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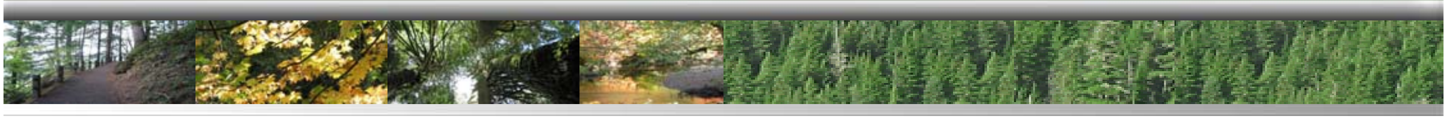

# The FORSight Resource

Volume 5, Issue 2 Q4 2008


We wish you Happy Holidays and best wishes for a prosperous New Year...
*from all of us at FORSight Resources*

***Upcoming Events...***

**SOFEW 2009 Annual Meeting**
March 8-10, 2009
Chapel Hill, NC

**Managing Forests Sustainably: Ecological Forestry in the Southeastern Coastal Plain**
March 22-25, 2009
Newton, GA
http://www.jonesctr.org

**Western Forest Economists Annual Meeting**
May 5-7, 2009
Welches, OR

**13th Symposium on Systems Analysis in Forest Resources**
May 26-29, 2009
Charleston, SC

***Inside this issue:***



## Barber Revisited: On the Aggregation of Age Classes in Harvest Scheduling Models, Part II

In a previous newsletter we provided a brief introduction to research conducted by Richard Barber which examined age-class aggregation in harvest scheduling models and the subsequent bias introduced into yield estimates. In addition to providing an overview of Barber's work, we provided justification for revisiting the topic with a detailed investigation. This article summarizes the results of that study and outlines the significance to forest planners.

As outlined in the introductory article, yield bias introduced by aggregate analysis results from shifts in the assumed harvest age. These shifts originate from a combination of age class width (ACW), planning period width (PPW), and assumptions about initial age class age and harvest timing within a planning period. Barber's work explored a single case, ACW = PPW, where the assumed initial age class age was equal to the age class end point (i.e., age class 1-5 was assumed to be 5). This study expands upon Barber's work, considering the cases outlined in Table 1.

A hypothetical 1,000-acre test forest was used for the

*(Continued on page 2)*

Barber, Richard L. 1985. The Aggregation of Age Classes in Timber Resource Scheduling Models: Its Effect and Bias. For. Sci. 31:73-82

*Table 1. Test cases run, including abbreviations for each case.*

| Planning Period Width | Age Class Width | Initial Age (Within Age Class) | Harvest Timing (Within Planning Period) | Abbreviation |
|---|---|---|---|---|
| ***1-year planning period width, 5-year age class width (PP1AC5##)*** | | | | |
| 1 | 5 | Mid-point | End-point | PP1AC5ME |
| 1 | 5 | End-point | End-point | PP1AC5EE |
| ***5-year planning period width, 5-year age class width (PP5AC5##)*** | | | | |
| 5 | 5 | Mid-point | Mid-point | PP5AC5MM |
| 5 | 5 | Mid-point | End-point | PP5AC5ME |
| 5 | 5 | End-point | Mid-point | PP5AC5EM |
| 5 | 5 | End-point | End-point | PP5AC5EE |
| ***5-year planning period width, 10-year age class wdith (PP5AC10##)*** | | | | |
| 5 | 10 | Mid-point | Mid-point | PP5AC10MM |
| 5 | 10 | Mid-point | End-point | PP5AC10ME |
| 5 | 10 | End-point | Mid-point | PP5AC10EM |
| 5 | 10 | End-point | End-point | PP5AC10EE |
| ***10-year planning period width, 5-year age class width (PP10AC5##)*** | | | | |
| 10 | 5 | Mid-point | Mid-point | PP10AC5MM |
| 10 | 5 | Mid-point | End-point | PP10AC5ME |
| 10 | 5 | End-point | Mid-point | PP10AC5EM |
| 10 | 5 | End-point | End-point | PP10AC5EE |

*(Continued from page 1)*

study. All stands were Douglas fir (Pseudotsuga menziesii) plantations with a planting density of 360 trees per acre. Following Barber (1985), three initial age class distributions were used, uniform, negative skew, and positive skew. In each distribution, one-twelfth of the area was assigned to each five year interval from 1 to 60 years. The distributions differed in their assignment of acres within each five year interval as follows:

- Uniform – area uniformly distributed across all ages,
- Negative skew – entire area placed at the lower limit of the interval, and
- Positive skew – entire area placed at the upper limit of the interval.

