tamarack	50	64	51	24	8	41	6	5	6	0	4
Balm of Gilead	228	544	27	26	57	12	13	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>4298</b>	<b>2959</b>	<b>2773</b>	<b>2757</b>	<b>2742</b>	<b>2707</b>	<b>3154</b>	<b>3179</b>	<b>2767</b>	<b>2734</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	633	80	95	211	177	104	66	66
Aspen	2399	2513	2479	2491	2483	2445	2387	2371	2340	2393
Lowland Spruce	104	127	218	209	250	466	534	218	240	254
Tamarack	2	0	3	76	51	24	8	41	6	5
Balm of Gilead	520	27	50	56	12	9	22	69	178	190
<b>Total</b>	<b>3243</b>	<b>2918</b>	<b>3383</b>	<b>2913</b>	<b>2892</b>	<b>3155</b>	<b>3129</b>	<b>2803</b>	<b>2831</b>	<b>2908</b>

**Table B. 4.** Scenario B1: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	421	220	95	211	177	104	66	66	77	119
Aspen	2028	3096	2091	2125	2134	2450	2782	2660	2719	2637	2747
Lowland Spruce	376	256	784	344	317	249	247	249	251	246	248
Tamarack	50	41	51	27	8	41	6	5	6	0	4
Balm of Gilead	228	493	50	26	57	12	13	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>4307</b>	<b>3195</b>	<b>2618</b>	<b>2727</b>	<b>2930</b>	<b>3151</b>	<b>3002</b>	<b>3104</b>	<b>3138</b>	<b>3314</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	421	220	95	211	177	104	66	66
Aspen	2252	2517	2514	2520	2512	2529	2539	2546	2525	2512
Lowland Spruce	245	247	245	249	241	271	312	375	252	272
Tamarack	2	0	3	54	51	27	8	41	6	5
Balm of Gilead	483	48	37	58	12	9	22	69	178	190
<b>Total</b>	<b>3200</b>	<b>3064</b>	<b>3220</b>	<b>3100</b>	<b>2912</b>	<b>3048</b>	<b>3059</b>	<b>3135</b>	<b>3027</b>	<b>3045</b>

**Table B. 5.** Scenario B2: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	477	179	95	211	177	104	66	66	77	119
Aspen	2028	3004	2077	2073	2088	2195	2751	2682	2712	2598	2559
Lowland Spruce	376	278	760	346	314	245	275	252	245	246	250
Tamarack	50	44	51	27	8	41	6	5	6	0	4
Balm of Gilead	228	506	46	26	57	12	13	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>4310</b>	<b>3114</b>	<b>2568</b>	<b>2679</b>	<b>2671</b>	<b>3148</b>	<b>3027</b>	<b>3091</b>	<b>3099</b>	<b>3128</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	477	179	95	211	177	104	66	66
Aspen	2297	2515	2513	2490	2475	2499	2465	2445	2596	2420
Lowland Spruce	249	230	241	242	235	247	372	352	247	276
Tamarack	2	0	3	56	51	27	8	41	6	5
Balm of Gilead	496	44	37	58	12	9	22	69	178	190
<b>Total</b>	<b>3262</b>	<b>3041</b>	<b>3271</b>	<b>3026</b>	<b>2869</b>	<b>2993</b>	<b>3045</b>	<b>3011</b>	<b>3093</b>	<b>2957</b>

**Table B. 6.** Scenario B3: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	584	92	95	211	177	104	66	66	77	119
Aspen	2028	2737	2104	1998	2103	2170	2693	2653	2637	2615	2385
Lowland Spruce	376	401	661	359	324	254	246	248	246	247	248
Tamarack	50	52	51	27	8	41	6	5	6	0	4
Balm of Gilead	228	521	43	26	57	12	13	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>4295</b>	<b>2951</b>	<b>2506</b>	<b>2703</b>	<b>2655</b>	<b>3060</b>	<b>2995</b>	<b>3017</b>	<b>3116</b>	<b>2951</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	584	92	95	211	177	104	66	66
Aspen	2329	2485	2485	2480	2435	2463	2421	2385	2501	2610
Lowland Spruce	243	236	235	249	260	233	327	334	257	278
Tamarack	2	0	3	64	51	27	8	41	6	5
Balm of Gilead	504	41	43	58	12	9	22	69	178	190
<b>Total</b>	<b>3296</b>	<b>3014</b>	<b>3351</b>	<b>2943</b>	<b>2854</b>	<b>2944</b>	<b>2955</b>	<b>2933</b>	<b>3007</b>	<b>3149</b>

**Table B. 7.** Scenario C0: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	292	302	95	211	177	94	76	66	77	119
Aspen	2028	3453	2701	2353	2228	2730	3063	2969	2586	2452	3415
Lowland Spruce	376	109	953	386	242	179	198	244	303	323	160
Tamarack	50	12	74	27	15	41	6	5	6	0	4
Balm of Gilead	228	450	41	28	85	12	10	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>4316</b>	<b>4071</b>	<b>2890</b>	<b>2782</b>	<b>3140</b>	<b>3371</b>	<b>3317</b>	<b>3024</b>	<b>3030</b>	<b>3894</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	292	302	95	211	177	94	76	66
Aspen	2333	2552	2533	2730	3058	2962	2498	2490	3247	2501
Lowland Spruce	137	148	131	155	244	208	476	423	253	280
Tamarack	2	0	3	24	74	27	15	41	6	5
Balm of Gilead	440	39	38	83	12	12	22	66	178	190
<b>Total</b>	<b>3130</b>	<b>2991</b>	<b>2997</b>	<b>3294</b>	<b>3483</b>	<b>3420</b>	<b>3188</b>	<b>3114</b>	<b>3759</b>	<b>3042</b>

