Scientific Peer Review of H&H Model Project
Review Results

Final Report

Prepared for:

Oregon Department of Forestry
Salem, OR

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August 31, 2006

Citation: **Marmorek, D.R., C. Murray, T. Droessler, G. Dunsworth, R. Monserud, R. Kiester, S. Northway.** 2006. Scientific Peer Review of H&H Model Project, Review Results. Final report prepared by ESSA Technologies Ltd., Vancouver, BC for Oregon Department of Forestry, Salem, OR. 134 pp.

Executive Summary

The Harvest and Habitat (H&H) models are intended to assist in making decisions about whether to make changes in the Northwest and Southwest Oregon Forest Management Plans (FMPs), pursuing a Habitat Conservation Plan (HCP), and setting harvest levels for Annual Operation Plans. A peer review of the H&H models was conducted by a team of seven scientists (the authors of this report). The specific objectives of the model peer review were to assess the strengths and weaknesses of the models, including level of confidence in model results; assess model credibility for decision-making and help determine appropriate model application, and suggest model improvements. During an intensive 2-week period in July, the Panel reviewed available reports and informal documentation (e.g. technical memos), interviewed key members of the H&H team, independently wrote responses to a pre-defined set of peer review questions, reviewed these responses to determine areas of consensus and disagreement, and discussed their findings with the H&H team.

Overall the Panel members were extremely impressed by the dedicated effort of the H&H model team over the last several years. They have completed a great deal of work in a very short period of time with limited staff and funding resources. All of the personnel that the Panel interviewed were extremely open, helpful, and knowledgeable.

Strengths and Weaknesses of the Models and the Modeling Process. Strengths include the qualifications and tremendous dedication of the modeling team, including outside contractors; the very advanced heuristic algorithm for allocating forest management activities over space and time; the detailed work behind estimates of harvest costs and road locations; the interactive process of model exploration with Forest Districts; and the rapidly improving forest inventory (soon to be incorporated into the model). The Panel certainly felt that the modeling was well worth doing, and provided helpful information to decision makers, despite some notable weaknesses. Weaknesses include the lack of formal project management, the inadequate staff resources and time for properly documenting the model and its applications, including sensitivity analyses; the risks associated with the maintenance and continued development (only one developer, one operator); the use of strata based averages of existing forest inventory data, rather than using the inventory data directly; the limited consideration of variability and uncertainty in model inputs, rules and outputs; and the use of forest structure classes as an indicator of wildlife habitat, rather than the actual habitat attributes required by focal species.

Level of Confidence in Model Results. The Panel had a moderate to high level of confidence in the model's output for indicating levels of harvest, though the lack of consideration of variability and uncertainty in model input, rules and output gave a low level of confidence for determining if outcomes were really significantly different amongst management alternatives. The Panel had a low level of confidence in the model's use of forest structure as an indicator of wildlife habitat, and therefore a low level of confidence for assessing the wildlife implications of different management alternatives.

Use of the Models for Making Decisions. All reviewers felt that once the forest inventory data were used directly, the H&H models could be used in their current form for setting harvest levels for Annual Operation Plans, though not for assessing the implications of such plans for wildlife habitat. However, for making decisions about the Northwest and Southwest Oregon FMPs and whether to pursue an HCP, four out of five reviewers felt that the H&H models should not be used in their current form. These reviewers felt that application of the models to such decisions should wait until 5 conditions are completed: 1) stand inventory data used directly in model in place of strata averages; 2) variability/uncertainty better incorporated into model rules and output (e.g. statistical confidence intervals and other measures of

confidence regarding inputs and assumptions and flowing through to output tables and figures); 3) greater analysis, visualization and transparency of output; 4) wildlife habitat for ~10 vertebrate species represented in terms of actual habitat attributes (e.g. dead wood, shrubs) rather than structure classes; and 5) near term results from adaptive management trials of the key assumptions of the FMP should be incorporated into model. Conditions 1-4 will take one to two years; the time required for condition 5 will vary by assumption. Results from adaptive management trials obtained over the next two years should certainly be incorporated into the next version of the model, and the results of adaptive management trials should be part of regular model application and testing. In the meantime, interim decisions on timber harvest could be made based on existing information (including existing model runs) prior to completion of these 5 conditions, provided that such decisions did not foreclose the option of choosing a different long term strategy (i.e. TA vs. HCP) in a couple of years after the above improvements have been completed. The fifth reviewer felt while the above improvements were all valuable and worthwhile, the models could also be used in their current form for aiding such decisions.

Improvements in Future Modeling Efforts. Some improvements are outlined in the above paragraph. The following table describes the Panel's recommended improvements for the future.

Input Data	Rules	Output / Runs	Project Management	Field Monitoring
Strata aggregation → stand-based inventory growth projection; stand-level imputation Move away from structure classes to habitat attributes of vertebrates and invertebrates Set the period length so that yield tables can be grown to a period mid-point (e.g. 6-year instead of 5-year interval)	Incorporate variation into analysis, e.g. stand-based inventory growth projection; use "bootstrap" module of FVS that uses different random starts to each simulation Include future northern spotted owl circles in model explicitly Improve habitat models Better reforestation / regeneration model to fit into FVS level of overall results diagram (on page 44 of the ODF H&H Model Final Report)	Include ecological classification in reporting Incorporate variability and confidence intervals on output Document sensitivity analysis Use different random starts to each simulation (Monte Carlo) More analysis of results already obtained; work on visualization of output; emphasize transparency as a major function of model	ODF extremely vulnerable to staff departures – must train more modelers to run / change/ document model output. Risk management plan. Document code / runs / rules to increase transparency Make conscious choice in balance between Harvest and Habitat in workload Institute formal project management to deal with continuous improvement, periodicity of analyses, expectations and time tyranny, and to permit continuous response to requests Build a complete prototype and apply it on a small scale Differentiate between development versions and production versions Open up the process to frequent outside review	Adaptive Management program to test critical uncertainties, efficacy of thinning

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1. Introduction

1.1 Review Goals and Objectives

The Harvest and Habitat (H&H) models are intended to assist in making decisions about whether to make changes in the Northwest and Southwest Oregon Forest Management Plans (FMP), whether to pursue a Habitat Conservation Plan (HCP), and setting harvest levels for Annual Operation Plans. The peer review targeted the modeling approach, the models themselves, the model outputs, and their interpretation, and was based on the best available science.

The specific objectives of the review were to:

- Assess the strengths and weaknesses of the models (including the level of confidence in model results).
- Determine what kinds of decisions can, and cannot, be made credibly using the models.
- Help the ODF determine the most appropriate application of the models in the decision-making process.
- Improve future modeling efforts.

1.2 Methods

Questions for the Review. ESSA Technologies of Vancouver B.C. was selected by ODF to conduct the peer review based on a competitive proposal. The ESSA team (David Marmorek [panel chair], Carol Murray, Don Robinson) developed a set of questions for the review (Appendix A), based on the terms of reference for the review and ESSA's experience in both applying models to resource management decisions and organizing (as well as attending) peer review panels. The set of questions for the peer review was approved by the Oregon Board of Forestry.

Evidence for the Review. The ODF contact for the peer review (Jeff Brandt, Adaptive Management Unit Manager) asked the H&H model team to assemble reports, technical memos and other material which would serve as a body of evidence for the peer review, and made all of this material available on an ODF website. To assist reviewers, the H&H model team also prepared a file which cross referenced each of the documents to each of the questions. ODF then assembled personnel from the H&H team to provide the peer review panel with oral information on the work, and answer their questions, during an intensive "Review Week" from July 10-14, 2006 (see Schedule for Review Week, Appendix B). The H&H team provided additional written material during the Review Week to further answer specific questions asked by the panel as they progressed with their review. A full list of the materials provided to the panel before and during the Review Week is provided in Appendix C. During the Review Week, informal notes from each half-day session were printed and distributed to the panel at the end of that session to help give them a record of the verbal evidence, allowing them to focus on listening to the discussions.

Selection of the Panel. ESSA drew from their own network of contacts as well as suggestions from ODF and recommendations from independent academics to develop a list of candidate reviewers with expertise and experience in one or more of six key areas: 1) forest science, including growth and yield relationships; 2) harvest scheduling modeling; 3) forest ecology; 4) wildlife science; 5) decision support systems; and 6) familiarity with the Oregon forestry situation. Any candidate reviewers with a potential conflict of interest or unavailability during the time period of the review were excluded from further

consideration. From the remaining candidates, ESSA then assembled a Panel of five individuals whose expertise and experience (described in Appendix D) jointly covered the six required areas of expertise. The five members of the Panel selected were:

- Dr. Terry Droessler, Forest Analytics LLC, Monmouth OR;
- Mr. Glen Dunsworth, Glen Dunsworth Ecological Consulting, Lantzville BC;
- Dr. Ross Kiester, Biodiversity Futures Consulting, Corvallis OR;
- Dr. Robert Monserud, PNW Research Station, USFS, Portland OR; and
- Mr. Steven Northway, Nanaimo BC.

Prior to the Review Week, the Panel reviewed the questions and available materials. ESSA organized a conference call with the reviewers on July 5th, 2006 to ensure that the questions were clear and comprehensive, to discuss the materials provided for the review, and to elicit the Panel's suggestions for further documentation or presentations to be provided during the Review Week. The Review Week itself was organized into four parts: 1) Monday through Wednesday noon focused on a review of the written evidence and well as interviews and dialogue with H&H Team personnel (all of these discussions were recorded in writing); 2) panelists worked independently for the remainder of Wednesday to complete their answers to the review questions; 3) the Panel worked jointly on Thursday to synthesize their main findings, determining where they agreed and where they disagreed; and 4) the Panel presented their main findings to H&H team members, and engaged in further dialogue with the team to explain both the rationale and nature of their conclusions.

Principles for the Review Week. The Panel agreed to the following principles for their peer review:

- Panelists will be hard on the problem, and easy on the people from the H&H team whom they interview.
- During the interview portion of the Review Week, panelists will engage in dialogue with members of the H&H team to both find answers to their questions and to explore whether their preliminary recommendations are reasonable.
- Panelists will independently answer the review questions, based on their assessment of both the written evidence and oral discussions with H&H personnel.
- Panelists' answers to the review questions will include their rationale and supportive evidence, making explicit the assumptions and uncertainties inherent in their answers.
- The independent reviews will be included in the report (Section 4), together with a jointly authored synthesis (Section 2).
- Once independent reviews have been completed and circulated, the Panel will endeavor to clarify areas of agreement and disagreement.
- In compiling the synthesis, the Panel will work together to identify their overall conclusions and recommendations for each of the six categories of questions, as well as additional overview questions provided by Drs. Hobbs and DeBruyckere.

Structure of this Report. Section 2 reflects the synthesis developed by the Panel on Thursday (which focused on the 'bottom line' questions) as well as a synthesis completed subsequently for other more technical questions. Section 3 provides a collation of panelists' responses to each question, drawn from the reviews completed independently by each panelist, which are contained in Section 4. We have endeavored to reflect the full diversity of the Panel's opinions.

2. Summary

This section summarizes the views of the panel under the main topics and themes that guided the review (see Appendix A for the list of questions addressed by the reviewers). There was more agreement among panel members for some questions than for others; the panel worked hard to determine areas of agreement and disagreement. Figure 2.1 illustrates the diversity of ratings provided by the five reviewers for questions 1 through 16. The more informative insights are on each reviewer's detailed answers to all of the questions (provided in Section 3 by question, and in Section 4 by reviewer).

Overall the Panel members were extremely impressed by the dedicated effort of the H&H model team over the last several years to complete a great deal of work in a very short period of time with limited staff and funding resources. All of the personnel that the Panel interviewed were extremely open, helpful, and knowledgeable.

2.1 Appropriateness of Model Structure

Are the structural features of these models (e.g. spatial/temporal scale and resolution, major components and functional relationships) appropriate to the decision problem they are trying to address, and to the available data?

- Yes, in general, with the following qualifications and recommended improvements (described in more detail in the third column of the table in Section 2.6):
    - The structure needs to be improved so that model output will reflect the variability / uncertainty in both input data and critical functional relationships. The Panel feels this would help both decision makers and scientists to discriminate between alternatives that are truly different, versus those that are essentially the same given the uncertainties in input data, functional relationships and future random events.
    - The structural features are appropriate for timber, somewhat appropriate for Northern spotted owl and marbled murrelet (though with some needed improvements), but not appropriate for broader biodiversity (structural classes used for coarse filter species are not a good proxy indicator for general biodiversity).
    - There is a technical problem with taking the midpoint of a five-year interval as being two years.

Are the simplifying assumptions and limitations of the models clearly described?

- Yes…
    - The limitations and assumptions were clear via oral discussions with the developer and with the modeling team.
- …and No
    - The team has not had sufficient staff resources and time to properly document the model framework and its implementation. There are hundreds of identifiable assumptions made in the process of creating this model, but the written documentation only provides some of these. ODF should obtain additional resources to properly document assumptions and runs of the model - or make a conscious and explicit decision *not* to document the models (and make this decision clear). While not documenting the models might save money in

the short term, it would be very expensive in the longer term if there are departures of key staff.

- The code is proprietary and therefore unavailable and undocumented.

2.2 Adequacy of Input Data

Is the accuracy and precision of underlying data sufficient for the intended purpose, and the scale it needs to be applied?

- Yes…
  - The data are adequate for the intended purpose, but the model strata structure (required initially due to poor inventory data) is no longer required and actually ignores valuable information about spatial variability contained in the forest inventory data
  - However, use of the models should be limited to be consistent with the qualities of the data (see concerns below).
  - The data are adequate to address question of whether intended stand treatments and harvest schedules will address the problem of stand and landscape simplification.
  - Harvest Unit Boundary mapping and the Road Network appear to be well executed.
- …and No
  - Strata-based simplifications of inventory data are insufficient, but soon the actual data will be used directly in the model (a necessary and high priority improvement).
  - Habitat data are insufficient to assess coarse filter species needs, and assess spotted owl impacts.
  - The linkage between forest stand information, structure classes and habitat is weak.
  - Accuracy and precision require a measure of variation/uncertainty, which is lacking.

Have sensitivity analyses been done to assess which input data are most critical to the choice of alternative management strategies?

- No, or at least it's difficult to tell because there was no written documentation of such analyses. The sensitivity analyses that were done appear to have focused on the impact of different expressions of goals and constraints (rather than the input data or functional relationships). These analyses were described orally, and it appears that the foresters in local districts had an opportunity to informally game with the model to gain confidence in its performance. There is currently an excellent opportunity in the Elliott District Forest to assess the sensitivity of the model to strata summaries of the inventory versus direct representation of the inventory.

2.3 Validity of Underlying Assumptions

Are the underlying assumptions sound / valid, for each of the major model components (i.e. wood harvest, revenue and costs, growth and yield, biodiversity)?

- Yes…
  - In general. The Sessions optimization algorithm using simulated annealing is superb, state-of-the-art.
  - However, assumptions for harvest seem more sound/valid than assumptions for biodiversity.

- …and No
    - The assumption that a strata-based inventory represents the inherent variability of stands is not valid. The current excellent forest inventory (50% stand coverage) now supports a stand-based yield projection system (with Forest Vegetation Simulator [FVS] using stand inventory tree lists directly).
    - Estimation of known habitat requirements for northern spotted owl, marbled murrelet and coarse filter species through structural classes is not well supported with empirical data. The measure of success seems limited to achieving adequate Complex Structure, rather than monitoring actual wildlife response.

Do the FVS growth models take into account the major biological factors which need to be considered in estimating growth and yield for these Oregon forests? (Variants of the USFS Forest Vegetation Simulator can consider root rot, dwarf mistletoe, and insects such as spruce budworm – are any of these critical to these forests, and missing?)

- Yes (for the major factors of stand growth and yield, and background mortality); other factors were evaluated and considered to be either not significant or easily represented.
- …and No (mostly due to limitations in the inventory data).
    - Minor factors such as root rot were considered in a simple manner because input data for more detailed representation are mostly lacking.
    - FVS has a module for snags and downed logs that was not used because the inventory existing at the time was inadequate to calibrate the model.
    - FVS does not grow new plantations, so regenerated stands and early silviculture could not be explicitly modeled.

2.4 Natural Disturbances and Processes

Do the models deal adequately with important natural disturbances and processes in these forests (e.g. windthrow, fire, root disease, Swiss needle cast, natural regeneration after harvesting or fire)?

- Yes, in general, but only for Swiss needle cast and *Phellinus*.
- Endemic levels of disturbance are felt to be incorporated in the yield model.
- Fire was not considered to be a major risk due to the high road density and ability to control fires. The Panel was told that if a major fire did occur, despite the high level of fire control, "we would just start over with what's left". This uncertainty of a random and rare but major fire event is not factored into any of the harvest volume calculations. While it might not affect the relative difference between alternatives it might affect the absolute level of harvest.

Do the models facilitate creation of harvest areas that mimic the sizes and shape of natural disturbances?

- Apparently not, but this was not considered to be important or high-priority for these models.

2.5 Key Functional Relationships and Constraints

Have the models been through a detailed sensitivity analysis to determine which functional relationships, parameters and constraints most strongly affect the choices amongst alternative decisions?

- Yes and no. It's difficult to tell what was done, and how much was done, as it was not well documented due to a lack of sufficient time and staff resources. Discussions with the team

revealed that extensive sensitivity studies were performed on model parameters and goals during model development, but these were not formally defined or documented.

Are the key functional relationships, parameters and constraints (e.g. habitat requirements of focal fish and wildlife species) grounded in strong empirical data?

- Yes (for the tree, stand, and harvest engineering parts of the model) and no (for the habitat aspects of the model).

2.6 Usefulness of the Models for Decision-making

How useful are the H&H models for the intended strategic and tactical level decisions to which they will be applied? [Specifically, can they be used to decide among the 4 options: FMP using a HCP, FMP using Take Avoidance, wood-emphasis, or reserve-based? Are these models appropriate for making decisions about: 1) whether to make changes in the Northwest and Southwest Oregon FMPs, 2) whether to pursue a HCP, and 3) setting harvest levels for Annual Operation Plans?]

We addressed this question in three parts, pertaining to each of the types of decisions (first column of table below). For each decision, we first asked if the H&H tool should be used in its current form. For those Panel members who felt that the H&H tool was not currently useful for a certain type of decision, we asked them what improvements would be required before the tool could be applied, and how long those improvements would take.

Types of decisions	**Use H&H tool in its current form for this decision?**	**If model not currently appropriate, then when? What model improvements need to occur first?**
1. Changing NW and SW OR Forest Management Plan (FMP)	No (4/5). 4 out of 5 panel members felt that it was inappropriate to use current H&H model for assisting in this decision, due to model weaknesses in the input data for stand inventory, the representation of wildlife habitat, and the representation of both spatial variability and uncertainty.	Need to wait until 5 conditions are completed: 1) stand inventory data used directly in model in place of strata averages; 2) variability better incorporated into model rules and output (e.g. confidence intervals); 3) greater analysis, visualization and transparency of output; 4) wildlife habitat for ~10 vertebrate species represented in terms of actual habitat attributes (e.g. dead wood, shrubs) rather than structure classes; and 5) near term results from adaptive management trials of the key assumptions of the FMP should be incorporated into model. Conditions 1-4 will take 1-2 years; the time required for condition 5 will vary by assumption. Results from adaptive management trials obtained over the next two years should certainly be incorporated into the next version of the model, and the results of adaptive management trials should be part of regular model application and testing.
	Yes (1/5). 1 panel member felt that despite the above weaknesses the current model may be useful to knowledgeable analysts and decision makers for exploring the *harvest level* impacts of changes in various parts of the FMP (but not *wildlife habitat* implications).	Implement conditions 4 and 5 to improve wildlife habitat portion of the model.

Types of decisions	Use H&H tool in its current form for this decision?	If model not currently appropriate, then when? What model improvements need to occur first?
2. Deciding among the 4 options and whether to pursue an HCP	All panel members agreed that while the models helped to show the differences between the Wood Emphasis and Reserve-Based alternatives, the outcomes of these alternatives were so far apart that decisions would depend mostly on social value tradeoffs, and would not be greatly assisted by modeling. So the modeling issue boils down to whether the model can help decide between FMP+HCP and FMP+TA.	
	No (4/5). Four panel members felt that the model output is misleading because of the weaknesses outlined above under decision 1, particularly the lack of confidence intervals around the output which makes it unclear whether the harvest levels actually differ between HCP and TA. They also felt that the HCP vs. TA decision is not dependent on model predictions at all, but rather almost totally dependent on a risk analysis of barred owl vs. northern spotted owl population dynamics, and marbled murrelet dynamics (i.e. analyses outside of the model). Hence the model isn't of much use in deciding amongst these alternatives. The fourth panel member was concerned that the post-processing approach to the impact of owl circles led to inaccurate outcomes.[1]	Make the improvements outlined under decision 1, and also get more information on barred owl vs. spotted owl population interactions. Spend the time and effort to work with John Sessions (or others) to modify the code to find harvest schedule solutions in the face of future owl circle limitations, rather than post-processing results. After all of these steps are completed (~5 years), reapply the model with a more realistic set of NSO population scenarios, and re-examine the HCP vs. TA decision.
	Yes (1/5). One reviewer felt that the current model had been helpful in supporting HCP vs. TA decisions, despite its weaknesses and the crucial need for better information on northern spotted owl and marbled murrelet.	
3. Setting harvest levels for Annual Operation Plans	Soon (5/5). This is the most appropriate type of application of the current model. All five reviewers felt that once the strata inventory was replaced with direct stand inventory information, the model would be helpful for examining *harvest* levels, though not wildlife habitat.	For wildlife habitat indicators, make the improvements outlined under condition 4 of decision 1. Conditions 2 and 3 of decision 1 would help to manage expectations by adding variability and transparency.

2.7 Credibility of the Models

Is the model credible—able to address decision issues for which it was intended?

- Generally, yes, the model is credible, though the appropriateness of the model varies for different types of decisions (see Section 2.6), and the harvest output is much more credible than wildlife habitat output;
- Credibility could be improved with the improvements described in Section 2.6 above.

How should outputs from models like this be used?

- The model's output can be used to assist in making management decisions for which its structure and output is appropriate (see Section 2.6).

[1] It is important to note that the weaknesses mentioned (for both the first and second decision type) are technical. The Panel felt that despite these weaknesses, the models were more useful in informing decisions among alternatives than if no modeling had been completed. Much confidence can be gained by forestalling long-term decisions until the short-term technical improvements can be made.

- It can be used to guide policy and provide strategic direction, using the output primarily as a general guide to the magnitude of harvest levels over time.
- It can be used as a feedback tool in adaptively refining the management plan.
- It can be used to display uncertainty to the managers (after variation has been incorporated), so that decisions can be taken which are most robust to various uncertainties.

What types of discussions should we be having about the outputs?

- Greater examination of variability and uncertainty.
- Improving documentation, communication.

And how should it NOT be used?

- Focusing on only one projection (as in H&H Final Report).
- Guiding specific actions on harvest blocks.

Can we do something to put confidence intervals around model output or explain it better to move away from one number and talk about a range of numbers?

- Yes.
    - A limited Monte Carlo simulation procedure could generate a measure of response surface variability for a given decision variable.
    - Regarding growth and yield inputs: attempt to reflect the natural variability in forest growth.
    - Regarding definition of structural classes: attempt to reflect the uncertainty inherent in threshold values for TPA (trees per acre), DBH (diameter at breast height) and DDI (diameter diversity index).

2.8 Model Testing

Is the model adequately tested? (i.e. input data checked, rules implemented correctly, computations correct given rules, functional relationships confirmed empirically, model output assessed by field personnel for reasonableness) ?

- Yes, testing appears to be quite extensive and thorough for computational aspects of the model.
    - Carrying the testing all the way through to field foresters was thorough, and laudable.
    - There was also independent testing by MB&G.
    - Functional relationships between DDI+TPA, structure and habitat cannot be tested because they are not known or understood empirically.
    - More written documentation of these tests is required, but was not possible due to the limited staff resources and time

2.9 Overall Strengths and Weaknesses

What are the inherent strengths and weaknesses, particularly to goals and objectives that program is trying to achieve with it?

- Strengths:
    - Optimization model achieved through heuristic algorithms.

  - Ability to deal with spatially explicit nature of the problem, roads, and large problem size.
  - Strong inventory (now); was not true seven years ago.
- Weaknesses:
  - No formal project management (e.g. no goals for incorporating new information, or for timeliness of additional analysis – i.e. avoiding gearing up for, or explicitly choosing to gear up for, an analysis every five years).
  - Habitat portion of the model (approach to using structural classes, rather than structural attributes, for species whose structural attribute needs are well understood and can be modeled from the inventory data).
  - Risks associated with the maintenance and continued development (only one developer, one operator).

Are there any fatal flaws in the model, underlying data / assumptions, or its application?

- No

Are there any other kinds of models in existence we should consider using to overcome weaknesses of the current suite of models?

- Your choices were fine (Sessions model, FVS).
- In near future, an improved regeneration model should be available from Martin Richie (PSW-Redding) using additional Stand Management Cooperative (SMC) data.
- Dave Hann (OSU) is recalibrating his OREGANON model using all SMC data. When available, this should be re-examined.
- Patchworks is a model of similar capabilities (Moore and Lockwood); has a graphical user interface to allow for a broader set of users and provide insurance that the modeling can evolve as better data are collected in the future.
- FPS (there were different views among panel members on this – one strongly advocated the recommendation while another advocated equally strongly against it).

2.10 Process of Model Development

What about our model development process?

- Excellent.
  - Recruited Dr. Sessions, a world authority.
  - Realized forest inventory was weak and limiting, and improved it greatly.
  - Contracted with MB&G to conduct certain analyses (growth model evaluation; yield table generation) and to do independent testing.
- Few people involved in model creation, given size and complexity. This has advantages but can also constrain development (e.g. documentation, source code control).
- Seemed under funded and under staffed to meet timeline expectations.
- Outside panel could have been (and could be in future) used at major decision points.

How can you make something like this more transparent?

- Try to display variability and uncertainty.
- Switch from stratum aggregation to stand-based yield prediction.
- Consider visual aids such as a 3-D models.
- Asking field foresters to examine model results was a strong attempt at transparency.
- More complete documentation.

Is there anything we can do to develop a clear set of stakeholder expectations from the next round of modeling?

- Display variability and uncertainty rather than ignore it.
- Explain that a single mean projection is not certainty, and that a Low projection might be as equally likely as a High projection (given the same initial conditions, targets, and goals).

Do you have advice for us on how to set clear expectations?

- Have a frank discussion among operations staff and Board re expectations and needs.
- Be clear that while the model will not guide specific stand actions it must reasonably portray an agreed management direction - should not be a line or a number but a *range*.

2.11 Next Steps

What are the key priorities for overall improvement in the models, given the intended applications?

Input Data	Rules	Output / Runs	Project Management	Field Monitoring
Strata aggregation → stand-based inventory growth projection; stand-level imputation Move away from structure classes to habitat attributes of vertebrates and invertebrates Set the period length so that yield tables can be grown to a period mid-point (e.g. 6-year instead of 5-year interval)	Incorporate variation into analysis, e.g. stand-based inventory growth projection; use "bootstrap" module of FVS that uses different random starts to each simulation Include future northern spotted owl circles in model explicitly Improve habitat models Better reforestation / regeneration model to fit into FVS level of overall results diagram (on page 44 of the ODF H&H Model Final Report)	Include ecological classification in reporting Incorporate variability and confidence intervals on output Document sensitivity analysis Use different random starts to each simulation (Monte Carlo) More analysis of results already obtained; work on visualization of output; emphasize transparency as a major function of model	ODF extremely vulnerable to staff departures – must train more modelers to run / change/ document model output. Risk management plan. Document code / runs / rules to increase transparency Make conscious choice in balance between Harvest and Habitat in workload Institute formal project management to deal with continuous improvement, periodicity of analyses, expectations and time tyranny, and to permit continuous response to requests Build a complete prototype and apply it on a small scale Differentiate between development versions and production versions Open up the process to frequent outside review	Adaptive Management program to test critical uncertainties, efficacy of thinning

Additional thoughts and suggestions from the panel during the presentation and discussion of the key review results on Friday July 14th, including responses to questions from the H&H team:

- Regarding project management:
  - Start small: build a complete prototype fairly quickly and apply it on a small scale, where the complexity is not so great as to hinder learning. Then build on that. (This is known in the trade as "agile development".)
  - Involve other modelers in "model evaluation days", to keep in step with new ideas and new data and provide a regular look with fresh eyes. Small teams have some advantages, but don't provide as many opportunities for cross-fertilization.
  - Time your model-running schedule to coincide with when new data are available, e.g. annually once the new inventory data are released. That would also be a good time to move from the prototype and try it on the whole Tillamook District, for example.
  - Take the time to fully and clearly document the process, which will make subsequent iterations go more smoothly. Also be clear about what kind of turnaround time is needed to answer questions at this kind of scale. A two-year turnaround need not be more expensive than a five-year turnaround, but you need to leave a fair trail behind of what is done each time.
  - Remember that modeling is a continual exercise in process, not a discrete thing. The model should be available to be run at any time and at any point. Differentiate between

development versions and production versions, and keep track of them in an automated fashion using revision control systems. This is all part of good project management.

