

Attachment 4: Model and Data Descriptions and Assumptions

The purpose of this attachment is to describe the updates and revisions made to spatial data, forest inventory, yield tables, and the Harvest & Habitat (H&H) model. It will also describe assumptions that have been made and areas where additional work is necessary to improve the accuracy and confidence of the new structure based management (SBM) model results. The SBM model used in the analysis of the strategies for the achievement of the Board of Forestry Performance Measure Targets for the Clatsop and Tillamook State Forests was generated from an updated and revised version of the 'Forest Management Plan with Take-Avoidance' model from the H&H model.

Spatial Data

The spatial data identifies the physical locations of natural resources (such as stands, harvest units, riparian areas, and northern spotted owls) and other land attributes (such as counties and taxing districts) that are used by the model for decision making or generating reports. For this project, it was only necessary to update the following items:

- Forest boundaries (to account for recent land exchanges)
- Stand boundaries and numbers (to reflect changes in the forest inventory system)
- Recent clearcut and partial cut harvests
- Northern spotted owl home ranges
- Marbled murrelet management areas
- On Tillamook district, additional high landslide hazard locations that were not operable and rock outcrops that were not silviculturally capable of growing trees were identified

With these changes, the spatial data used in the model was current through December 31, 2007. These updates account for the impacts to the forests from the December 2007 windstorms.

Forest Inventory

The forest inventory provides information on the current condition of trees (such as species, size, and volume) and other vegetation across the forest. The inventory is used to generate the yield tables that project the growth of the forest and its potential outputs (i.e., stand structure and volume). Four important updates and revisions have been incorporated into the State Forests Stand Level Inventory (SLI) program for use in the current modeling updates. These four are: the transition from a strata-based inventory to an imputed inventory, revision of the stand structure classification algorithm, incorporation of refined stand typing on the Tillamook district, and normal annual updates to the inventory.

Imputed Inventory

Until 2007, SLI was based on a strata inventory system. Under this system, the hundreds or thousands of individual stands are placed in similar groups of stand types (generally 30 to 60 types). Then the average of all the inventory measurements within a stand type is applied to all of

the stands within the type (both measured and unmeasured). During the last year, SLI has transitioned from the strata system to an imputation system. With an imputation system, each stand with measurements represents itself and each unmeasured stand is represented by a similar individually measured stand.

The total timber volume on each district is essentially the same under both inventory systems. There is less than a two percent difference between the strata and imputed calculation of total timber volume on the three north coast districts. However, the imputed inventory better represents the individual stands and the variation of forest conditions across the landscape. Using volume as an example of variation from the average strata, the volume of a measured stand can be as little as 30 percent of the strata average and up to 300 percent more than the strata average.

The transition from a strata based inventory to an imputed inventory completes one of the primary recommendations of the Scientific Peer Review of the H&H Model Project.

Stand Structure Algorithm

As was reported at the July 2008 Board meeting, a revised stand structure algorithm has been developed and incorporated into SLI. Table 1 summarizes the current stand structure for each district, forest, and region by percent. Under the new algorithm, the total complex structure (Layered and Older Forest Structure) comprise 13 percent of the three north coast districts. The previous estimates for complex structure, presented to the Board in November 2007, ranged from 3 to 11 percent, based on the SLI at the time.

Table 1. Current Stand Structure (Percent)

District	Regeneration (REG)	Closed Single Canopy (CSC)	Understory (UDS)	Layered (LYR)	Older Forest Structure (OFS)
Astoria / Clatsop State Forest	11	22	46	20	1
Forest Grove	4	16	64	16	0
Tillamook	8	9	76	6	1
Region	8	14	65	12	1

Tillamook Stand Typing

During the Harvest and Habitat Model Project it was determined that the stand types used in SLI were not stratified enough to provide inputs for yield tables and harvest modeling that have a high degree of confidence. Therefore, the district undertook a stand typing project that was completed in late 2005. This project increased the number of stands on the Tillamook district from approximately 1,900 stands to 5,800 stands, and reduced the average stand size from 135 acres to 44 acres.

This retyping project has resulted in more uniform stands that will result in a more accurate stand inventory, which will result in more reliable yield tables and harvest modeling results. A short-

term side effect of this retyping project has been to reduce the total number of stands with an adequate number of inventory plots and the overall percentage of stands (11%) that have been measured (see Table 2, Inventory Status). Additional inventory data is currently being collected through an active contract and another contract is being prepared. Together these two contracts will double the number of measured stands on the Tillamook by the end of 2009. The low number of measured stands has negatively affected the imputation process because there are many unmeasured stands that currently do not have a “good” match in the measured stands for imputation, which may result in less accurate results in the yield tables.

