Challenge Paper
As-Is Response Compilation

The Challenge Dialogue System™

Development of a Strategic Plan for Forest Inventory and Monitoring Activities in Mountain Pine Beetle Areas

Forest Analysis Branch
BC Ministry of Forests

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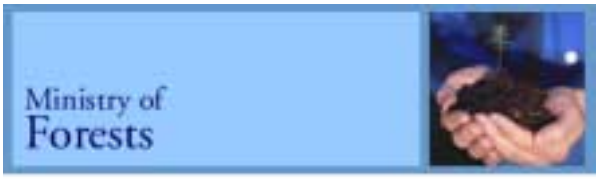

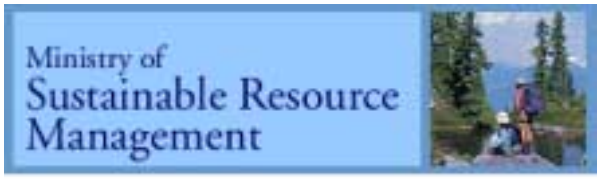

March 21, 2005

The Challenge Dialogue System

We are using the Challenge Dialogue System™ (CDS) developed by the *Innovation Expedition* to guide our Dialogue prior to and during the face-to-face workshop on the Forest Inventory and Monitoring Strategy for the Mountain Pine Beetle Areas.

CDS is an efficient and effective vehicle for engaging diverse stakeholders and assisting them to collaborate and innovate in order to accomplish a complex task. CDS is a structured but flexible methodology for moving a team of people from ideas to action quickly and effectively. More information on CDS is available at the Innovation Expedition's website at: www.innovationexpedition.com.

Don Simpson and Keith Jones, Innovation Expedition

Please e-mail any further comments to

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Thank you! - Introduction & Continuing to Set Context

March 21, 2005

This is just a quick note of *thanks* to those of you that took the time from your busy schedules to respond to the *Challenge Paper*[1].

Reactions and responses to the paper are included in this *As-Is Response Compilation* document (edition 2). Following the receipt of further comments, we have had a total of thirty-eight respondents from a circulation of about 140. We thought you would be interested in seeing everyone's comments (they are mixed together by category and are not attributed) so you can see the range of opinion on this complex topic. *The additional comments have been italicised so you can find them easily.*

Please note that no synthesis has been done as yet. These perspectives will be shared at the workshop at the end of March.

You have provided valuable and insightful reactions and comments. This information helps us to see to what extent the strategy development team members and inventory and monitoring stakeholders are aligned, where they are not aligned and where there is still some confusion.

You have expressed some great thoughts on how we need to progress and on what is most important right now, and you have offered some good ideas on items and initiatives that might offer us some direction.

We will now take this collective response to prepare a Workshop Agenda, Workshop Workbook and process that will reflect where we are at collectively as far as possible. This will not be easy with such diversity of opinions, but it is clear in scanning the material that there is a lot of strong will and commitment to get on with some tangible actions in certain key areas — so that's what we'll aim for at the Workshop!

We look forward to seeing some of you at the Workshop on March 30-31, in the Lower Mainland .

Thanks again for your interest and input.

Kind regards,

Melanie Boyce, Fern Schultz and the consulting team

[1] The *Challenge Paper* is one of a number of tools developed by the *Innovation Expedition* for its *Challenge Dialogue System*™ - a disciplined process that engages diverse groups on discovering collaborative and innovative solutions to complex challenges. www.innovation.com

INPUT REQUEST 1: Key Challenge and Background Statements

- **Are you aligned with our Key Challenge? What is missing? What is included but is not relevant in your view?**
- **In your view, are there any Background Statements that need clarification, should be added, or that are not relevant?**
- **Please remember the intent here is to get everyone on the same page.**

The Key Challenge Statement

At the initial stages of this Challenge Dialogue, ministry staff envisioned that the inventory and monitoring strategy will need to focus on the following —

The development of a strategic plan for forest inventory and monitoring activities in mountain pine beetle areas that meets the short and long term business needs of government agencies, the forest industry and other key stakeholders. The plan must:

1. **consider information requirements of forest managers and of the Chief Forester for AAC determinations;**
2. **address, to the extent feasible, the information requirements for management for other forest and resource values by government, industry and communities; and**
3. **be achievable and sustainable in appropriate timeframes under existing and foreseeable technology, institutional and resourcing conditions.**

Are you aligned with the Key Challenge? What is missing? What is not relevant?