**Table B. 8.** Scenario C1: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	297	302	95	211	177	96	67	73	77	119
Aspen	2028	3420	2208	2286	2112	2630	2957	3082	2511	2480	3115
Lowland Spruce	376	130	945	386	244	182	209	220	282	300	183
Tamarack	50	17	69	27	15	41	6	5	6	0	4
Balm of Gilead	228	456	40	28	85	12	10	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>4319</b>	<b>3563</b>	<b>2823</b>	<b>2668</b>	<b>3042</b>	<b>3277</b>	<b>3398</b>	<b>2934</b>	<b>3034</b>	<b>3616</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	297	302	95	211	177	96	67	73
Aspen	2288	2500	2500	2516	2701	3021	2495	2514	2918	2501
Lowland Spruce	150	122	131	178	246	208	476	423	253	280
Tamarack	2	0	3	29	69	27	15	41	6	5
Balm of Gilead	445	38	38	83	12	12	22	66	178	190
<b>Total</b>	<b>3103</b>	<b>2912</b>	<b>2970</b>	<b>3108</b>	<b>3123</b>	<b>3480</b>	<b>3186</b>	<b>3140</b>	<b>3422</b>	<b>3049</b>

**Table B. 9.** Scenario C2: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	342	280	95	211	177	104	60	73	77	119
Aspen	2028	3274	2127	2210	2095	2480	2902	3146	2497	2487	2893
Lowland Spruce	376	193	911	387	267	165	215	203	280	283	209
Tamarack	50	40	50	27	11	41	6	5	6	0	4
Balm of Gilead	228	474	47	25	83	12	10	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>4323</b>	<b>3415</b>	<b>2746</b>	<b>2666</b>	<b>2876</b>	<b>3236</b>	<b>3436</b>	<b>2918</b>	<b>3024</b>	<b>3421</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	342	280	95	211	177	104	60	73
Aspen	2284	2491	2493	2494	2560	2959	2508	2510	2727	2491
Lowland Spruce	142	127	130	160	274	202	489	408	253	280
Tamarack	2	0	3	52	50	27	11	41	6	5
Balm of Gilead	464	45	36	80	12	12	22	66	178	190
<b>Total</b>	<b>3110</b>	<b>2915</b>	<b>3004</b>	<b>3067</b>	<b>2991</b>	<b>3412</b>	<b>3208</b>	<b>3128</b>	<b>3223</b>	<b>3038</b>



**Table B. 10.** Scenario C3: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

<b>Cover Type</b>	<b>Current*</b>	<b>5 Years</b>	<b>10 Years</b>	<b>15 Years</b>	<b>20 Years</b>	<b>25 Years</b>	<b>30 Years</b>	<b>35 Years</b>	<b>40 Years</b>	<b>45 Years</b>	<b>50 Years</b>
<b>Spruce/fir</b>	363	469	200	94	213	177	104	58	74	77	119
<b>Aspen</b>	2028	2985	2091	2218	2074	2389	2863	3131	2495	2515	2751
<b>Lowland Spruce</b>	376	327	856	375	220	183	222	193	274	266	238
<b>Tamarack</b>	50	46	46	27	13	41	6	5	6	0	4
<b>Balm of Gilead</b>	228	480	67	21	80	12	7	22	63	178	195
<b>Total</b>	3045	4307	3261	2736	2600	2803	3201	3409	2912	3035	3308

<b>Cover Type</b>	<b>55 Years</b>	<b>60 Years</b>	<b>65 Years</b>	<b>70 Years</b>	<b>75 Years</b>	<b>80 Years</b>	<b>85 Years</b>	<b>90 Years</b>	<b>95 Years</b>	<b>100 Years</b>
<b>Spruce/fir</b>	218	252	469	200	94	213	177	104	58	74
<b>Aspen</b>	2282	2435	2403	2453	2468	2934	2500	2563	2678	2520
<b>Lowland Spruce</b>	175	127	126	137	305	237	505	359	238	291
<b>Tamarack</b>	2	0	3	59	46	27	13	41	6	5
<b>Balm of Gilead</b>	463	65	38	75	12	15	22	63	178	190
<b>Total</b>	3140	2879	3040	2925	2927	3425	3218	3130	3157	3081

**Table B. 11.** Scenario G0: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	134	256	142	211	177	62	108	66	77	119
Aspen	2028	3677	3622	3291	2783	2920	2632	2815	2803	3579	3666
Lowland Spruce	376	77	334	779	269	239	354	301	361	228	189
Tamarack	50	19	56	30	61	11	3	6	1	3	2
Balm of Gilead	228	401	33	59	59	12	13	20	65	178	195
<b>Total</b>	<b>3045</b>	<b>4308</b>	<b>4302</b>	<b>4301</b>	<b>3383</b>	<b>3360</b>	<b>3063</b>	<b>3249</b>	<b>3295</b>	<b>4064</b>	<b>4172</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	134	256	142	211	177	62	108	66
Aspen	3089	3056	2921	2536	2793	2832	3628	3521	3102	2921
Lowland Spruce	118	113	251	152	263	189	141	411	393	293
Tamarack	3	12	19	56	30	61	11	3	6	1
Balm of Gilead	401	34	55	41	27	17	20	68	178	190
<b>Total</b>	<b>3830</b>	<b>3467</b>	<b>3379</b>	<b>3042</b>	<b>3255</b>	<b>3310</b>	<b>3978</b>	<b>4064</b>	<b>3787</b>	<b>3470</b>