- Regarding the structure work and the coarse filter matrix:
  - To deal with coarse filter species, collapse the list and grow attributes, not structure classes (e.g. project dead wood and shrubs, not just live trees). The inventory already contains much of this attribute information. Just like the tree list, implement this on a stand-by-stand basis, which does not require any changes to the model design. Based on input from the MB&G review, dead wood modeling is dependable enough that it should be incorporated.
  - The structural classes work in guiding the project towards greater structure, and the implication is that this will lead to increased biological richness. You need to verify through the results of adaptive management trials currently underway. You need to model more than just structural classes, and see if you are actually getting the habitat attributes that you want for various species. Field trials can inform you as to whether these habitat attributes are indeed associated with better species abundances – and then add any new knowledge gained by this back into the model.
- Regarding uncertainty:
  - There are 3 kinds: uncertainties in input data (e.g. measurement error, sampling error and aggregation error in the forest inventory), stochastic uncertainties (e.g. fire, spatial distribution of future spotted owl), and the functional relationships in the model (e.g. stand growth rules, rate of Northern spotted owl population decline). It is important to show and understand uncertainty and how each type affects outputs and decisions. Different kinds of uncertainty may affect the output but not necessarily the relative ordering of the key performance measures. Uncertainty can be incorporated as confidence bands around output points or lines and help decision makers determine whether output scenarios are truly different from each other.
  - The model could be set up within a batch process whereby the model can iterate through Monte Carlo analyses that vary different factors (e.g. growth and yield curves, rates of spotted owl decline, wildlife habitat functional relationships) to see which factors affect decisions amongst alternatives for a given set of weights on parts of the objective function.

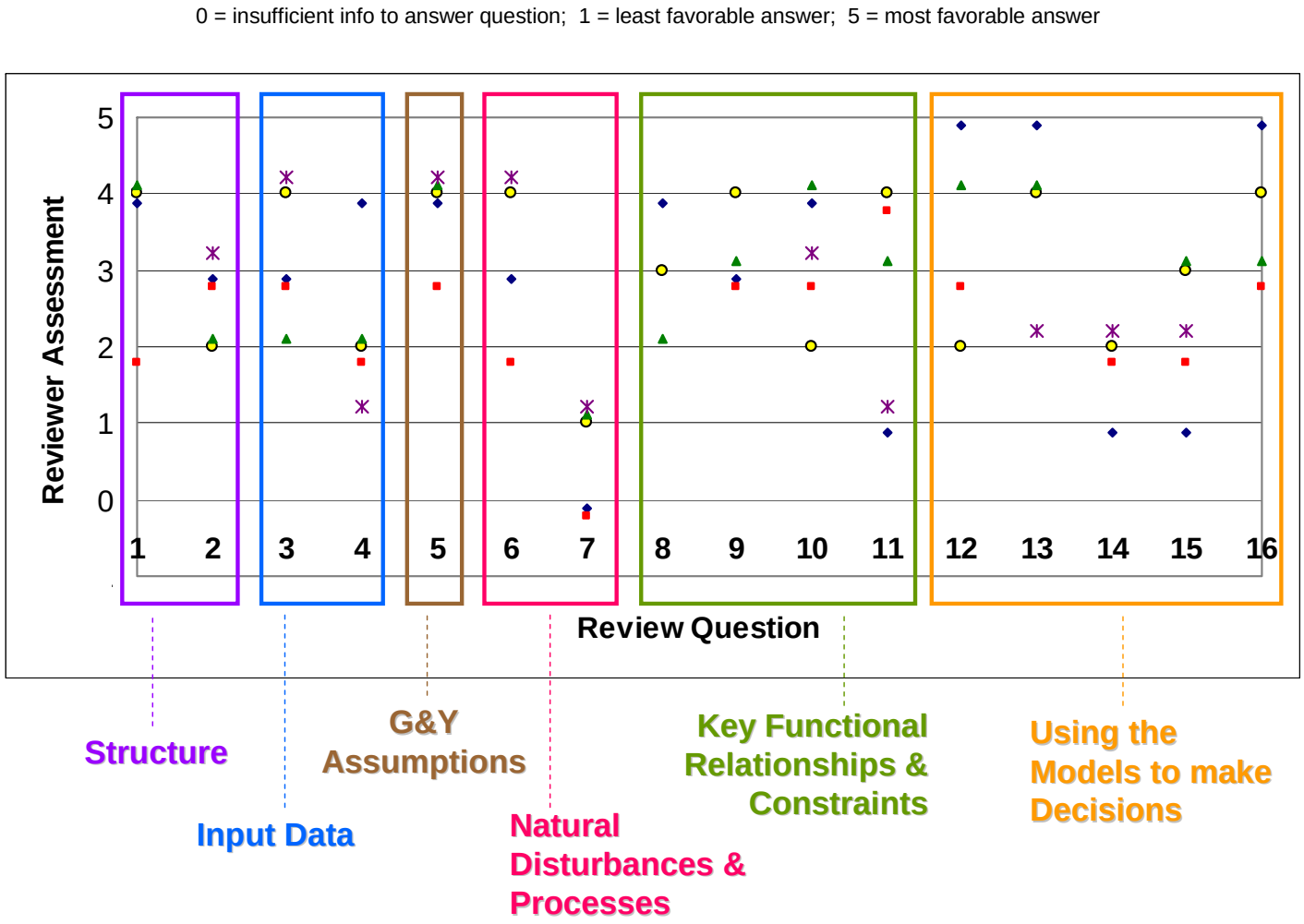

Figure 2.1 Distribution of assessments for questions 1 through 16 across the review panel.
Some symbols are slightly above or below the lines corresponding to the actual assessment numbers (0-5) purely for the purposes of preventing overlap and allowing the distribution of assessments across all reviewers to be viewed for each question.

2.12 Comments from the Chair

My role during the week was to facilitate the Panel, and ensure that their independent and joint conclusions were fairly presented in this report. I was tremendously impressed by the dedication of both the H&H model team, and the Panel members. Both groups are very professional, and deeply committed to advancing the quality of decision support systems for management of forests and wildlife habitat. These comments allow me to add a few insights which might be helpful.

Decision making is difficult. It involves weighing different objectives or values, and making decisions despite uncertainty in the outcomes for each of these objectives. Hammond et al. (1999[2]) have written a wonderful book which might be helpful to the Board of Forestry in making their decisions, and to the H&H Model Team in organizing model output to assist those decisions. The task set for the H&H models is especially difficult because optimization is desired for multiple criteria.

There are many different types of uncertainties in model outputs (Figure 2.2). What's important is to figure out which uncertainties really affect the choice of alternative actions, and focus on reducing those.

The members of this Panel are applied scientists. They would like decision makers to use models in a manner that is both helpful and scientifically defensible. They therefore have stressed the importance of ensuring that model output clarify the *range* of potential outcomes of alternatives, but does not hide the abundant uncertainties in those outcomes. While managers might prefer the simplicity of single lines of projected outcomes (as displayed in the Final Report of the H&H Model Project), there is a great risk of believing too much in those lines. If the uncertainty around these alternatives is quite different, then even though one option may appear better *on average*, it may be more risky. Figure 2.3 is adapted from a graph on page 44 of the Final Report. In this representation, it's assumed that uncertainty in harvest levels increases over time, and that the level of uncertainty is about the same for both the HCP and TA alternatives. However, the level of uncertainty might be quite different (e.g. indeed, it's probably higher with the TA alternative given the uncertainty in future trends of northern spotted owl), and that difference in uncertainty might affect decisions. It's not only the average value that matters, but also the risk of reaching really low values for a given objective. Ideally, decisions should be made that are the best at meeting various objectives, while being robust to various key uncertainties that affect those decisions. This is why it's important to have modelers document the uncertainties in projected outcomes, and clearly communicate those uncertainties in a manner that helps decision makers make choices.

- David Marmorek

[2] Hammond, J.S., R.L. Keeney, H. Raiffa. 1999. "Smart Choices: A Practical Guide to Making Better Decisions". Harvard Business School Press.

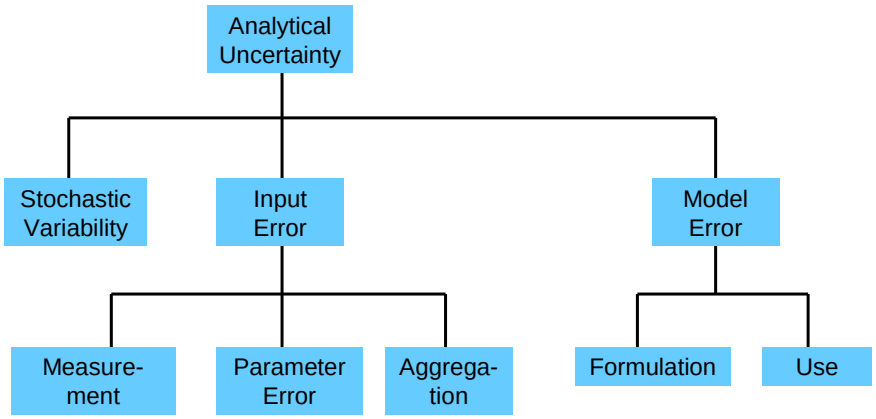

Figure 2.2 Sources of uncertainties in model output.
Stochastic variability includes unexpected random events like fires, exotic species invasions, and major storms. Input error occurs because things can't be perfectly measured, and simplifying assumptions are made to aggregate over space and time. Model error occurs because models are necessary simplifications of all of the processes in nature (the rules are incomplete), and sometimes errors are made in how models are used (e.g. coding errors, misapplying rules from a different location or species). Source: Suter et al. 1987.

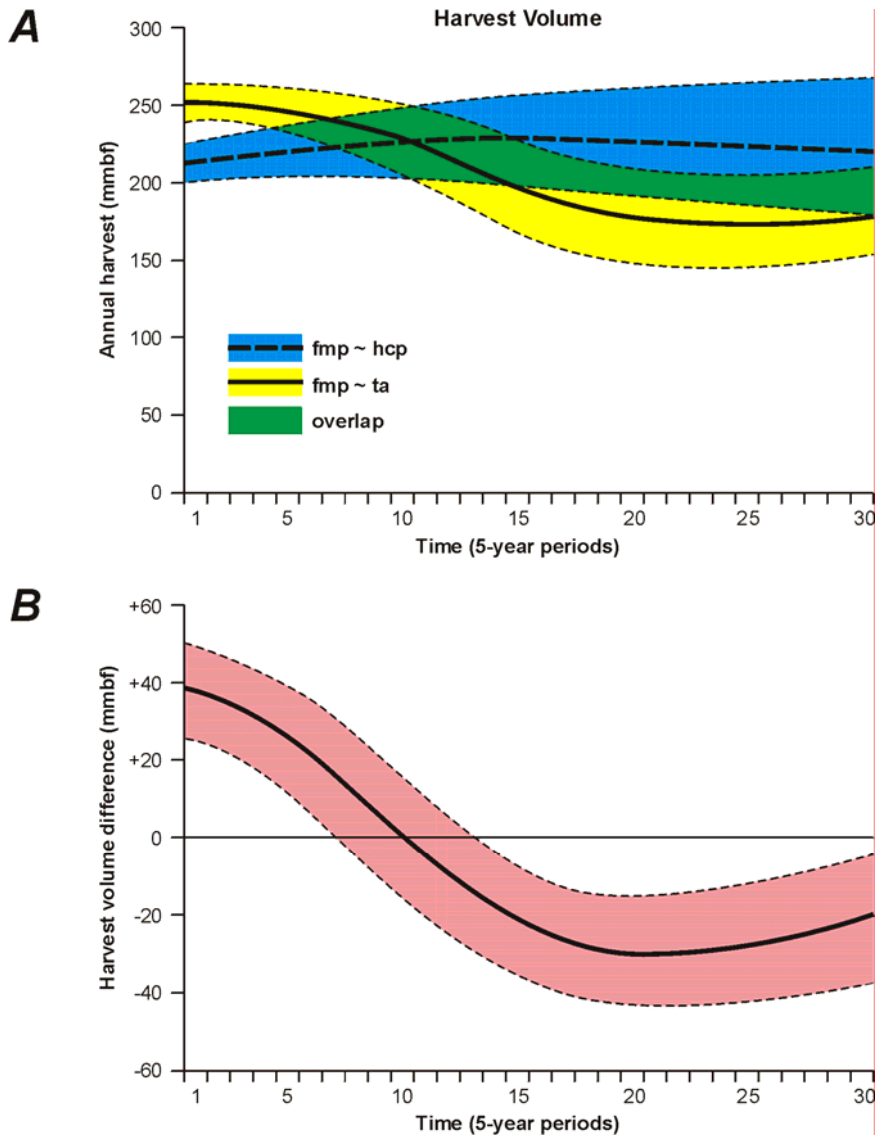

Figure 2.3 Illustration of the importance of confidence intervals.
Graph A: Harvest volumes under the FMP-HCP and FMP-TA alternatives (from page 44 of H&H Model Project Final (March 2006)), with hypothetical 90% confidence intervals. Graph B: Approximate differences between HCP and TA harvest volumes (drawn by eye) from Graph A, with hypothetical 90% confidence intervals. This graph assumes that the uncertainties affecting the HCP are independent from those in the TA alternative. If the uncertainties are strongly correlated among the two options (e.g. the same assumptions cause higher harvest estimates in both the HCP and TA options), then the confidence intervals in Graph B (the difference) would be much narrower. That is, there would be much less uncertainty in the projected difference between the two alternatives than in the projections for each alternative.

3. Full Results by Question

This section presents the contents of the full review reports written by each reviewer, organized by question. This will allow the reader to easily view the range of opinions across reviewers for any given review question.

A. Structure

1. Are the structural features of these models (e.g. spatial/temporal scale and resolution, major components and functional relationships) appropriate to:
a) the decision problem they are trying to address, and
b) the available data?

Overall assessment:

Insufficient information provided to answer question	Not appropriate at all	---------->			Very appropriate	Don't know - not my field of expertise
0	1	2	3	4	5	?
		X		XXX	X	

Droessler

Answer: Yes, they are necessary and appropriate, but insufficient.

Rationale: There are no confidence intervals around the "answers" so there is no way to discriminate whether one scenario is truly different from another (HCP vs. TA as an example). The trend lines alone indicate differences between scenarios, but without confidence limits, determining whether they are truly different is not possible.

Recommendations: Estimate confidence intervals (or at least some measure of uncertainty, confidence or risk) for the "answers" so that uncertainty is available to decision makers.

Overall assessment: 2

Dunsworth

Answer: a) Yes, for timber, NSO and MAMU habitat and No for biodiversity, b) Yes

Rationale: There is significant and useful detailed structure in the modeling framework for the portrayal of spatial and temporal constraints on timber, NSO and MAMU habitat. However, the structural classes used for the coarse filter species assessment provide a very weak structure for the assessment of biodiversity or a broader range of biological richness. The state of knowledge of structural requirements for at least some of these species (see J. Weikel 2004 review) is specific to structural attributes and that detail is lost in the generalization to structural classes. In addition the ecological distribution of structural classes cannot be assessed appropriately because no ecological units were included in the model. Either

the National Vegetation Classification System (NVCS) coverage used for the Oregon Gap Analysis or the International Terrestrial Ecological Classification System (ITECS) used by NatureServe could be used.

Recommendations: Consider renaming the Coarse Filter Wildlife Matrix-Species List to be the Species Accounting System. Then look to improving the model with the inclusion of deadwood dynamics (i.e. green trees moving to snags moving to coarse woody debris) possibly acting on the snag model recommendation from Mason, Bruce and Girard (March 8, 2005) to use the FFE extension of FVS for snag and downed log modeling. An additional improvement would be the inclusion of a shrub model which it appears could possibly be derived from the existing inventory, at least as a first approximation. Then the species model parameter list would need to be revised to replace structural classes with structural attributes. Finally, inclusion of NCVS or ITECS ecological units is recommended and should be used to report the distribution of complex structure within a District.

Overall assessment: 4

Kiester

Answer: a) The many spatial scales ranging from the smallest unit of treatment to a district are well represented in the model. The various polygons match the strategic and tactical level of analysis and provide some insight into operation scale issues. There is some overall disconnect between tactical and operational scales. This disconnect represents a real tension in the construction and use of the model. On the one hand the more the model considers an operational scale the better it communicates to the Foresters implementing operations. One the other hand the implementing foresters wish to retain authority to design operational plans and therefore may be wary of a model that provides too much specific detail. Overall I believe that the modeling effort is striking an appropriate balance between these competing desires.

b) Data on trees in the new stand survey and harvest engineering efforts are definitely at appropriate scales. There is a problem with taking the midpoint of a 5 year interval as being 2 years. This bias in this use of the stand survey data needs to be addressed (it is a fundamental problem in any discretization of a continuous process)

Rationale: The visualization of the polygon type spatial hierarchy presented in the discussion by the model team clearly showed what we needed to know.

Recommendations: Solve the discretization problem. Create visualization of the spatial structure of the model.

Overall assessment: 4

Monserud

Answer: Yes

Rationale:

Recommendations: Eliminate strata aggregation step now that a strong inventory supports stand-based yield projections.

Overall assessment: 4

Northway

Answer: Yes, the H&H model structure is generally appropriate for dealing with strategic and tactical forest management questions.

There were however several *ad hoc* procedures implemented by the user to accommodate current limitations in the model structure. One of these was the treatment of new NSO circles. Their impact was included as a *post hoc* analysis. This lead to an iterative set of model runs which could not fully address the risk of future NSO circles.

Yes, nothing need be lost from the available data in using it with the model. Any limitations are in the basic data.

Rationale: At the moment the limitation is in the basic data available to drive the model. As the stand-based data becomes available, it seems likely that the habitat functional relationships may become limiting. Now, the available habitat data may be more limiting than our understanding of the functional relationships, but as the available data improves this may reverse.

Under this scenario, the H&H model structure will not be limiting, I expect it to be the habitat relationships.

Recommendations: Review any *ad hoc* procedures as possible features with which to augment the current model structure, especially the treatment of new NSO circles.

Overall assessment: 5

2. Are the simplifying assumptions and limitations of the models clearly described?

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	2	3	4	5	?
		XX	XXX			

Droessler

Answer: Generally yes, but detail and clearly described rationale varies considerably across the models.

Rationale: The H&H model code ultimately shows assumptions and limitations, but it is proprietary and therefore unavailable and undocumented.

Recommendations: Document the code implementation of objective function, goals, constraints, weights, assumptions and limitations.

Overall assessment: 3

Dunsworth

Answer: In general, No. But the limitations and assumptions were clear upon interrogation.

Rationale: The Final Report does not provide sufficient description of the model framework and implementation to determine all the assumptions and limitations. During our interviews we were able to expose many of the limitations and assumptions both through Q+A and through existing documentation not included in the Final Report. As an example it is unclear in the report why there would be differences in Habitat Suitability determination among common Coarse Filter Species like black-tailed deer foraging or thermal habitat (Generalist- Multiple Structure- see page 39 in the Final Report). This was clear once we saw the Habitat Suitability coding for each species and their ecological rationale. Another example, it was unclear without further reading that 27 of the 58 Coarse Filter Species selected were deemed by the J. Weikel 2004 review to be "possible monitoring species but lack necessary species habitat information".

Recommendations: Further or more complete documentation is required. As an example, it should be clearer how the Coarse Filter Species habitat suitability was determined specific to what elements contribute to suitability and how.

Overall assessment: 2

Kiester

Answer: There are hundred of identifiable assumptions made in the process of creating this model. The written documentation gives some of these, but in general it would be difficult to reconstruct what was done from the documentation alone. On the other hand it was clear in discussion with the model team that they had a good idea of all of the other assumptions that they had had to make.

Rationale: Individual questions asked by the review team always elicited a detailed answer from the model team.

Recommendations: This is the fundamental issue of documentation. Overall the model is barely documented. Some parts of the model are deliberately undocumented because they are proprietary products. The modeling team is well aware of this lack. Documenting a model of this complexity of structure and of interaction with folks providing input is a very large task. It will not occur unless some personnel are assigned to this task (if this is to be done at least one technical writer would be required).

Overall assessment: 2

Monserud

Answer: Yes

Rationale:

Recommendations: Emphasize that strata aggregation eliminates variation in growth projections.

Overall assessment: 3

Northway

Answer:

- Limited in existing documentation.
- Yes, in discussion with the analysts.

Rationale:

- The documents, with which we were provided, were not sufficient to allow a 3rd party to duplicate the analysis.
- With the documents with which we were presented and 2 days of questioning the analyst, I feel I could closely duplicate the analysis.

Recommendations:

- Documentation would be a huge task and would provide information for a very limited audience. I would not recommend embarking on a detailed documentation task, unless public sector transparency demanded it. I think the current documentation, coupled with 3 party reviews, is adequate.
- Perform a benchmarking exercise of the documentation policy of similar exercises.

Overall assessment: 3

B. Input Data

3. Is the accuracy and precision of the input data generally sufficient for the intended applications of the models? Are weaknesses in the input data recognized by the model users?

Overall assessment:

Insufficient information provided to answer question	Data grossly insufficient; weaknesses not at all recognized	---------->			Input data sufficient; weaknesses recognized	Don't know - not my field of expertise
0	1	2	3	4	5	?
		X	XX	XX		

Droessler

Answer: Variable, but most weaknesses are recognized by the model users.

Rationale: The average stand tables used to populate strata ignore the variability between stands within a strata. So although measurement errors and sampling errors are recognized to exist, they were ignored. The habitat portion of the model relies on a linkages between (DDI + TPA), stages of stand development (structure) and wildlife habitat. The accuracy and precision of these linkages are known to be weak because the habitat requirements are not well defined for many species.

Recommendations: Go stand-based rather than strata based or introduce variability. De-emphasize the habitat capabilities of the model.

Overall assessment: 3

Dunsworth

Answer: a) No. b) Yes.

Rationale: The use of broad inventory strata tended to collapse much of the known and improving stand level inventory detail into planning polygons that made the predictions less precise than they might be. The model developer and users are cognizant of this limitation but tended to downplay this limitation in the writing of the Final Report. The same is true but less so of the use of Structural Classes instead of structural attributes for coarse filter species.

Recommendations: Move to a stand level inventory as quickly as possible. Include in that inventory stand structures particularly snags (number, size and decay class), coarse woody debris (cover, size and decay class), shrub, and forb cover.

Overall assessment: 2

Kiester

Answer: Under the assumption that the transition to stand-based modeling (from modeling via strata) will occur the tree and stand data used will be more than sufficient. Beyond the characterization of stand structure the data used to link stand structure to wildlife and biodiversity targets are not yet sufficient.

Rationale: The stand inventory procedure now bring implemented is well designed and will provide the necessary tree and stand data.

Recommendations: Complete transition to new inventory based model as soon as possible. Look into other Oregon research and modeling efforts such as Clams and the Gap Analysis Program for ideas and perhaps data to help wit the wildlife and biodiversity component.

Overall assessment: 4

Monserud

Answer: Growth model approach (Stratum Aggregation) is artificial and forced by a weak inventory 6-7 yrs ago. This situation is currently being ameliorated by a new, strong forest inventory.

Rationale:

Recommendations: Keep expanding inventory coverage, and plan for remeasurement cycle(s) to follow.

Overall assessment: 3

Northway

Answer:

- Yes, the use of the model is consistent with the quality of the data.
- I am not convinced that all users recognize the weakness of the modeling process.

Rationale:

- The application of the model has been defined by the accuracy and precision of the input data. It is to be used as a decision support tool for strategic and tactical planning.
- The weaknesses of the modeling process were well appreciated by the analysts.
- I did not get an appreciation as to whether the decision makers recognized the weaknesses of the modeling process.
- I had weak indication that some users were judging it on its applicability to operational decision-making, concluding that it was flawed. This could only happen if they did not recognize the limitations of the input data.

Recommendations: Work even harder at stressing that it is to support high-level decision making, not operational planning. In spite of seemingly great efforts, this message is not universally appreciated.

Overall assessment: 4

4. Have sensitivity analyses been done to assess which input data are most critical to the choice of alternative management strategies?

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses done on input data	---------->			Sufficient sensitivity analyses of input data	Don't know - not my field of expertise
0	1	2	3	4	5	?
	X	XXX		X		

Droessler

Answer: Generally no.

Rationale: Some ad-hoc runs to define "solution clouds" have been undertaken, but no formal sensitivity analyses have been defined, implemented and documented.

Recommendations: Allocate the time/budget to define, implement and document a formal sensitivity analysis.

Overall assessment: 2

Dunsworth

Answer: Some, but insufficient to cover all variables and not all those done were documented in the Final Report or in other written documentation.

Rationale: Sensitivity analysis should be directed at model components of the greatest uncertainty. Given that one of the major modeled differences between HCP and TA was % of owl clusters harvested per decade and that this was contingent on reaching complex structure targets in the HCP alternative, some sensitivity analysis was done on those targets testing the range in the FMP (40-60%). But no testing was done to determine the sensitivity to changing the proportions of LYR and OFS in the make up of complex structure or to test the sensitivity of the individual elements defining those classes (i.e. DDI, Tree height and DBH) or to test minimum time to achieving any structural target. Similarly, there was no sensitivity testing done on how changing the discount rate would influence the NPV determinations.

Recommendations: More sensitivity analysis should be done, particularly on the components of structural classes LYR and OFS, the timing of achieving complex structure targets, and on the discount rate.

Overall assessment: 2

Kiester

Answer: Overall, a well-designed and documented sensitivity analysis of the effect of variation in the input data does not appear to have been done. However, conversations with the model team indicate some level of experience in undertaking this activity.

Rationale: Conversations with model team.

Recommendations: As the new stand inventory data come online do a pilot sensitivity analysis of the data.

Overall assessment: 2

Monserud

Answer: This was hard to tell and not well documented. I asked Pam Overhulser and she described a long (1.5 yrs) series of sensitivity analyses done on individual model settings, levels, and variables. This sounded to be rather thorough model testing, which was independently evaluated by MBG.

Rationale:

Recommendations: Formalize a plan to examine sources of variation and their importance on decision making

Overall assessment: 4

Northway

Answer: No.

Rationale: Sensitivities were done, though not well documented, on the impact of different expressions of the goals and constraints. I saw no evidence of sensitivity analysis being done on input data. It was clearly recognized as an issue by the analysts.

Recommendations: Sensitivities of the decisions to uncertainties in the input data and functional relationships should be pursued. I carefully say "decisions", because many uncertainties may affect absolute results without affecting decisions.

Overall assessment: 1

C. Growth and Yield Assumptions

5. Do the FVS growth models take into account the major biological factors which need to be considered in estimating growth and yield for these Oregon forests? (Variants of the USFS Forest Vegetation Simulator can consider root rot, dwarf mistletoe, and insects such as spruce budworm – are any of these critical to these forests, and missing?).

Overall assessment:

Insufficient information provided to answer question	No major biological factors taken into account	---------->			All major biological factors taken into account	Don't know - not my field of expertise
0	1	2	3	4	5	?
			X	XXXX		

Droessler

Answer: Yes and No.

Rationale: Structure-based management utilizes silvicultural treatments to achieve structural targets. An estimate of existing stand clumpiness is available from the SLI data and a distance-dependent model could have been used to explicitly model existing spatial structure and the differential growth and spatial impacts of silvicultural treatments. The underlying spatial distribution of trees in FVS is whatever existed on the research plots the model was built from, which is assumed to be approximately uniform no matter the silvicultural manipulations.

FVS also does not grow new plantations, so regenerated stands and early silviculture could not be explicitly modeled. Evidently stand tables from Districts were substituted.

The FVS tripling option was available to interject variability and not used.

The decision to use FVS was based in part on model evaluation and testing done by MBG. The model comparisons did not comprehensively consider all important aspects of the available models, especially related to differential growth rates based on distance-dependent tree competition.

The distance-dependent competition in FPS recognizes stand clumpiness (available from SLI data) and is designed for modeling the differential growth of trees from silvicultural practices that manipulate tree lists to create openings and achieve structure, which is fundamental to the ODF structure-based management approach.

Recommendations: I strongly recommend the FPS model should be revisited at least on a pilot project level.

Overall assessment: 3

Dunsworth

Answer: Yes, but the full utility of FVS has not been captured.

Rationale: FVS has a module for snags and downed logs (FFE extension of FVS for snag and downed log) that was not used because the existing inventory was inadequate to calibrate the model. The improvements in the inventory now and in the near future would rectify this problem.

Recommendations: Use the FFE extension of FVS for snag and downed log in FVS calibrating it with the improved stand level inventory.

Overall assessment: 4

Kiester

Answer: Swiss Needle Cast and Root Rot are included in the model in an ad hoc manner. The model does not capture the stochastic nature of stand dynamics. Not everyone would say that stochasticity is a biological factor, but I believe that it is useful to think of it that way. Tables produced by expert judgment now handle reforestation and young stands.

Rationale: Section 7 lists how Swiss Needle Cast and Root Rot enter into the calculations of the model.

Recommendations: If it is clear that a variant of FVS could appropriately deal with these 2 factors on ODF lands it should be made to do so. Perhaps a pilot study could estimate the degree of improvement in the model that such a change would produce. The stochastic variant of FVS should be incorporated as soon as possible for a variety of reasons including the one given here that forests have inherently stochastic dynamics. The question of the use of other models for regeneration and young stand development should be revisited.

Overall assessment: 4

Monserud

Answer: Yes to the major factors: stand growth and yield, and background mortality. Minor factors such as root rot were considered in a simple manner because input data for more detailed representation are mostly lacking. The models are available but apparently the data are not.

Rationale: I am quite comfortable to the selection of FVS as a growth model. Excellent choice. It is easily the most widely used stand simulator in the country (over 20 regional variants), for well over 2 decades. Because it has been used extensively (and intensively) as a management planning tool (providing yield

streams under a range of management alternatives), it has of necessity been heavily tested. Robinson and Monserud (2003 For. Ecol. Manage. 172(1): 53-67) compared the available stand simulators in the Northwest for model adaptability, and concluded that FVS was the most adaptable model in the region. Their rationale included portability, extendability, source code availability, and documentation as important criteria. The FVS simulator is supported by the USFS Ft. Collins Service Center, both in maintaining current variants and developing new variants, as well as implementing new modules such as the Fire and Fuels Extension.