(i) This issue is so HUGE and so dynamic. The strategy and action plans have to also have the flexibility to be dynamic. The Statement contains "consider" and "to the extent feasible", maybe it is the same thing, but I would prefer more precision in a strategy statement – who, what, where and when. There has been too much lollygagging already.

The issue for forest managers is the magnitude and rate of spread, the site conditions that will determine "shelf life" and the timber supply impacts short- and long-term – not AAC and the cumbersome AAC processes.

It is not appropriate to limit the strategy to resourcing conditions if that means funds available. The strategy and action plans need to be built to meet the needs and then prioritized if required to meet the funds. This will also provide leverage for federal funding requests.

(ii) I am generally in agreement with this section, "Key Challenge".

(iii) In my view, the wishy-washy statement #2 will not result, with #1, in the outcomes itemised in #3. Again, my logic here is that the interior pine forests are probably the best examples of BC's 'working forest,' and not all workers are working in timber management. And, if we continue to emphasise timber inventories throughout the forest landbase, we will be in a continual situation of resource use conflict because of lack of good technical information, lack of leadership, lack of political will, etc.

(iv) As long as key challenge statement #2 includes information requirements for fish and wildlife habitat, biodiversity concerns and water implications I believe the Challenge Statement answers my concerns about ensuring we can use the collected information for monitoring other resource values.

(v) Interpret that Key Challenge is to develop one "umbrella" for everyone (industry, gov't, etc.) and integrate data under; although process seems focused to gov't re: AAC determinations

Value for operational and strategic / analytical planning…may allow for out-of-the-box initiatives when developing FSP objectives

Should be considering the after the "honeymoon" and data exchange agreements…. "heavy" to what gov't will attain from this exercise

Clarify who has already participated in "Common Ground Initiative" and where that stands and it's influences or correlation to this process.

(vi) The Key Challenge Statement #3: be achievable and sustainable…. In particular in regard to "under existing…. resourcing conditions"?? If you are talking about current government VRI inventory staff and VRI contractors; the people knowledgeable within government is rapidly shrinking year by year; as is the contracting community. People competent with doing photo interpretation require a number of years to develop their skills.

If you are talking within current budgets; "achievable and sustainable" is at risk! I hope there is some budget within the MOF for Beetle Inventory, because the VRI is next to non-existent at this time, with no government funding and little, funding (FIA) provincially either; government needs to recognize the serious nature of this issue and fund accordingly in the near future.

The private sector (licensees) doesn't have the resources, nor the desire to lead this type of undertaking. The expertise is still within government and the private contracting community; what's left of it!

(vii) The key challenge deals adequately with AAC and non-timber resources. However, it does not explicitly cover operational availability of fibre, merchantability, shelf life, etc. Inventories need to provide more than simply strategic level information when it comes to timber. We need to know not just how much there is at a TSA level, but where it is with some reliability.

(viii) Aligned with key challenge: yes, I am not too worried about missing or non-relevant items - these will come out "in the wash".

(ix) I am somewhat aligned with the Key Challenge but I believe that there are some serious shortcomings of the approach.

Firstly, there is, in my view, an inadequate rationale as to why this inventory and monitoring strategy is being proposed for the MPB area. There are the standard inventory catch-phrases utilised but there is no definition of the resource stewardship reasons for doing so – one of which might be to track the natural and managed succession of the largest-scale natural disturbance in the province's history. And what is the rationale for doing this now? I'm not saying that there aren't these rationales but I don't think the Key Challenge reflects them.

Secondly, the approach outline is very traditional and conventional, very timber oriented, and very forest-company oriented. This narrow focus does not reflect the extent, intensity and seriousness of the epidemic to the local area and the province. The area affected has a number of subsistence-based activities, a multitude of resource uses/users, a vast network of remote and rural communities, and is a working example of integrated resource management. There will be a considerable period of time when the local populace will be facing timber shortages and severe alterations of other resource values. Thus, the inventory cannot be focused on timber alone or primarily.

Thirdly, there appears to be little involvement, if any, in this process of the communities and First Nations living on the affected landbase. They cannot be excluded from the process.

Fourthly, there appears to be little focus on the leadership and stewardship obligations of government, industry and the other stakeholders. A number of the background statements indicate: industry's reluctance to do this, government's lack of resources to do that, protocols needed but cannot agree what and how…..

The Key Challenge needs to grasp this shortcoming, and needs to facilitate and catalyze all parties coming together to resolve it. This is where true innovation will be needed.