**Table B. 12.** Scenario G1: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	209	286	111	211	177	83	87	66	77	119
Aspen	2028	3589	3394	2543	2697	3108	2707	2730	2658	3512	3468
Lowland Spruce	376	84	529	667	252	237	316	315	353	216	197
Tamarack	50	19	65	38	49	8	3	6	1	3	2
Balm of Gilead	228	409	35	60	57	12	10	20	67	178	195
<b>Total</b>	<b>3045</b>	<b>4310</b>	<b>4310</b>	<b>3419</b>	<b>3267</b>	<b>3542</b>	<b>3119</b>	<b>3158</b>	<b>3146</b>	<b>3986</b>	<b>3981</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	209	286	112	211	177	83	87	66
Aspen	2519	2772	3080	2672	2782	2678	3519	3369	2534	2712
Lowland Spruce	164	116	143	84	270	203	182	558	315	309
Tamarack	3	12	19	65	38	49	8	3	6	1
Balm of Gilead	409	35	53	41	28	15	20	70	178	190
<b>Total</b>	<b>3313</b>	<b>3187</b>	<b>3503</b>	<b>3147</b>	<b>3230</b>	<b>3157</b>	<b>3906</b>	<b>4083</b>	<b>3121</b>	<b>3278</b>

**Table B. 13.** Scenario G3: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	352	302	95	211	177	73	97	66	77	119
Aspen	2028	3316	2831	2263	2579	3111	2884	2654	2557	3208	2933
Lowland Spruce	376	157	914	362	244	220	291	288	334	227	258
Tamarack	50	28	90	17	45	8	3	6	1	3	2
Balm of Gilead	228	456	40	53	60	12	7	20	68	178	195
<b>Total</b>	<b>3045</b>	<b>4309</b>	<b>4177</b>	<b>2791</b>	<b>3140</b>	<b>3529</b>	<b>3258</b>	<b>3064</b>	<b>3025</b>	<b>3693</b>	<b>3507</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	352	301	97	211	177	73	97	66
Aspen	2551	2717	3103	2527	2754	2635	3324	2770	2539	2641
Lowland Spruce	119	100	91	147	291	213	409	411	274	307
Tamarack	3	12	28	90	17	45	8	3	6	1
Balm of Gilead	445	38	56	21	59	7	20	70	178	190
<b>Total</b>	<b>3337</b>	<b>3119</b>	<b>3631</b>	<b>3086</b>	<b>3218</b>	<b>3111</b>	<b>3939</b>	<b>3328</b>	<b>3093</b>	<b>3205</b>

**Table B. 14.** Scenario Gvar: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	605	219	95	211	177	44	126	66	77	119
Aspen	2028	2760	2476	2264	2508	2785	3146	2554	2545	2502	2823
Lowland Spruce	376	349	823	364	261	218	238	245	326	295	231
Tamarack	50	68	53	17	45	8	3	6	1	3	2
Balm of Gilead	228	503	23	53	60	12	3	24	69	178	195
<b>Total</b>	<b>3045</b>	<b>4285</b>	<b>3593</b>	<b>2794</b>	<b>3085</b>	<b>3200</b>	<b>3434</b>	<b>2954</b>	<b>3006</b>	<b>3054</b>	<b>3370</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	605	219	95	211	177	44	126	66
Aspen	2769	2588	2784	2446	2737	2626	2700	2717	2349	2568
Lowland Spruce	26	108	153	173	262	262	438	419	255	302
Tamarack	3	12	68	53	17	45	8	3	6	1
Balm of Gilead	492	21	64	52	12	11	24	71	178	190
<b>Total</b>	<b>3508</b>	<b>2981</b>	<b>3673</b>	<b>2942</b>	<b>3123</b>	<b>3155</b>	<b>3347</b>	<b>3254</b>	<b>2913</b>	<b>3127</b>

**Table B. 15.** Scenario D: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	803	71	95	211	177	104	66	66	77	119
Aspen	2028	2308	2239	2250	2274	2152	2219	2310	2235	2270	2296
Lowland Spruce	376	592	735	332	274	252	260	179	217	214	111
Tamarack	50	83	53	17	45	8	3	6	1	3	2
Balm of Gilead	228	523	43	26	57	12	13	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>4309</b>	<b>3140</b>	<b>2720</b>	<b>2862</b>	<b>2601</b>	<b>2598</b>	<b>2583</b>	<b>2582</b>	<b>2742</b>	<b>2724</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	803	71	95	211	177	104	66	66
Aspen	2293	2247	2257	2286	2295	2334	2365	2269	2287	2196
Lowland Spruce	114	144	205	187	197	375	495	361	269	270
Tamarack	3	12	83	53	17	45	8	3	6	1
Balm of Gilead	506	41	43	58	12	9	22	69	178	190
<b>Total</b>	<b>3134</b>	<b>2696</b>	<b>3392</b>	<b>2654</b>	<b>2617</b>	<b>2974</b>	<b>3067</b>	<b>2805</b>	<b>2806</b>	<b>2723</b>