Strategic harvest schedule models (model II linear programming formulation) were developed using the Woodstock optimization software (www.Remsoft.com). The models consisted of an objective function maximizing net present value (6% real discount rate) over a 150-year planning horizon. General modeling assumptions include: 1) all stands harvested must be replanted, 2) all harvested stands are regenerated to the same forest type and planting density, and 3) harvest levels cannot increase or decrease between planning periods.

Yield tables were constructed for existing and regenerated stands utilizing the FORSim Pacific Northwest Growth Simulator v2008.7 (FORSight Resources 2008), implementing the Stand Management Cooperative (SMC) variant of the ORGANON growth and yield model (Hann 2006). FORSim PNW was used to generate merchandized yields for No. 1, No. 2, No. 3, No. 4, and utility grade sawlogs (see Northwest Log Rules Advisory Group 2006 for product specifications). A third degree polynomial was fit to ORGANON 5-year periodic yields for each product to allow annual interpolation.

*Table 2. Volume bias values by test case and initial age class distribution.*

| Case | Uniform | Neg. Skew | Pos. Skew |
|---|---|---|---|
| PP1AC5ME | **0.009** | **0.028** | **-0.008** |
| PP1AC5EE | 0.025 | 0.044 | **0.008** |
| PP5AC5MM | **0.03** | **0.05** | **0.013** |
| PP5AC5ME | 0.056 | 0.076 | 0.038 |
| PP5AC5EM | 0.056 | 0.076 | 0.038 |
| PP5AC5EE | 0.071 | 0.091 | 0.053 |
| PP5AC10MM | **0.035** | **0.054** | **0.017** |
| PP5AC10ME | 0.051 | 0.071 | 0.034 |
| PP5AC10EM | 0.075 | 0.095 | 0.057 |
| PP5AC10EE | 0.09 | 0.11 | 0.071 |
| PP10AC5MM | **0.032** | **0.051** | **0.015** |
| PP10AC5ME | 0.072 | 0.093 | 0.055 |
| PP10AC5EM | 0.049 | 0.069 | 0.031 |
| PP10AC5EE | 0.087 | 0.108 | 0.069 |

*Bold values indicate the minimal bias for each planning period/age class width combination.*

The test cases from Table 1 are compared are against annual models with one-year age classes developed for each initial age class distribution. Because periodic/aggregate analysis is used to approximate annual models, these serve as appropriate standards. Results are reported for both 100-year and 1-year time resolutions to allow comparisons of long term averages as was all implications on short term scheduling. Bias is represented as the percent (as a decimal) over- or under-estimate relative to the standard case.

Table 2 shows the volume bias results. Volume bias does not vary with the planning horizon subset examined. The even volume flow constraint prevents volume from deviating between period, meaning average annual harvest volume is the same throughout the planning horizon. As a result, volume bias is the same at all time resolution levels, leading to the omission of time resolution from Table 2. In all periodic models volume bias is minimized with the age class mid-point/planning period mid-point (MM) assumption. In the case of the annual model, volume bias is minimized with the age class mid-point assumption (ME) for both the uniform and negative skewed distributions. With the positive skewed distribution, the ME and EE cases produce bias of the same magnitude, one positive and one negative.

Average annual harvest area bias is shown in Table 3. A clear trend does not exist across all cases as does with volume bias. The assumption set minimizing bias varies with the initial age class distribution. In general, however, bias is lower at the one-period subset than at the 100-year subset. This is expected as bias is cumulative in the sense that it builds throughout the planning horizon, becoming increasingly exaggerated later in the time horizon. A final yet important observation is that the assumption set minimizing volume bias