Fifthly, there is no mention of the range of uses of timber (e.g., sawlogs, wood chips, firewood, fence posts, fuel pellets, etc.) which can use a range of tree/wood qualities, and which are more conducive to local business operations.

Sixthly, I think it would have been useful for the authors to define, at the beginning of the Key Challenge, what they meant by the terms, 'forest inventory,' and 'forest monitoring activities.'

(x) The key challenge relates to forest inventory and monitoring activities for a target population of MPB areas. In this manner it addresses MPB as an exclusive population within the inventory. The business requirements for TSR further focus the target into the timber harvest landbase. This approach allows the study to focus upon MPB but it may not serve the long term resource management needs. The population changes due to both MPB and secondary forest health or other issues, changes to the definition of the THLB, and changes to higher level resource plans will not necessarily be supported by a focused study and hence point 2 of the challenge may not be addressed fully.

(xi) I'm in agreement with the challenge.

(xii) I agree with the key challenge statement and can suggest no changes that may improve it. The statement is sufficiently broad and generic that it could be interpreted in almost any way to support almost any approach or strategy that might be imagined by different individuals with different backgrounds and ideas. The statement suggests only that there is a need and desire to develop a strategic plan for forest inventory and monitoring activities in areas affected by mountain pine beetle. It does not specify what kind or kinds of forest inventory activities are envisaged nor does it specify what kinds of monitoring activities may occur. Anything is possible under these directives.

The key considerations following the challenge statement do impose some restrictions or guidelines.

Statement 1 regarding supporting AAC determinations suggests to me an assumption that any system designed will provide comprehensive and complete coverage for an entire area of interest (up to the entire province conceivably). It is not conceivable to me that AAC determinations could be made reliably on the basis of spot assessments or some kind of systematic sampling strategy. Others may well argue the opposite and suggest that spot or systematic sampling will provide the information necessary to support determinations of AAC.

Statement 2 regarding supporting other information requirements muddies the water quite a bit and opens the door to expanding the design of any proposed approach to one that might want to try to be everything to everyone. It is extremely unlikely that it will prove possible to design any single approach, or combination of approaches, that will satisfy all, or even a broad range of, information requirements for forest information. This statement opens the door to encourage interested parties to propose just about any information gathering strategy they will to see in support of just about any information need that can be related to forest inventory and management.

I welcome statement 3 as it imposes a need to consider cost, technical feasibility and likelihood of success. Otherwise, the dialogue may just expand into an exercise in imagining and proposing elaborate, expensive and technically unfeasible projects that will ultimately not be capable of providing the answers required.

(xiii) The problem of how to achieve the Key Challenge and provide timely information is quite daunting. It may be possible to satisfy some information requirements at the strategic level, but it may not address the stand level needs of other users. I agree that the plan needs to focus on what is actually do-able given time frames and resources.

(xiv) I would add that once an Inventory and Monitoring Strategy is determined that a Communication Strategy be developed simultaneously to market and inform stakeholders and to maintain support.

Secondly to encourage dialogue it would be beneficial to receive input on the operational data/information needs from industry. The attributes which need to be identified to describe a dead forest may be significantly different from conventional timber inventory used to describe a living forest.

The Key Challenge statement should recognize the unconventional purpose of describing dead trees and modeling for decay and associated declining value of the affected stock.

(xv) I believe in the old axiom…"you get what you pay for". The amount of resources that you allocate to a problem (assuming that the project is well managed) will determine the quality and flexibility of the information that results. If you try to nickel and dime the issue then the results will be compromised. If this is the problem that everyone says it is then let's address it with a reasonable amount of resources.

Given the size and scope of the area that is to be affected there may not be an opportunity to generate a "wall to wall" survey in any great detail. We may want to perform a province-wide survey with coarser techniques, relying on the more detailed (and expensive) techniques for strategically important areas.

(xvi) Yes, aligned with the Key Challenge as stated.

(xvii) I am aligned with the Key Challenge which matches the desire of the proponent but think the documentation is not aligned to that challenge. The background material provided to encourage dialogue is so broad reaching as to be nearly meaningless or at the very least overwhelming. Questions should focus on the 3 Challenge statements which primarily ask "What information requirements (business needs) have to be addressed as a result of the MPB outbreak and when?" The question of what inventory approach to consider is irrelevant before understanding what is needed.

I also feel this document is written with the notion that a remote sensing project is the answer to a question that has yet to be fleshed out.