Regarding Dr. Droessler's strong recommendation to reevaluate FPS, I disagree. Robinson and Monserud (2003) also evaluated FPS for model adaptability, and found it lacking in several key areas. The code is proprietary and thus cannot be examined for logical and biological consistency and integrity. Because the code and executables are proprietary, FPS is not extendable (i.e., the addition of new features or capabilities). The statistical fit for FPS is not publicly documented. The FPS modeling system has not been published in the peer-reviewed literature, rendering the system a black box with unknown reliability and structure. The argument could be made that the Session's model is also proprietary (true), but there is one major difference. The Sessions model and its earlier variants have been extensively published in the peer-reviewed literature, whereas FPS has not.

Recommendations: Increase sampling of factors such as root rot if they are important on some districts. Implement the FVS-Root Disease module for those districts when data become available. Work with the folks at the USFS Ft. Collins Service Center (perhaps through MB&G) on the use of FVS variants such as the Fuels and Fire Extention (FFE), the Root Disease extention, and the Bootstrap Module (currently being implemented).

Overall assessment: 4

Northway

Answer: Yes.

Rationale: No better alternative is available. The current analysis is limited by the inventory data, not by FVS.

Recommendations:

- Keep a watch on the research around the impact of global warming on forest growth and pests.
- Consider risk management.

Overall assessment: 4

D. Natural Disturbances and Processes

6. Do the models deal adequately with important natural disturbances and processes in these forests (e.g. windthrow, fire, root disease, Swiss needle cast, natural regeneration after harvesting or fire)?

Overall assessment:

Insufficient information provided to answer question	No important natural disturbances or processes dealt with	---------->			All important natural disturbances and processes dealt with	Don't know - not my field of expertise
0	1	2	3	4	5	?
		X	X	XX		

Droessler

Answer: Generally yes, but some capabilities of the models were not used.

Rationale: Modelers are aware of tripling, windthrow, fire, root disease and other modules, but decided they could not implement them for lack of calibration data or inability to interpret the results in the context of the scenarios under consideration. Risk, uncertainty and variability were generally ignored.

Recommendations: The sources of error and their impact need to be explicitly acknowledged and incorporated.

Overall assessment: 2

Dunsworth

Answer: Yes, but only for Swiss needle cast and Phellinus

Rationale: Growth loss impacts were reviewed with the Districts where this is an operational problem. Those risk areas were zone mapped, growth reductions estimated and included in the model by zone. Phellinus was included only in Districts where it was significant (Forest Grove and North Cascade) and growth reductions estimated and applied to random stands.

Recommendations: No Change

Overall assessment: (not provided)

Kiester

Answer: At large scales, the model does not consider catastrophic disturbances and this is an appropriate design decision. As mentioned Root Rot and Swiss Needle Cast are dealt with through the use of an ad hoc adjustment (see above #5). Natural regeneration and reforestation are accomplished through expert produced tables.

Rationale: Section 7 shows how these factors are and are not incorporated into the model.

Recommendations: Modeling and projecting reforestation and regeneration should be revisited especially since young stand behavior is very important in multi-species, uneven-age stand development (compared to single species, even-aged plantations).

Overall assessment: 4

Monserud

Answer: In a rather ad hoc manner. SWC adjustments were incorporated into the analysis, and root rot was considered.

Rationale:

Recommendations: Perhaps these are less important until the stand inventory is fully operational in 2-3 years. After that, then perhaps attention can turn to monitoring disturbance factors.

Overall assessment: 3

Northway

Answer: Yes.

Rationale: Endemic levels of disturbance are felt to be incorporated in the yield model. Epidemic effects of the common disturbances (root disease and needle cast) are dealt with explicitly.

Recommendations: Consider risk management.

Overall assessment: 4

7. Do the models facilitate creation of harvest areas that mimic the sizes and shape of natural disturbances?

Overall assessment:

Insufficient information provided to answer question	No, they do not facilitate this very well at all	---------->			Yes, they facilitate this very well	Don't know - not my field of expertise
0	1	2	3	4	5	?
XX	XXX					

Droessler

Answer: Unclear.

Rationale: The sizes and shapes of natural disturbances were not discussed.

Recommendations: This is probably not a high-priority issue.

Overall assessment: 0

Dunsworth

Answer: No, Patterns of natural disturbance were not used in the model.

Rationale: The intent of the model was to capture the regulatory requirements of the FMP for maximum block size at 120 acres. Complex structure patch distribution that is in the FMP was not included in the modeling Final Report but was assessed in consultation with wildlife biologists. They determined that the patch distribution achieved using the complex structure targets were sufficient to meet the spirit and intent of the FMP for complex structure distribution.

Recommendations: No change

Overall assessment: 1

Kiester

Answer: No. No data were presented and few probably exist on the historical patterns of such disturbances which would be needed to established targets for such a management approach. So the model does not consider this approach due to lack of data and this design decision is appropriate under the circumstances.

Rationale: Section 7 and discussion with the model team.

Recommendations: Sit tight on this one. We're not there yet for ODF lands although this approach is being tried on other lands in Oregon (Blue River District, Willamette National Forest).

Overall assessment: 1

Monserud

Answer: Don't know. Not addressed.

Rationale:

Recommendations: This strikes me as unimportant, given that the Forest Planning Act restrictions are met (they are). Unask the question.

Overall assessment: 0

Northway

Answer: No.

Rationale: This was never expressed as a possible aspiration.

Recommendations:

Overall assessment: 1

E. Key Functional Relationships and Constraints

8. Have the models been through a detailed sensitivity analysis to determine which functional relationships, parameters and constraints most strongly affect the choices amongst alternative decisions?

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses of functional relationships	---------->			Sufficient sensitivity analyses of functional relationships	Don't know - not my field of expertise
0	1	2	3	4	5	?
		X	X	X	X	

Droessler

Answer: See 4.

Rationale:

Recommendations:

Overall assessment: (none provided)

Dunsworth

Answer: No, see question 4

Rationale:

Recommendations:

Overall assessment: 2

Kiester

Answer: Little written documentation is available on this question. However, discussions with the model team indicate that extensive informal sensitivity studies on model parameters and goals were undertaken in the process of developing the model. Less clear is to what extent there were sensitivity studies done on the human inputs to the model.

Rationale: Extensive discussions with model team.

Recommendations: Restructure the overall model architecture to allow easier batch processing and automation of the task of saving run parameters with run results in a database system to facilitate analysis. For example the cut and paste processes shown in flow chart #5 need to be automated. This work would be important because it will produce the tool necessary to undertake formal sensitivity studies and run

Monte Carlo simulations to estimate confidence intervals of results (see # 15 below). Think about how you use human derived input into the model. How different are the inputs that you get from different experts? This task might be facilitated by providing more detail in flow chart #5 so that the points where the role of expert variability occurs would be highlighted.

Overall assessment: 3

Monserud

Answer: I do not see a sensitivity analysis documented, but the model appears to have been extensively tested. JS answered that he does not think that there exists some hidden super-sensitive variable that can drastically change important decisions. I asked Pam Overhulser and she described a long (1.5 yrs) series of sensitivity analyses done on individual model settings, levels, and variables. This sounded to be rather thorough model testing, which was independently evaluated by MBG.

Rationale:

Recommendations: Continue to examine model behavior. If documentation is important to ODF, then additional staff need to be hired.

Overall assessment: 4

Northway

Answer: Yes, a sensitivity analysis of parameters and constraints has been fully explored, though the process is not documented. (I discussed the "functional relationships" with the input data in question 4.)

Rationale: In discussion with the analysts, it became clear that a very complete sensitivity analysis had been performed on parameters and constraints. I also have the impression that this was shared with the decision makers.

Recommendations: A more complete documentation.

Overall assessment: 5

9. Are the key functional relationships, parameters and constraints (e.g. habitat requirements of focal fish and wildlife species) grounded in strong empirical data? Have model tests been done to assess the validity of key functional relationships?

Overall assessment:

Insufficient information provided to answer question	Not well grounded at all and validity not tested	---------->			Very well grounded and tested	Don't know - not my field of expertise
0	1	2	3	4	5	?
		x (habitat)	XXX	X	x (timber)	

Droessler

Answer: Variable.

Rationale: Little is known about habitat requirements/preferences/utilization range for many species (no strong empirical data). DDI + TPA are assumed to be highly correlated to forest structure (stages of stand development), which is assumed to be correlated with habitat, but the linkages are not well understood.

Recommendations: De-emphasize the habitat aspect of the model.

Overall assessment: 3

Dunsworth

Answer: No, not completely

Rationale: The habitat requirements for NSO and MAMU are likely best grounded in empirical data but even those have not had specific District calibration done to reflect known variability in species biology. NSO habitat needs were derived form the NW Forest Plan and MAMU conservation areas were mapped from photography and field surveys. For the Coarse Filter Species there was limited local empirical data and approximations to structural class were made using a review of the existing NA literature (Mike Davis pers. comm., J. Weikel 2004).

Recommendations: As quickly as possible develop better understanding of habitat elements and species local biology for coarse filter species. This should be done as part of a strongly needed Adaptive Management and Monitoring program in support of the FMP. This program should focus both on improving knowledge of species use of habitat elements and the abundance and growth dynamics of those structures in natural and managed stands.

Overall assessment: 3

Kiester

Answer: Again the tree, stand, and harvest engineering parts of the model have a solid empirical basis while the wildlife and biodiversity aspects are less well grounded.

Rationale: Section 7.

Recommendations: See # 3 above.

Overall assessment: 4

Monserud

Answer: It appears that they have tried, and have built wildlife habitat constraints for those few species with enough supporting data. Not clear if validation has been done.

Rationale:

Recommendations: The connection between wildlife populations and habitat requirements is vague at best. This is due to the limited state of knowledge of the full biology for wildlife species, not due to any shortcoming in ODF or the H&H model.

Overall assessment: 3

Northway

Answer: Yes, on the timber modeling side. No, on the habitat modeling side.

Rationale:

- I think this is a result of the state of knowledge in the fields of study.
- Stand structure is implicitly being used as a surrogate for measures of habitat and biodiversity.

Recommendations:

- Improve the habitat model as data and relationships become available.
- Implement an adaptive monitoring program.

Overall assessment: 2 (for habitat) and 5(for timber)

10. Is it clear how the optimization algorithm used in the model attempts to meet the multiple competing objectives and constraints (e.g. timber production, wildlife habitat conservation, cost minimization)?

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	2	3	4	5	?
		X	XX	XX		

Droessler

Answer: Maybe.

Rationale: Specifics are buried in code and the code is not available or documented.

Recommendations: Document the code.

Overall assessment: 3

Dunsworth

Answer: Yes

Rationale: The model optimizes three elements; NPV, Harvest flow, and complex structure. However, the model could also use coarse filter species habitat in the optimization algorithm to reflect the biodiversity objectives inherent in the FMP. This could be done by setting either a no habitat extirpation rule or use an agreed acceptable minimum based on consultation with ODF biologists.

Recommendations: The model should be recoded to allow coarse filter species habitat in the optimization algorithm. Runs should be done to test the sensitivity of achieving biodiversity objectives inherent in the FMP. This could be done by setting either a no habitat extirpation rule for coarse filter species or use an agreed acceptable minimum based on consultation with ODF biologists. If this is done the coarse filter species list should be reduced to those species where there is the strongest confidence in the habitat relationships.

Overall assessment: 4

Kiester

Answer: No, it is not clear except in a very general way. I do agree completely with the idea that the model should use heuristics techniques such as simulated annealing for optimization. The interaction between the users of the model and the model to achieve optimization are complex and sometimes difficult to follow.

Rationale: The optimization routines in the Sessions H&H Model are proprietary.

Recommendations: It would be good if the model could be made to iterate on its own rather than looping through user input for optimization (create a “hands free” version). Next time you undertake a project of this kind consider alternative business models. My own opinion is that open source code is a critical ingredient in open government.

Overall assessment: 2

Monserud

Answer: Yes. The weights (Lagrangian multipliers) on Goals and Targets are set rather adaptively (many iterative runs for a given District). This strong degree of intervention concerned me; Pam Overhulser did a good job of explaining what she did, and why.

Rationale:

Recommendations: Try to add transparency to the procedures for determining the weights on goals and targets. This is crucial.

Overall assessment: 4

Northway

Answer: Yes, it was made generally clear in discussions with the analyst, but not well documented.

Rationale:

- The analyst provided us with a general understanding.
- We were not provided with specifics of the search algorithm or how the objectives and constraints were implemented.

Recommendations: Better documentation.

Overall assessment: 3

11. How easy is it to update key model functional relationships or parameters as new data are acquired?

Overall assessment:

Insufficient information provided to answer question	Very difficult	---------->			Very easy	Don't know - not my field of expertise
0	1	2	3	4	5	?
	XX		X	XX		

Droessler

Answer: Variable.

Rationale: In theory, the heuristic model approach is relatively easily updated. Some updates can be done by staff, while others require changes in code. For example, new inventory data can easily be incorporated as it is collected. Incorporating a new variable into the objective function is more involved and requires Dr. Sessions to change the code.

Recommendations: None.

Overall assessment: 4

Dunsworth

Answer: Relatively easy

Rationale: Based on discussions with John Sessions key model functional relationships can be altered or created by changing the model code and that he can do that with relative ease. Unfortunately this can not be done easily by anyone other than John Sessions. This is a serious limitation for future use of the model.

Recommendations: Consider developing a user interface for the model that would make it easy for users other than the model developer to modify the model parameters.

Overall assessment: 3

Kiester

Answer: Since ODF has an ongoing relationship with Sessions having him update functional relationships in the model does not appear to be that difficult. ODF appears to have the in-house capability to update parameters. Both ODF and Sessions constantly recompile the code so easy changes to the code are easy to implement.

Rationale: Discussion with ODF model team and Sessions.

Recommendations: At this point in the development of the model I believe that it is much more important to investigate the properties of the model that you already have (via sensitivity analysis and Monte Carlo variance estimation) than to undertake any reworking of the model itself.

Overall assessment: 4

Monserud

Answer: Currently, it appears to be a major undertaking. For example, incorporating the most recent inventory data to rebuild the strata-based yield tables was rejected by MBG as too expensive (time and money).

Rationale:

Recommendations: This situation should improve when the current Aggregated Strata are eliminated and a stand-level projection system is incorporated. This eliminates the costly aggregation step.

Overall assessment: 1

Northway

Answer:

- No, it is not easy to include new kinds of data or relationships.
- Yes, it would be easy to replace an existing input table with an identically structured table of new numbers.

Rationale: I am taking "easy" to mean fast, cheap and technically unchallenging. Aside from the trivial problem of updating an existing input table, all other changes require changes to the H&H model programming code. This is technically challenging, and depending on the standard of coding in the existing model could be time consuming.

Recommendations:

- Review the management of the H&H model code with an eye to minimizing risks associated with maintaining and extending it. The alternatives might range from service assurances (complete with penalty clauses) in a license, to insurance, or even re-implementation with more formal project controls.
- Continue to review other models of similar capabilities (i.e. Patchworks www.spatial.ca) for minimizing the costs and managing the risks.

Overall assessment: 1

F. Using the Models to Make Decisions

12. How useful are the models for the intended strategic and tactical level decisions to which they will be applied? [Specifically, can they be used to decide among the 4 options: FMP using a HCP, FMP using Take Avoidance, wood-emphasis, or reserve-based? Are these models appropriate for making decisions about: 1) whether to make changes in the Northwest and Southwest Oregon FMPs, 2) whether to pursue a HCP, and 3) setting harvest levels for Annual Operation Plans?]

Overall assessment:

Insufficient information provided to answer question	Not at all useful or appropriate	---------->			Very useful and appropriate	Don't know - not my field of expertise
0	1	2	3	4	5	?
		X	X	X	XX	

Droessler

Answer: Somewhat useful for yield flows, not useful for HCP and TA alternatives.

Rationale: The model will be useful for setting harvest levels for AOPs when stand-based inventory is used. The lack of variability oversimplifies the results (even for growth and yield) and renders it impossible to reliably discriminate between the four options. Incorporating variability information via a stand-based inventory will help with yield.

The habitat – structure linkage is weak (even though generally based on state of the science) and discriminating between the HCP and TA options based on the model may not be possible in the near future.

Recommendations: De-emphasize the ability of the model to provide habitat information.

Overall assessment: 3

Dunsworth

Answer (please specify what applications of the models you feel are appropriate, and what applications are not):

1. No, without the feedback from an adaptive management program testing the adequacy of the assumptions and approaches in the FMP it would be unwise to act on model forecasts.
2. Yes, for comparisons between TA, WE and RB but the value of the comparison between HCP and TA is limited due to the post-processing approach to the impact of owl circles.
3. Yes, in the absence of the advice from this model harvest levels will be set and the model will significantly help to guide that decision.

Rationale: The model goals and switches table clearly shows the differences between the model runs used to reflect the four scenarios. These appear to reflect the policy distinctions but in the implementation of

the model they have chosen "for a variety of reasons, we believe that simply tracking the impacted harvest units is the best method to use." (M. Davis memo, June 13, 2005). This means that the power of the model to find harvest solutions that would work to maintain a relatively high even flow in the face of owl circles was removed and a worst case, simple subtraction option applied. The team was clear that this was one of their time constraint issues and would require coding time from J. Sessions to accomplish.

Recommendations: Spend the time and effort to modify the code to find harvest schedule solutions in the face of owl circle limitations. Do not modify the FMP until guidance from the AM Program is in place.

Overall assessment: 4

Kiester

Answer (please specify what applications of the models you feel are appropriate, and what applications are not):

4 Options: Significant analysis has been done on the first two options comparing FMP+HCP and FMP+TA. The analyses of the wood-emphasis and reserve based design help check the behavior of the model.

Making changes in the FMPs: The models at this time have relatively little to say about this issue.

Whether to pursue HCP: This is a difficult call at this point. The model does produce feasible results under both scenarios, but it needs more analysis and confidence intervals to really address this question.

Setting harvest levels: Clearly the model generates feasible and sensible harvest schedules. These harvest levels have been examined by the operational foresters in the Model Report Sessions and Model Run Days. Their concurrence indicates that the model performs this function well.

Rationale: Overall evaluation of the model structure.

Recommendations: Implementing confidence intervals will help a great deal.

Overall assessment: 2

Monserud

Answer (in general):

- Very useful for allocating volume growth and structural development across the landscape.
- There exists so much uncertainty regarding the connection between wildlife population levels and wildlife habitat needs that I am uncomfortable concluding anything about future wildlife viability. This deficiency is not due to ODF, but rather due to the state of knowledge of wildlife biology.

Answer (please specify what applications of the models you feel are appropriate, and what applications are not):

Re:
1) Whether to make changes in the Northwest and Southwest Oregon FMPs:

This is a highly-charged political decision. I recommend waiting 2 years before seriously visiting this. I expect that in 2 years ODF will have a more complete inventory, a better H&H modeling system using stand-based projection incorporating variability rather than the current strata-based projections, and perhaps a new regeneration growth model from Martin Ritchie and SMC.

2) Whether to pursue a HCP vs. TA strategy:

This is fundamentally a risk analysis and investment strategy question rather than a H&H modeling question. It reduces to one question: what are the long-term (e.g., 20 yrs) prospects for NSO population levels? Will the barred owl continue to out-compete the NSO to the point that NSO effectively disappears? If yes, then owl circles will disappear and land will be freed up for alternative management under TA. If yes, then land will be locked up as of today's state of the NSO for decades even under the decline of NSO, under the HCA. If no and NSO population increases, then under TA more owl circles will be added and less land available for harvest. If no and NSO population increases, then under HCA the land allocation does not change. Given the nature of this risk reduction decision, the H&H model is almost irrelevant. The decision is not dependent on model predictions at all; the decision is almost totally dependent on a risk analysis of barred owl vs. NSO population dynamics.

The H&H model can inform one aspect of the decision: the harvest volume level over time under each decision (HCA vs. TA). It is necessary to know if these two projections (H&H Final Report, P.44, bottom graph) are significantly different. We cannot tell---no variability is presented. If I were charged with making a recommendation, then I would focus on the H&H Model projections for the next 5-10 years. Unless the harvest volume projections for HCA are clearly significantly higher than TA, then I would continue with TA and revisit the decision in 5 years, when we will have a more complete inventory, a better H&H model (stand-based projection), and more information on barred owl vs. NSO dynamics.

3) Setting harvest levels for Annual Operation Plans?

The model is designed and well-suited for this purpose. The optimization portion is complete and excellent. The yield-table portion can be improved greatly by using the current stand-level inventory (50%) as input to a stand-based FVS system to generate a yield table for each stand. A by-product of this change will be that stand-level variability will automatically be incorporated into the analysis, solving another problem. These aspects will only improve with time as the inventory coverage increases.

Recommendations: Eliminate the strata-based approach as soon as the forest inventory can support a stand-based projection system. Not clear how appropriate the murrelet and owl-based constraints/ alternatives are because of a poor state of knowledge on key wildlife population dynamics.

Overall assessment: 5

Northway

Answer:

- In the hands of a good analyst and knowledgeable decision maker, the model is useful for supporting strategic and tactical forest level decisions. It should not be used to make the decision, but rather to support the decision making process.
- The model can also be used to inform questions not directly addressed. This exercise illustrated how the model could be used to estimate the impacts of new NSO circles even without explicitly dealing with them (except in a *post hoc* and *ad hoc* way).

Rationale:

- As long as the model does not have the potential to mislead the decision maker, it has utility. (This is not as weak a test as it might seem.)
- HCP vs. TA vs. WE vs. RB: I feel the harvest volume and stand structure trade-off is fairly represented by the modeling. The model results should be part of the decision making process between these alternatives. The choice between these options will be partially driven by social choices not represented in the model, especially in the cases of the WE and RB options. And in a choice between the HCP and TA options, the decision may depend on a risk assessment of the impact of future NSO and marbled murrelets populations, the "no surprises" clause and certainty in operational planning.
- Informing changes in the FMPs: I feel the H&H model can contribute to the decisions about the impact of making changes to the FMPs. Specifically, I think it can inform about the harvest level impacts of 1) targets for stand structure types, 2) targets for patch size, composition and configuration, 3) riparian conservation options, and in a more limited way 4) in-stand structural components and 5) forest health options.
- The utility of this information in judging the impact on habitat is more limited. Until more specific relationships are developed and better inventories are available conclusions will be limited to the impact on crude surrogates for habitat and biodiversity.
- AOP harvest levels: I feel the model is useful in setting harvest levels, in the broader context of the planning process. The decisions considered above are driven primarily by relative differences. There is less risk in decisions about relative differences than in absolute levels. Harvest levels are absolute. A broader planning process is in place to manage the risk. The harvest level is periodically re-evaluated. An inventory depletion to harvest scale might be monitored. The IP tests the feasibility of the harvest levels.
- I understand that the model results suggesting a shift to somewhat more reliance on clearcuts cf. thinnings is being implemented in operational programs. I also understand that operational transportation strategies are being reviewed in light of some of the model results. These are both successful examples of the utility of tactical level planning informing operational activities.

Recommendations: Implement an adaptive management program with both passive and active components.

Overall assessment: 5

13. Do the models allow the exploration of different management strategies under multiple competing hypotheses (e.g. different assumptions about habitat requirements of focal wildlife species)?

Overall assessment:

Insufficient information provided to answer question	No, not at all	---------->			Yes, very much	Don't know - not my field of expertise
0	1	2	3	4	5	?
		X		XX	X	

Droessler

Answer: Limited.

Rationale: Strongest for harvest questions, weak for habitat.

Recommendations: De-emphasize the ability of the model to provide habitat information.

Overall assessment: (none provided)

Dunsworth

Answer: Yes

Rationale: The model is sufficiently detailed to reflect different management strategies under multiple competing hypotheses. The caveat for wildlife species is that their habitat needs must be generalized to structural classes and this generalization could mask significant differences in species response to management strategies or limit the management strategies assessed to those that alter structure classes and not structural attributes.

Recommendations: Look to improving the model with the inclusion of deadwood dynamics (i.e. green trees moving to snags moving to coarse woody debris) possibly acting on the snag model recommendation from Mason, Bruce and Girard (March 8, 2005) to use the FFE extension of FVS for snag and downed log modeling. An additional improvement would be the inclusion of a shrub model which it appears could possibly be derived from the existing inventory, at least as a first approximation. Then the species model parameter list would need to be revised to replace structural classes with structural attributes (See Question 1).

Overall assessment: 4

Kiester

Answer: The model does a good job of examining the trade-offs between harvest volume and stand structural diversity although the visualization of this trade-off could be better. The larger question of how the model supports other aspects of the operationalization of GPV is open. There is an overall question of the balance of whether the model provides a level playing field for the competition between harvest and wildlife/biodiversity values. Clearly the goals can be changed to study this balance, but it is also clear that the model does more justice to the harvest component than to the habitat component.

Rationale: Discussion of model structure.

Recommendations: I think the team should explicitly state the rationale for the decision on the balance of effort between harvest and habitat.

Overall assessment: 4

Monserud

Answer: Yes.

Rationale: The Sessions model is very good at this.

Recommendations: Continue to use as a decision support system. Look for novel ways to display differences among alternatives.

Overall assessment: 5

Northway

Answer: Not for most habitat definitions.

Rationale: Programming would be necessary to explore the impact of different habitat definitions, unless the change can be reflected in the input data files.

Recommendations: SEE 11.

Overall assessment: 2

14. Is the model output deterministic, or does it provide a distribution of outcomes that recognizes uncertainties in both functional relationships and natural environmental variation?

Overall assessment:

Insufficient information provided to answer question	Completely deterministic	---------->			Distribution with uncertainties fully recognized	Don't know - not my field of expertise
0	1	2	3	4	5	?
	X	XXX				X

Droessler

Answer: Deterministic.

Rationale: Variability information was generally not incorporated into the model, even where estimates were available.

Recommendations: Incorporate variability in the model AND do sensitivity analyses.

Overall assessment: 2

Dunsworth

Answer: No, the model is not deterministic

Rationale: The simulated annealing process at the core of the model is a random search heuristic and as such is not deterministic. It could provide a distribution of outcomes recognizing uncertainty in the growth and yield functions and in the development of complex structure. The later could be developed out of the recommended sensitivity analysis of complex structure (see Question 4).

Recommendations: Other Panel members are better qualified to recommend

Overall assessment: ?

Kiester

Answer: At the moment the model is largely deterministic and does not reflect either sampling variability or stochastic dynamics very well. The optimization routine of the Sessions model is a stochastic optimization procedure (simulated annealing) and random functions are used in some of the ad hoc modifications of the model (such as the effect of Root Rot) but those processes do not get at the issue here.

Rationale: Examination of flow charts and discussion with model team.

Recommendations: As discussed above, using the stochastic version of FVS and setting the model up for Monte Carlo runs would be very desirable. Visualization of the data in the form of frequency distributions should happen at all steps of the model from input to final output. Where the model now produces .txt files it should automatically produce a frequency distribution graphic (perhaps as a .pdf file) as well. This would be easy to implement immediately.

Overall assessment: 2

Monserud

Answer: Currently. results presented as deterministic, although the simulated annealing algorithm is fundamentally stochastic. This situation strikes me as strange.

Rationale:

Recommendations: Incorporate variation into projections/solutions so that uncertainty can be displayed and quantified. Could incorporate the Bootstrap module of Gregg/Hummel when stand-based FVS projections can be implemented and the strata are eliminated. Could also move the stand inventory (tree list) and FVS projections into a preprocessor that then feeds the H&H model the yield tables (for each stand and alternative). This would allow for running different random starts with FVS, with subsequent optimization. Then examine the set (say, 20-30) of optima and examine commonalities and variation.

Overall assessment: 1

Northway

Answer:

- The model is not deterministic.
- The model does not directly provide measures of uncertainty.

Rationale:

- Simulated annealing is a random search algorithm. The search pattern differs for different random number sequences and so in that sense it is not deterministic. In some situations it will consistently find the same solution for all random number sequences and so in that sense it can appear deterministic. (The appeal of SA is based both on its demonstrated success in tough problems and on a proof demonstrating that there exists, for each problem, in a specific class of problems, an annealing schedule that will result in finding the global optimum.)
- The differences among runs with different random number sequences do not tell you anything about the uncertainty inherent in the underlying problem.

Recommendations:

- If deriving information about uncertainties is of interest, I feel it is a specialized enough endeavor to require a workshop with invited experts.
- Learning about the uncertainties is only the first step in managing risk through devising strategies that are robust in the face of uncertainty.

Overall assessment: 2

15. Is model uncertainty clearly communicated in documents provided to decision makers (e.g. the Board of Forestry)?

Overall assessment:

Insufficient information provided to answer question	Uncertainties not included in documentation	---------->			Uncertainties clear in documentation	Don't know - not my field of expertise
0	1	2	3	4	5	?
	X	XX	XX			

Droessler

Answer: Generally no.

Rationale: Variation can be effectively communicated via confidence intervals, which requires variability was incorporated into the model (generally not).

Recommendations: Undertake a comprehensive inclusion of variability into the model.

Overall assessment: 2

Dunsworth

Answer: No, not completely.

Rationale: The model results presented to the Board in the Final Report provide single line solutions for each scenario with no confidence intervals. Level of confidence and elements of concern are discussed in the text (pages 48-51, Final Report). However, even if these confidence concerns were handled the uncertainty in the forecasts due to uncertainty in the data and complexity of the optimization solutions would remain.