**Table B. 16.** Scenario D\*: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	375	302	95	211	177	104	66	66	77	119
Aspen	2028	2323	2354	2016	2039	2053	2003	2310	2316	2314	2315
Lowland Spruce	376	539	518	507	277	271	263	179	217	214	111
Tamarack	50	262	264	11	38	8	3	6	1	3	2
Balm of Gilead	228	291	190	26	55	12	13	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>3790</b>	<b>3628</b>	<b>2654</b>	<b>2621</b>	<b>2522</b>	<b>2385</b>	<b>2583</b>	<b>2663</b>	<b>2786</b>	<b>2743</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	375	302	95	211	177	104	66	66
Aspen	2287	2319	2293	2290	2291	2308	2279	2300	2315	2306
Lowland Spruce	114	144	205	187	197	366	378	453	282	284
Tamarack	3	12	96	170	11	38	8	3	6	1
Balm of Gilead	291	186	26	60	12	7	22	69	178	190
<b>Total</b>	<b>2913</b>	<b>2913</b>	<b>2996</b>	<b>3009</b>	<b>2606</b>	<b>2930</b>	<b>2865</b>	<b>2928</b>	<b>2846</b>	<b>2847</b>

**Table B. 17.** Scenario E: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
<b>Spruce/fir</b>	363	514	179	94	213	177	104	58	74	77	119
<b>Aspen</b>	2028	2783	2152	2181	2099	2254	2304	2918	2524	2164	2427
<b>Lowland Spruce</b>	376	470	754	364	200	163	269	193	258	295	262
<b>Tamarack</b>	50	56	46	27	13	41	6	5	6	0	4
<b>Balm of Gilead</b>	228	478	73	13	91	12	7	22	63	178	195
<b>Total</b>	3045	4301	3205	2679	2615	2647	2689	3196	2925	2713	3008

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
<b>Spruce/fir</b>	218	252	514	179	94	213	177	104	58	74
<b>Aspen</b>	2032	2075	2204	2121	2135	2759	2610	2651	2245	2099
<b>Lowland Spruce</b>	149	158	126	154	226	318	526	284	256	285
<b>Tamarack</b>	2	0	3	69	46	27	13	41	6	5
<b>Balm of Gilead</b>	467	70	23	91	12	12	22	63	178	190
<b>Total</b>	2868	2555	2869	2614	2514	3328	3349	3143	2742	2654



**Table B. 18.** Scenario E: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	375	302	95	211	177	104	66	66	77	119
Aspen	2028	2656	2201	1993	2020	1999	2329	2319	2321	2322	2321
Lowland Spruce	376	539	518	507	277	271	263	179	217	214	111
Tamarack	50	262	264	11	38	8	3	6	1	3	2
Balm of Gilead	228	291	190	26	55	12	13	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>4123</b>	<b>3475</b>	<b>2631</b>	<b>2602</b>	<b>2468</b>	<b>2711</b>	<b>2592</b>	<b>2668</b>	<b>2794</b>	<b>2749</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	375	302	95	211	177	104	66	66
Aspen	2331	2306	2321	2298	2309	2285	2301	2301	2295	2296
Lowland Spruce	114	144	205	187	197	366	378	453	282	284
Tamarack	3	12	96	170	11	38	8	3	6	1
Balm of Gilead	291	186	26	60	12	7	22	69	178	190
<b>Total</b>	<b>2957</b>	<b>2901</b>	<b>3024</b>	<b>3016</b>	<b>2623</b>	<b>2908</b>	<b>2886</b>	<b>2929</b>	<b>2826</b>	<b>2837</b>

**Table B. 19.** Benchmark 40: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	874	58	95	211	177	104	66	66	77	119
Aspen	2028	7372	1867	1422	2751	2994	2996	2469	2581	7063	2228
Lowland Spruce	376	1265	274	319	259	222	260	179	217	214	111
Tamarack	50	150	17	14	45	8	3	6	1	3	2
Balm of Gilead	228	549	23	26	57	12	13	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>10210</b>	<b>2240</b>	<b>1876</b>	<b>3324</b>	<b>3412</b>	<b>3375</b>	<b>2743</b>	<b>2928</b>	<b>7535</b>	<b>2656</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	874	58	95	211	177	104	66	66
Aspen	1447	2800	2975	2956	2458	2493	7122	1855	1773	2840
Lowland Spruce	114	144	205	187	197	683	387	214	254	251
Tamarack	3	12	150	17	14	45	8	3	6	1
Balm of Gilead	525	23	50	56	12	9	22	69	178	190
<b>Total</b>	<b>2307</b>	<b>3231</b>	<b>4255</b>	<b>3274</b>	<b>2776</b>	<b>3441</b>	<b>7717</b>	<b>2244</b>	<b>2276</b>	<b>3348</b>

**Table B. 20.** Benchmark 45: Annual acres harvested of modeled forest cover type by 5-yr period. \*Current levels were provided by the Koochiching County Land Department.

Cover Type	Current*	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years	35 Years	40 Years	45 Years	50 Years
Spruce/fir	363	874	58	95	211	177	104	66	66	77	119
Aspen	2028	6012	1447	1872	1394	2735	3076	2988	2591	2450	6049
Lowland Spruce	376	1265	274	319	259	222	260	179	217	214	111
Tamarack	50	150	17	14	45	8	3	6	1	3	2
Balm of Gilead	228	549	23	26	57	12	13	22	63	178	195
<b>Total</b>	<b>3045</b>	<b>8851</b>	<b>1820</b>	<b>2326</b>	<b>1967</b>	<b>3154</b>	<b>3455</b>	<b>3261</b>	<b>2938</b>	<b>2922</b>	<b>6477</b>

Cover Type	55 Years	60 Years	65 Years	70 Years	75 Years	80 Years	85 Years	90 Years	95 Years	100 Years
Spruce/fir	218	252	874	58	95	211	177	104	66	66
Aspen	1459	1884	1406	2741	3073	2969	2546	2436	6025	1486
Lowland Spruce	114	144	205	187	197	683	387	214	254	251
Tamarack	3	12	150	17	14	45	8	3	6	1
Balm of Gilead	525	23	50	56	12	9	22	69	178	190
<b>Total</b>	<b>2319</b>	<b>2315</b>	<b>2686</b>	<b>3059</b>	<b>3391</b>	<b>3918</b>	<b>3141</b>	<b>2825</b>	<b>6529</b>	<b>1994</b>