Is it possible that an appropriate choice is to take no action at this time and only do inventory after the beetle has run its course?

(xviii) Seems OK.

(xix) I am in support of the key Challenge Statement. I would like to see a commitment in the plan to gather information to support management decisions to mitigate the effect of the MPB outbreak on mid-term timber supply. I will discuss this further in my response to the paper, but in short we need to be taking measures now to ensure we salvage all that we can, and in doing so not frustrate opportunities or efforts to conduct forest management activities to mitigate the mid-term timber shortfall.

(xx) The Key Challenge Statement appears to have a distinct TSR bias by virtue of project sponsorship. Recognition of the diverse business needs of licensees, BCTS and other ministries (e.g., WLAP) is needed if there is ultimately to be an expectation of shared responsibilities. That said, a single focus (TSR) makes project success much more likely under tight timelines. It may help to portray TSR as an expedient surrogate for other business needs.

(xxi) Most of challenge statement is general except considering the requirements for the Chief Forester for AAC determinations, maybe should drop AAC reference.

Forest managers – given the second bullet this first bullet might be made more specific in terms of "timber" values rather than couched under a general term of requirements of forest managers.

(xxii) Section 1; We need to develop an integrated strategy with a MPB focus which means that we also need to regard (i.e. have certainty) the non-MPB areas that will sustain the mid-term harvest flows. As this strategy includes monitoring we need to secure funding for long term data collection.

Section 2 and 3; In integrating with other opportunities we need to ensure that we do not override these other initiatives (VRI, NFI) projects as they have separate business drivers and focus upon the entire landbase.

(xxiii) Q: Are you aligned with our Key Challenge?

A: Yes, I am aligned with the key challenge, but I think the strategic plan should consider both short- and long-term issues. The short term strategy should focus on assessing the quantity and quality of the dead wood and where it is in a spatial context. The long-term strategy should consider issues of detection and tracking of regeneration in affected areas.

Q: What is missing?

1. A discussion on the establishment of an early warning system that could have potentially fore-told the severity of this particular beetle attack is missing. Many forest managers were aware of the attack, but the severity and consequences were under-estimated. At this stage it is too late to take pre-emptive action to reduce the impact of the attack. Now we are limited to addressing salvage logistics. The development of this strategy could go a long way in raising awareness of the need for an early warning system based on a study of historic attack patterns and systematic ground data collection to gather intelligence on eminent attacks of not only mountain pine beetles, but other epidemic pest attacks.

2. Licensee are identified as key players in the production of inventory information. As such they are recognized as key stake-holders. However, the average BC tax payer who by virtue of the crown ownership of the forest land has a major interest in the forest resources is not identified as a stake-holder. Which agency protects the public's interest in these issues? How should these interests be protected in the strategic planning and execution of any developed strategies.

3. There should be an acknowledgement of the need for short and long-term strategies. In my opinion, the short-term strategies should address data collection to quantify the amount of damaged wood in order to allow for informed decisions on salvage. The long-term strategies should have two aspects: a) establishment of an early warning system to detect infestations and forecast major attacks, and b) track stand dynamics of regenerating stands.

(xxiv) Put time bounds around short vs. long term business needs

Timeframes: short term business requirements may be happening faster than this strategy can respond to, shelf-life as an example.

There appears to be a number of MPB strategies and unrelated work already under development; who is going to link them all together and who is going to be in charge of all of this provincially? I was told that Research Branch would be doing this.

(xxv) Point 3. How about affordable and cost-effective to industry? If past MSRM and MoF initiatives are any indication, ministry staff expectations have generally been to transfer the resourcing costs on to industry. Therefore, two of the key challenges must be a cost-effective and affordable strategy and who provides the funding and resources?

(xxvi) I am more or less aligned with the key challenge. I find it interesting that the focus is on AAC and not on MAI and the ecological capacity of the land base to support the off take of products. I would hope that the lessons learned from this process will also be applicable to the non MPB infested areas of the Province.

(xxvii)Yes, I'm aligned with the Key Challenge. Missing from this statement is a clear description of the fundamental problem we have in inventory – the FIA funding mechanism where industry it the key delivery agent while MSRM simply sets standards and stores data with little or no control over priority of data acquisition as set by the priorities of client agencies, particularly the Chief Forester.

(xxviii) Remove the term "and foreseeable" from the Challenge Statement.

a. Focus efforts on deliverables.
b. Evaluate based on existing conditions.
c. Control expectations and costs.