Recommendations: Efforts should be made to generate confidence intervals around the scenario solutions that reflect uncertainty in the data and the range of feasible spatial solutions.

Overall assessment: 3

Kiester

Answer: The documentation discusses levels of confidence the team has in the model in a qualitative way. At this more general level the team is able to communicate a sense of the uncertainties that is valuable. For example, the breath-taking uncertainty of spotted owl dynamics is well discussed. But confidence intervals reflecting both sampling and dynamic stochasticity are not given. My own opinion is that, for example, the two output curves shown in the two figures on page 44 of the Report are essentially identical. But a single estimate of variance will trump any amount of opinion.

Rationale: Examination of the flow charts and discussion with the model team.

Recommendations: Adapt the system to be able to perform Monte Carlo runs. Estimate and visualize confidence intervals.

Overall assessment: 3

Monserud

Answer: No.

Rationale: Only one time series is presented in the main document, with no variation displayed or discussed. Such simplification can be very misleading.

Recommendations: At least show results of High and Low solutions along with the mean.

Overall assessment: 1

Northway

Answer: No, I saw no documents that discussed uncertainties, save the NOS options.

Rationale: The analysts are clearly aware of the uncertainties in the modeling effort and I expect that it is communicated in ways other than the formal documents I have seen. The appreciation of uncertainty can only be of a qualitative nature, as no quantitative assessment of uncertainty has been undertaken.

Recommendations: SEE 14.

Overall assessment: 2

16. Do the models support the implementation of adaptive management (i.e. can model predictions and key functional relationships be tested and iteratively improved)?

Overall assessment:

Insufficient information provided to answer question	Don't support implementation of AM at all	---------->			Fully support implementation of AM	Don't know - not my field of expertise
0	1	2	3	4	5	?
			XX	X	XX	

Droessler

Answer: Yes and No.

Rationale: Generally yes for growth and yield questions (once variability information is included such that reliable discrimination of alternatives is possible).

Generally no for habitat questions since habitat - structure linkages are particularly weak.

Recommendations: Undertake a comprehensive inclusion of variability in the model. De-emphasize the habitat component.

Overall assessment: 3

Dunsworth

Answer: Yes, to a limited extent.

Rationale: The problem being addressed by the modeled scenarios is forest simplification and its impact on sustaining NSO, MAMU species and maintaining the biological richness of the original forests. The hypothesis is that stands can be made more complex and subsequently more suitable for a broader range of species (particularly late successional species) through thinnings than by age alone. To do this in an active adaptive management process would require departing from the spirit and intent of the HCP or the TA approaches and including some of all four options over relatively large areas. In doing this I suspect

the conditions for granting the HCP would be violated and the HCP could not be granted. Thus, AM could likely only be applied under a TA scenario where the stand manipulation options are limited.

However, it could be possible to apply AM with both an active (experimental) and passive (operational) approach to the question of whether the use of thinnings as applied in the model could create the expected stand complexity and if coarse filter species respond to these structural changes as expected. The core hypotheses on species response should be related to structural attributes rather than structural class. The suite of monitored species should be broadened to include invertebrates, vascular plants, bryophytes and lichens. In this way well understood functional relationships can be tested and habitat needs for less well understood species derived.

Recommendations: Development of and Adaptive Management and Monitoring program to test the efficacy of thinning in creating useful complex structure for a broad suite of organisms is a critical part of implementing the FMP. This program should start immediately and should include both an active and passive adaptive management component. The Program should focus on stand structure monitoring and species abundance assessments under as wide a range of thinning options as possible across the range of ecological units in the Districts.

Overall assessment: 3

Kiester

Answer: The complete answer to this question lies in the entire policy context in which the model is used. The model is sufficiently flexible that it will be able to do its part in the adaptive management cycle if managers choose to use it.

Rationale: See #11.

Recommendations: Here is where the model as a tool for transparency and communication comes to the fore. I do not believe it is an understatement to say that effective visualization of the results is at least as important as the model structure. The model gets you the answer, the visualization gets the answer used.

Overall assessment: 4

Monserud

Answer: Yes

Rationale: The model is very good at this, and is being examined by field personnel to ensure that the model is reasonable.

Recommendations:

Overall assessment: 5

Northway

Answer: Yes.

Rationale:

- The model and its functional relationships make specific predictions that can be tested through passive adaptive management.
- The model can be used to help design the active portion of adaptive management by helping in the design the experiments. Model runs can help identify high leverage areas of uncertainty.

Recommendations:

- Implement an adaptive management program.
- Use the model to help identify critical areas for active experiments.

Overall assessment: 5

17. What are the key priorities for overall improvement in the models, given the intended applications? (This synthesizes recommendations from previous questions; please consider pg. 55 of Doc 10A, Enhancements for the Future.)

Droessler

Answer: Utilize stand-based inventory; Improve yield tables by using a distance-dependent growth model which explicitly utilizes the openings created by structure-based management, at least as a pilot project (yields will need to be regenerated from the stand-based inventory anyway); Incorporate variability and report confidence intervals or measures. Design, implement and document a sensitivity analysis study. Document what the code does. De-emphasize the habitat component.

Dunsworth

Answer: Key priorities for change are;

a) move to a stand-based inventory as quickly as possible,

b) move away from structural classes for assessment of species response,

c) implement an AM+M Program to test the efficacy of thinnings in creating complex structure,

d) improve understanding of key habitat attributes for coarse filter species and broaden the species list to include non-vertebrates,

e) include ecological classification in future model reporting.

Rationale: The stand-based inventory is a fundamental short-coming in the application of the model and combined with the use of structural classes for species habitat assessment significantly reduces the models utility. The AM+M Program is a critical part of the implementation of the FMP and the key practice in that Plan is the application of thinning as a tool to create stand complexity and a broaden available habitat. Ecological classification is a necessary framework for evaluating distribution of stand structure across landscapes.

Kiester

Answer:

- Make a conscious decision about the level of documentation the project will support.
- Make a conscious decision about the balance of work effort between harvest and habitat.
- Reengineer the model to be able to do sensitivity analysis and Monte Carlo variance estimation by creating a batch processing system and implement automated storage of results and run parameters.
- Undertake much more analysis of the results already obtained.
- Develop visualization of results and uncertainties.
- Improve the model by using the stochastic version of FVS, a better model for reforestation and regeneration, and solve the discretization problem.
- Emphasize transparency as one of the most important products.

Rationale: See #1-#16.

Monserud

Answer:

1. Eliminate the Strata Aggregation, and replace with a Stand-based Growth Projection system as soon as possible. The inventory is probably strong enough to do this now, or the near future. This apparently can be accomplished now without modification to the H&H model simply by making every inventory stand its own stratum. This will eliminate unnecessary aggregation, preserve all measured variation, and improve model integrity.
2. Begin the stand level imputation (e.g., most similar neighbor) now, based on the current state of the forest inventory.
3. Try much harder to incorporate variation into the analysis, and then display and discuss the resulting uncertainty. This is fundamental. The Bootstrap Module for FVS (developers: Tommy Gregg and Susan S. Hummel, Portland, OR) might aid in this effort. See also #14 for another suggestion.
4. Try to train at least one backup/redundant person for Pam Overhulser that is capable of independently run the H&H model. Likewise, have a contingency plan for a backup for John Sessions (e.g., Pete Bettinger, Univ. Georgia). If documentation is important to ODF, hire a support person for Pam.

Northway

Answer:

- Review the risk mitigation scheme for the H&H computer program maintenance and extension.
- Implement an adaptive management program.
- Explicitly include the identification of future NSO circles in the H&H model.
- Improve the habitat model as data and relationships become available.
- Update the inventory data as the stand-based inventory becomes available.

Rationale:

- An adaptive management program is the key to continual improvement.
- Explicitly including future NSO circle identification in the model will allow the model to find mitigation strategies while producing a goal defined harvest level.
- The uncertainty in the habitat portion of the model is larger than the uncertainty on the harvest side. This can only be remedied by improving the habitat model and the data required to drive it.
- The new inventory will result in general improvements to many parts of the model.

Overview and Conclusions

18. Credibility: Is the model credible—able to address decision issues for which it was intended? How should outputs from models like this be used? What types of discussions should we be having about the outputs? And how should it NOT be used? Can we do something to put confidence intervals around model output or explain it better to move away from one number and talk about a range of numbers?

Droessler

Model output credibility would be greatly improved with the inclusion of variability information such as confidence intervals. Where CI's cannot be explicitly calculated, some measure of confidence/risk/ variability should be incorporated and carried through to results.

The flexibility of goal programming allows the user to run and re-run the model by adjusting objective function weights until a solution meets specific goals. There is a **perception** that this process could be used inappropriately to limit the range of model output to pre-conceived levels and not produce the full range of possible outputs from the model.

Dunsworth

Is the model credible – able to address decision issues for which it was intended? Yes

How should outputs from models like this be used? What types of discussions should we be having about the outputs? and how should it NOT be used? They should be used to guide policy and provide strategic direction. They should not be used to guide harvest block specific actions.

Can we do something to put confidence intervals around model output or explain it better to move away from one number and talk about a range of numbers? Yes we should and two areas to explore are in the growth and yield inputs (attempt to reflect the natural variability in forest growth) and in the definition of structural classes (attempt to reflect the uncertainty inherent in threshold values for TPA, DBH and DDI).

Kiester

The credibility of the model is good in the sense that it reflects good science and good modeling. But transparency and communication need to be stronger. Better documentation and better visualization would significantly improve credibility.

Monserud

Yes. This is an incredibly detailed planning model, perhaps the most detailed forest management optimizer in the world. The Sessions optimization model state-of-the-art. ODF is fortunate to have such a tool and such an esteemed developer (Dr. Sessions).

How should outputs from models like this be used?

- To assist in making management decisions.
- As a feedback tool in adaptively refining the management plan.
- After variation has been incorporated, to display uncertainty to the managers.

What types of discussions should we be having about the outputs? Examining variability and uncertainty much more than at present.

And how should it NOT be used? Focusing on only ONE projection, such as presented in the H&H Final Report.

Can we do something to put confidence intervals around model output or explain it better to move away from one number and talk about a range of numbers? Yes. A limited Monte Carlo simulation procedure could generate a measure of response surface variability for a given decision variable. This requires much more computing, but would temper the "perfect prediction" phenomenon resulting from displaying only one time series projection (as done in the H&H Final Report). See # 14 and #17-3.

Northway

- The model is credible in addressing strategic and tactical forest management questions. The model capabilities are at the cutting edge of applied models.
- As better information becomes available the continued use of basic measures of stand structure as a surrogate for biodiversity will become problematic.
- If deriving information about uncertainties is of interest, I feel it is a specialized enough endeavor to require a workshop with invited experts.
- Learning about the uncertainties is only the first step in managing risk through devising strategies that are robust in the face of uncertainty.

19. Adequacy of Input Data: Is the accuracy and precision of underlying data sufficient for the intended purpose, and the scale it needs to be applied?

Droessler

The strata-based inventory data is insufficient and plans are in place to replace it with a stand-based inventory. The habitat part of the model is based on (DDI + TPA) which defines stages of stand development (structure class), which is used as a surrogate for habitat. The linkage between (DDI + TPA), structure and habitat is weak.

Dunsworth

The accuracy and precision of the underlying data is likely sufficient to address the question of whether or not the intended stand treatments and harvest schedules will address the problem of stand and landscape simplification. However, they are likely insufficient to assess coarse filter species needs and may be insufficient to assess NSO impacts.

Kiester

See #3.

Monserud

Accuracy and precision require a measure of variation, and I do not see any displayed or discussed. Based on the documentation, then it appears to be: No.

The underlying inventory began as very weak, 6-7 years ago when this work was begun. As a result, this Structural Stratum Aggregation Methodology was developed. This eliminated variation, has unknown accuracy, and is unlinked spatially to the rest of the H&H model.

However, the inventory now is quite good. It gets better each year. It appears that the underlying inventory data now is quite strong, and certainly has sufficient accuracy and precision. If the Structural Stratum Aggregation Methodology could be replaced by a Stand-based (direct FVS) projection system, then the Growth & Yield projections would have sufficient accuracy and precision.

With 50% inventory coverage currently, the scale of application (viz., entire District) is appropriate.

Additional features (data layers) that appears to he very well executed are the Harvest Unit Boundary mapping and the Road Network. These add greatly to the accuracy of the final H&H model optimizations.

Northway

Yes, the data is adequate for the intended purpose. (It is more a case of limiting the use to be consistent with the qualities of the data. This data may be sufficient but better data will lead to less uncertainty in the interpretation of the results.)

20. Underlying Assumptions: Are the underlying assumptions sound / valid, for each of the major model components (i.e. wood harvest, revenue and costs, growth and yield, biodiversity)?

Droessler

The assumption that a strata-based inventory represents the inherent variability of stands is not valid. The linkages between (DDI + TPA), structure and habitat are weak.

Dunsworth

The underlying assumptions for the harvest questions seem sound and valid or at least more sound and valid than the assumptions for biodiversity. The translation or estimation of known habitat attribute requirements for NSO, MAMU and coarse filter species through structural classes is not well supported with empirical data and is an artifact of a weak inventory.

Kiester

The underlying assumptions about wildlife and biodiversity are problematic. See #3:

Monserud

a. In general, Yes. The Sessions optimization is superb, state-of-the-art.

b. The most limiting assumption is the Structural Stratum Aggregation Methodology. Unfortunately, these aggregates float free of spatial location, and contain no variability. This was forced by the initially weak forest inventory. Now that your forest inventory is now excellent (and with 50% stand coverage), this very limiting assumption is no longer needed or useful. The inventory now supports a Stand-based Yield Projection system (with FVS using stand inventory tree lists directly).

c. The wildlife habitat structural requirements seem to involve circular reasoning (rampant in the wildlife biology field, not specific to ODF) that never connects to the animal in question. The unit of success seems limited to achieving adequate Complex Structure, rather than monitoring the actual response of the wildlife population to the presence of this structure. The animal itself seems to be missing from the loop. I attribute this disconnect to the realities of dealing with legal mandates and the state of wildlife biology, and not due to any shortcomings of ODF professionals.

   Consider the murrelet (caveat: I am a biometrician, not a wildlife biologist). After long prodding from Tim Max (PNW Biometrician), murrelet wildlife experts finally agreed (ca. 2001) to a statistically unbiased population sample (line transect sampling at sea). The current population estimate is approximately 20,000 +- 10,000. Let's say that each murrelet needs 1 ac for nesting. That means that approximately 30,000 ac are needed; this is not a large amount of habitat area in the coastal forests of the Pacific Northwest. I can only conclude that forest habitat is not limiting to population levels. Something else is limiting, and the biologists have not yet elucidated this dynamic. Furthermore, I have heard that murrelet population levels are high in Alaska, even out to the Aleutians, where trees are scarce or completely missing. This means that the murrelet is quite flexible and resourceful in its nesting requirements. None of this variation in nesting requirements is reflected in the murrelet constraints required by the wildlife regulations.

d. The fine-tuning of the Targets and Goals in the Simulated Annealing Optimization seemed a bit heavy handed, to the point of certain analyses becoming self-fulfilling prophecies (e.g., bottom graph, p.44 of H&H Final Report). Why not set these Targets and Goals for each District ahead of time and then optimize the H&H model, accepting the consequences, and then examining the reasonableness of the optimal runs? Documentation would have helped here to explain exactly what the process was and how it was executed (still not entirely clear to me). During the Review, Pam Overhulser did a good job of explaining what she did, and why.

Northway

- Yes, the underlying assumptions are valid.
- As a caveat, the implicit use of stand structure as a surrogate for biodiversity is questionable.

21. Testing: Is the model adequately tested? (i.e. input data checked, rules implemented correctly, computations correct given rules, functional relationships confirmed empirically, model output assessed by field personnel for reasonableness)?

Droessler

An admirable job was done on testing the computational aspects of the model. The functional relationships between (DDI + TPA), structure and habitat can not be tested because they are not known or understood empirically.

Dunsworth

Yes, the checking and feedback with staff biologists and foresters has been exceptional.

Kiester

The model has been qualitatively tested. A formal sensitivity analysis would be a great improvement.

Monserud

Based on discussion with ODF staff and Dr. Sessions, model testing appears to be quite extensive and thorough. Carrying the testing all the way through to field foresters is thorough and laudable. This is excellent. MBG was also involved in independent testing, which is also excellent. See #4, #8.

Northway

Yes, testing input, output and application of rules has been rigorous.

22. Next Steps: What can be realistically changed or improved (given time and resources)?

Droessler

A comprehensive incorporation of variability. Design, implement and document model sensitivity. Improved growth and yield tables (including regen tables) using a distance-dependent growth model. New yield tables must be generated anyway when the stand-based inventory is substituted for the strata-average inventory, so a different growth model could be used to generate those yields.

Dunsworth

Key priorities for improvement are:

- move to a stand-based inventory as quickly as possible,
- move away from structural classes for assessment of species response,
- implement an AM+M Program to test the efficacy of thinnings in creating complex structure,
- improve understanding of key habitat attributes for coarse filter species and broaden the species list to include non-vertebrates,
- include ecological classification in future model reporting.

Kiester

See #17:

Monserud

a. Eliminate the Strata Aggregation, and replace with a Stand-based Growth Projection system as soon as possible. The inventory is probably strong enough to do this now, or the near future. This apparently can be accomplished now without modification to the H&H model simply by making every inventory stand its own stratum. This will eliminate unnecessary aggregation, preserve all measured variation, improve model integrity, and improve transparency to field foresters and specialists.

b. Begin the stand level imputation (e.g., most similar neighbor) now, based on the current state of the forest inventory. As additional stands are inventoried this and next year, the accuracy of the imputation can then be checked and evaluated (validation).

c. Try much harder to incorporate variation into the analysis, and then display and discuss the resulting uncertainty. This is fundamental. The Bootstrap Module for FVS (developers: Tommy Gregg and Susan S. Hummel, Portland, OR) might aid in this effort. See #14 and #17-3.

d. Try to train at least one backup/redundant person for Pam Overhulser that is capable of independently running the H&H model. Likewise, have a contingency plan for a backup for John Sessions (e.g., Pete Bettinger, Univ. Georgia).

e. Re wildlife habitat structural needs: The current inventory apparently monitors some features of the shrub and ground vegetation layer. First, build structural stand classes that are relevant to wildlife questions or habitat needs. Then use the stand inventory shrub/understory data to construct a simple ANOVA model: calculate class means, along with associated variances. Assume that these means are constant over time (albeit with the observed variation for a given cell). Then apply these to the stand-based projections over time. (This is a hypothesis that can be tested). Note that this Static-Mean model will not work with the current Structural Stratum Aggregation methodology because stand variation has been eliminated due to aggregation.

Northway

- Review the risk mitigation scheme for the H&H computer program's maintenance and extension.
- Implement an adaptive management program.
- Explicitly include the identification of future NSO circles in the H&H model.
- Improve the habitat model as data and relationships become available.
- Update the inventory data as the stand-based inventory becomes available.

23. Overall Strengths and Weaknesses: What are the inherent strengths and weaknesses, particularly to goals and objectives that program is trying to achieve with it? Are their any fatal flaws in the model, underlying data / assumptions, or its application? Are there any other kinds of models in existence we should consider using to overcome weaknesses of the current suite of models?

Droessler

The heuristic process selected is a considerable strength.

The habitat portion of the model is weak with little ability to improve it in the foreseeable future (too many unknowns or possibly unknowables).

Dunsworth

There are no fatal flaws in the modeling process. The strength of the model is that it is spatial, uses engineered harvest blocks and realistic road networks, provides for the inclusion of all FMP constraints and can simulate stand-level treatment options at a significant level of detail. The weaknesses are in the fact that the changes can only be done by one person and he is near retirement and the model can only be operated by one ODF staff person. An additional weakness in the model is its approach to spatial habitat supply using structural classes rather than structural attributes for species whose structural attribute needs are well understood and can be modeled from the inventory data.

Should consider object-oriented program models like Patchworks (Moore and Lockwood) with a graphical user interface to allow for a broader set of users and provide insurance that the modeling can evolve as better data is collected once John Sessions has retired.

Kiester

The model is limited by the state of the art in wildlife habitat modeling. Inclusion of biodiversity would require newer paradigms such as Gap Analysis.

Monserud

What are the inherent strengths and weaknesses, particularly to goals and objectives that program is trying to achieve with it?

- Strengths: see #24-a. The H&H optimization model is amazingly detailed and the state-of-the-art. It provides the necessary decision support for your management decisions, especially regarding timber projection and harvest. Your strong inventory is also a great strength, whereas 7 yrs ago it was a liability.
- Weaknesses: Mainly things beyond your control, relating to the vast uncertainty associated with predicting (or even measuring) wildlife population dynamics and habitat needs. Regarding the procedure for dubbing in regenerated stands, an improved model should soon be available from Martin Ritchie and SMC.

Are their any fatal flaws in the model, underlying data / assumptions, or its application?

- No, in my opinion. “No fatal flaws” is also a quote from John Sessions. After 1.5 yrs of testing, Pam Overhulser made a similar statement.

Are there any other kinds of models in existence we should consider using to overcome weaknesses of the current suite of models?

- Your choices were fine (Sessions model, FVS). In the near future, an improved regeneration model should be available from Martin Richie (PSW-Redding) using additional SMC data. This will plug one hole. Also, Dave Hann (OSU) is recalibrating OREGANON using all SMC data. When available, this should be re-examined.

Northway

- There are no fatal flaws in the modeling exercise.
- The strengths of the model include its ability to deal with 1) the spatially explicit nature of the problem, 2) the roads and 3) the large problem size.
- The weaknesses in the model include its limited information on habitat relationships and the risks associated with the maintenance and continued development of the H&H computer program.
- Patchworks is a model of similar capabilities www.spatial.ca.

24. Process of Model Development: What do you have to say about our model development process? How can you make something like this more transparent? Is there anything we can do to develop a clear set of stakeholder expectations from the next round of modeling? Do you have advice for us on how to set clear expectations? How should we go about evaluating alternative models that could be used?

Droessler

An outside panel could have been (and could be in the future) effectively utilized at major decision points to improve the model considerably.

Dunsworth

What do you have to say about our model development process?

The model development process seemed to be well managed and inclusive but under-funded and staffed to meet the timeline expectations of the clients. John Sessions and Pam Overhulser have been key players and have put an extraordinary amount of effort into the development and implementation process. I would have preferred a more balanced effort in the model process between the timber and biodiversity components. For a variety of reasons habitat for other than NSO and MAMU was given a lower priority for the limited modeling resources and that shows.

How can you make something like this more transparent?

I think model development in perhaps an object-oriented programming environment and the use of graphical user interfaces could have made the model more transparent and more broadly useable. More complete documentation would also help but these aspects are expensive and often seen as frills under the pressure of limited budgets and time constraints to generate answers.

Is there anything we can do to develop a clear set of stakeholder expectations from the next round of modeling?

There is an obvious disconnect in expectations between the ODF operations staff and the Board even given the periodic staff contacts and explicit text explaining that this model is strategic and not operational. In part this is reinforced by the heroic efforts of the developers to use realistic harvest blocks and road networks (with engineering input). Regardless of its applications the modelers want the stakeholders to “believe” the model output and that can create expectations that the model can do more

than it was intended. In the next round of modeling the stand-based inventory along with realistic blocks and roads may go a long way to engender operations trust.

Do you have advice for us on how to set clear expectations?

Have as frank and open a discussion between operations staff and the Board about expectations and needs. Fundamentally this means there has to be agreement on "the problem". Often the problem for the strategic planner and the problem for the operations person are not aligned. Encourage expression of opinion on strategic and operational needs and work to show the linkage between strategic problem solving and operational implementation. It is important to be clear that although the model will not guide specific stand actions it must reasonably portray an agreed management direction. That guidance on direction should not be a line or number but a range and that success in implementation of that direction requires the buy-in of operations staff to operate within that range. Without that buy-in the strategic planning will have failed.

How should we go about evaluating alternative models that could be used?

At this point the evaluation of alternative models would only be driven by a fatal flaw in the existing model. None exists and so in the short term there is more need to improve the data driving the model than to look for an alternative model. In the longer term there are some inherent risks in being reliant on two key people. Pam Overhulser could feasibly re-train another analyst but not without significant effort and time lost doing her job. John Sessions could not be easily replaced and so his departure may invoke an evaluation of alternatives and at that time I would look for object-oriented programming models with a GUI similar to Patchworks.

Kiester

Remarkably few people were involved in the creation of this model given its size and complexity. A lean team has many advantages. But some of the processes of model development were severely constrained by lack of staff. QA/QC via documentation and source code control is the usual standard but cannot be achieved here without more staff.

Monserud

What do you have to say about our model development process?

Excellent. First, you have recruited Dr. Sessions, a world authority. And he has delivered a state-of-the-art simulated annealing optimizer of amazing complexity and accuracy. Second, you realized that the forest inventory was weak and limiting, and then developed a strong inventory that currently has reached 50% stand coverage. Third, you contracted with MBG to conduct certain analyses (growth model evaluation; yield table generation) and to do independent testing.

How can you make something like this more transparent?

This is not easy for such a complex optimization.

1. First, try to display variability and uncertainty.
2. Second, switch from Stratum Aggregation to Stand-based Yield prediction. This will allow you to demonstrate complete and continuous spatial integrity throughout the modeling process. Field foresters looking at the results of a given management prescription can then go back to the

original forest inventory for a given stand or adjacent stands and incorporate their knowledge and experience to see if the model results are believable.

3. At first, I was concerned that the code was proprietary. Now that I hear from Dr. Sessions that ODF has the code, and that a model review team could look at relevant parts to address some concern, then I am no longer troubled by this. (Note: my concerns have already been addressed when John showed us the Target and Goals section of the code Tuesday. I have no more need to see the code).
4. The Simulated Annealing Optimization is an incredibly complex and abstract procedure to try to explain to your users. (It is clear to me, but I am an optimizer). Maybe use some visual aid such as a 3-D model of the Cascade Range as a surface, with these isolated and towering local optima---volcanoes. Then explain the difficulty in trying to find any one of the volcanoes while blindfolded. And then, explain the difficulty of then finding a second one to see if it is higher than the first. And finally, explain the difficulty of finding the highest volcano in this sea of mountains.
5. Going to your field foresters to examine model results was an extremely strong attempt at transparency. This is very wise, and admirable.

Is there anything we can do to develop a clear set of stakeholder expectations from the next round of modeling?

Try to display variability and uncertainty rather than ignore it (e.g., H&H Final Report). Then begin the long educational process of explaining that a single mean projection is not certainty, and that a Low projection might be as equally likely as a High projection (given the same initial conditions, targets, and goals).

Do you have advice for us on how to set clear expectations?

I think that your expectations are realistic and excellent. For example, you correctly realized that the forest inventory was limiting, and then ameliorated the situation with an excellent inventory. No change in attitude needed.

How should we go about evaluating alternative models that could be used?

Your approach and operating procedures are just fine.

Northway

I am not fully aware of your model development process, but I feel that it might have benefited from a formal project management process. That having been said, from what I have seen you seem to have hit most of the points. There must have been a steering committee, user groups and stakeholder involvement. The inclusion of the Wood Emphasis and the Reserve Base options show a strong commitment from the stakeholders and the ODF.

A serious look at an alternative model should be done by having the proponent reproduce one of your existing runs and then spend a day with your analysts as they get hands-on experience.

Any final overall comments, conclusions or recommendations not already addressed:

Droessler

A commendable effort with many positive non-model outcomes (SLI, GIS layers, etc.).

Dunsworth

This has been a heroic effort in model development and implementation and the planning teams are to be commended. Many of the model components (spatial reality, roading and stand level treatments) are cutting edge. Many of the weaknesses identified in my review appear to be a result of the pressures of time, the pragmatic nature of the developers, and the "can do" attitude of the implementation team. This reflects the reality of development and implementation in an operational rather than academic environment. My particular thanks to Pam Overhulser, John Sessions, and Mike Davis for their patience, clarity and frankness.

Kiester

Transparency is a major utility of the model. It provides and audit trail of the data and decisions that were used to give an answer.

The structural complexity of the model is very great compared to the staff available for its maintenance and for the analysis of its output. Implementation of many of the recommendations listed here would require significant staff. The modeling team should attempt to understand carefully the balance between its resources and improvement goals

Monserud

You have an excellent system in place for supporting your management decisions. The Sessions optimizer is sufficiently detailed and quite accurate for addressing your management problems spatially, at the level that management is implemented. The H&H model is state-of-the-art. Your Stratum Aggregation procedure is a nuisance necessitated by the lack of a strong inventory 7-yrs ago. This inventory shortcoming has now been completely ameliorated with a strong system. Thus, you can soon move to a stand-based yield projection system that will make the entire H&H model spatially connected throughout. This will increase model integrity and transparency even more. As a scientist, a forester, and an Oregon taxpayer, I am quite pleased with the initiative that ODF has shown in developing this H&H model and in implementing a strong forest inventory. Excellent forest stewardship.

When I was first asked to participate, I was apprehensive that we might be expected to merely give our blessing, with criticism ignored. I was assured that this fear was false, an assurance that has indeed proved correct. I am extremely pleased with the high degree of professionalism exhibited by ODF personnel and the ESSA facilitators throughout this review process. Thank you. You asked for an independent review, and we were free to provide it. I only hope that it is useful.

4. Full Results by Reviewer

This section presents the contents of the full review reports written by each reviewer. This will allow the reader to better understand the perspectives of each of the reviewers across all of the questions.