## Appendix C: Volume Harvested -- By Period

**Table C. 1.** Total timber volume harvested for all scenarios and the Initial Benchmark (cords/year).

Period	A1	A2	A3	B1	B2	B3	C0	C1	C2	C3
1	85278	82234	79516	86960	87977	84625	91648	91278	88444	84017
2	70581	65734	63149	70428	65387	62408	86388	74963	73294	71209
3	63805	65262	64189	59196	58796	57912	62641	62856	62214	62082
4	61948	62910	62789	60979	60847	62247	60386	61347	61691	61324
5	62785	62273	62202	65709	61031	61163	69566	68630	65864	64244
6	59482	59942	58039	71655	70418	68360	76501	75861	74545	74028
7	82185	80799	77689	71803	72570	71962	74892	77596	79498	79808
8	82471	78207	77629	72730	73261	72102	64316	64112	64143	64511
9	64394	68026	69534	74842	74871	75979	66393	68157	68867	70075
10	71972	67542	67355	76963	74101	70996	88024	80887	75722	74205
11	77487	77909	78220	76412	78556	78987	68120	71810	72980	73141
12	69949	68998	68806	69777	69020	68710	65193	61859	64016	63377
13	70551	73756	74414	69846	72349	75283	62008	66589	67518	67896
14	66055	66636	67293	68955	68485	67793	72539	69643	70144	67805
15	68375	66282	66238	65119	65177	65202	79856	73902	70953	69507
16	65667	68409	66751	68229	67670	67073	77283	78680	77413	77451
17	76076	77185	73822	70333	69505	67785	67047	67097	67829	68781
18	76971	73052	72335	74825	71887	69615	68935	70634	70820	71721
19	70179	71926	69209	73140	75022	73090	85376	78227	73782	73580
20	75755	71367	70800	71730	71243	75882	66308	70324	70369	72190

Period	G0	G1	G3	Gvar	D	D*	E	Comp romise	Bench	Bench 45
1	95203	94247	89390	80091	72435	72464	80872	81046	205812	177879
2	100608	98009	88580	76263	60876	76619	69655	75764	43870	38226
3	84503	72087	67948	67683	60986	62155	61603	60689	38090	49105
4	68688	68377	67909	67989	70515	61577	61167	61068	67523	42826
5	71248	76344	78434	73041	62059	55103	61148	56583	71556	69209
6	64649	66809	69947	76113	58547	58350	61929	64591	69772	77737
7	64781	65102	65383	65456	62567	67072	78031	64312	55733	74069
8	64538	64947	65112	65304	61281	68932	72144	64973	59833	63330
9	86316	85973	81211	69207	65933	70591	63536	68236	157631	65374
10	87732	84753	74998	74915	66529	70470	72113	68191	51118	144255
11	74477	69036	74407	80742	69803	74914	67696	75063	47747	49298
12	69505	67128	67649	66264	65493	73392	61318	73815	66063	49270
13	72390	76161	80984	82429	83495	75371	67249	76574	91928	59523
14	66967	70611	70700	67313	68817	76369	64120	77785	69549	67984
15	65541	66679	66355	67005	63743	64949	62838	67277	56952	77211
16	66815	66920	67793	69131	69381	67537	77954	71969	68480	84611
17	84551	84821	86045	75814	67771	64625	81735	70242	160479	67356
18	85738	86274	72462	72641	69335	71648	82253	70801	44335	63334
19	72363	65110	68594	65900	67012	72859	68077	69512	44274	144828
20	69655	68298	66985	66036	65759	72087	66818	68029	67948	41734

**Table C. 2.** Total volume harvested from the aspen forest cover type for all scenarios and the Initial Benchmark (cords/year).

Period	A1	A2	A3	B1	B2	B3	C0	C1	C2	C3
1	59186	52233	47585	66740	66114	58873	76806	75890	70768	62556
2	55689	54451	52947	53005	49278	49303	64978	53769	53112	52793
3	55515	57191	56119	51186	50772	49726	54083	54298	53715	53879
4	53869	54951	54851	51724	51654	52931	51523	52455	52609	52884
5	54889	54418	54361	57567	52899	52927	62269	61293	58761	56897
6	53276	53549	51646	65877	64283	62709	71577	70711	69220	68592
7	78391	76895	73786	66497	67251	66695	69289	72505	74779	75267
8	76581	72267	71690	66512	67116	65900	57404	57252	57299	57685
9	56150	59857	61365	66385	66422	67560	57046	59052	59908	61303
10	63471	59154	58966	67452	64592	61526	79504	72033	66608	64765
11	61081	61266	61468	59029	60960	61356	52755	56092	57045	56995
12	62503	61819	61734	61110	60583	60301	57699	54614	56590	55491
13	55160	58037	58263	57983	59529	60473	53537	58013	58130	56212
14	57799	58458	59049	58516	58757	59374	62205	58885	59339	58607
15	60604	58549	58505	58568	58512	58650	71469	65670	62957	61271
16	56446	58291	55473	60988	59894	58909	69303	70699	69521	69010
17	64184	64580	61585	62269	60646	59420	56373	56423	57057	57495
18	66983	64846	64349	63915	61480	59584	57398	59055	59364	61140
19	61231	63026	60310	64058	66001	63914	76104	69143	64852	64903
20	66404	61992	61465	62113	61570	66292	56552	60421	60466	62071