Normal Updates

Updates to SLI occur at least once per year and consist of incorporating data from the most recent inventory measurements, adjusting or deleting stands to account for recent harvest activities, and making other corrections. The SLI data used to create the yield tables for the three north coast districts was updated through December 31, 2007. In addition to the normal adjustments, this process incorporated the impacts of the December 2007 windstorm.

Table 2. Inventory Status

District	Total Acres	Total Stands	Measured Stands (Full SLI Plots) ¹	
			% of Stands	% of Acres
Astoria	136,770	1,079	58	73
Tillamook	249,970	5,478	11	23
Forest Grove	114,227	1,227	53	65
Region	501,587	7,784	24	46

¹ Measured stands (Full SLI Plots) include all stands in data from planting records, stocking surveys, and the full SLI Plots. Of these measurements, only stands with the full SLI Plots are suitable for generating yield tables; stands with the full SLI Plots are indicated here.

Areas for Continued Improvement of Forest Inventory

The State Forests Division plans to continue improving the following aspects of the forest inventory.

- Continue to evaluate and improve the stand structure algorithm, with a focus on the following:
 - Refining the threshold for layering of hemlock and mixed hardwood stands;
 - Refining the distinction between Regeneration and Closed Single Canopy Stands;
 - Incorporating a “death and decay” model for snags and down wood; and
 - Developing a predictive model for understory vegetation.
- Continue the accelerated inventory on the Tillamook District until 50% of the stands have been inventoried; maintain the inventory on the other districts.

Yield Tables

While the forest inventory provides information of the current condition of the individual stands and forest, it is the yield tables that project the potential growth of these stands into the future and affect the predicted outputs (stand structure and volume) of the individual stands under a variety of management prescriptions. The structure based management harvest model uses the outputs from the yield tables to generate its solutions.

The yield tables are generated by the Forest Vegetation Simulator (FVS)¹ growth model using the same growth parameters and management prescriptions as were used in the yield tables for the H&H Model. However, changes were made regarding the initial forest inventory, stand structure algorithm, and log prices.

Initial Forest Inventory

The yield tables for this project were updated during the summer of 2008 using the measured stands from the updated SLI inventory (as described above). As a result, the new yield tables will allow the structure based management harvest model to use the imputed inventory rather than the strata based inventory used in the H&H.

Stand Structure Algorithm

Where possible, the yield tables used the same stand characteristics and calculations as SLI to determine the stand structure of future stands. Overall, the yield tables result in initial stand structures very similar to SLI for total complex structure (LYR and OFS), REG, and the combined values of CSC and UDS. Because the yield tables could not project changes in understory vegetation, snags, and downed wood, the yield tables were not highly reliable in distinguishing between the following structures:

- CSC and UDS: The stand structure algorithm in the yield tables rely on a Stand Density Index to distinguish between CSC and UDS. However, in the new yield tables this proved insufficient and nearly all CSC stands were classified as UDS. While this short-coming makes analysis of wildlife habitat more difficult, it does not affect the model solutions because these structures are not a factor the model uses to develop a solution.
- LYR and OFS: In the yield tables, the distinguishing characteristic between LYR and OFS is the presence of 8 trees per acre that have a DBH of 32 inches or more, since information on snags and downed wood is not available for the future stands. The yield tables identify many stands that should be LYR as OFS, which results in a higher proportion of OFS to LYR than would be anticipated. However, the total amount of complex stand structure identified in the yield tables is consistent with expectations.

¹ Dixon, Gary E. 2002. *Essential FVS: A User's Guide to the Forest Vegetation Simulator*. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center

This issue makes analysis of wildlife habitat more uncertain. It also reduces the flexibility of conducting model runs, because targets need to be set for combined values for LYR and OFS. Setting specific OFS targets using these yield tables would provide less accurate results.

Because of these issues, the stand structure results from the model are displayed using three categories: REG, CSC/UDS, and LYR/OFS (complex).