4.1 Reviewer's Report: Dr. Terry Droessler

Scientific Peer Review of H&H Model Project Reviewer's Report

Prepared by: Terry Droessler
Date: 7/13/2006 PM

A. Structure

1. Are the structural features of these models (e.g. spatial/temporal scale and resolution, major components and functional relationships) appropriate to:
a) the decision problem they are trying to address, and
b) the available data?

Answer: Yes, they are necessary and appropriate, but insufficient.

Rationale: There are no confidence intervals around the "answers" so there is no way to discriminate whether one scenario is truly different from another (HCP vs. TA as an example). The trend lines alone indicate differences between scenarios, but without confidence limits, determining whether they are truly different is not possible.

Recommendations: Estimate confidence intervals (or at least some measure of uncertainty, confidence or risk) for the "answers" so that uncertainty is available to decision makers.

Overall assessment:

Insufficient information provided to answer question	Not appropriate at all	---------->			Very appropriate	Don't know - not my field of expertise
0	1	2x	3	4	5	?

2. Are the simplifying assumptions and limitations of the models clearly described?

Answer: Generally yes, but detail and clearly described rationale varies considerably across the models.

Rationale: The H&H model code ultimately shows assumptions and limitations, but it is proprietary and therefore unavailable and undocumented.

Recommendations: Document the code implementation of objective function, goals, constraints, weights, assumptions and limitations.

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	2	3x	4	5	?

B. Input Data

3. Is the accuracy and precision of the input data generally sufficient for the intended applications of the models? Are weaknesses in the input data recognized by the model users?

Answer: Variable, but most weaknesses are recognized by the model users.

Rationale: The average stand tables used to populate strata ignore the variability between stands within a strata. So although measurement errors and sampling errors are recognized to exist, they were ignored. The habitat portion of the model relies on a linkages between (DDI + TPA), stages of stand development (structure) and wildlife habitat. The accuracy and precision of these linkages are known to be weak because the habitat requirements are not well defined for many species.

Recommendations: Go stand-based rather than strata based or introduce variability. De-emphasize the habitat capabilities of the model.

Overall assessment:

Insufficient information provided to answer question	Data grossly insufficient; weaknesses not at all recognized	---------->			Input data sufficient; weaknesses recognized	Don't know - not my field of expertise
0	1	2	3x	4	5	?

4. Have sensitivity analyses been done to assess which input data are most critical to the choice of alternative management strategies?

Answer: Generally no.

Rationale: Some ad-hoc runs to define "solution clouds" have been undertaken, but no formal sensitivity analyses have been defined, implemented and documented.

Recommendations: Allocate the time/budget to define, implement and document a formal sensitivity analysis.

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses done on input data	---------->			Sufficient sensitivity analyses of input data	Don't know - not my field of expertise
0	1	2x	3	4	5	?

C. Growth and Yield Assumptions

5. Do the FVS growth models take into account the major biological factors which need to be considered in estimating growth and yield for these Oregon forests? (Variants of the USFS Forest Vegetation Simulator can consider root rot, dwarf mistletoe, and insects such as spruce budworm – are any of these critical to these forests, and missing?).

Answer: Yes and No.

Rationale: Structure-based management utilizes silvicultural treatments to achieve structural targets. An estimate of existing stand clumpiness is available from the SLI data and a distance-dependent model could have been used to explicitly model existing spatial structure and the differential growth and spatial impacts of silvicultural treatments. The underlying spatial distribution of trees in FVS is whatever existed on the research plots the model was built from, which is assumed to be approximately uniform no matter the silvicultural manipulations.

FVS also does not grow new plantations, so regenerated stands and early silviculture could not be explicitly modeled. Evidently stand tables from Districts were substituted.

The FVS tripling option was available to interject variability and not used.

The decision to use FVS was based in part on model evaluation and testing done by MBG. The model comparisons did not comprehensively consider all important aspects of the available models, especially related to differential growth rates based on distance-dependent tree competition.

The distance-dependent competition in FPS recognizes stand clumpiness (available from SLI data) and is designed for modeling the differential growth of trees from silvicultural practices that manipulate tree lists to create openings and achieve structure, which is fundamental to the ODF structure-based management approach.

Recommendations: I strongly recommend the FPS model should be revisited at least on a pilot project level.

Overall assessment:

Insufficient information provided to answer question	No major biological factors taken into account	---------->			All major biological factors taken into account	Don't know - not my field of expertise
0	1	2	3x	4	5	?

D. Natural Disturbances and Processes

6. Do the models deal adequately with important natural disturbances and processes in these forests (e.g. windthrow, fire, root disease, Swiss needle cast, natural regeneration after harvesting or fire)?

Answer: Generally yes, but some capabilities of the models were not used.

Rationale: Modelers are aware of tripling, windthrow, fire, root disease and other modules, but decided they could not implement them for lack of calibration data or inability to interpret the results in the context of the scenarios under consideration. Risk, uncertainty and variability were generally ignored.

Recommendations: The sources of error and their impact need to be explicitly acknowledged and incorporated.

Overall assessment:

Insufficient information provided to answer question	No important natural disturbances or processes dealt with	---------->			All important natural disturbances and processes dealt with	Don't know - not my field of expertise
0	1	2x	3	4	5	?

7. Do the models facilitate creation of harvest areas that mimic the sizes and shape of natural disturbances?

Answer: Unclear.

Rationale: The sizes and shapes of natural disturbances were not discussed.

Recommendations: This is probably not a high-priority issue.

Overall assessment:

Insufficient information provided to answer question	No, they do not facilitate this very well at all	---------->			Yes, they facilitate this very well	Don't know - not my field of expertise
0x	1	2	3	4	5	?

E. Key Functional Relationships and Constraints

8. Have the models been through a detailed sensitivity analysis to determine which functional relationships, parameters and constraints most strongly affect the choices amongst alternative decisions?

Answer: See 4.

Rationale:

Recommendations:

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses of functional relationships	---------->			Sufficient sensitivity analyses of functional relationships	Don't know - not my field of expertise
0	1	2	3	4	5	?

9. Are the key functional relationships, parameters and constraints (e.g. habitat requirements of focal fish and wildlife species) grounded in strong empirical data? Have model tests been done to assess the validity of key functional relationships?

Answer: Variable.

Rationale: Little is known about habitat requirements/preferences/utilization range for many species (no strong empirical data). DDI + TPA are assumed to be highly correlated to forest structure (stages of stand development), which is assumed to be correlated with habitat, but the linkages are not well understood.

Recommendations: De-emphasize the habitat aspect of the model.

Overall assessment:

Insufficient information provided to answer question	Not well grounded at all and validity not tested	---------->			Very well grounded and tested	Don't know - not my field of expertise
0	1	2	3x	4	5	?

10. Is it clear how the optimization algorithm used in the model attempts to meet the multiple competing objectives and constraints (e.g. timber production, wildlife habitat conservation, cost minimization)?

Answer: Maybe.

Rationale: Specifics are buried in code and the code is not available or documented.

Recommendations: Document the code.

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	2	3x	4	5	?

11. How easy is it to update key model functional relationships or parameters as new data are acquired?

Answer: Variable.

Rationale: In theory, the heuristic model approach is relatively easily updated. Some updates can be done by staff, while others require changes in code. For example, new inventory data can easily be incorporated as it is collected. Incorporating a new variable into the objective function is more involved and requires Dr. Sessions to change the code.

Recommendations: None.

Overall assessment:

Insufficient information provided to answer question	Very difficult	---------->			Very easy	Don't know - not my field of expertise
0	1	2	3	4x	5	?

F. Using the Models to Make Decisions

12. How useful are the models for the intended strategic and tactical level decisions to which they will be applied? [Specifically, can they be used to decide among the 4 options: FMP using a HCP, FMP using Take Avoidance, wood-emphasis, or reserve-based? Are these models appropriate for making decisions about: 1) whether to make changes in the Northwest and Southwest Oregon FMPs, 2) whether to pursue a HCP, and 3) setting harvest levels for Annual Operation Plans?]

Answer: Somewhat useful for yield flows, not useful for HCP and TA alternatives.

Rationale: The model will be useful for setting harvest levels for AOPs when stand-based inventory is used. The lack of variability oversimplifies the results (even for growth and yield) and renders it impossible to reliably discriminate between the four options. Incorporating variability information via a stand-based inventory will help with yield.

The habitat – structure linkage is weak (even though generally based on state of the science) and discriminating between the HCP and TA options based on the model may not be possible in the near future.

Recommendations: De-emphasize the ability of the model to provide habitat information.

Overall assessment:

Insufficient information provided to answer question	Not at all useful or appropriate	---------->			Very useful and appropriate	Don't know - not my field of expertise
0	1	2	3x	4	5	?

13. Do the models allow the exploration of different management strategies under multiple competing hypotheses (e.g. different assumptions about habitat requirements of focal wildlife species)?

Answer: Limited.

Rationale: Strongest for harvest questions, weak for habitat.

Recommendations: De-emphasize the ability of the model to provide habitat information.

Overall assessment:

Insufficient information provided to answer question	No, not at all	---------->			Yes, very much	Don't know - not my field of expertise
0	1	2	3	4	5	?

14. Is the model output deterministic, or does it provide a distribution of outcomes that recognizes uncertainties in both functional relationships and natural environmental variation?

Answer: Deterministic.

Rationale: Variability information was generally not incorporated into the model, even where estimates were available.

Recommendations: Incorporate variability in the model AND do sensitivity analyses.

Overall assessment:

Insufficient information provided to answer question	Completely deterministic	---------->			Distribution with uncertainties fully recognized	Don't know - not my field of expertise
0	1	2x	3	4	5	?

15. Is model uncertainty clearly communicated in documents provided to decision makers (e.g. the Board of Forestry)?

Answer: Generally no.

Rationale: Variation can be effectively communicated via confidence intervals, which requires variability was incorporated into the model (generally not).

Recommendations: Undertake a comprehensive inclusion of variability into the model.

Overall assessment:

Insufficient information provided to answer question	Uncertainties not included in documentation	---------->			Uncertainties clear in documentation	Don't know - not my field of expertise
0	1	2x	3	4	5	?

16. Do the models support the implementation of adaptive management (i.e. can model predictions and key functional relationships be tested and iteratively improved)?

Answer: Yes and No.

Rationale: Generally yes for growth and yield questions (once variability information is included such that reliable discrimination of alternatives is possible).

Generally no for habitat questions since habitat - structure linkages are particularly weak.

Recommendations: Undertake a comprehensive inclusion of variability in the model. De-emphasize the habitat component.

Overall assessment:

Insufficient information provided to answer question	Don't support implementation of AM at all	---------->			Fully support implementation of AM	Don't know - not my field of expertise
0	1	2	3x	4	5	?

17. What are the key priorities for overall improvement in the models, given the intended applications? (This synthesizes recommendations from previous questions; please consider pg. 55 of Doc 10A, Enhancements for the Future.)

Answer: Utilize stand-based inventory; Improve yield tables by using a distance-dependent growth model which explicitly utilizes the openings created by structure-based management, at least as a pilot project (yields will need to be regenerated from the stand-based inventory anyway); Incorporate variability and report confidence intervals or measures. Design, implement and document a sensitivity analysis study. Document what the code does. De-emphasize the habitat component.

Rationale:

Overview and Conclusions

18. Credibility: Is the model credible—able to address decision issues for which it was intended? How should outputs from models like this be used? What types of discussions should we be having about the outputs? And how should it NOT be used? Can we do something to put confidence intervals around model output or explain it better to move away from one number and talk about a range of numbers?

Model output credibility would be greatly improved with the inclusion of variability information such as confidence intervals. Where CI's cannot be explicitly calculated, some measure of confidence/risk/ variability should be incorporated and carried through to results.

The flexibility of goal programming allows the user to run and re-run the model by adjusting objective function weights until a solution meets specific goals. There is a **perception** that this process could be used inappropriately to limit the range of model output to pre-conceived levels and not produce the full range of possible outputs from the model.

19. Adequacy of Input Data: Is the accuracy and precision of underlying data sufficient for the intended purpose, and the scale it needs to be applied?

The strata-based inventory data is insufficient and plans are in place to replace it with a stand-based inventory. The habitat part of the model is based on (DDI + TPA) which defines stages of stand development (structure class), which is used as a surrogate for habitat. The linkage between (DDI + TPA), structure and habitat is weak.

20. Underlying Assumptions: Are the underlying assumptions sound / valid, for each of the major model components (i.e. wood harvest, revenue and costs, growth and yield, biodiversity)?

The assumption that a strata-based inventory represents the inherent variability of stands is not valid. The linkages between (DDI + TPA), structure and habitat are weak.

21. Testing: Is the model adequately tested? (i.e. input data checked, rules implemented correctly, computations correct given rules, functional relationships confirmed empirically, model output assessed by field personnel for reasonableness)?

An admirable job was done on testing the computational aspects of the model. The functional relationships between (DDI + TPA), structure and habitat can not be tested because they are not known or understood empirically.

22. Next Steps: What can be realistically changed or improved (given time and resources)?

A comprehensive incorporation of variability. Design, implement and document model sensitivity. Improved growth and yield tables (including regen tables) using a distance-dependent growth model. New yield tables must be generated anyway when the stand-based inventory is substituted for the strata-average inventory, so a different growth model could be used to generate those yields.

23. Overall Strengths and Weaknesses: What are the inherent strengths and weaknesses, particularly to goals and objectives that program is trying to achieve with it? Are their any fatal flaws in the model, underlying data / assumptions, or its application? Are there any other kinds of models in existence we should consider using to overcome weaknesses of the current suite of models?

The heuristic process selected is a considerable strength.

The habitat portion of the model is weak with little ability to improve it in the foreseeable future (too many unknowns or possibly unknowables).

24. Process of Model Development: What do you have to say about our model development process? How can you make something like this more transparent? Is there anything we can do to develop a clear set of stakeholder expectations from the next round of modeling? Do you have advice for us on how to set clear expectations? How should we go about evaluating alternative models that could be used?

An outside panel could have been (and could be in the future) effectively utilized at major decision points to improve the model considerably.

Any final overall comments, conclusions or recommendations not already addressed:

A commendable effort with many positive non-model outcomes (SLI, GIS layers, etc.).

4.2 Reviewer's Report: Mr. Glen Dunsworth

H+H Model Review Sessions
Scientific Peer Review of H&H Model Project
Reviewer's Report

Prepared by: Glen Dunsworth
Date: July 14, 2006

A. Structure

1. Are the structural features of these models (e.g. spatial/temporal scale and resolution, major components and functional relationships) appropriate to:
a) the decision problem they are trying to address, and
b) the available data?

Answer: a) Yes, for timber, NSO and MAMU habitat and No for biodiversity, b) Yes

Rationale: There is significant and useful detailed structure in the modeling framework for the portrayal of spatial and temporal constraints on timber, NSO and MAMU habitat. However, the structural classes used for the coarse filter species assessment provide a very weak structure for the assessment of biodiversity or a broader range of biological richness. The state of knowledge of structural requirements for at least some of these species (see J. Weikel 2004 review) is specific to structural attributes and that detail is lost in the generalization to structural classes. In addition the ecological distribution of structural classes cannot be assessed appropriately because no ecological units were included in the model. Either the National Vegetation Classification System (NVCS) coverage used for the Oregon Gap Analysis or the International Terrestrial Ecological Classification System (ITECS) used by NatureServe could be used.

Recommendations: Consider renaming the Coarse Filter Wildlife Matrix-Species List to be the Species Accounting System. Then look to improving the model with the inclusion of deadwood dynamics (i.e. green trees moving to snags moving to coarse woody debris) possibly acting on the snag model recommendation from Mason, Bruce and Girard (March 8, 2005) to use the FFE extension of FVS for snag and downed log modeling. An additional improvement would be the inclusion of a shrub model which it appears could possibly be derived from the existing inventory, at least as a first approximation. Then the species model parameter list would need to be revised to replace structural classes with structural attributes. Finally, inclusion of NCVS or ITECS ecological units is recommended and should be used to report the distribution of complex structure within a District.

Overall assessment:

Insufficient information provided to answer question	Not appropriate at all	---------->			Very appropriate	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

2. Are the simplifying assumptions and limitations of the models clearly described?

Answer: In general, No. But the limitations and assumptions were clear upon interrogation.

Rationale: The Final Report does not provide sufficient description of the model framework and implementation to determine all the assumptions and limitations. During our interviews we were able to expose many of the limitations and assumptions both through Q+A and through existing documentation not included in the Final Report. As an example it is unclear in the report why there would be differences in Habitat Suitability determination among common Coarse Filter Species like black-tailed deer foraging or thermal habitat (Generalist- Multiple Structure- see page 39 in the Final Report). This was clear once we saw the Habitat Suitability coding for each species and their ecological rationale. Another example, it was unclear without further reading that 27 of the 58 Coarse Filter Species selected were deemed by the J. Weikel 2004 review to be "possible monitoring species but lack necessary species habitat information".

Recommendations: Further or more complete documentation is required. As an example, it should be clearer how the Coarse Filter Species habitat suitability was determined specific to what elements contribute to suitability and how.

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	**2**	3	4	5	?

B. Input Data

a) Is the accuracy and precision of the input data generally sufficient for the intended applications of the models?
b) Are weaknesses in the input data recognized by the model users?

Answer: a) No. b) Yes.

Rationale: The use of broad inventory strata tended to collapse much of the known and improving stand level inventory detail into planning polygons that made the predictions less precise than they might be. The model developer and users are cognizant of this limitation but tended to downplay this limitation in the writing of the Final Report. The same is true but less so of the use of Structural Classes instead of structural attributes for coarse filter species.

Recommendations: Move to a stand level inventory as quickly as possible. Include in that inventory stand structures particularly snags (number, size and decay class), coarse woody debris (cover, size and decay class), shrub, and forb cover.

Overall assessment:

Insufficient information provided to answer question	Data grossly insufficient; weaknesses not at all recognized	---------->	Input data sufficient; weaknesses recognized	Don't know - not my field of expertise
0	1	**2**	3 4 5	?

4. Have sensitivity analyses been done to assess which input data are most critical to the choice of alternative management strategies?

Answer: Some, but insufficient to cover all variables and not all those done were documented in the Final Report or in other written documentation.

Rationale: Sensitivity analysis should be directed at model components of the greatest uncertainty. Given that one of the major modeled differences between HCP and TA was % of owl clusters harvested per decade and that this was contingent on reaching complex structure targets in the HCP alternative, some sensitivity analysis was done on those targets testing the range in the FMP (40-60%). But no testing was done to determine the sensitivity to changing the proportions of LYR and OFS in the make up of complex structure or to test the sensitivity of the individual elements defining those classes (i.e. DDI, Tree height and DBH) or to test minimum time to achieving any structural target. Similarly, there was no sensitivity testing done on how changing the discount rate would influence the NPV determinations.

Recommendations: More sensitivity analysis should be done, particularly on the components of structural classes LYR and OFS, the timing of achieving complex structure targets, and on the discount rate.

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses done on input data	---------->	Sufficient sensitivity analyses of input data	Don't know - not my field of expertise
0	1	**2**	3 4 5	?

C. Growth and Yield Assumptions

5. Do the FVS growth models take into account the major biological factors which need to be considered in estimating growth and yield for these Oregon forests? (Variants of the USFS Forest Vegetation Simulator can consider root rot, dwarf mistletoe, and insects such as spruce budworm – are any of these critical to these forests, and missing?).

Answer: Yes, but the full utility of FVS has not been captured.

Rationale: FVS has a module for snags and downed logs (FFE extension of FVS for snag and downed log) that was not used because the existing inventory was inadequate to calibrate the model. The improvements in the inventory now and in the near future would rectify this problem.

Recommendations: Use the FFE extension of FVS for snag and downed log in FVS calibrating it with the improved stand level inventory.

Overall assessment:

Insufficient information provided to answer question	No major biological factors taken into account	---------->			All major biological factors taken into account	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

D. Natural Disturbances and Processes

6. Do the models deal adequately with important natural disturbances and processes in these forests (e.g. windthrow, fire, root disease, Swiss needle cast, natural regeneration after harvesting or fire)?

Answer: Yes, but only for Swiss needle cast and Phellinus

Rationale: Growth loss impacts were reviewed with the Districts where this is an operational problem. Those risk areas were zone mapped, growth reductions estimated and included in the model by zone. Phellinus was included only in Districts where it was significant (Forest Grove and North Cascade) and growth reductions estimated and applied to random stands.

Recommendations: No Change

Overall assessment:

Insufficient information provided to answer question	No important natural disturbances or processes dealt with	---------->			All important natural disturbances and processes dealt with	Don't know - not my field of expertise
0	1	2	3	4	5	?

7. Do the models facilitate creation of harvest areas that mimic the sizes and shape of natural disturbances?

Answer: No, Patterns of natural disturbance were not used in the model.

Rationale: The intent of the model was to capture the regulatory requirements of the FMP for maximum block size at 120 acres. Complex structure patch distribution that is in the FMP was not included in the modeling Final Report but was assessed in consultation with wildlife biologists. They determined that the patch distribution achieved using the complex structure targets were sufficient to meet the spirit and intent of the FMP for complex structure distribution.

Recommendations: No change

Overall assessment:

Insufficient information provided to answer question	No, they do not facilitate this very well at all	---------->			Yes, they facilitate this very well	Don't know - not my field of expertise
0	**1**	2	3	4	5	?

E. Key Functional Relationships and Constraints

8. Have the models been through a detailed sensitivity analysis to determine which functional relationships, parameters and constraints most strongly affect the choices amongst alternative decisions?

Answer: No, see question 4

Rationale:

Recommendations:

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses of functional relationships	---------->			Sufficient sensitivity analyses of functional relationships	Don't know - not my field of expertise
0	1	**2**	3	4	5	?

9. Are the key functional relationships, parameters and constraints (e.g. habitat requirements of focal fish and wildlife species) grounded in strong empirical data? Have model tests been done to assess the validity of key functional relationships?

Answer: No, not completely

Rationale: The habitat requirements for NSO and MAMU are likely best grounded in empirical data but even those have not had specific District calibration done to reflect known variability in species biology. NSO habitat needs were derived form the NW Forest Plan and MAMU conservation areas were mapped from photography and field surveys. For the Coarse Filter Species there was limited local empirical data and approximations to structural class were made using a review of the existing NA literature (Mike Davis pers. comm., J. Weikel 2004).

Recommendations: As quickly as possible develop better understanding of habitat elements and species local biology for coarse filter species. This should be done as part of a strongly needed Adaptive Management and Monitoring program in support of the FMP. This program should focus both on improving knowledge of species use of habitat elements and the abundance and growth dynamics of those structures in natural and managed stands.

Overall assessment:

Insufficient information provided to answer question	Not well grounded at all and validity not tested	---------->			Very well grounded and tested	Don't know - not my field of expertise
0	1	2	**3**	4	5	?

10. Is it clear how the optimization algorithm used in the model attempts to meet the multiple competing objectives and constraints (e.g. timber production, wildlife habitat conservation, cost minimization)?

Answer: Yes

Rationale: The model optimizes three elements; NPV, Harvest flow, and complex structure. However, the model could also use coarse filter species habitat in the optimization algorithm to reflect the biodiversity objectives inherent in the FMP. This could be done by setting either a no habitat extirpation rule or use an agreed acceptable minimum based on consultation with ODF biologists.

Recommendations: The model should be recoded to allow coarse filter species habitat in the optimization algorithm. Runs should be done to test the sensitivity of achieving biodiversity objectives inherent in the FMP. This could be done by setting either a no habitat extirpation rule for coarse filter species or use an agreed acceptable minimum based on consultation with ODF biologists. If this is done the coarse filter species list should be reduced to those species where there is the strongest confidence in the habitat relationships.

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

11. How easy is it to update key model functional relationships or parameters as new data are acquired?

Answer: Relatively easy

Rationale: Based on discussions with John Sessions key model functional relationships can be altered or created by changing the model code and that he can do that with relative ease. Unfortunately this can not be done easily by anyone other than John Sessions. This is a serious limitation for future use of the model.

Recommendations: Consider developing a user interface for the model that would make it easy for users other than the model developer to modify the model parameters.

Overall assessment:

Insufficient information provided to answer question	Very difficult	---------->			Very easy	Don't know - not my field of expertise
0	1	2	**3**	4	5	?

F. Using the Models to Make Decisions

12. How useful are the models for the intended strategic and tactical level decisions to which they will be applied? [Specifically, can they be used to decide among the 4 options: FMP using a HCP, FMP using Take Avoidance, wood-emphasis, or reserve-based? Are these models appropriate for making decisions about: 1) whether to make changes in the Northwest and Southwest Oregon FMPs, 2) whether to pursue a HCP, and 3) setting harvest levels for Annual Operation Plans?]

Answer *(please specify what applications of the models you feel are appropriate, and what applications are not)*:

1. No, without the feedback from an adaptive management program testing the adequacy of the assumptions and approaches in the FMP it would be unwise to act on model forecasts.
2. Yes, for comparisons between TA, WE and RB but the value of the comparison between HCP and TA is limited due to the post-processing approach to the impact of owl circles.
3. Yes, in the absence of the advice from this model harvest levels will be set and the model will significantly help to guide that decision.

Rationale: The model goals and switches table clearly shows the differences between the model runs used to reflect the four scenarios. These appear to reflect the policy distinctions but in the implementation of

the model they have chosen "for a variety of reasons, we believe that simply tracking the impacted harvest units is the best method to use." (M. Davis memo, June 13, 2005). This means that the power of the model to find harvest solutions that would work to maintain a relatively high even flow in the face of owl circles was removed and a worst case, simple subtraction option applied. The team was clear that this was one of their time constraint issues and would require coding time from J. Sessions to accomplish.

Recommendations: Spend the time and effort to modify the code to find harvest schedule solutions in the face of owl circle limitations. Do not modify the FMP until guidance from the AM Program is in place.

Overall assessment:

Insufficient information provided to answer question	Not at all useful or appropriate	---------->			Very useful and appropriate	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

13. Do the models allow the exploration of different management strategies under multiple competing hypotheses (e.g. different assumptions about habitat requirements of focal wildlife species)?

Answer: Yes

Rationale: The model is sufficiently detailed to reflect different management strategies under multiple competing hypotheses. The caveat for wildlife species is that their habitat needs must be generalized to structural classes and this generalization could mask significant differences in species response to management strategies or limit the management strategies assessed to those that alter structure classes and not structural attributes.

Recommendations: Look to improving the model with the inclusion of deadwood dynamics (i.e. green trees moving to snags moving to coarse woody debris) possibly acting on the snag model recommendation from Mason, Bruce and Girard (March 8, 2005) to use the FFE extension of FVS for snag and downed log modeling. An additional improvement would be the inclusion of a shrub model which it appears could possibly be derived from the existing inventory, at least as a first approximation. Then the species model parameter list would need to be revised to replace structural classes with structural attributes (See Question 1).

Overall assessment:

Insufficient information provided to answer question	No, not at all	---------->			Yes, very much	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

14. Is the model output deterministic, or does it provide a distribution of outcomes that recognizes uncertainties in both functional relationships and natural environmental variation?

Answer: No, the model is not deterministic

Rationale: The simulated annealing process at the core of the model is a random search heuristic and as such is not deterministic. It could provide a distribution of outcomes recognizing uncertainty in the growth and yield functions and in the development of complex structure. The later could be developed out of the recommended sensitivity analysis of complex structure (see Question 4).

Recommendations: Other Panel members are better qualified to recommend

Overall assessment:

Insufficient information provided to answer question	Completely deterministic	---------->			Distribution with uncertainties fully recognized	Don't know - not my field of expertise
0	1	2	3	4	5	**?**

15. Is model uncertainty clearly communicated in documents provided to decision makers (e.g. the Board of Forestry)?

Answer: No, not completely.

Rationale: The model results presented to the Board in the Final Report provide single line solutions for each scenario with no confidence intervals. Level of confidence and elements of concern are discussed in the text (pages 48-51, Final Report). However, even if these confidence concerns were handled the uncertainty in the forecasts due to uncertainty in the data and complexity of the optimization solutions would remain.

Recommendations: Efforts should be made to generate confidence intervals around the scenario solutions that reflect uncertainty in the data and the range of feasible spatial solutions.

Overall assessment:

Insufficient information provided to answer question	Uncertainties not included in documentation	---------->			Uncertainties clear in documentation	Don't know - not my field of expertise
0	1	2	**3**	4	5	?

16. Do the models support the implementation of adaptive management (i.e. can model predictions and key functional relationships be tested and iteratively improved)?

Answer: Yes, to a limited extent.

Rationale: The problem being addressed by the modeled scenarios is forest simplification and its impact on sustaining NSO, MAMU species and maintaining the biological richness of the original forests. The

hypothesis is that stands can be made more complex and subsequently more suitable for a broader range of species (particularly late successional species) through thinnings than by age alone. To do this in an active adaptive management process would require departing from the spirit and intent of the HCP or the TA approaches and including some of all four options over relatively large areas. In doing this I suspect the conditions for granting the HCP would be violated and the HCP could not be granted. Thus, AM could likely only be applied under a TA scenario where the stand manipulation options are limited.

However, it could be possible to apply AM with both an active (experimental) and passive (operational) approach to the question of whether the use of thinnings as applied in the model could create the expected stand complexity and if coarse filter species respond to these structural changes as expected. The core hypotheses on species response should be related to structural attributes rather than structural class. The suite of monitored species should be broadened to include invertebrates, vascular plants, bryophytes and lichens. In this way well understood functional relationships can be tested and habitat needs for less well understood species derived.