*(Continued on page 3)*

*Table 3. Harvest area bias values by test case and initial age class distribution.*

| | 100-year Subset | | | 1-period Subset | | |
|---|---|---|---|---|---|---|
| Case | Uniform ACD | Neg. Skew | Pos. Skew | Uniform ACD | Neg. Skew | Pos. Skew |
| PP1AC5ME | **-0.014** | **-0.044** | 0.014 | 0.025 | **-0.027** | 0.009 |
| PP1AC5EE | -0.04 | -0.069 | **-0.013** | **0.007** | -0.044 | **-0.008** |
| PP5AC5MM | 0.068 | 0.035 | 0.097 | 0.037 | **-0.016** | 0.021 |
| PP5AC5ME | 0.02 | **-0.011** | 0.049 | 0.009 | -0.042 | **-0.007** |
| PP5AC5EM | -- | **--** | -- | -- | -- | **--** |
| PP5AC5EE | **-0.007** | -0.037 | **0.021** | **-0.008** | -0.059 | -0.024 |
| PP5AC10MM | 0.062 | 0.029 | 0.091 | 0.07 | 0.016 | 0.053 |
| PP5AC10ME | 0.03 | **-0.002** | 0.058 | 0.051 | **-0.003** | 0.034 |
| PP5AC10EM | **-0.011** | -0.042 | 0.016 | 0.023 | -0.029 | **0.007** |
| PP5AC10EE | -0.035 | -0.065 | **-0.009** | **0.006** | -0.046 | -0.01 |
| PP10AC5MM | 0.058 | 0.025 | 0.087 | 0.034 | **-0.019** | 0.017 |
| PP10AC5ME | **-0.013** | -0.043 | 0.015 | **-0.013** | -0.064 | -0.029 |
| PP10AC5EM | 0.028 | **-0.004** | 0.056 | 0.014 | -0.038 | **-0.002** |
| PP10AC5EE | -0.038 | -0.067 | **-0.011** | -0.03 | -0.08 | -0.046 |

*Results are shown for 100-year and 1-period subsets of the 150-year planning horizon. Bold values indicate the minimal bias*

*(Continued from page 2)*

(MM) often results in the largest average annual harvest area bias.

To test the implications of implementing the plans generated with the test cases, target values were applied to the standard model with the uniform age class distribution. Common practice is to use the strategic plan to set volume or area targets for on the ground management.  In general, only the first year is implemented, with re-planning efforts in subsequent years to include updated information from inventory and silvicultural treatments. This was mimicked by setting either harvest area or volume targets for the first planning period. Targets were derived from the test case that minimized area or volume bias, depending on the targets used, for each of the four age class/planning period width combinations.

Results for the area targets are outlined in Table 4. In three of the cases, a fall down in harvest volume of at least 2.5% was recorded. In the fourth case, PP10AC5, the solution was infeasible. Only when the even flow volume constraint was relaxed did area targets lead to a feasible solution. No test case produced feasible solutions when harvest volume targets were set. This is an expected result given the positive volume bias discussed earlier. The volume generated with the test cases cannot be sustained throughout the planning horizon. Relaxing the even flow constraint to first apply in the second period produced feasible solutions, but there was a notable decline between first and second period harvest volumes. This serves as an illustration of the declining even flow effect; even flow volume cannot be sustained long term, so there is a decline in even flow volume in subsequent rounds of planning.

The results indicate that constrained harvest schedule models with aggregated age classes consistently exhibit positive volume bias relative to models with annual age classes, regardless of initial age class distribution. This differs from observations made by Barber (1985), who noted a bias toward underestimating harvest volume. Differences can be attributed in part to assumed harvest age calculations as well as differences in methodology. The latter is important because it indicates that extending Barber's earlier work to constrained mathematical programming models should be approached with caution. Whether his results can be extended to unconstrained mathematical models remains unclear, but this has little practical importance as few forest planning models fit the unconstrained case.

The significance of these results becomes apparent when strategic plan implementation is considered. Feasibility is an immediate concern, with none of the volume targets producing a feasible solution. Even when plans were feasible, a decline in harvest volume from projected levels was observed (see Table 4). This presents additional feasibility concerns in the presence of minimum volume constraints, often implemented for wood or mill supply requirements. If these constraints are binding, there will be a shortfall when the plan is implemented. Additional acreage can be harvested to reach the needed volume, but this cannot be sustained into the future. In addition, increasing harvest acreage can present complications if area-based goals or constraints are included in the model, such as wildlife habitat or a target ending age class distribution. Increasing harvest acreage will directly impact these goals, possibly causing additional feasibility concerns.