Pond Values

The pond value is the value of a log delivered to a sawmill, and is the basis of calculating the gross value of the timber. The yield tables provide the gross value of the timber harvest under various management prescriptions from which the model calculates the net revenue by subtracting logging and transportation costs. Prior to developing the updated yield tables, the Department consulted with several forest economists on the process to determine the pond values. As a result, the pond values in the yield tables are based on a five year average of the pond values published on the Department's web site from the second quarter of 2003 through the first quarter of 2008. These prices were adjusted for inflation using the "producer price index" indexed to 1983.

Areas for Continued Improvement in Yield Table Development

An analysis of the updated yield tables has identified a number of projects that would improve future yield tables. These projects include calibration of FVS, identifying a reforestation/regeneration growth model, reviewing and revising the management prescriptions, incorporating a "death and decay" model for snags and downed wood, improving the yield table stand structure algorithm, and updating the reforestation cost tables.

- **Calibration of FVS:** The yield tables are based on the Pacific Northwest Coast Variant of the FVS growth model. During the analysis of the yield table outputs, it became apparent that this regional variant needs to be calibrated for the Clatsop and Tillamook State Forests. The data required to calibrate the growth model includes tree growth information from permanent plots; this information should be available for these two forests by the end of 2009.
- **Regeneration Growth Model:** It is generally recognized that FVS does not grow stands less than 15 years old as accurately as desired. Identification of a young stand growth model to complement FVS will improve the accuracy of future yield tables. The Peer Review of the H&H Model Project also made this recommendation.
- **Management Prescriptions:** Each stand in the yield tables has up to 105 different management prescriptions that provide a variety of thinning intensities and timing options for use by the model. The current management prescriptions were based on the strata based yield tables. The new yield tables should be reviewed to determine whether changes in the prescriptions should be made, because the stands are based on actual measures rather than strata averages.
- **Snags and Downed Wood:** Calibrating and incorporating a "death and decay" model for snags and downed wood into the yield tables will allow these two structural components to be projected into the future. Incorporation of snags and downed wood into the yield tables

will provide a better estimate of OFS and allow a more detailed analysis of habitat for a wider variety of wildlife species.

- Stand Structure Algorithm: As noted above, the stand structure algorithm in the yield tables does not result in a highly reliable distinction between CSC and UDS or LYR and OFS. The incorporation of snags and downed wood will help improve the identification of OFS. In addition, an analysis of the result of the stand structure algorithm in SLI may identify stand characteristics that could be used in the yield table to distinguish between CSC and UDS.
- Reforestation Cost Tables: The cost to establish a new plantation after a regeneration type harvest is identified in one of the yield tables. These tables were not updated in the current set of model runs due to a timing conflict. They should be updated before the end of 2008.

Structure Based Management (SBM) Harvest Model

The structure based management harvest model used in this project is based on the 'Forest Management Plan with Take-Avoidance' strategy from the H&H Model. It has been updated and revised to better analyze the Performance Measure targets. However, it was not necessary to change many of the operational rules and strategies, such as: Forest Practice Act Rules, riparian management strategies (e.g. Appendix J of the *Northwest Oregon State FMP*), recent thinning, etc. Unless noted below, the operational rules and strategies have not changed.

Model Description and Assumptions

Two-Phased Solution

In addition to analyzing the achievement of the Performance Measure Targets in 20 years, it is essential to analyze the trends of various management options beyond 20 years. To provide the data for this analysis, the architecture of the H&H model was revised so the results of the first 20 years of management (Phase 1) could be repeated exactly the same in multiple runs of the model with different goals beyond the initial 20 years (Phase 2). A Phase 1 SBM model run that achieves 20 percent complex structure through a series of management activities can be used as the starting point of several Phase 2 runs with different long-term goals (21 to 80 years), such as maintaining the 20 percent structure or increasing the total complex structure to 30 or 40 percent and beyond.

Salmon Anchor Habitats (SAH)

Year 1 (i.e., the first year of the first period) in the H&H Model was 2004 and the SAH strategies in the model were designed to sunset after 10 years (2 periods). Year 1 of the SBM model is 2008; the sunset date for these strategies has been adjusted to 5 years or after the first period.

Swiss Needle Cast

The H&H Model included a strategy to clearcut all Douglas-fir stands that are severely infected with Swiss needle cast in the first 20 years (4 periods). Since Year 1 in the SBM model has changed from 2004 to 2008, this strategy has been changed from 20 years to 15 years (3 periods).