Recommendations: Development of and Adaptive Management and Monitoring program to test the efficacy of thinning in creating useful complex structure for a broad suite of organisms is a critical part of implementing the FMP. This program should start immediately and should include both an active and passive adaptive management component. The Program should focus on stand structure monitoring and species abundance assessments under as wide a range of thinning options as possible across the range of ecological units in the Districts.

Overall assessment:

Insufficient information provided to answer question	Don't support implementation of AM at all	---------->	Fully support implementation of AM	Don't know - not my field of expertise
0	1	2 **3** 4	5	?

17. What are the key priorities for overall improvement in the models, given the intended applications? (This synthesizes recommendations from previous questions; please consider pg. 55 of Doc 10A, Enhancements for the Future.)

Answer: key priorities for change are;

a) move to a stand-based inventory as quickly as possible,

b) move away from structural classes for assessment of species response,

c) implement an AM+M Program to test the efficacy of thinnings in creating complex structure,

d) improve understanding of key habitat attributes for coarse filter species and broaden the species list to include non-vertebrates,

e) include ecological classification in future model reporting.

Rationale: The stand-based inventory is a fundamental short-coming in the application of the model and combined with the use of structural classes for species habitat assessment significantly reduces the models utility. The AM+M Program is a critical part of the implementation of the FMP and the key practice in that Plan is the application of thinning as a tool to create stand complexity and a broaden available habitat. Ecological classification is a necessary framework for evaluating distribution of stand structure across landscapes.

Overview and Conclusions

18. Credibility:

Is the model credible – able to address decision issues for which it was intended? Yes

How should outputs from models like this be used? What types of discussions should we be having about the outputs? and how should it NOT be used?

They should be used to guide policy and provide strategic direction. They should not be used to guide harvest block specific actions.

Can we do something to put confidence intervals around model output or explain it better to move away from one number and talk about a range of numbers?

Yes we should and two areas to explore are in the growth and yield inputs (attempt to reflect the natural variability in forest growth) and in the definition of structural classes (attempt to reflect the uncertainty inherent in threshold values for TPA, DBH and DDI).

19. Adequacy of Input Data:

Is the accuracy and precision of underlying data sufficient for the intended purpose, and the scale it needs to be applied?

The accuracy and precision of the underlying data is likely sufficient to address the question of whether or not the intended stand treatments and harvest schedules will address the problem of stand and landscape simplification. However, they are likely insufficient to assess coarse filter species needs and may be insufficient to assess NSO impacts.

20. Underlying Assumptions:

Are the underlying assumptions sound / valid, for each of the major model components (i.e. wood harvest, revenue and costs, growth and yield, biodiversity)?

The underlying assumptions for the harvest questions seem sound and valid or at least more sound and valid than the assumptions for biodiversity. The translation or estimation of known habitat attribute requirements for NSO, MAMU and coarse filter species through structural classes is not well supported with empirical data and is an artifact of a weak inventory.

21. Testing:

Is the model adequately tested? (i.e. input data checked, rules implemented correctly, computations correct given rules, functional relationships confirmed empirically, model output assessed by field personnel for reasonableness)?

Yes, the checking and feedback with staff biologists and foresters has been exceptional.

22. Next Steps:

What can be realistically changed or improved (given time and resources)?

Key priorities for improvement are;

a. move to a stand-based inventory as quickly as possible,
b. move away from structural classes for assessment of species response,
c. implement an AM+M Program to test the efficacy of thinnings in creating complex structure,
d. improve understanding of key habitat attributes for coarse filter species and broaden the species list to include non-vertebrates,
e. include ecological classification in future model reporting.

23. Overall Strengths and Weaknesses:

What are the inherent strengths and weaknesses, particularly to goals and objectives that program is trying to achieve with it? Are their any fatal flaws in the model, underlying data / assumptions, or its application? Are there any other kinds of models in existence we should consider using to overcome weaknesses of the current suite of models?

There are no fatal flaws in the modeling process. The strength of the model is that it is spatial, uses engineered harvest blocks and realistic road networks, provides for the inclusion of all FMP constraints and can simulate stand-level treatment options at a significant level of detail. The weaknesses are in the fact that the changes can only be done by one person and he is near retirement and the model can only be operated by one ODF staff person. An additional weakness in the model is its approach to spatial habitat supply using structural classes rather than structural attributes for species whose structural attribute needs are well understood and can be modeled from the inventory data.

Should consider object-oriented program models like Patchworks (Moore and Lockwood) with a graphical user interface to allow for a broader set of users and provide insurance that the modeling can evolve as better data is collected once John Sessions has retired.

24. Process of Model Development:

What do you have to say about our model development process?

The model development process seemed to be well managed and inclusive but under-funded and staffed to meet the timeline expectations of the clients. John Sessions and Pam Overhulser have been key players and have put an extraordinary amount of effort into the development and implementation process. I would have preferred a more balanced effort in the model process between the timber and biodiversity components. For a variety of reasons habitat for other than NSO and MAMU was given a lower priority for the limited modeling resources and that shows.

How can you make something like this more transparent?

I think model development in perhaps an object-oriented programming environment and the use of graphical user interfaces could have made the model more transparent and more broadly useable. More complete documentation would also help but these aspects are expensive and often seen as frills under the pressure of limited budgets and time constraints to generate answers.

Is there anything we can do to develop a clear set of stakeholder expectations from the next round of modeling?

There is an obvious disconnect in expectations between the ODF operations staff and the Board even given the periodic staff contacts and explicit text explaining that this model is strategic and not operational. In part this is reinforced by the heroic efforts of the developers to use realistic harvest blocks and road networks (with engineering input). Regardless of its applications the modelers want the stakeholders to "believe" the model output and that can create expectations that the model can do more than it was intended. In the next round of modeling the stand-based inventory along with realistic blocks and roads may go a long way to engender operations trust.

Do you have advice for us on how to set clear expectations?

Have as frank and open a discussion between operations staff and the Board about expectations and needs. Fundamentally this means there has to be agreement on "the problem". Often the problem for the strategic planner and the problem for the operations person are not aligned. Encourage expression of opinion on strategic and operational needs and work to show the linkage between strategic problem solving and operational implementation. It is important to be clear that although the model will not guide specific stand actions it must reasonably portray an agreed management direction. That guidance on direction should not be a line or number but a range and that success in implementation of that direction requires the buy-in of operations staff to operate within that range. Without that buy-in the strategic planning will have failed.

How should we go about evaluating alternative models that could be used?

At this point the evaluation of alternative models would only be driven by a fatal flaw in the existing model. None exists and so in the short term there is more need to improve the data driving the model than to look for an alternative model. In the longer term there are some inherent risks in being reliant on two key people. Pam Overhulser could feasibly re-train another analyst but not without significant effort and time lost doing her job. John Sessions could not be easily replaced and so his departure may invoke an evaluation of alternatives and at that time I would look for object-oriented programming models with a GUI similar to Patchworks.

Any final overall comments, conclusions or recommendations not already addressed:

This has been a heroic effort in model development and implementation and the planning teams are to be commended. Many of the model components (spatial reality, roading and stand level treatments) are cutting edge. Many of the weaknesses identified in my review appear to be a result of the pressures of time, the pragmatic nature of the developers, and the "can do" attitude of the implementation team. This reflects the reality of development and implementation in an operational rather than academic environment. My particular thanks to Pam Overhulser, John Sessions, and Mike Davis for their patience, clarity and frankness.

4.3 Reviewer's Report: Dr. A. Ross Kiester

Scientific Peer Review of H&H Model Project Reviewer's Report

Prepared by: A. Ross Kiester
Date: 13 July 2006

A. Structure

1. Are the structural features of these models (e.g. spatial/temporal scale and resolution, major components and functional relationships) appropriate to:
a) the decision problem they are trying to address, and
b) the available data?

Answer: a) The many spatial scales ranging from the smallest unit of treatment to a district are well represented in the model. The various polygons match the strategic and tactical level of analysis and provide some insight into operation scale issues. There is some overall disconnect between tactical and operational scales. This disconnect represents a real tension in the construction and use of the model. On the one hand the more the model considers an operational scale the better it communicates to the Foresters implementing operations. One the other hand the implementing foresters wish to retain authority to design operational plans and therefore may be wary of a model that provides too much specific detail. Overall I believe that the modeling effort is striking an appropriate balance between these competing desires.

b) Data on trees in the new stand survey and harvest engineering efforts are definitely at appropriate scales. There is a problem with taking the midpoint of a 5 year interval as being 2 years. This bias in this use of the stand survey data needs to be addressed (it is a fundamental problem in any discretization of a continuous process)

Rationale: The visualization of the polygon type spatial hierarchy presented in the discussion by the model team clearly showed what we needed to know.

Recommendations: Solve the discretization problem. Create visualization of the spatial structure of the model.

Overall assessment:

Insufficient information provided to answer question	Not appropriate at all	---------->			Very appropriate	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

2. Are the simplifying assumptions and limitations of the models clearly described?

Answer: There are hundred of identifiable assumptions made in the process of creating this model. The written documentation gives some of these, but in general it would be difficult to reconstruct what was done from the documentation alone. On the other hand it was clear in discussion with the model team that they had a good idea of all of the other assumptions that they had had to make.

Rationale: Individual questions asked by the review team always elicited a detailed answer from the model team.

Recommendations: This is the fundamental issue of documentation. Overall the model is barely documented. Some parts of the model are deliberately undocumented because they are proprietary products. The modeling team is well aware of this lack. Documenting a model of this complexity of structure and of interaction with folks providing input is a very large task. It will not occur unless some personnel are assigned to this task (if this is to be done at least one technical writer would be required)

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	**2**	3	4	5	?

B. Input Data

3. Is the accuracy and precision of the input data generally sufficient for the intended applications of the models? Are weaknesses in the input data recognized by the model users?

Answer: Under the assumption that the transition to stand-based modeling (from modeling via strata) will occur the tree and stand data used will be more than sufficient. Beyond the characterization of stand structure the data used to link stand structure to wildlife and biodiversity targets are not yet sufficient.

Rationale: The stand inventory procedure now bring implemented is well designed and will provide the necessary tree and stand data.

Recommendations: Complete transition to new inventory based model as soon as possible. Look into other Oregon research and modeling efforts such as Clams and the Gap Analysis Program for ideas and perhaps data to help wit the wildlife and biodiversity component.

Overall assessment:

Insufficient information provided to answer question	Data grossly insufficient; weaknesses not at all recognized	---------->			Input data sufficient; weaknesses recognized	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

4. Have sensitivity analyses been done to assess which input data are most critical to the choice of alternative management strategies?

Answer: Overall, a well-designed and documented sensitivity analysis of the effect of variation in the input data does not appear to have been done. However, conversations with the model team indicate some level of experience in undertaking this activity.

Rationale: Conversations with model team.

Recommendations: As the new stand inventory data come online do a pilot sensitivity analysis of the data.

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses done on input data	---------->			Sufficient sensitivity analyses of input data	Don't know - not my field of expertise
0	1	**2**	3	4	5	?

C. Growth and Yield Assumptions

5. Do the FVS growth models take into account the major biological factors which need to be considered in estimating growth and yield for these Oregon forests? (Variants of the USFS Forest Vegetation Simulator can consider root rot, dwarf mistletoe, and insects such as spruce budworm – are any of these critical to these forests, and missing?).

Answer: Swiss Needle Cast and Root Rot are included in the model in an ad hoc manner. The model does not capture the stochastic nature of stand dynamics. Not everyone would say that stochasticity is a biological factor, but I believe that it is useful to think of it that way. Tables produced by expert judgment now handle reforestation and young stands.

Rationale: Section 7 lists how Swiss Needle Cast and Root Rot enter into the calculations of the model.

Recommendations: If it is clear that a variant of FVS could appropriately deal with these 2 factors on ODF lands it should be made to do so. Perhaps a pilot study could estimate the degree of improvement in the model that such a change would produce. The stochastic variant of FVS should be incorporated as soon as possible for a variety of reasons including the one given here that forests have inherently stochastic dynamics. The question of the use of other models for regeneration and young stand development should be revisited.

Overall assessment:

Insufficient information provided to answer question	No major biological factors taken into account	---------->			All major biological factors taken into account	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

D. Natural Disturbances and Processes

6. Do the models deal adequately with important natural disturbances and processes in these forests (e.g. windthrow, fire, root disease, Swiss needle cast, and natural regeneration after harvesting or fire)?

Answer: At large scales, the model does not consider catastrophic disturbances and this is an appropriate design decision. As mentioned Root Rot and Swiss Needle Cast are dealt with through the use of an ad hoc adjustment (see above #5). Natural regeneration and reforestation are accomplished through expert produced tables.

Rationale: Section 7 shows how these factors are and are not incorporated into the model.

Recommendations: Modeling and projecting reforestation and regeneration should be revisited especially since young stand behavior is very important in multi-species, uneven-age stand development (compared to single species, even-aged plantations).

Overall assessment:

Insufficient information provided to answer question	No important natural disturbances or processes dealt with	---------->			All important natural disturbances and processes dealt with	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

7. Do the models facilitate creation of harvest areas that mimic the sizes and shape of natural disturbances?

Answer: No. No data were presented and few probably exist on the historical patterns of such disturbances which would be needed to established targets for such a management approach. So the model does not consider this approach due to lack of data and this design decision is appropriate under the circumstances.

Rationale: Section 7 and discussion with the model team.

Recommendations: Sit tight on this one. We're not there yet for ODF lands although this approach is being tried on other lands in Oregon (Blue River District, Willamette National Forest).

Overall assessment:

Insufficient information provided to answer question	No, they do not facilitate this very well at all	---------->			Yes, they facilitate this very well	Don't know - not my field of expertise
0	**1**	2	3	4	5	?

E. Key Functional Relationships and Constraints

8. Have the models been through a detailed sensitivity analysis to determine which functional relationships, parameters and constraints most strongly affect the choices amongst alternative decisions?

Answer: Little written documentation is available on this question. However, discussions with the model team indicate that extensive informal sensitivity studies on model parameters and goals were undertaken in the process of developing the model. Less clear is to what extent there were sensitivity studies done on the human inputs to the model.

Rationale: Extensive discussions with model team.

Recommendations: Restructure the overall model architecture to allow easier batch processing and automation of the task of saving run parameters with run results in a database system to facilitate analysis. For example the cut and paste processes shown in flow chart #5 need to be automated. This work would be important because it will produce the tool necessary to undertake formal sensitivity studies and run Monte Carlo simulations to estimate confidence intervals of results (see # 15 below). Think about how you use human derived input into the model. How different are the inputs that you get from different experts? This task might be facilitated by providing more detail in flow chart #5 so that the points where the role of expert variability occurs would be highlighted.

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses of functional relationships	---------->			Sufficient sensitivity analyses of functional relationships	Don't know - not my field of expertise
0	1	2	**3**	4	5	?

9. Are the key functional relationships, parameters and constraints (e.g. habitat requirements of focal fish and wildlife species) grounded in strong empirical data? Have model tests been done to assess the validity of key functional relationships?

Answer: Again the tree, stand, and harvest engineering parts of the model have a solid empirical basis while the wildlife and biodiversity aspects are less well grounded.

Rationale: Section 7.

Recommendations: See # 3 above.

Overall assessment:

Insufficient information provided to answer question	Not well grounded at all and validity not tested	---------->			Very well grounded and tested	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

10. Is it clear how the optimization algorithm used in the model attempts to meet the multiple competing objectives and constraints (e.g. timber production, wildlife habitat conservation, cost minimization)?

Answer: No, it is not clear except in a very general way. I do agree completely with the idea that the model should use heuristics techniques such as simulated annealing for optimization. The interaction between the users of the model and the model to achieve optimization are complex and sometimes difficult to follow.

Rationale: The optimization routines in the Sessions H&H Model are proprietary.

Recommendations: It would be good if the model could be made to iterate on its own rather than looping through user input for optimization (create a "hands free" version). Next time you undertake a project of this kind consider alternative business models. My own opinion is that open source code is a critical ingredient in open government.

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	**2**	3	4	5	?

11. How easy is it to update key model functional relationships or parameters as new data are acquired?

Answer: Since ODF has an ongoing relationship with Sessions having him update functional relationships in the model does not appear to be that difficult. ODF appears to have the in-house capability to update parameters. Both ODF and Sessions constantly recompile the code so easy changes to the code are easy to implement.

Rationale: Discussion with ODF model team and Sessions.

Recommendations: At this point in the development of the model I believe that it is much more important to investigate the properties of the model that you already have (via sensitivity analysis and Monte Carlo variance estimation) than to undertake any reworking of the model itself.

Overall assessment:

Insufficient information provided to answer question	Very difficult	---------->			Very easy	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

F. Using the Models to Make Decisions

12. How useful are the models for the intended strategic and tactical level decisions to which they will be applied? [Specifically, can they be used to decide among the 4 options: FMP using a HCP, FMP using Take Avoidance, wood-emphasis, or reserve-based? Are these models appropriate for making decisions about: 1) whether to make changes in the Northwest and Southwest Oregon FMPs, 2) whether to pursue a HCP, and 3) setting harvest levels for Annual Operation Plans?]

Answer (please specify what applications of the models you feel are appropriate, and what applications are not):

4 Options: Significant analysis has been done on the first two options comparing FMP+HCP and FMP+TA. The analyses of the wood-emphasis and reserve based design help check the behavior of the model.

Making changes in the FMPs: The models at this time have relatively little to say about this issue.

Whether to pursue HCP: This is a difficult call at this point. The model does produce feasible results under both scenarios, but it needs more analysis and confidence intervals to really address this question.

Setting harvest levels: Clearly the model generates feasible and sensible harvest schedules. These harvest levels have been examined by the operational foresters in the Model Report Sessions and Model Run Days. Their concurrence indicates that the model performs this function well.

Rationale: Overall evaluation of the model structure.

Recommendations: Implementing confidence intervals will help a great deal.

Overall assessment:

Insufficient information provided to answer question	Not at all useful or appropriate	---------->			Very useful and appropriate	Don't know - not my field of expertise
0	1	**2**	3	4	5	?

13. Do the models allow the exploration of different management strategies under multiple competing hypotheses (e.g. different assumptions about habitat requirements of focal wildlife species)?

Answer: The model does a good job of examining the trade-offs between harvest volume and stand structural diversity although the visualization of this trade-off could be better. The larger question of how the model supports other aspects of the operationalization of GPV is open. There is an overall question of the balance of whether the model provides a level playing field for the competition between harvest and wildlife/biodiversity values. Clearly the goals can be changed to study this balance, but it is also clear that the model does more justice to the harvest component than to the habitat component.

Rationale: Discussion of model structure.

Recommendations: I think the team should explicitly state the rationale for the decision on the balance of effort between harvest and habitat.

Overall assessment:

Insufficient information provided to answer question	No, not at all	---------->			Yes, very much	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

14. Is the model output deterministic, or does it provide a distribution of outcomes that recognizes uncertainties in both functional relationships and natural environmental variation?

Answer: At the moment the model is largely deterministic and does not reflect either sampling variability or stochastic dynamics very well. The optimization routine of the Sessions model is a stochastic optimization procedure (simulated annealing) and random functions are used in some of the ad hoc modifications of the model (such as the effect of Root Rot) but those processes do not get at the issue here.

Rationale: Examination of flow charts and discussion with model team.

Recommendations: As discussed above, using the stochastic version of FVS and setting the model up for Monte Carlo runs would be very desirable. Visualization of the data in the form of frequency distributions should happen at all steps of the model from input to final output. Where the model now produces .txt files it should automatically produce a frequency distribution graphic (perhaps as a .pdf file) as well. This would be easy to implement immediately.

Overall assessment:

Insufficient information provided to answer question	Completely deterministic	---------->			Distribution with uncertainties fully recognized	Don't know - not my field of expertise
0	1	**2**	3	4	5	?

15. Is model uncertainty clearly communicated in documents provided to decision makers (e.g. the Board of Forestry)?

Answer: The documentation discusses levels of confidence the team has in the model in a qualitative way. At this more general level the team is able to communicate a sense of the uncertainties that is valuable. For example, the breath-taking uncertainty of spotted owl dynamics is well discussed. But confidence intervals reflecting both sampling and dynamic stochasticity are not given. My own opinion is that, for example, the two output curves shown in the two figures on page 44 of the Report are essentially identical. But a single estimate of variance will trump any amount of opinion.

Rationale: Examination of the flow charts and discussion with the model team.

Recommendations: Adapt the system to be able to perform Monte Carlo runs. Estimate and visualize confidence intervals.

Overall assessment:

Insufficient information provided to answer question	Uncertainties not included in documentation	---------->			Uncertainties clear in documentation	Don't know - not my field of expertise
0	1	2	**3**	4	5	?

16. Do the models support the implementation of adaptive management (i.e. can model predictions and key functional relationships be tested and iteratively improved)?

Answer: The complete answer to this question lies in the entire policy context in which the model is used. The model is sufficiently flexible that it will be able to do its part in the adaptive management cycle if managers choose to use it.

Rationale: See #11.

Recommendations: Here is where the model as a tool for transparency and communication comes to the fore. I do not believe it is an understatement to say that effective visualization of the results is at least as important as the model structure. The model gets you the answer, the visualization gets the answer used.

Overall assessment:

Insufficient information provided to answer question	Don't support implementation of AM at all	---------->			Fully support implementation of AM	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

17. What are the key priorities for overall improvement in the models, given the intended applications? (This synthesizes recommendations from previous questions; please consider pg. 55 of Doc 10A, Enhancements for the Future.)

Answer:

- Make a conscious decision about the level of documentation the project will support.
- Make a conscious decision about the balance of work effort between harvest and habitat.
- Reengineer the model to be able to do sensitivity analysis and Monte Carlo variance estimation by creating a batch processing system and implement automated storage of results and run parameters.
- Undertake much more analysis of the results already obtained.
- Develop visualization of results and uncertainties.
- Improve the model by using the stochastic version of FVS, a better model for reforestation and regeneration, and solve the discretization problem.
- Emphasize transparency as one of the most important products.

Rationale: See #1-#16.

Overview and Conclusions

18. Credibility: Is the model credible—able to address decision issues for which it was intended? How should outputs from models like this be used? What types of discussions should we be having about the outputs? And how should it NOT be used? Can we do something to put confidence intervals around model output or explain it better to move away from one number and talk about a range of numbers?

The credibility of the model is good in the sense that it reflects good science and good modeling. But transparency and communication need to be stronger. Better documentation and better visualization would significantly improve credibility.

19. Adequacy of Input Data: Is the accuracy and precision of underlying data sufficient for the intended purpose, and the scale it needs to be applied?

See #3 above.

20. Underlying Assumptions: Are the underlying assumptions sound / valid, for each of the major model components (i.e. wood harvest, revenue and costs, growth and yield, biodiversity)?

The underlying assumptions about wildlife and biodiversity are problematic. See #3.

21. Testing: Is the model adequately tested? (i.e. input data checked, rules implemented correctly, computations correct given rules, functional relationships confirmed empirically, model output assessed by field personnel for reasonableness)?

The model has been qualitatively tested. A formal sensitivity analysis would be a great improvement.

22. Next Steps: What can be realistically changed or improved (given time and resources)?

See #17.

23. Overall Strengths and Weaknesses: What are the inherent strengths and weaknesses, particularly to goals and objectives that program is trying to achieve with it? Are their any fatal flaws in the model, underlying data / assumptions, or its application? Are there any other kinds of models in existence we should consider using to overcome weaknesses of the current suite of models?

The model is limited by the state of the art in wildlife habitat modeling. Inclusion of biodiversity would require newer paradigms such as Gap Analysis.

24. Process of Model Development: What do you have to say about our model development process? How can you make something like this more transparent? Is there anything we can do to develop a clear set of stakeholder expectations from the next round of modeling? Do you have advice for us on how to set clear expectations? How should we go about evaluating alternative models that could be used?

Remarkably few people were involved in the creation of this model given its size and complexity. A lean team has many advantages. But some of the processes of model development were severely constrained by lack of staff. QA/QC via documentation and source code control is the usual standard but cannot be achieved here without more staff.

Any final overall comments, conclusions or recommendations not already addressed:

Transparency is a major utility of the model. It provides and audit trail of the data and decisions that were used to give an answer.

The structural complexity of the model is very great compared to the staff available for its maintenance and for the analysis of its output. Implementation of many of the recommendations listed here would require significant staff. The modeling team should attempt to understand carefully the balance between its resources and improvement goals

4.4 Reviewer's Report: Dr. Robert A. Monserud

Scientific Peer Review of H&H Model Project Reviewer's Report

Prepared by: Robert A. Monserud
Date: 10-14 July 2006

A. Structure

1. Are the structural features of these models (e.g. spatial/temporal scale and resolution, major components and functional relationships) appropriate to:
a) the decision problem they are trying to address, and
b) the available data?

Answer: Yes

Rationale:

Recommendations: Eliminate strata aggregation step now that a strong inventory supports stand-based yield projections.

Overall assessment:

Insufficient information provided to answer question	Not appropriate at all	---------->			Very appropriate	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

2. Are the simplifying assumptions and limitations of the models clearly described?

Answer: Yes

Rationale:

Recommendations: Emphasize that strata aggregation eliminates variation in growth projections.

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	2	**3**	4	5	?

B. Input Data

3. Is the accuracy and precision of the input data generally sufficient for the intended applications of the models? Are weaknesses in the input data recognized by the model users?

Answer: Growth model approach (Stratum Aggregation) is artificial and forced by a weak inventory 6-7 yrs ago. This situation is currently being ameliorated by a new, strong forest inventory.

Rationale:

Recommendations: Keep expanding inventory coverage, and plan for remeasurement cycle(s) to follow.

Overall assessment:

Insufficient information provided to answer question	Data grossly insufficient; weaknesses not at all recognized	---------->	Input data sufficient; weaknesses recognized	Don't know - not my field of expertise
0	1	2 **3** 4	5	?

4. Have sensitivity analyses been done to assess which input data are most critical to the choice of alternative management strategies?

Answer: This was hard to tell and not well documented. I asked Pam Overhulser and she described a long (1.5 yrs) series of sensitivity analyses done on individual model settings, levels, and variables. This sounded to be rather thorough model testing, which was independently evaluated by MBG.

Rationale:

Recommendations: Formalize a plan to examine sources of variation and their importance on decision making

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses done on input data	---------->	Sufficient sensitivity analyses of input data	Don't know - not my field of expertise
0	1	2 3 **4**	5	?

C. Growth and Yield Assumptions

5. Do the FVS growth models take into account the major biological factors which need to be considered in estimating growth and yield for these Oregon forests? (Variants of the USFS Forest Vegetation Simulator can consider root rot, dwarf mistletoe, and insects such as spruce budworm – are any of these critical to these forests, and missing?).

Answer: Yes to the major factors: stand growth and yield, and background mortality. Minor factors such as root rot were considered in a simple manner because input data for more detailed representation are mostly lacking. The models are available but apparently the data are not.

Rationale: I am quite comfortable to the selection of FVS as a growth model. Excellent choice. It is easily the most widely used stand simulator in the country (over 20 regional variants), for well over 2 decades. Because it has been used extensively (and intensively) as a management planning tool (providing yield streams under a range of management alternatives), it has of necessity been heavily tested. Robinson and Monserud (2003 For. Ecol. Manage. 172(1): 53-67) compared the available stand simulators in the Northwest for model adaptability, and concluded that FVS was the most adaptable model in the region. Their rationale included portability, extendability, source code availability, and documentation as important criteria. The FVS simulator is supported by the USFS Ft. Collins Service Center, both in maintaining current variants and developing new variants, as well as implementing new modules such as the Fire and Fuels Extension.

Regarding Dr. Droessler's strong recommendation to reevaluate FPS, I disagree. Robinson and Monserud (2003) also evaluated FPS for model adaptability, and found it lacking in several key areas. The code is proprietary and thus cannot be examined for logical and biological consistency and integrity. Because the code and executables are proprietary, FPS is not extendable (i.e., the addition of new features or capabilities). The statistical fit for FPS is not publicly documented. The FPS modeling system has not been published in the peer-reviewed literature, rendering the system a black box with unknown reliability and structure. The argument could be made that the Session's model is also proprietary (true), but there is one major difference. The Sessions model and its earlier variants have been extensively published in the peer-reviewed literature, whereas FPS has not.

Recommendations: Increase sampling of factors such as root rot if they are important on some districts. Implement the FVS-Root Disease module for those districts when data become available. Work with the folks at the USFS Ft. Collins Service Center (perhaps through MB&G) on the use of FVS variants such as the Fuels and Fire Extention (FFE), the Root Disease extention, and the Bootstrap Module (currently being implemented).

Overall assessment:

Insufficient information provided to answer question	No major biological factors taken into account	---------->			All major biological factors taken into account	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

D. Natural Disturbances and Processes

6. Do the models deal adequately with important natural disturbances and processes in these forests (e.g. windthrow, fire, root disease, Swiss needle cast, natural regeneration after harvesting or fire)?

Answer: In a rather ad hoc manner. SWC adjustments were incorporated into the analysis, and root rot was considered.

Rationale:

Recommendations: Perhaps these are less important until the stand inventory is fully operational in 2-3 years. After that, then perhaps attention can turn to monitoring disturbance factors.

Overall assessment:

Insufficient information provided to answer question	No important natural disturbances or processes dealt with	---------->			All important natural disturbances and processes dealt with	Don't know - not my field of expertise
0	1	2	**3**	4	5	?

7. Do the models facilitate creation of harvest areas that mimic the sizes and shape of natural disturbances?

Answer: Don't know. Not addressed.

Rationale:

Recommendations: This strikes me as unimportant, given that the Forest Planning Act restrictions are met (they are). Un-ask the question.