Period	G0	G1	G3	Gvar	D	D*	E	Comp romise	Bench	Bench 45
1	83012	80822	72219	55156	40754	52127	56775	60709	163294	135361
2	88348	81956	66985	58373	46557	54899	53023	54044	37552	31909
3	68322	58215	58883	58588	52901	51843	53686	50377	30277	41293
4	57867	58031	57712	57556	59927	51049	52757	50540	57229	32532
5	63706	68917	71345	66130	54729	47463	54027	48943	64687	62339
6	57966	60382	64227	71775	52535	52302	55880	58543	63760	71725
7	57824	58419	58789	58730	58027	62531	73490	59771	51192	69529
8	57032	57536	57866	58096	55401	63052	65597	59093	53953	57450
9	78197	78009	73020	60083	57549	62207	54360	59853	149248	56990
10	78976	75926	65509	65707	58187	62128	62413	59850	42777	135914
11	59703	53596	58873	65515	53084	62696	51942	62845	30657	32208
12	61901	59464	60090	58877	57268	61794	52893	62217	58180	41387
13	64143	67945	70295	64504	61044	60855	55074	62058	64877	32473
14	56811	60395	58457	57171	61088	59364	54491	60780	63923	62358
15	57373	58381	58401	60355	57965	59521	55702	61849	51377	71637
16	57655	57981	59012	59647	58361	56937	68462	61369	53262	69392
17	78801	78508	76591	65718	56576	54992	69923	60609	150080	56957
18	77104	74645	62723	63449	60107	61287	72898	60440	37738	56738
19	59917	54478	58601	55610	57712	63321	59154	59974	35177	135731
20	59850	58249	56966	56081	56288	62428	56797	58370	58733	32519

**Table C. 3.** Total aspen product volume harvested from all forest cover types for all scenarios and the Initial Benchmark (cords/year).

Period	A1	A2	A3	B1	B2	B3	C0	C1	C2	C3
1	49027	44374	41260	53475	53491	48587	60137	59504	55745	49841
2	41158	39793	38557	40158	36967	36680	49010	40886	40718	41057
3	41601	43180	42597	38416	38627	38036	41190	41250	41020	41051
4	41205	41920	41820	39420	39489	40378	40701	41280	41205	41083
5	41803	41353	41274	43670	40181	40115	47655	46826	44894	43459
6	40434	40556	38939	50060	48681	47457	54869	54142	53000	52435
7	59239	57973	55318	50686	50833	50159	53482	55414	56746	56864
8	59380	55933	55416	51364	51807	50750	44705	44354	44304	44497
9	45375	48272	49583	52980	53106	53905	46461	47788	48326	49221
10	51455	48199	48122	54513	52445	50222	63979	58002	53710	52326
11	54609	54594	54748	52486	54189	54406	47376	50190	51084	51068
12	48204	47537	47263	47372	46366	46125	44762	42026	43705	43082
13	42871	45283	45612	44503	45922	47079	42044	45275	45294	43965
14	44279	44602	44970	45051	45086	45396	48889	46389	46524	45573
15	45885	44256	44140	44393	44233	44230	54862	50544	48536	47274
16	42909	44149	41874	46426	45564	44831	53402	54217	53393	52973
17	49331	49744	47247	47809	46395	45281	43564	43403	43818	44058
18	52206	50553	50270	49795	47930	46389	45115	46166	46306	47475
19	49033	50501	48590	51456	52898	51310	60842	55245	51844	51887
20	53626	50145	49748	50267	50027	53608	46168	49277	49258	50534

Period	G0	G1	G3	Gvar	D	D*	E	Comp romise	Bench	Bench 45
1	63831	62439	56784	45885	35787	40569	45512	46452	128311	106308
2	67959	63507	52755	46013	34461	43953	41006	44077	30042	24748
3	53237	45665	46154	45846	39857	39044	40789	38462	24497	32019
4	46796	46623	46084	45851	45892	38636	40818	38421	46291	26080
5	50789	54420	55806	51618	41197	35933	40996	37423	51574	47783
6	46008	47704	50200	54828	39473	39176	42400	44732	50724	55162
7	45999	46050	46065	45870	44606	47351	55578	45039	40856	53700
8	45996	46065	45929	46072	43051	48032	50844	44505	43550	44806
9	64614	64178	59803	49147	45529	49004	43786	47206	120624	46480
10	65716	62981	54352	53867	46820	49390	50700	47551	37029	106807
11	54052	49137	53307	58444	47331	52066	46427	52227	32771	33038
12	49671	47536	47599	46038	43866	49011	41240	49594	46714	32179
13	51820	54648	56399	52381	47964	45873	41965	46806	53700	27317
14	46042	48582	46796	45985	46887	44666	41866	45920	51362	48183
15	45893	46346	46257	46033	43317	44003	41442	46577	40934	54991
16	46068	45971	45883	46240	43819	42912	51294	46241	42669	53636
17	62772	62184	60123	50923	43372	41733	53332	45200	119076	44041
18	62018	59954	50202	50034	46349	46972	56046	45880	31012	44555
19	50365	45671	48541	46299	45948	50269	47312	47542	30500	106128
20	50511	48938	47497	45977	45642	49971	45969	46790	49636	28011

**Table C. 4.** Total aspen product volume from the aspen forest cover type for all scenarios and the Initial Benchmark (cords/year).