Northern Spotted Owl Populations

The H&H Model attempted to model northern spotted owl population trends using three different scenarios to help inform the decisions on whether or not to pursue a long-term Habitat Conservation Plan for northern spotted owls. The SBM model does not model population trends for three reasons:

- The population trends between the previously used scenarios do not vary appreciably during the first 20 years, so differences would not affect the achievement of the Performance Measure Targets; and
- The difference in the long-term population trends between the previously used scenarios is very large. During the analysis of the SBM model outputs, it was recognized that the range of outputs that results from these different population trends was so large that they were not useful in decision making.
- There is significant uncertainty about the population trends for northern spotted owls.

For this modeling effort, the known number and location of the existing northern spotted owl activity centers remain static over time. While it is recognized that this assumption is not likely to reflect actual owl populations in the future, it is representative of the relative amount of constraint on the land base from northern spotted owls as indicated from previous population trend scenarios during the first 20 years. The model then applies the State Forests take-avoidance strategies in the same method as they were in the H&H model.

Marbled Murrelet Populations

The H&H Model also modeled two marbled murrelet population scenarios for the same reasons that it modeled northern spotted owl scenarios. The SBM model does not model trends in the marbled murrelet population scenarios for reasons similar to the decision not to model northern spotted owl populations. For this modeling effort, it is assumed that existing marbled murrelet locations remain static over time and the model applies the State Forests take-avoidance strategies as was used in the H&H Model.

Landscape Design

A number of changes have been made to the H&H model in order to analyze the intent of Performance Measure 6's direction to "develop and maintain complex structure in those areas where it is anticipated to result in the greatest benefits to both aquatic and terrestrial species of concern..." The SBM model uses landscape designs developed by district staff and resource specialists that identify specific locations for the development of complex structure. The model can be set to use one of four landscape designs for a single run. The intent of four landscape designs is to provide additional tools for analyzing different approaches to attempt to achieve the performance measure targets. The landscape designs used in the SBM model include the following :

- 1) District level – The landscape design identifies 20 percent of each district for wildlife habitat and the development of complex structure.

- 2) Forest level – The landscape design covers 20 percent of a state forest; this different configuration of a landscape design is only applicable to the Tillamook State Forest, since it is the only state forest composed of more than one district. In an aggregated Tillamook state forest level landscape design, the 20 percent complex habitat is not distributed equally on both districts. Instead, the acres are allocated to a district based on the best habitat and the potential to achieve complex structure.
- 3) Region level – In the region level landscape design, the 20 percent complex structure goal is proportioned across the three north coast districts where it is expected to produce the greatest benefit to species of concern.
- 4) FMP Implementation Plan level (Base Case) – This level of landscape design uses the landscape designs that are included in the district implementation plans that were approved in 2003. These landscape designs designated approximately half of each district for the development of complex structure.

During the development of the district landscape designs, it was determined that the Tillamook district only had the potential to achieve approximately 15 percent complex structure in 20 years. As a foundational species of concern strategy, it was determined that the Tillamook district landscape design could achieve 20 percent for the district, forest, and region level landscape designs beyond the initial 20 years.

New rules regarding the landscape design have been added to this SBM model. These rules apply to locations that have been designated through landscape design for the development of complex structure and stay in affect 20 years for the district, forest, and region level landscape designs. Implementing these landscape design rules for 20 years was an operational decision made for conducting the model runs in order to achieve the Performance Measures. The length of time to apply these model rules and landscape designs is a policy choice that can be clarified. The length of time that the landscape design rules are in effect is a variable in the model that can be changed in future runs.

The landscape design rules that are applied to the mapped 20% complex structure areas for the first 20 years are:

- No clearcutting
- No heavy thinning (i.e., partial cuts with a residual basal area of less than 80 square feet of basal area per acre)
- Only moderate thinnings for stands that are currently complex (i.e., partial cuts with a residual stand density index of 35 percent of it maximum)

For the FMP implementation plan level (Base Case) of landscape design, these rules are applied within the mapped landscape design until 50 percent of the forest is in complex stand types (approximately 60 to 80 years).

Harvest Availability

The H&H Model identified portions in each district that could not be harvested for a variety of reasons, including access, deed restrictions, rock out crops, other uses (road right-of-way),

stream bank and bed, and protected wildlife species sites. These areas ranged from 9 to 20 percent of a district under the strategies employed by the H&H model. The revised model also has areas that have no or very little harvesting allowed. The amount and reason for these areas is currently being analyzed and will be included in updated current condition summaries for each district.