Overall assessment:

Insufficient information provided to answer question	No, they do not facilitate this very well at all	---------->			Yes, they facilitate this very well	Don't know - not my field of expertise
0	1	2	3	4	5	?

E. Key Functional Relationships and Constraints

8. Have the models been through a detailed sensitivity analysis to determine which functional relationships, parameters and constraints most strongly affect the choices amongst alternative decisions?

Answer: I do not see a sensitivity analysis documented, but the model appears to have been extensively tested. JS answered that he does not think that there exists some hidden super-sensitive variable that can drastically change important decisions. I asked Pam Overhulser and she described a long (1.5 yrs) series of sensitivity analyses done on individual model settings, levels, and variables. This sounded to be rather thorough model testing, which was independently evaluated by MBG.

Rationale:

Recommendations: Continue to examine model behavior. If documentation is important to ODF, then additional staff need to be hired.

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses of functional relationships	---------->			Sufficient sensitivity analyses of functional relationships	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

9. Are the key functional relationships, parameters and constraints (e.g. habitat requirements of focal fish and wildlife species) grounded in strong empirical data? Have model tests been done to assess the validity of key functional relationships?

Answer: It appears that they have tried, and have built wildlife habitat constraints for those few species with enough supporting data. Not clear if validation has been done.

Rationale:

Recommendations: The connection between wildlife populations and habitat requirements is vague at best. This is due to the limited state of knowledge of the full biology for wildlife species, not due to any shortcoming in ODF or the H&H model.

Overall assessment:

Insufficient information provided to answer question	Not well grounded at all and validity not tested	---------->			Very well grounded and tested	Don't know - not my field of expertise
0	1	2	**3**	4	5	?

10. Is it clear how the optimization algorithm used in the model attempts to meet the multiple competing objectives and constraints (e.g. timber production, wildlife habitat conservation, cost minimization)?

Answer: Yes. The weights (LaGrangian multipliers) on Goals and Targets are set rather adaptively (many iterative runs for a given District). This strong degree of intervention concerned me. Pam Overhulser did a good job of explaining what she did, and why.

Rationale:

Recommendations: Try to add transparency to the procedures for determining the weights on goals and targets. This is crucial.

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	2	3	**4**	5	?

11. How easy is it to update key model functional relationships or parameters as new data are acquired?

Answer: Currently, it appears to be a major undertaking. For example, incorporating the most recent inventory data to rebuild the strata-based yield tables was rejected by MBG as too expensive (time and money).

Rationale:

Recommendations: This situation should improve when the current Aggregated Strata are eliminated and a Stand-level projection system is incorporated. This eliminates the costly aggregation step.

Overall assessment:

Insufficient information provided to answer question	Very difficult	---------->			Very easy	Don't know - not my field of expertise
0	**1**	2	3	4	5	?

F. Using the Models to Make Decisions

12. How useful are the models for the intended strategic and tactical level decisions to which they will be applied? [Specifically, can they be used to decide among the 4 options: FMP using a HCP, FMP using Take Avoidance, wood-emphasis, or reserve-based? Are these models appropriate for making decisions about: 1) whether to make changes in the Northwest and Southwest Oregon FMPs, 2) whether to pursue a HCP, and 3) setting harvest levels for Annual Operation Plans?]

Answer (in general):

- Very useful for allocating volume growth and structural development across the landscape.
- There exists so much uncertainty regarding the connection between wildlife population levels and wildlife habitat needs that I am uncomfortable concluding anything about future wildlife viability. This deficiency is not due to ODF, but rather due to the state of knowledge of wildlife biology.

Answer (please specify what applications of the models you feel are appropriate, and what applications are not):

Re:
1) Whether to make changes in the Northwest and Southwest Oregon FMPs:

This is a highly-charged political decision. I recommend waiting 2 years before seriously visiting this. I expect that in 2 years ODF will have a more complete inventory, a better H&H modeling system using stand-based projection incorporating variability rather than the current strata-based projections, and perhaps a new regeneration growth model from Martin Ritchie and SMC.

2) Whether to pursue a HCP vs. TA strategy:

This is fundamentally a risk analysis and investment strategy question rather than a H&H modeling question. It reduces to one question: what are the long-term (e.g., 20 yrs) prospects for NSO population levels? Will the barred owl continue to out-compete the NSO to the point that NSO effectively disappears? If yes, then owl circles will disappear and land will be freed up for alternative management under TA. If yes, then land will be locked up as of today's state of the NSO for decades even under the decline of NSO, under the HCA. If no and NSO population increases, then under TA more owl circles will be added and less land available for harvest. If no and NSO population increases, then under HCA the land allocation does not change. Given the nature of this risk reduction decision, the H&H model is almost irrelevant. The decision is not dependent on model predictions at all; the decision is almost totally dependent on a risk analysis of barred owl vs. NSO population dynamics.

The H&H model can inform one aspect of the decision: the harvest volume level over time under each decision (HCA vs. TA). It is necessary to know if these two projections (H&H Final Report, P.44, bottom graph) are significantly different. We cannot tell---no variability is presented. If I were charged with making a recommendation, then I would focus on the H&H Model projections for the next 5-10 years. Unless the harvest volume projections for HCA are clearly significantly higher than TA, then I would continue with TA and revisit the decision in 5 years, when we will have a more complete inventory, a better H&H model (stand-based projection), and more information on barred owl vs. NSO dynamics.

3) Setting harvest levels for Annual Operation Plans?

The model is designed and well-suited for this purpose. The optimization portion is complete and excellent. The yield-table portion can be improved greatly by using the current stand-level inventory (50%) as input to a stand-based FVS system to generate a yield table for each stand. A by-product of this change will be that stand-level variability will automatically be incorporated into the analysis, solving another problem. These aspects will only improve with time as the inventory coverage increases.

Recommendations: Eliminate the strata-based approach as soon as the forest inventory can support a stand-based projection system. Not clear how appropriate the murrelet and owl-based constraints/alternatives are because of a poor state of knowledge on key wildlife population dynamics.

Overall assessment:

Insufficient information provided to answer question	Not at all useful or appropriate	---------->			Very useful and appropriate	Don't know - not my field of expertise
0	1	2	3	4	**5**	?

13. Do the models allow the exploration of different management strategies under multiple competing hypotheses (e.g. different assumptions about habitat requirements of focal wildlife species)?

Answer: Yes.

Rationale: The Sessions model is very good at this.

Recommendations: Continue to use as a decision support system. Look for novel ways to display differences among alternatives.

Overall assessment:

Insufficient information provided to answer question	No, not at all	---------->			Yes, very much	Don't know - not my field of expertise
0	1	2	3	4	**5**	?

14. Is the model output deterministic, or does it provide a distribution of outcomes that recognizes uncertainties in both functional relationships and natural environmental variation?

Answer: Currently. results presented as deterministic, although the simulated annealing algorithm is fundamentally stochastic. This situation strikes me as strange.

Rationale:

Recommendations: Incorporate variation into projections/solutions so that uncertainty can be displayed and quantified. Could incorporate the Bootstrap module of Gregg/Hummel when stand-based FVS projections can be implemented and the strata are eliminated. Could also move the stand inventory (tree list) and FVS projections into a preprocessor that then feeds the H&H model the yield tables (for each stand and alternative). This would allow for running different random starts with FVS, with subsequent optimization. Then examine the set (say, 20-30) of optima and examine commonalities and variation.

Overall assessment:

Insufficient information provided to answer question	Completely deterministic	---------->			Distribution with uncertainties fully recognized	Don't know - not my field of expertise
0	**1**	2	3	4	5	?

15. Is model uncertainty clearly communicated in documents provided to decision makers (e.g. the Board of Forestry)?

Answer: No

Rationale: Only one time series is presented in the main document, with no variation displayed or discussed. Such simplification can be very misleading.

Recommendations: At least show results of High and Low solutions along with the mean.

Overall assessment:

Insufficient information provided to answer question	Uncertainties not included in documentation	---------->			Uncertainties clear in documentation	Don't know - not my field of expertise
0	**1**	2	3	4	5	?

16. Do the models support the implementation of adaptive management (i.e. can model predictions and key functional relationships be tested and iteratively improved)?

Answer: Yes

Rationale: The model is very good at this, and is being examined by field personnel to ensure that the model is reasonable.

Recommendations:

Overall assessment:

Insufficient information provided to answer question	Don't support implementation of AM at all	---------->			Fully support implementation of AM	Don't know - not my field of expertise
0	1	2	3	4	**5**	?

17. What are the key priorities for overall improvement in the models, given the intended applications? (This synthesizes recommendations from previous questions; please consider pg. 55 of Doc 10A, Enhancements for the Future.)

Answer:

1. Eliminate the Strata Aggregation, and replace with a Stand-based FVS Growth Projection system as soon as possible. The inventory is probably strong enough to do this now, or the near future. This apparently can be accomplished now without modification to the H&H model simply by making every inventory stand its own stratum. This will eliminate unnecessary aggregation, preserve all measured variation, and improve model integrity.
2. Begin the stand level imputation (e.g., most similar neighbor) now, based on the current state of the forest inventory.

3. Try much harder to incorporate variation into the analysis, and then display and discuss the resulting uncertainty. This is fundamental. The Bootstrap Module for FVS (developers: Tommy Gregg and Susan S. Hummel, Portland, OR) might aid in this effort. See also #14 for another suggestion.
4. Try to train at least one backup/redundant person for Pam Overhulser that is capable of independently run the H&H model. Likewise, have a contingency plan for a backup for John Sessions (e.g., Pete Bettinger, Univ. Georgia). If documentation is important to ODF, hire a support person for Pam.

Overview and Conclusions

18. Credibility: Is the model credible – able to address decision issues for which it was intended?

Yes. This is an incredibly detailed planning model, perhaps the most detailed forest management optimizer in the world. The Sessions optimization model state-of-the-art. ODF is fortunate to have such a tool and such an esteemed developer (Dr. Sessions).

How should outputs from models like this be used?

- To assist in making management decisions.
- As a feedback tool in adaptively refining the management plan.
- After variation has been incorporated, to display uncertainty to the managers.

What types of discussions should we be having about the outputs?

Examining variability and uncertainty much more than at present.

And how should it NOT be used?

Focusing on only ONE projection, such as presented in the H&H Final Report.

Can we do something to put confidence intervals around model output or explain it better to move away from one number and talk about a range of numbers?

Yes. A limited Monte Carlo simulation procedure could generate a measure of response surface variability for a given decision variable. This requires much more computing, but would temper the "perfect prediction" phenomenon resulting from displaying only one time series projection (as done in the H&H Final Report). See # 14 and #17-3.

19. Adequacy of Input Data: Is the accuracy and precision of underlying data sufficient for the intended purpose, and the scale it needs to be applied?

Accuracy and precision require a measure of variation, and I do not see any displayed or discussed. Based on the documentation, then it appears to be: No.

The underlying inventory began as very weak, 6-7 years ago when this work was begun. As a result, this Structural Stratum Aggregation Methodology was developed. This eliminated variation, has unknown accuracy, and is unlinked spatially to the rest of the H&H model.

However, the inventory now is quite good. It gets better each year. It appears that the underlying inventory data now is quite strong, and certainly has sufficient accuracy and precision. If the Structural Stratum Aggregation Methodology could be replaced by a Stand-based (direct FVS) projection system, then the Growth & Yield projections would have sufficient accuracy and precision.

With 50% inventory coverage currently, the scale of application (viz., entire District) is appropriate.

Additional features (data layers) that appears to he very well executed are the Harvest Unit Boundary mapping and the Road Network. These add greatly to the accuracy of the final H&H model optimizations.

20. Underlying Assumptions: Are the underlying assumptions sound / valid, for each of the major model components (i.e. wood harvest, revenue and costs, growth and yield, biodiversity)?

In general, Yes. The Sessions optimization is superb, state-of-the-art.

The most limiting assumption is the Structural Stratum Aggregation Methodology. Unfortunately, these aggregates float free of spatial location, and contain no variability. This was forced by the initially weak forest inventory. Now that your forest inventory is now excellent (and with 50% stand coverage), this very limiting assumption is no longer needed or useful. The inventory now supports a Stand-based Yield Projection system (with FVS using stand inventory tree lists directly).

The wildlife habitat structural requirements seem to involve circular reasoning (rampant in the wildlife biology field, not specific to ODF) that never connects to the animal in question. The unit of success seems limited to achieving adequate Complex Structure, rather than monitoring the actual response of the wildlife population to the presence of this structure. The animal itself seems to be missing from the loop. I attribute this disconnect to the realities of dealing with legal mandates and the state of wildlife biology, and not due to any shortcomings of ODF professionals.

Consider the murrelet (caveat: I am a biometrician, not a wildlife biologist). After long prodding from Tim Max (PNW Biometrician), murrelet wildlife experts finally agreed (ca. 2001) to a statistically unbiased population sample (line transect sampling at sea). The current population estimate is approximately 20,000 +- 10,000. Let's say that each murrelet needs 1 ac for nesting. That means that approximately 30,000 ac are needed; this is not a large amount of habitat area in the coastal forests of the Pacific Northwest. I can only conclude that forest habitat is not limiting to population levels. Something else is limiting, and the biologists have not yet elucidated this dynamic. Furthermore, I have heard that murrelet population levels are high in Alaska, even out to the Aleutians, where trees are scarce or completely missing. This means that the murrelet is quite flexible and resourceful in its nesting requirements. None of this variation in nesting requirements is reflected in the murrelet constraints required by the wildlife regulations.

The fine-tuning of the Targets and Goals in the Simulated Annealing Optimization seemed a bit heavy handed, to the point of certain analyses becoming self-fulfilling prophecies (e.g., bottom graph, p.44 of H&H Final Report). Why not set these Targets and Goals for each District ahead of time and then optimize the H&H model, accepting the consequences, and then examining the reasonableness of the

optimal runs? Documentation would have helped here to explain exactly what the process was and how it was executed (still not entirely clear to me). During the Review, Pam Overhulser did a good job of explaining what she did, and why.

21. Testing: Is the model adequately tested? (i.e. input data checked, rules implemented correctly, computations correct given rules, functional relationships confirmed empirically, model output assessed by field personnel for reasonableness)?

Based on discussion with ODF staff and Dr. Sessions, model testing appears to be quite extensive and thorough. Carrying the testing all the way through to field foresters is thorough and laudable. This is excellent. MBG was also involved in independent testing, which is also excellent. See #4, #8.

22. Next Steps: What can be realistically changed or improved (given time and resources)?

Eliminate the Strata Aggregation, and replace with a Stand-based Growth Projection system as soon as possible. The inventory is probably strong enough to do this now, or the near future. This apparently can be accomplished now without modification to the H&H model simply by making every inventory stand its own stratum. This will eliminate unnecessary aggregation, preserve all measured variation, improve model integrity, and improve transparency to field foresters and specialists.

Begin the stand level imputation (e.g., most similar neighbor) now, based on the current state of the forest inventory. As additional stands are inventoried this and next year, the accuracy of the imputation can then be checked and evaluated (validation).

Try much harder to incorporate variation into the analysis, and then display and discuss the resulting uncertainty. This is fundamental. The Bootstrap Module for FVS (developers: Tommy Gregg and Susan S. Hummel, Portland, OR) might aid in this effort. See #14 and #17-3.

Try to train at least one backup/redundant person for Pam Overhulser that is capable of independently running the H&H model. Likewise, have a contingency plan for a backup for John Sessions (e.g., Pete Bettinger, Univ. Georgia).

Re wildlife habitat structural needs: The current inventory apparently monitors some features of the shrub and ground vegetation layer. First, build structural stand classes that are relevant to wildlife questions or habitat needs. Then use the stand inventory shrub/understory data to construct a simple ANOVA model: calculate class means, along with associated variances. Assume that these means are constant over time (albeit with the observed variation for a given cell). Then apply these to the stand-based projections over time. (This is a hypothesis that can be tested). Note that this Static-Mean model will not work with the current Structural Stratum Aggregation methodology because stand variation has been eliminated due to aggregation.

23. Overall Strengths and Weaknesses:

What are the inherent strengths and weaknesses, particularly to goals and objectives that program is trying to achieve with it?

Strengths: see #24-a. The H&H optimization model is amazingly detailed and the state-of-the-art. It provides the necessary decision support for your management decisions, especially regarding timber projection and harvest. Your strong inventory is also a great strength, whereas 7 yrs ago it was a liability.

Weaknesses: Mainly things beyond your control, relating to the vast uncertainty associated with predicting (or even measuring) wildlife population dynamics and habitat needs. Regarding the procedure for dubbing in regenerated stands, an improved model should soon be available from Martin Ritchie and SMC.

Are their any fatal flaws in the model, underlying data / assumptions, or its application?

No, in my opinion. "No fatal flaws" is also a quote from John Sessions. After 1.5 yrs of testing, Pam Overhulser made a similar statement.

Are there any other kinds of models in existence we should consider using to overcome weaknesses of the current suite of models?

Your choices were fine (Sessions model, FVS). In the near future, an improved regeneration model should be available from Martin Richie (PSW-Redding) using additional SMC data. This will plug one hole. Also, Dave Hann (OSU) is recalibrating OREGANON using all SMC data. When available, this should be re-examined.

24. Process of Model Development:

What do you have to say about our model development process?

Excellent. First, you have recruited Dr. Sessions, a world authority. And he has delivered a state-of-the-art simulated annealing optimizer of amazing complexity and accuracy. Second, you realized that the forest inventory was weak and limiting, and then developed a strong inventory that currently has reached 50% stand coverage. Third, you contracted with MBG to conduct certain analyses (growth model evaluation; yield table generation) and to do independent testing.

How can you make something like this more transparent?

This is not easy for such a complex optimization.

First, try to display variability and uncertainty.

Second, switch from Stratum Aggregation to Stand-based Yield prediction. This will allow you to demonstrate complete and continuous spatial integrity throughout the modeling process. Field foresters looking at the results of a given management prescription can then go back to the original forest inventory for a given stand or adjacent stands and incorporate their knowledge and experience to see if the model results are believable.

At first, I was concerned that the code was proprietary. Now that I hear from Dr. Sessions that ODF has the code, and that a model review team could look at relevant parts to address some concern, then I am no longer troubled by this. (Note: my concerns have already been addressed when John showed us the Target and Goals section of the code Tuesday. I have no more need to see the code).

The Simulated Annealing Optimization is an incredibly complex and abstract procedure to try to explain to your users. (It is clear to me, but I am an optimizer). Maybe use some visual aid such as a 3-D model of the Cascade Range as a surface, with these isolated and towering local optima---volcanoes. Then explain the difficulty in trying to find any one of the volcanoes while blindfolded. And then, explain the difficulty of then finding a second one to see if it is higher than the first. And finally, explain the difficulty of finding the highest volcano in this sea of mountains.

Going to your field foresters to examine model results was an extremely strong attempt at transparency. This is very wise, and admirable.

Is there anything we can do to develop a clear set of stakeholder expectations from the next round of modeling?

Try to display variability and uncertainty rather than ignore it (e.g., H&H Final Report). Then begin the long educational process of explaining that a single mean projection is not certainty, and that a Low projection might be as equally likely as a High projection (given the same initial conditions, targets, and goals).

Do you have advice for us on how to set clear expectations?

I think that your expectations are realistic and excellent. For example, you correctly realized that the forest inventory was limiting, and then ameliorated the situation with an excellent inventory. No change in attitude needed.

How should we go about evaluating alternative models that could be used?

Your approach and operating procedures are just fine.

Any final overall comments, conclusions or recommendations not already addressed:

You have an excellent system in place for supporting your management decisions. The Sessions optimizer is sufficiently detailed and quite accurate for addressing your management problems spatially, at the level that management is implemented. The H&H model is state-of-the-art. Your Stratum Aggregation procedure is a nuisance necessitated by the lack of a strong inventory 7-yrs ago. This inventory shortcoming has now been completely ameliorated with a strong system. Thus, you can soon move to a stand-based yield projection system that will make the entire H&H model spatially connected throughout. This will increase model integrity and transparency even more. As a scientist, a forester, and an Oregon taxpayer, I am quite pleased with the initiative that ODF has shown in developing this H&H model and in implementing a strong forest inventory. Excellent forest stewardship.

When I was first asked to participate, I was apprehensive that we might be expected to merely give our blessing, with criticism ignored. I was assured that this fear was false, an assurance that has indeed proved correct. I am extremely pleased with the high degree of professionalism exhibited by ODF personnel and

the ESSA facilitators throughout this review process. Thank you. You asked for an independent review, and we were free to provide it. I only hope that it is useful.

-Bob

4.5 Reviewer's Report: Mr. Steven Northway

Scientific Peer Review of H&H Model Project Reviewer's Report

Prepared by: Steven Northway

The comments below are based on my general experience in strategic forest planning and specific H&H project readings and discussions. I have made every effort to ensure the accuracy of my conclusions, but in the eventuality that I misunderstood something, I apologize.

Date: 13 July 2006

A. Structure

1. Are the structural features of these models (e.g. spatial/temporal scale and resolution, major components and functional relationships) appropriate to:
a) the decision problem they are trying to address, and
b) the available data?

Answer:

a) Yes, the H&H model structure is generally appropriate for dealing with strategic and tactical forest management questions.

There were however several *ad hoc* procedures implemented by the user to accommodate current limitations in the model structure. One of these was the treatment of new NSO circles. Their impact was included as a *post hoc* analysis. This lead to an iterative set of model runs which could not fully address the risk of future NSO circles.

b) Yes, nothing need be lost from the available data in using it with the model. Any limitations are in the basic data.

Rationale: At the moment the limitation is in the basic data available to drive the model. As the stand-based data becomes available, it seems likely that the habitat functional relationships may become limiting. Now, the available habitat data may be more limiting than our understanding of the functional relationships, but as the available data improves this may reverse.

Under this scenario, the H&H model structure will not be limiting, I expect it to be the habitat relationships.

Recommendations: Review any *ad hoc* procedures as possible features with which to augment the current model structure, especially the treatment of new NSO circles.

Overall assessment:

Insufficient information provided to answer question	Not appropriate at all	---------->			Very appropriate	Don't know - not my field of expertise
0	1	2	3	4	***5***	?

2. Are the simplifying assumptions and limitations of the models clearly described?

Answer:

- Limited in existing documentation.
- Yes, in discussion with the analysts.

Rationale:

- The documents, with which we were provided, were not sufficient to allow a 3rd party to duplicate the analysis.
- With the documents with which we were presented and 2 days of questioning the analyst, I feel I could closely duplicate the analysis.

Recommendations:

- Documentation would be a huge task and would provide information for a very limited audience. I would not recommend embarking on a detailed documentation task, unless public sector transparency demanded it. I think the current documentation, coupled with 3 party reviews, is adequate.
- Perform a benchmarking exercise of the documentation policy of similar exercises.

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->			Very clear	Don't know - not my field of expertise
0	1	2	***3***	4	5	?

B. Input Data

3. Is the accuracy and precision of the input data generally sufficient for the intended applications of the models? Are weaknesses in the input data recognized by the model users?

Answer:

- Yes, the use of the model is consistent with the quality of the data.
- I am not convinced that all users recognize the weakness of the modeling process.

Rationale:

- The application of the model has been defined by the accuracy and precision of the input data. It is to be used as a decision support tool for strategic and tactical planning.
- The weaknesses of the modeling process were well appreciated by the analysts.
- I did not get an appreciation as to whether the decision makers recognized the weaknesses of the modeling process.
- I had weak indication that some users were judging it on its applicability to operational decision-making, concluding that it was flawed. This could only happen if they did not recognize the limitations of the input data.

Recommendations: Work even harder at stressing that it is to support high-level decision making, not operational planning. In spite of seemingly great efforts, this message is not universally appreciated.

Overall assessment:

Insufficient information provided to answer question	Data grossly insufficient; weaknesses not at all recognized	---------->			Input data sufficient; weaknesses recognized	Don't know - not my field of expertise
0	1	2	3	***4***	5	?

4. Have sensitivity analyses been done to assess which input data are most critical to the choice of alternative management strategies?

Answer: No.

Rationale: Sensitivities were done, though not well documented, on the impact of different expressions of the goals and constraints. I saw no evidence of sensitivity analysis being done on input data. It was clearly recognized as an issue by the analysts.

Recommendations: Sensitivities of the decisions to uncertainties in the input data and functional relationships should be pursued. I carefully say "decisions", because many uncertainties may affect absolute results without affecting decisions.

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses done on input data	---------->			Sufficient sensitivity analyses of input data	Don't know - not my field of expertise
0	***1***	2	3	4	5	?

C. Growth and Yield Assumptions

5. Do the FVS growth models take into account the major biological factors which need to be considered in estimating growth and yield for these Oregon forests? (Variants of the USFS Forest Vegetation Simulator can consider root rot, dwarf mistletoe, and insects such as spruce budworm – are any of these critical to these forests, and missing?).

Answer: Yes.

Rationale: No better alternative is available. The current analysis is limited by the inventory data, not by FVS.

Recommendations:

- Keep a watch on the research around the impact of global warming on forest growth and pests.
- Consider risk management.

Overall assessment:

Insufficient information provided to answer question	No major biological factors taken into account	---------->			All major biological factors taken into account	Don't know - not my field of expertise
0	1	2	3	***4***	5	?

D. Natural Disturbances and Processes

6. Do the models deal adequately with important natural disturbances and processes in these forests (e.g. windthrow, fire, root disease, Swiss needle cast, natural regeneration after harvesting or fire)?

Answer: Yes.

Rationale: Endemic levels of disturbance are felt to be incorporated in the yield model. Epidemic effects of the common disturbances (root disease and needle cast) are dealt with explicitly.

Recommendations: Consider risk management.

Overall assessment:

Insufficient information provided to answer question	No important natural disturbances or processes dealt with	---------->			All important natural disturbances and processes dealt with	Don't know - not my field of expertise
0	1	2	3	***4***	5	?

7. Do the models facilitate creation of harvest areas that mimic the sizes and shape of natural disturbances?

Answer: No.

Rationale: This was never expressed as a possible aspiration.

Recommendations:
Overall assessment:

Insufficient information provided to answer question	No, they do not facilitate this very well at all	---------->			Yes, they facilitate this very well	Don't know - not my field of expertise
0	***1***	2	3	4	5	?

E. Key Functional Relationships and Constraints

8. Have the models been through a detailed sensitivity analysis to determine which functional relationships, parameters and constraints most strongly affect the choices amongst alternative decisions?

Answer: Yes, a sensitivity analysis of parameters and constraints has been fully explored, though the process is not documented. (I discussed the "functional relationships" with the input data in question 4.)

Rationale: In discussion with the analysts, it became clear that a very complete sensitivity analysis had been performed on parameters and constraints. I also have the impression that this was shared with the decision makers.

Recommendations: A more complete documentation.

Overall assessment:

Insufficient information provided to answer question	No sensitivity analyses of functional relationships	---------->			Sufficient sensitivity analyses of functional relationships	Don't know - not my field of expertise
0	1	2	3	4	***5***	?

9. Are the key functional relationships, parameters and constraints (e.g. habitat requirements of focal fish and wildlife species) grounded in strong empirical data? Have model tests been done to assess the validity of key functional relationships?

Answer: Yes, on the timber modeling side. No, on the habitat modeling side.

Rationale:

- I think this is a result of the state of knowledge in the fields of study.
- Stand structure is implicitly being used as a surrogate for measures of habitat and biodiversity.

Recommendations:

- Improve the habitat model as data and relationships become available.
- Implement an adaptive monitoring program.

Overall assessment:

Insufficient information provided to answer question	Not well grounded at all and validity not tested	---------->	Very well grounded and tested	Don't know - not my field of expertise
0	1	***2*** 3 4	***5***	?

10. Is it clear how the optimization algorithm used in the model attempts to meet the multiple competing objectives and constraints (e.g. timber production, wildlife habitat conservation, cost minimization)?

Answer: Yes, it was made generally clear in discussions with the analyst, but not well documented.

Rationale:

- The analyst provided us with a general understanding.
- We were not provided with specifics of the search algorithm or how the objectives and constraints were implemented.

Recommendations: Better documentation.

Overall assessment:

Insufficient information provided to answer question	Not clear at all	---------->	Very clear	Don't know - not my field of expertise
0	1	2 ***3*** 4	5	?

11. How easy is it to update key model functional relationships or parameters as new data are acquired?

Answer:

- No, it is not easy to include new kinds of data or relationships.
- Yes, it would be easy to replace an existing input table with an identically structured table of new numbers.

Rationale: I am taking "easy" to mean fast, cheap and technically unchallenging. Aside from the trivial problem of updating an existing input table, all other changes require changes to the H&H model programming code. This is technically challenging, and depending on the standard of coding in the existing model could be time consuming.

Recommendations:

- Review the management of the H&H model code with an eye to minimizing risks associated with maintaining and extending it. The alternatives might range from service assurances (complete with penalty clauses) in a license, to insurance, or even re-implementation with more formal project controls.
- Continue to review other models of similar capabilities (i.e. Patchworks www.spatial.ca) for minimizing the costs and managing the risks.

Overall assessment:

Insufficient information provided to answer question	Very difficult	---------->			Very easy	Don't know - not my field of expertise
0	***1***	2	3	4	5	?

F. Using the Models to Make Decisions

12. How useful are the models for the intended strategic and tactical level decisions to which they will be applied? [Specifically, can they be used to decide among the 4 options: FMP using a HCP, FMP using Take Avoidance, wood-emphasis, or reserve-based? Are these models appropriate for making decisions about: 1) whether to make changes in the Northwest and Southwest Oregon FMPs, 2) whether to pursue a HCP, and 3) setting harvest levels for Annual Operation Plans?]