Planners are left with the question of whether it is better to minimize bias in harvest volume or harvest area. In general, it is believed that implementing the management strategy defined by the model (both harvest area and silvicultural regimes) is more important than meeting volume objectives. Regardless of how a planner chooses to proceed, there are implications for feasibility, both long and short term. Perhaps the best approach is to minimize area bias when area-based goals are present and volume bias when volume-

*(Continued on page 4)*

*Table 4. Impact on annual harvest volume when area targets are used as constraints*.*

| Case | Test Case Volume | Annual Volume | Fall Down |
|---|---|---|---|
| PP1AC5EE | 1,485,147 | 1,448,591 | -2.5% |
| PP5AC5EE | 1,551,975 | 1,432,616 | -8.3% |
| PP5AC10EE | 1,578,577 | 1,448,589 | -9.0% |
| PP10AC5ME | 1,553,557 | *Infeasible* | ----- |

** Area targets from the test case are used as constraints in the uniform initial age class distribution standard model .*

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based goals are present. This may not be possible given that forest planning problems often include both. The decision of which approach to follow is beyond the scope of this research, but it is a critical topic for planners and it requires further study.

Regardless of the assumption set a planner chooses to follow, it is important to understand the issues those assumptions may cause. As with any modeling exercise, the harvest schedule model is an abstraction of reality, and, as such, some bias is inevitable. A thorough understanding of bias sources is critical for planners to maximize the utility of their models and understand issues that may arise during implementation.

**FORSight Resources** provides world-class expertise to companies and agencies facing critical natural resource decisions. The company's offerings include forest planning, acquisition due diligence, forest inventory &biometrics, GIS & data services, custom system/application development and hardware/software sales.

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## FORSight Resources assists Brookfield Asset Management with timberland acquisition

Brookfield has entered into an agreement to acquire a 67,661 acre tree farm in the North Puget Sound/Skagit Region of Washington State from Hampton Affiliates for US $163 million. The tree farm consists of four management units of hemlock and Douglas fir located along the west side foothills of the Cascade Mountains between Everett and Bellingham.

Brookfield was assisted in the transaction by FORSight Resources, LLC, an industry-leading forestry consulting firm with a focus on decision-support services to natural resources decision makers. FORSight Resources has analyzed over 13 million acres of potential timberland acquisitions over the past four years and has assisted clients in purchasing over $2 billion in timberland assets.

"FORSight Resources played an important supporting role in the successful purchase of the North Cascades Tree Farm. They anticipated our needs and completed a very thorough analysis with extremely quick turnaround on this time-sensitive project." said Reid Carter of Brookfield Asset Management.

# The FORSight Library...

## Thinning Guidelines for Loblolly Pine Plantations in Eastern Texas based on Alternative Management Criteria

Charles T Stiff and William F. Stansfield. 2004. pg. 323-329 In: Proceedings of the 12th Biennial Southern Silvicultural Research Conference, February 24-28, 2003, Gen. Tech. Rep. SRS-71, Asheville, NC, USDA Forest Service Southern Research Station, 594 p.

**Abstract–** Separate thinning guidelines were developed for maximizing land expectation value (LEV), present net worth (PNW), and total sawlog yield (TSY) of existing and future loblolly pine (Pinus taeda L.) plantations in eastern Texas. The guidelines were created using data from simulated stands which were thinned one time during their rotation using a combination row (20 percent) and selection thin to achieve a residual stocking target.

LEV for future stands which had been thinned indicated optimal rotation ages of 20, 24, 28, and 32 yrs for site index 85, 75, 65, and 55 ft, respectively. For existing stands at optimal rotation age, PNW increases with both thinning age and site index. However, for future stands at optimal rotation age, LEV reaches maximum values at thinning ages that vary by site index. TSY reached maximum values at residual stocking levels, which increase with increasing site index for both existing and future stands. Marginal analyses indicated that when thinning older stands of poorer site quality, economic criteria (PNW or LEV) increased with higher initial stocking, and total sawlog yield (TSY) decreased with lower initial stocking. Regression tree analysis used thinning age and residual stocking for predicting PNW, LEV, and TSY by initial stand attributes (site index, and initial stand age and stocking). Thinning guidelines were derived from the tree-based models. A 4-step procedure is provided for applying the guidelines.

For a copy of this paper, visit our website:
http://FORSightResources.com/library

Few things are impossible to diligence and skill. Great works are performed not by strength, but perseverance.
- Samuel Johnson