Performance Measure and Northwest Oregon State FMP (Base Case) Model Runs

The primary work on the structure based management harvest model has been to analyze the strategies to achieve the Performance Measures; however, a “base case” model has also been run to simulate strategies contained in the *Northwest Oregon State FMP* (NW FMP) coupled with the existing landscape designs (approximately 50 percent complex structure). This scenario is intended to provide a basis of comparing the differences of the PM scenarios with how the FMP would likely continue to be implemented over the next 20 years or longer.

Given the time available, the SBM model developed for the performance measure analysis has been adapted to approximate current management practices. These adaptations include:

- Using the approved 2003 district implementation plan landscape designs
- Achieving 50 percent complex structure across the landscape in 50 to 80 years
- Achieving a non-declining relatively even flow of timber volume

This “base case” for the FMP does not include the management strategies contained in the draft Western Oregon Habitat Conservation Plan (i.e., spotted owl clusters). This scenario utilizes the same strategies for northern spotted owl and marbled murrelet as the performance measure models. These runs are also different from the H&H project, because the H&H project did not include the clearcutting and partial cutting restrictions for the landscape design as described above, that were used in the base case scenario. The current FMP does not prohibit clearcut harvest in desired future condition (DFC) areas of complex, except for harvest of OFS when OFS is the DFC. In practice the Department has aligned its silvicultural prescriptions with the DFC, which has resulted in very little clearcut harvest activities occurring in areas designed for LYR structures as well.

Model Solution Review

The H&H Model developed a process called the Model Solution Review (MSR) to assess and validate the model function, inputs, and outputs. The MSRs are conducted by the districts and use ArcView (a geographic information system application) to review harvest operations scheduled for the first four periods (20 years) of the model. The districts check for errors in the spatial data, compliance with the management rules and strategies in effect for the model, and analyze the model outputs using actual outputs from recent forest operations.

The SBM model runs used in the analysis of the strategies to achieve the performance measures have undergone an initial MSR by the districts. Overall, the districts found no significant data errors and that the rules and strategies were correctly applied (with a few minor exceptions). In

addition, the stands selected by the model for clearcut and partial cut harvest were reasonable. The districts note that stand selection for harvest in these model runs are superior to those made in the H&H model.

The districts also analyzed the harvest volume estimates generated by the model to recent harvests using timber cruise and log scaling information, with the following results:

- Forest Grove found that the model's volume per acre estimates differed by +1 percent on clearcuts and -12 percent on partial cuts;
- Astoria found that the model's volume per acre estimates differed by +11 percent on clearcuts and +10 percent on partial cuts; and
- Tillamook found that the model's volume per acre estimates differed by +33 percent on clearcuts and +14 percent on partial cuts.

The findings on Forest Grove and Astoria are reasonable for this type of modeling, but could still have an effect on achieving the performance measure targets. However, the results on Tillamook district are considerably different. District and division staffs have conducted an analysis of differences in harvest volume per acre using cruise and log scale information from 175 stands and/or harvest units. The analysis has not yet identified the cause of this error; however, several potential sources have been identified including:

- A low percentage of stands with SLI plot measurements;
- Tree height sampling and estimation procedures in SLI may need to be adjusted; and
- Differences in merchantability standards between yield tables, SLI, cruising, and log scaling.

Based on the overestimate of the harvest volumes per acre on the Tillamook district, the model's clearcut and partial cut volumes have been reduced by 32.9 and 13.9 percent to bring them in alignment with timber cruise and log scaling data in the charts contained in Attachment 5, Model Outputs and Analysis. The harvest acres from the model have not been adjusted. Staff are continuing to analyze this issue and will resolve it as soon as possible.

Areas for Continued Improvement in Model Development and Application

Analysis of functionality and outputs of the SBM model has only recently begun, so all areas for continued improvement may not be identified. Areas currently identified for continued improvement include the following.

- **Logging and Transportation Costs:** Logging and transportation costs within the model were not updated in the current set of model runs due to a timing conflict. They should be updated before the end of 2008.
- **Sensitivity Analysis:** There is a need to conduct several analyses to determine the models sensitivity to log prices, stand structure algorithms, inventory basis (i.e., strata versus imputation) and others.

- Peer Review: Continue to evaluate and implement recommendations from the Peer Review of the H&H Model Project.
- Timber volume estimates: Evaluate, refine and calibrate timber volume estimates that are different in the growth and yield model than actual cut-out results from recent harvests.