Answer:

- In the hands of a good analyst and knowledgeable decision maker, the model is useful for supporting strategic and tactical forest level decisions. It should not be used to make the decision, but rather to support the decision making process.
- The model can also be used to inform questions not directly addressed. This exercise illustrated how the model could be used to estimate the impacts of new NSO circles even without explicitly dealing with them (except in a *post hoc* and *ad hoc* way).

Rationale:

- As long as the model does not have the potential to mislead the decision maker, it has utility. (This is not as weak a test as it might seem.)
- HCP vs. TA vs. WE vs. RB: I feel the harvest volume and stand structure trade-off is fairly represented by the modeling. The model results should be part of the decision making process between these alternatives. The choice between these options will be partially driven by social choices not represented in the model, especially in the cases of the WE and RB options. And in a choice between the HCP and TA options, the decision may depend on a risk assessment of the impact of future NSO and marbled murrelets populations, the "no surprises" clause and certainty in operational planning.
- Informing changes in the FMPs: I feel the H&H model can contribute to the decisions about the impact of making changes to the FMPs. Specifically, I think it can inform about the harvest level impacts of 1) targets for stand structure types, 2) targets for patch size, composition and configuration, 3) riparian conservation options, and in a more limited way 4) in-stand structural components and 5) forest health options.
- The utility of this information in judging the impact on habitat is more limited. Until more specific relationships are developed and better inventories are available conclusions will be limited to the impact on crude surrogates for habitat and biodiversity.
- AOP harvest levels: I feel the model is useful in setting harvest levels, in the broader context of the planning process. The decisions considered above are driven primarily by relative differences. There is less risk in decisions about relative differences than in absolute levels. Harvest levels are absolute. A broader planning process is in place to manage the risk. The harvest level is periodically re-evaluated. An inventory depletion to harvest scale might be monitored. The IP tests the feasibility of the harvest levels.
- I understand that the model results suggesting a shift to somewhat more reliance on clearcuts cf. thinnings is being implemented in operational programs. I also understand that operational transportation strategies are being reviewed in light of some of the model results. These are both successful examples of the utility of tactical level planning informing operational activities.

Recommendations: Implement an adaptive management program with both passive and active components.

Overall assessment:

Insufficient information provided to answer question	Not at all useful or appropriate	---------->			Very useful and appropriate	Don't know - not my field of expertise
0	1	2	3	4	***5***	?

13. Do the models allow the exploration of different management strategies under multiple competing hypotheses (e.g. different assumptions about habitat requirements of focal wildlife species)?

Answer: Not for most habitat definitions.

Rationale: Programming would be necessary to explore the impact of different habitat definitions, unless the change can be reflected in the input data files.

Recommendations: SEE 11.

Overall assessment:

Insufficient information provided to answer question	No, not at all	---------->			Yes, very much	Don't know - not my field of expertise
0	1	***2***	3	4	5	?

14. Is the model output deterministic, or does it provide a distribution of outcomes that recognizes uncertainties in both functional relationships and natural environmental variation?

Answer:

- The model is not deterministic.
- The model does not directly provide measures of uncertainty.

Rationale:

- Simulated annealing is a random search algorithm. The search pattern differs for different random number sequences and so in that sense it is not deterministic. In some situations it will consistently find the same solution for all random number sequences and so in that sense it can appear deterministic. (The appeal of SA is based both on its demonstrated success in tough problems and on a proof demonstrating that there exists, for each problem, in a specific class of problems, an annealing schedule that will result in finding the global optimum.)
- The differences among runs with different random number sequences do not tell you anything about the uncertainty inherent in the underlying problem.

Recommendations:

- If deriving information about uncertainties is of interest, I feel it is a specialized enough endeavor to require a workshop with invited experts.
- Learning about the uncertainties is only the first step in managing risk through devising strategies that are robust in the face of uncertainty.

Overall assessment:

Insufficient information provided to answer question	Completely deterministic	---------->			Distribution with uncertainties fully recognized	Don't know - not my field of expertise
0	1	***2***	3	4	5	?

15. Is model uncertainty clearly communicated in documents provided to decision makers (e.g. the Board of Forestry)?

Answer: No, I saw no documents that discussed uncertainties, save the NOS options.

Rationale: The analysts are clearly aware of the uncertainties in the modeling effort and I expect that it is communicated in ways other than the formal documents I have seen. The appreciation of uncertainty can only be of a qualitative nature, as no quantitative assessment of uncertainty has been undertaken.

Recommendations: SEE 14.

Overall assessment:

Insufficient information provided to answer question	Uncertainties not included in documentation	---------->			Uncertainties clear in documentation	Don't know - not my field of expertise
0	1	***2***	3	4	5	?

16. Do the models support the implementation of adaptive management (i.e. can model predictions and key functional relationships be tested and iteratively improved)?

Answer: Yes.

Rationale:

- The model and its functional relationships make specific predictions that can be tested through passive adaptive management.
- The model can be used to help design the active portion of adaptive management by helping in the design the experiments. Model runs can help identify high leverage areas of uncertainty.

Recommendations:

- Implement an adaptive management program.
- Use the model to help identify critical areas for active experiments.

Overall assessment:

Insufficient information provided to answer question	Don't support implementation of AM at all	---------->			Fully support implementation of AM	Don't know - not my field of expertise
0	1	2	3	4	***5***	?

17. What are the key priorities for overall improvement in the models, given the intended applications? (This synthesizes recommendations from previous questions; please consider pg. 55 of Doc 10A, Enhancements for the Future.)

Answer:

- Review the risk mitigation scheme for the H&H computer program maintenance and extension.
- Implement an adaptive management program.
- Explicitly include the identification of future NSO circles in the H&H model.
- Improve the habitat model as data and relationships become available.
- Update the inventory data as the stand-based inventory becomes available.

Rationale:

- An adaptive management program is the key to continual improvement.
- Explicitly including future NSO circle identification in the model will allow the model to find mitigation strategies while producing a goal defined harvest level.
- The uncertainty in the habitat portion of the model is larger than the uncertainty on the harvest side. This can only be remedied by improving the habitat model and the data required to drive it.
- The new inventory will result in general improvements to many parts of the model.

Overview and Conclusions

18. Credibility: Is the model credible—able to address decision issues for which it was intended? How should outputs from models like this be used? What types of discussions should we be having about the outputs? And how should it NOT be used? Can we do something to put confidence intervals around model output or explain it better to move away from one number and talk about a range of numbers?

- The model is credible in addressing strategic and tactical forest management questions. The model capabilities are at the cutting edge of applied models.
- As better information becomes available the continued use of basic measures of stand structure as a surrogate for biodiversity will become problematic.
- If deriving information about uncertainties is of interest, I feel it is a specialized enough endeavor to require a workshop with invited experts.
- Learning about the uncertainties is only the first step in managing risk through devising strategies that are robust in the face of uncertainty.

19. Adequacy of Input Data: Is the accuracy and precision of underlying data sufficient for the intended purpose, and the scale it needs to be applied?

Yes, the data is adequate for the intended purpose. (It is more a case of limiting the use to be consistent with the qualities of the data. This data may be sufficient but better data will lead to less uncertainty in the interpretation of the results.)

20. Underlying Assumptions: Are the underlying assumptions sound / valid, for each of the major model components (i.e. wood harvest, revenue and costs, growth and yield, biodiversity)?

- Yes, the underlying assumptions are valid.
- As a caveat, the implicit use of stand structure as a surrogate for biodiversity is questionable.

21. **Testing:** Is the model adequately tested? (i.e. input data checked, rules implemented correctly, computations correct given rules, functional relationships confirmed empirically, model output assessed by field personnel for reasonableness)?

    - Yes, testing input, output and application of rules has been rigorous.

22. **Next Steps:** What can be realistically changed or improved (given time and resources)?

    - Review the risk mitigation scheme for the H&H computer program's maintenance and extension.
    - Implement an adaptive management program.
    - Explicitly include the identification of future NSO circles in the H&H model.
    - Improve the habitat model as data and relationships become available.
    - Update the inventory data as the stand-based inventory becomes available.

23. **Overall Strengths and Weaknesses:** What are the inherent strengths and weaknesses, particularly to goals and objectives that program is trying to achieve with it? Are their any fatal flaws in the model, underlying data / assumptions, or its application? Are there any other kinds of models in existence we should consider using to overcome weaknesses of the current suite of models?

    - There are no fatal flaws in the modeling exercise.
    - The strengths of the model include its ability to deal with 1) the spatially explicit nature of the problem, 2) the roads and 3) the large problem size.
    - The weaknesses in the model include its limited information on habitat relationships and the risks associated with the maintenance and continued development of the H&H computer program.
    - Patchworks is a model of similar capabilities www.spatial.ca.

24. **Process of Model Development:** What do you have to say about our model development process? How can you make something like this more transparent? Is there anything we can do to develop a clear set of stakeholder expectations from the next round of modeling? Do you have advice for us on how to set clear expectations? How should we go about evaluating alternative models that could be used?

    - I am not fully aware of your model development process, but I feel that it might have benefited from a formal project management process. That having been said, from what I have seen you seem to have hit most of the points. There must have been a steering committee, user groups and stakeholder involvement. The inclusion of the Wood Emphasis and the Reserve Base options show a strong commitment from the stakeholders and the ODF.
    - A serious look at an alternative model should be done by having the proponent reproduce one of your existing runs and then spend a day with your analysts as they get hands-on experience.

Any final overall comments, conclusions or recommendations not already addressed:

Appendix A: Review Questions

The first seventeen questions were developed prior to the Review Week. Questions 18 through 24 were added during the Review Week after discussions with Dr. Steve Hobbs and Dr. Lisa DeBruyckere about what they hoped to learn from the review.

A. Structure

1. Are the structural features of these models (e.g. spatial/temporal scale and resolution, major components and functional relationships) appropriate to:
    a) the decision problem they are trying to address, and
    b) the available data?
2. Are the simplifying assumptions and limitations of the models clearly described?

B. Input Data

3. Is the accuracy and precision of the input data generally sufficient for the intended applications of the models? Are weaknesses in the input data recognized by the model users?
4. Have sensitivity analyses been done to assess which input data are most critical to the choice of alternative management strategies?

C. Growth and Yield Assumptions

5. Do the FVS growth models take into account the major biological factors which need to be considered in estimating growth and yield for these Oregon forests? (Variants of the USFS Forest Vegetation Simulator can consider root rot, dwarf mistletoe, and insects such as spruce budworm – are any of these critical to these forests, and missing?).

D. Natural Disturbances and Processes

6. Do the models deal adequately with important natural disturbances and processes in these forests (e.g. windthrow, fire, root disease, Swiss needle cast, natural regeneration after harvesting or fire)?
7. Do the models facilitate creation of harvest areas that mimic the sizes and shape of natural disturbances?

E. Key Functional Relationships and Constraints

8. Have the models been through a detailed sensitivity analysis to determine which functional relationships, parameters and constraints most strongly affect the choices amongst alternative decisions?
9. Are the key functional relationships, parameters and constraints (e.g. habitat requirements of focal fish and wildlife species) grounded in strong empirical data? Have model tests been done to assess the validity of key functional relationships?
10. Is it clear how the optimization algorithm used in the model attempts to meet the multiple competing objectives and constraints (e.g. timber production, wildlife habitat conservation, cost minimization)?
11. How easy is it to update key model functional relationships or parameters as new data are acquired?

F. Using the Models to Make Decisions

12. How useful are the models for the intended strategic and tactical level decisions to which they will be applied? [Specifically, can they be used to decide among the 4 options: FMP using a HCP, FMP using Take Avoidance, wood-emphasis, or reserve-based? Are these models appropriate for making decisions about: 1) whether to make changes in the Northwest and Southwest Oregon FMPs, 2) whether to pursue a HCP, and 3) setting harvest levels for Annual Operation Plans?]

13. Do the models allow the exploration of different management strategies under multiple competing hypotheses (e.g. different assumptions about habitat requirements of focal wildlife species)?
14. Is the model output deterministic, or does it provide a distribution of outcomes that recognizes uncertainties in both functional relationships and natural environmental variation?
15. Is model uncertainty clearly communicated in documents provided to decision makers (e.g. the Board of Forestry)?
16. Do the models support the implementation of adaptive management (i.e. can model predictions and key functional relationships be tested and iteratively improved)?
17. What are the key priorities for overall improvement in the models, given the intended applications? (this synthesizes recommendations from previous questions; please consider pg. 55 of Doc A, Enhancements for the Future.)

Overview and Conclusions

18. **Credibility:** Is the model credible—able to address decision issues for which it was intended? How should outputs from models like this be used? What types of discussions should we be having about the outputs? And how should it NOT be used? Can we do something to put confidence intervals around model output or explain it better to move away from one number and talk about a range of numbers?
19. **Adequacy of Input Data:** Is the accuracy and precision of underlying data sufficient for the intended purpose, and the scale it needs to be applied?
20. **Underlying Assumptions:** Are the underlying assumptions sound / valid, for each of the major model components (i.e. wood harvest, revenue and costs, growth and yield, biodiversity)?
21. **Testing:** Is the model adequately tested? (i.e. input data checked, rules implemented correctly, computations correct given rules, functional relationships confirmed empirically, model output assessed by field personnel for reasonableness) ?
22. **Next Steps:** What can be realistically changed or improved (given time and resources)?
23. **Overall Strengths and Weaknesses:** What are the inherent strengths and weaknesses, particularly to goals and objectives that program is trying to achieve with it? Are their any fatal flaws in the model, underlying data / assumptions, or its application? Are there any other kinds of models in existence we should consider using to overcome weaknesses of the current suite of models?
24. **Process of Model Development:** What do you have to say about our model development process? How can you make something like this more transparent? Is there anything we can do to develop a clear set of stakeholder expectations from the next round of modeling? Do you have advice for us on how to set clear expectations? How should we go about evaluating alternative models that could be used?

Appendix B: Schedule for the Review Week

Monday July 10		Tuesday July 11		Wednesday July 12		Thursday July 13		Friday July 14	
Morning Travel to Salem	*Afternoon* Discussions	*Morning* Discussions	*Afternoon* Discussions	*Morning* Discussions	*Afternoon* Writing	*Morning* Facilitated session	*Afternoon* Facilitated session	*Morning* Presentation	*Afternoon* Travel home
Noon – 1:00 Panel convenes at Mill Creek Stn and Catering for a group lunch to review the agenda for the week and discuss any outstanding initial issues / answer any remaining initial questions 1:00 Panel heads to ODF offices to set up in meeting room	1:30 – 2:00 Conference call with Dr. Hobbs, Board chair 2:00 – 5:00 Program's perspective provided by State Forests Program manager Lisa DeBruyckere. Panel reviews background package, discusses / IDs any additional material needed to answer the questions (or additional questions).	9:00 - noon Discussions specific (primarily) to questions in categories A (Structural Features) and B (Input Data) but also covering the other review questions / topics to take advantage of John's presence: - John Sessions - Pam Overhulser - Dave Johnson - Mark Rassmussen	1:00 – 5:00 Discussions specific (primarily) to questions in categories C (Growth and Yield Assumptions) and D (Natural Disturbances and Processes) but also ranging across other review questions / topics: - Pam Overhulser - Dave Johnson - Mark Rassmussen - Dave Enck	9:00 - noon Discussions to address any remaining review questions / topics not yet fully covered: - Pam Overhulser - Mike Wilson	1:00 – 5:00 Panel members individually work on their answers to the review questions (and their rationale and recom-mendations) 8:00 pm Reviewers not done their individual reports by 5pm email interim report to Dave/Carol for synthesis of answers across the first set of review questions	9:00 - noon ESSA facilitates sharing of review answers and recommendations for questions 12 and 17 among the panel members; agreement on areas of convergence and divergence among reviewers	1:00 – 5:00 Morning session continued for questions 18 through 24 Evening ESSA drafts synthesis of question 12 and questions 17-24 for presentation	9:00 – 10:00 ESSA presents draft synthesis to panel members for discussion and feedback 10:00 - noon Presentation of review results to ODF and other interested parties	Noon Panel adjourns

Appendix C: Review Materials

The following materials were provided to the reviewers to help them answer the review questions. The first 25 were provided by ODF to the reviewers prior to the Review Week, and the remainder was provided during the Review Week in response to specific requests from the panel members. The matrix at the end of this section shows which of the review questions the first 24 materials addressed.

1. Work Plan & Key Elements:

   Anonymous. 2003. Work Plan to address harvest schedule modeling and sustainable harvest levels in the District Implementation Plans. March 2003. 5 pp.

2. Harvest Model Final Project Plan:

   Oregon Department of Forestry. 2004. Creating a new harvest & habitat model project Plan. April 24, 2003 (Updated: 4/12/04). 4 pp.

3. Purpose of Model and Alternatives:

   Anonymous. 2005. Mission of the harvest & habitat model project and purpose of the alternatives. July 19, 2005. 3 pp.

4. H&H Model System Chart:

   Anonymous. 2005. Harvest and Habitat Model District System Design Chart. 3/3/2005. 1 pp.

5. Harvest Unit Transportation Flowchart:

   Anonymous. n.d. Harvest system transport unit flow chart. 2 pp.

6. MSR Flow Chart:

   Anonymous. 2006. Model solution review systems chart. 1 pp.

7. Alternative Rules Documentation:

   Anonymous. 2006. H&H Model Linkages. 6/26/2006. 60 pp.

8. Overview of H&H Model Structure:

   Sessions, J. and P. Overhulser. n.d. Overview of the Harvest & Habitat Model Choices and Model Structure. 9 pp.

9. H&H BOF Final Report Presentation:

   Oregon Department of Forestry. 2006. Harvest & Habitat Model Project Final Report Oregon Board of Forestry Meeting. Powerpoint presentation. March 8, 2006

10 Current Information for Harvest & Habitat Model Project:

   A. Harvest & Habitat Project Final Report:

      Oregon Department of Forestry. 2006. Harvest & Habitat Model Project final report. Presented to the Oregon Board of Forestry, March 8, 2006. 62 pp. + appendices.

   B. Addendum to the Harvest & Habitat Model Project Final Report:

      Oregon Department of Forestry. 2006. Table 2: district summary of all alternatives: harvest volume, NPV, and complex structure, and Table 3: district summary of all alternatives: clearcut and thinning acres. *Excerpt from* Harvest & Habitat Model Project final report. Presented to the Oregon Board of Forestry, March 8, 2006 - Revised March 31, 2006. Pg. G2-3.

C. Addendum 2 to the Harvest & Habitat Model Project Final Report:

Oregon Department of Forestry. 2006. Results: Comparison of Alternatives, Three North Coast Districts Combined: All Alternatives. *Excerpt from* Harvest & Habitat Model Project final report. Presented to the Oregon Board of Forestry, March 8, 2006 - Revised March 31, 2006. Pg. 35-37.

11. Why Use Heuristic Programming Techniques:

Lennette, M. n.d. Why use a heuistic programming technique? Mason, Bruce and Girard, Inc., Portland, OR. 4 pp.

12. Literature & Trends in Forest Level Planning:

Bettinger, P. and W. Chung. 2004. The key literature of, and trends in, forest-level management planning in North America, 1950–2001. International Forestry Review. International Forestry Review 6(1), p. 40-50.

13. Parking Lot Topics Priority:

Anonymous. n.d. Priority of topics identified by H&H project. 1 pp.

14. Yield Table Creation Description:

Overhulser, P. and M. Rasmussen. 2006. Projecting future forest conditions for the H&H Model. 13 pp.

15. Quality Control Procedures:

Anonymous. 2006. Summary of Harvest & Habitat Model Quality Control Procedures, June 27, 2006. 10 pp.

16. Model Goals Matrix:

Anonymous. n.d. Harvest & habitat alternative goals and switches. 2 pp.

17. Stakeholder Input Process:

Anonymous. 2005. Harvest & Habitat Model Project, process for obtaining stakeholder input, model alternatives 3 & 4, July 14, 2005. 1 pp.

18. Harvest Unit Transport Design Standards:

Anonymous. n.d. Harvest unit and transportation design standards used for the harvest and habitat model. March 23, 2006. 8 pp.

19. Mission of the H&H Project:

Anonymous. 2005. Mission of the harvest & habitat model project and purpose of the alternatives. July 19, 2005. 3 pp.

20. Cascades Growth Model Report:

Fairweather, S.E. 2005. Recommendation of growth model and tree volume estimation system for the North Cascades Unit. Report prepared by Mason, Bruce and Girard, Inc., Portland, OR. for the Oregon Department of Forestry, Harvest Scheduling Model Yield Table Creation Project. 15 pp.

21. NW Growth Model Report:

Fairweather, S.E. 2004. Recommendation of growth model and tree volume estimation system to the H&H Core Team for the Tillamook, Forest Grove, Astoria, West Oregon, and Western Lane Districts. Report prepared by Mason, Bruce and Girard, Inc., Portland, OR. for the Oregon Department of Forestry, Harvest Scheduling Model Yield Table Creation Project. 23 pp.

22. SWO Growth Model Report:

Fairweather, S.E. 2005. Recommendation of the FVS ICASCA Growth Model for the Southwest Unit. Report prepared by Mason, Bruce and Girard, Inc., Portland, OR. for the Oregon Department of Forestry, Harvest Scheduling Model Yield Table Creation Project. 11 pp.

23. Example FMP~HCP Metadata Source Files:

Anonymous. n.d. Alternative 1 metadata comparisons between districts. 1 pp.

24. GIS Data Layer Responsibility:

Anonymous. 2004. GIS data layer responsibility, 4/16/04. 1 pp.

25. Sustainable Forestry Oregon Style:

Bordelon, M.A., D.C. McAllister and R. Holloway. 2000. Sustainable forestry Oregon style. Journal of Forestry, January 2000. p. 26-34.

26. NSO Modeling Scenario:

Anonymous. 2006. Process to develop H&H model owl scenarios, July 6, 2006. 12 pp.

27. **Kanaski, A.** 2006. Swiss Needle Cast and the H&H Model. Prepared January 31, 3 pp.

28. **Mason Bruce & Girard** memo from Marie Lennette to Pam Overhulser, March 8, 2005, regarding Snag model Recommendation.

29. Coarse Filter Matrix

30. **Weikel, J.** 2004. Assessment of using a coarse-filter approach to monitoring native species in association with the Northwest and Southwest Oregon State Forest Management Plans. Draft. 32 pp.

31. **Mason Bruce & Girard** memo from Roger Lord to Pam Overhulser, 8/4/2005, regarding Leave Tree Growth Effects Analysis. 9 pp.

32. **Mason Bruce & Girard** memo from Marie Lennette to ODF, 8/3/2005, regarding Expansion of Cruised Stands to Uncruised Stands.

33. **Anonymous.** 2006. Harvest & Habitat Model Project Review and Debriefing, Summary of Comments. February 24, 2006.

Draft Questions with References to Suggested Reading

A. Structure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1. Are the structural features of these models (e.g. spatial/temporal scale and resolution, major components and functional relationships) appropriate to: a) The decision problem they are trying to address, and b)The available data?	◆	◆	◆	◆	◆			◆	◆		◆	◆		◆			◆		◆				◆	◆	
2. Are the simplifying assumptions and limitations of the models clearly described?							◆			◆															
B. Input Data	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
3. Is the accuracy and precision of the input data generally sufficient for the intended applications of the models? Are weaknesses in the input data recognized by the model users?	◆	◆	◆	◆	◆	◆	◆			◆					◆								◆	◆	
4. Have sensitivity analyses been done to assess which input data are most critical to the choice of alternative management strategies?										◆					◆										
C. Growth and Yield Assumptions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
5. Do the FVS growth models take into account the major biological factors which need to be considered in estimating growth and yield for these Oregon forests? (Variants of the USFS Forest Vegetation Simulator can consider root rot, dwarf mistletoe, and insects such as spruce budworm – are any of these critical to these forests, and missing?).							◆			◆										◆	◆	◆			
D. Natural Disturbances and Processes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
6. Do the models deal adequately with important natural disturbances and processes in these forests (e.g. windthrow, fire, root disease, Swiss needle cast, and natural regeneration after harvesting or fire)?							◆																		
7. Do the models facilitate creation of harvest areas that mimic the sizes and shape of natural disturbances?							◆											◆							

E. Key Functional Relationships and Constraints	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
8. Have the models been through a detailed sensitivity analysis to determine which functional relationships, parameters and constraints most strongly affect the choices amongst alternative decisions?										◆					◆	◆									
9. Are the key functional relationships, parameters and constraints (e.g. habitat requirements of focal fish and wildlife species) grounded in strong empirical data? Have model tests been done to assess the validity of key functional relationships?														◆											◆
10. Is it clear how the optimization algorithm used in the model attempts to meet the multiple competing objectives and constraints (e.g. timber production, wildlife habitat conservation, cost minimization)?								◆		◆															
11. How easy is it to update key model functional relationships or parameters as new data are acquired?								◆																	
F. Using the Models to Make Decisions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
12. How useful are the models for the intended strategic and tactical level decisions to which they will be applied? [Specifically, can they be used to decide among the 4 options: FMP using a HCP, FMP using Take Avoidance, wood-emphasis, or reserve-based? Are these models appropriate for making decisions about: 1) whether to make changes in the Northwest and Southwest Oregon FMPs, 2) whether to pursue a HCP, and 3) setting harvest levels for Annual Operation Plans?]										◆															
13. Do the models allow the exploration of different management strategies under multiple competing hypotheses (e.g. different assumptions about habitat requirements of focal wildlife species)?								◆																	
14. Is the model output deterministic, or does it provide a distribution of outcomes that recognizes uncertainties in both functional relationships and natural environmental variation?								◆																	
15. Is model uncertainty clearly communicated in documents provided to decision makers (e.g. the Board of Forestry)?									◆	◆															
16. Do the models support the implementation of adaptive management (i.e. can model predictions and key functional relationships be tested and iteratively improved)?							◆	◆			◆														
17. What are the key priorities for overall improvement in the models, given the intended applications (this synthesizes recommendations from previous questions; please consider pg. 55 of Doc A, Enhancements for the Future)													◆		◆										

Appendix D: Brief Reviewer Biographies

Dr. Terry Droessler

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Dr. Droessler has a BS in natural resources and an MS and PhD in forest biometrics. He has 18 years of experience in quantitative natural resource analyses working for the USFS, EPA, forest products industry and consulting firms, specializing in growth and yield model setup, projection, testing and calibration, inventory processing, harvest scheduling, timberland appraisal, independent "third-party" verification and expert witness testimony.

Mr. Glen Dunsworth

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Mr. Dunsworth is an Ecological Consultant providing services in forest resource management, conservation biology, and strategic planning. He has extensive experience in the BC coastal forest industry with Macmillan Bloedel and Weyerhaeuser where he directed regeneration and biodiversity research and developed effective new strategic approaches to ecosystem management. Most recently Glen was the Ecological Team Leader for Macmillan Bloedel and Weyerhaeuser's structure-based management initiative (the Coast Forest Strategy) and its companion Adaptive Management and Effectiveness Monitoring Program.

A graduate of the University of Alberta Forestry post-graduate program, he specializes in biodiversity, genetics, landscape ecology and ecosystem-based management. He has strong technical writing skills with over 50 publications. He is qualified to administer large, multi-disciplinary teams and is a Registered Professional and a member in good standing of the College of Applied Biology. Consulting services to client organizations include industries or groups such as forestry, environmental, government, media, and crown corporations.

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Dr. Kiester grew up in southern California in the days when it was wonderful to be interested in herpetology. He received his undergraduate training in Zoology at the University of California at Berkeley and his Ph.D. from Harvard in Biology. He was also a Junior Fellow in the Society of Fellows at Harvard. He was a Professor at the University of Chicago and Tulane University for ten years. He then worked for 20 years for USDA Forest Service Research. At present he is the Principal of Biodiversity Futures Consulting.

Dr. Kiester's interests are in ecology and evolutionary biology, natural resources management, philosophy and herpetology. He also has a strong interest in quantitative and computer methods.

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Dr. Monserud is the Research Team Leader of the *Ecologically Sustainable Production of Forest Resource*s team for PNW. This team has responsibility for research on wood utilization and wood quality in all states of western USA. He joined the USFS in Moscow, Idaho in 1975 after finishing a PhD in Forest Biometrics at the Univ. Wisconsin in Madison. His research covers a broad range of topics and disciplines related to modeling forest dynamics and utilization (growth, mortality, and regeneration; productivity; genetics; physiology; climate change). He has worked internationally at all scales, from global (Budyko, Holdridge, and Biome models) to regional (Rocky Mts., Siberia, the Alps) to local (stands, individual trees, branches/leaves, annual rings).

He has written more than 140 publications, with more than 60 of these as refereed publications in international journals and books; and delivered over 70 invited papers and presentations before scientific and professional organizations. His papers have been cited over 2000 times in major refereed journals, as listed in Science Citation Index (through mid-2005). He has also served as referee for 24 journals, including *Forest Science, Forest Ecology and Management, Canadian Journal of Forest Research, Ecological Modelling, Forest Biometry, Modelling and Information Sciences, Journal of Applied Ecology, Journal of Environmental Economics and Management.*

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Mr. Northway is a Registered Professional Forester in the province of British Columbia with 30 years of industrial experience in strategic forest management planning. This includes experience in forest data acquisition with the design and implementation of a permanent sample plot program and with the design of a forest inventory storage (GIS) and compilation program. He also has experience in building stand and forest level models, including a distant-dependent stand model and a spatially explicit forest level model. A substantial part of his career was spent in forest policy analysis, including silviculture prescription design, land acquisition, economic timber supply and integrating spatially explicit harvest and biodiversity planning.