Period	A1	A2	A3	B1	B2	B3	C0	C1	C2	C3
1	41447	36528	33268	46490	46295	41021	53906	53234	49281	43250
2	40036	38958	37863	38545	35542	35599	47272	39163	38936	39100
3	40898	42478	41895	37721	37931	37334	40418	40477	40295	40400
4	39910	40658	40558	38142	38212	39093	39051	39629	39583	39524
5	41214	40766	40686	43086	39599	39532	47082	46251	44326	42884
6	40027	40110	38492	49646	48264	47039	54526	53789	52621	52080
7	58703	57438	54782	50154	50295	49618	52914	54876	56238	56364
8	58284	54837	54320	50270	50712	49650	43596	43219	43169	43356
9	42446	45344	46655	50054	50179	50979	43515	44846	45387	46287
10	47912	44656	44580	50962	48894	46672	60442	54461	50162	48773
11	46237	46100	46179	44410	45937	46049	39882	42597	43286	43341
12	47070	46531	46333	46127	45179	44987	43621	40905	42486	41533
13	40927	43288	43532	42983	44304	45189	40793	44012	43961	42340
14	43181	43557	43934	43742	43852	44312	47053	44553	44793	44105
15	45390	43762	43646	43934	43771	43771	54368	50050	48033	46763
16	42338	43550	41247	45907	45032	44278	52823	53638	52817	52356
17	48468	48852	46362	47048	45614	44509	42748	42587	42995	43219
18	50874	49239	48962	48392	46543	45014	43757	44802	44929	46147
19	46051	47519	45608	48448	49892	48306	57828	52259	48880	48934
20	50268	46787	46392	46903	46662	50240	42803	45891	45872	47137

Period	G0	G1	G3	Gvar	D	D*	E	Comp romise	Bench	Bench 45
1	58143	56529	50147	38072	27238	36226	38992	42109	119053	97050
2	66601	61937	50909	44632	33313	39961	38989	40085	29515	24221
3	51589	44187	45001	44693	39107	38202	40254	37620	23754	31276
4	45446	45302	44739	44499	44563	37325	39104	37110	44966	24754
5	50147	53786	55179	50988	40547	35280	40429	36770	50926	47135
6	45588	47248	49818	54618	38949	38652	42044	44208	50200	54638
7	45214	45344	45329	44979	44004	46748	55078	44437	40253	53097
8	44759	44805	44668	44803	41876	46857	49712	43330	42376	43632
9	61641	61209	56822	46137	42526	46001	40844	44202	117620	43476
10	62167	59432	50787	50309	43258	45828	47141	43989	33466	103245
11	46991	41966	45700	50263	38925	46946	38752	47107	24102	24369
12	48613	46459	46485	45160	42723	45417	39553	46000	45814	31279
13	50544	53265	54745	50098	45588	44513	40459	45446	51122	24739
14	44758	47282	45756	44738	45839	43102	40227	44356	50348	47169
15	45128	45603	45065	45510	42820	43507	40951	46081	40438	54495
16	45413	45321	45324	45627	43176	42288	50688	45617	41924	52891
17	62089	61483	59348	50072	42517	40915	52476	44382	118224	43188
18	60768	58543	48852	48754	44957	45555	54754	44463	29700	43243
19	47152	42559	45423	43110	42924	47238	44352	44511	27481	103109
20	47092	45511	44071	42552	42232	46555	42575	43375	46232	24607

**Table C. 5.** Total harvest volume from the lowland spruce forest cover type for all scenarios and the Initial Benchmark (cords/year).

Period	A1	A2	A3	B1	B2	B3	C0	C1	C2	C3
1	5996	9407	10919	3488	4062	5923	1666	1924	2749	4620
2	11324	8095	7162	11614	11034	9542	13773	13698	13319	12452
3	5197	5064	5064	4941	4956	5118	5394	5394	5404	5236
4	3031	2948	2927	4244	4182	4305	3218	3246	3546	2938
5	3112	3070	3057	3357	3347	3451	2513	2553	2318	2562
6	3888	4026	4026	3410	3767	3283	2801	2986	3007	3150
7	1826	1935	1935	3338	3352	3299	3434	3111	2897	2756
8	3166	3216	3216	3494	3422	3478	4188	3978	3963	3906
9	3046	2970	2970	3259	3251	3220	4148	3908	3762	3574
10	1674	1562	1562	2684	2682	2643	1694	2029	2287	2614
11	1366	1433	1433	2775	2733	2627	1524	1748	1684	1984
12	1940	1850	1850	3018	2864	2905	1984	1758	1803	1809
13	3313	3321	3321	3078	3037	2958	2112	2112	2101	2045
14	2881	2869	2869	3300	3222	3300	2180	2422	2192	1938
15	3613	3615	3615	2434	2547	2434	3523	3551	3937	4342
16	4146	5276	6436	2230	2765	3154	2917	2917	2828	3318
17	8012	8725	8358	4184	4979	4484	6501	6501	6752	7195
18	5222	3389	3169	6093	5590	5213	6966	6966	6689	5846
19	3711	3662	3662	3844	3784	3939	3840	3840	3840	3623
20	3608	3633	3592	3875	3930	3847	4014	4014	4014	4192

Period	G0	G1	G3	Gvar	D	D*	E	Comp romise	Bench	Bench 45
1	1282	1373	2392	4966	8201	7806	6685	7806	16926	16926
2	5504	8610	13553	12519	10984	8200	10819	8200	4146	4146
3	11716	9760	5603	5632	5162	7497	5111	7497	4952	4952
4	4096	3829	3700	3937	4128	4179	2684	4179	3834	3834
5	3814	3751	3413	3235	3653	3964	2336	3964	3193	3193
6	5228	4557	4132	3417	3693	3729	3764	3729	3693	3693
7	4119	4288	3973	3452	2540	2540	2756	2540	2540	2540
8	4863	4732	4560	4508	3270	3270	3627	3270	3270	3270
9	2762	2607	2834	3767	3027	3027	3978	3027	3027	3027
10	1961	2032	2694	2412	1546	1546	2874	1546	1546	1546
11	1429	1949	1455	332	1574	1574	1656	1574	1574	1574
12	1594	1625	1466	1620	2116	2116	2169	2116	2116	2116
13	3430	2035	1406	2336	3067	3067	1988	3067	3067	3067
14	1869	996	1981	2365	2566	2566	2154	2566	2566	2566
15	3659	3872	4161	3783	2912	2912	3241	2912	2912	2912
16	2478	2873	3028	3688	5237	5113	4420	5113	9436	9436
17	1736	2435	5581	6141	7289	5727	7721	5727	6492	6492
18	6018	8555	6876	6872	5749	6882	4621	6882	3117	3117
19	6359	4972	4117	3858	4054	4293	3868	4293	3851	3851
20	4190	4434	4405	4340	3856	4044	4094	4044	3600	3600



**Table C. 6.** Total harvest volume from the lowland spruce and aspen forest cover types for all scenarios and the Initial Benchmark (cords/year).

Period	A1	A2	A3	B1	B2	B3	C0	C1	C2	C3
1	65182	61640	58503	70229	70176	64796	78473	77814	73517	67176
2	67013	62546	60109	64618	60313	58845	78751	67467	66431	65246
3	60712	62255	61183	56127	55728	54844	59476	59692	59118	59115
4	56900	57899	57778	55968	55836	57236	54740	55701	56156	55822
5	58001	57488	57418	60924	56247	56378	64781	63845	61079	59459
6	57164	57575	55671	69287	68050	65992	74379	73697	72227	71742
7	80217	78831	75721	69835	70602	69994	72723	75616	77676	78023
8	79747	75483	74906	70006	70537	69378	61593	61230	61261	61591
9	59196	62828	64336	69644	69673	70781	61195	62959	63669	64877
10	65146	60716	60528	70136	67275	64169	81198	74061	68895	67378
11	62447	62699	62902	61803	63693	63983	54280	57839	58730	58979
12	64443	63669	63584	64128	63447	63206	59684	56372	58393	57300
13	58473	61357	61584	61062	62566	63431	55649	60125	60231	58257
14	60680	61326	61918	61816	61979	62674	64384	61307	61531	60545
15	64217	62164	62120	61002	61059	61084	74992	69221	66895	65613
16	60592	63567	61909	63218	62660	62062	72219	73616	72349	72328
17	72196	73305	69942	66453	65625	63904	62874	62924	63810	64690
18	72204	68235	67518	70008	67070	64798	64363	66021	66053	66987
19	64942	66689	63972	67903	69785	67853	79944	72983	68692	68526
20	70013	65624	65057	65987	65500	70139	60565	64435	64480	66264

Period	G0	G1	G3	Gvar	D	D*	E	Compromise	Bench	Bench 45
1	84294	82195	74611	60122	48955	59933	63460	68515	180220	152287
2	93852	90566	80537	70892	57541	63099	63842	62244	41699	36055
3	80038	67975	64486	64220	58064	59340	58797	57874	35229	46244
4	61963	61860	61412	61492	64056	55229	55441	54720	61063	36366
5	67520	72668	74757	69365	58382	51427	56363	52906	67880	65532
6	63194	64939	68359	75192	56228	56031	59644	62272	67452	75417
7	61944	62708	62762	62181	60566	65071	76246	62311	53732	72068
8	61895	62267	62426	62604	58671	66322	69225	62363	57223	60720
9	80960	80616	75854	63850	60576	65234	58338	62880	152275	60017
10	80936	77958	68203	68120	59733	63674	65287	61396	44323	137459
11	61132	55545	60328	65847	54658	64270	53598	64419	32232	33783
12	63495	61089	61557	60497	59384	63910	55063	64333	60296	43503
13	67573	69980	71701	66840	64111	63922	57063	65125	67944	35540
14	58681	61391	60438	59536	63655	61930	56645	63346	66489	64924
15	61032	62253	62562	64139	60877	62432	58943	64761	54289	74548
16	60133	60855	62040	63335	63598	62050	72882	66482	62698	78828
17	80537	80943	82172	71859	63865	60719	77644	66335	156572	63449
18	83123	83200	69598	70321	65856	68169	77519	67322	40856	59856
19	66276	59450	62718	59468	61766	67613	63023	64266	39028	139582
20	64040	62683	61370	60421	60144	66472	60892	62414	62333	36119

**Appendix D: Shadow Price Estimates -- Age 55+ aspen constraints**

**Table D.1** Shadow Price Estimates for the age 55+ aspen constraints for each scenario for the first ten 5-year planning periods (\$/acre)

		Scenario											
		A1	A2	A3	B1	B2	B3	C1	C2	C3	D	E	Bench
Period	1	0	0	0	0	0	11	0	0	0	8	0	0
	2	22	43	78	22	51	98	27	55	110	80	113	57
	3	6	23	38	6	22	46	9	26	53	40	48	53
	4	188	197	234	106	184	197	112	159	204	259	202	60
	5	135	158	181	57	102	120	66	83	87	210	111	70
	6	135	169	203	146	176	176	105	132	195	225	167	68
	7	173	203	235	108	149	159	92	117	127	241	105	78
	8	68	95	109	54	48	67	46	52	64	84	94	57
	9	100	112	106	63	66	74	73	81	83	23	66	68
	10	39	41	44	5	14	20	37	50	56	9	90	61