(xxix) The Key Challenge is fine. Based on the current fiscal and political environment, the last point would appear to be the most critical.

(xxx) I think we need more focus. The key Key Challenge is to

- *"Address the information requirements of the Chief Forester for AAC determinations".*

We should "consider" the information requirements of other forest managers (presumably this means within the BCFS? but perhaps BCTS as well) however, they are a diverse lot and it will not be possible to make them all happy.

In the final point (3) I am a little concerned about the word "foreseeable". Very little, if anything, about these 3 aspects of the challenge is "foreseeable". I suggest (fear) that we must present a variety of options given different outcomes with respect to the 3 variables.

(xxxi) The needs of those managers who must deal directly with the Mountain Pine Beetle (MPB) and its effects (e.g. early detection and attack, salvage of damaged timber, forest protection) do not seem to be considered. Point 2 states, "address, to the extent feasible, the information requirements for management for other resource values… That doesn't to me clearly mention the needs of those who most need the information on the MPB.

(xxxii)In addition to timber supply consideration for information requirements for the management of habitat supply. In particular stand structure and species composition.

(xxxiii) Agree with the Key Challenges.

Are there any Background Statements that need clarification, should be added, or that are not relevant?

(i) I don't recall seeing much on management of natural disturbance in protected areas and areas outside of the timber harvesting land base. There's a link from those factors to how disturbances may build momentum, and how unharvestable forest that is expected to contribute to forest management objectives (e.g. biodiversity, visual quality, wildlife habitat) will actually contribute.

(ii) The background statements discuss the VRI and NFI/CMI inventories. Point 3 in the challenge regards the development of an achievable and sustainable program within the appropriate time frames with existing technology and resourcing. Both the inventory and the existing sample designs were developed to address business drivers other than the dynamic change of catastrophic events such as MPB. The standards of data collection, compilation and analysis may be compromised if the MPB strategy assumes that it will integrate partial but temporally sensitive information into existing inventories and sampling standards. The databases should be discrete and independent information sources so that they can be managed independently to these different standards. That being said the VRI is a foundational database that will provide the key information to support the estimation of the MPB area of interest, its modelling attributes and its relation to higher level plans. The VRI base inventory and the NFI still have valid roles as these foundational inventories and it should not be assumed that the MPB data will replace them.

(iii) I think a discussion of the history of MPB attacks for the past 50 years would have been informative. Has reliable data been collected on these attacks over the past 50 years? Is this an area we should explore to learn from the past.

I think a discussion of past attack may improve on the choice of options in developing action strategies. There is a danger that the strategy development may get bogged down with discussion of salvage & regeneration dynamics. If this happens, the real issue of assessing the rate at which beetles are spreading to unaffected areas (or the possibility of other pest outbreaks) will be lost in the shuffle.

(iv) The Background Statements are clear in terms of what to be achieved by the end of the process. However, in order to get everyone on the same page, we need to clearly define the scope of this project (i.e. what kind of inventory we are talking about). The scope should be given to facilitate the discussion and comments, so that we do not go all over the board (something irrelevant).

(v) Not relevant? The discussion on terrestrial ecosystem mapping and predictive ecosystem mapping. I am not sure what relevance PEM or TEM have on the MPB problem. Are there any links between MPB attacks and site series? I think BEC mapping is relevant, but I am not sure if the PEM detail is. I might be wrong on this.

(vi) My take is that there are many kinds of inventories, but most commonly we define inventory by spatial scales (scope) according to management requirements (which determines information detail and cost). Are we talking about inventories at provincial, regional, TSA units (management), or TFL/operational (stand) level? The answer to this question would focus the discussion and comments on the lowest level (because we can always "scale-up" the inventory).

Another key word is "monitoring". Any inventory strategy/design has to have this capability, which should be emphasized. Again, what kind of monitoring capability we are talking about? That is, what we monitor (activities and changes), how often we do it (frequency), and for what purpose (business drivers)?

The current MOF mapping projects of MPB using the aerial overview and new interpretation for the measle mapping with new 2004 photography are not mentioned (see www.for.gov.bc.ca/hfp/forsite/overview/facts.htm).

(vii) Many of the Background Statements could be removed to strengthen the document. Some are irrelevant / others are not constructive due to editorial comments and/or misinformation.

A Background Statement on the current state of Forest Health monitoring responsibilities is needed.

The inclusion of a Background Statement should be driven by the business needs defined within the Challenge Statement.

(viii) At one time the CFS and later the BC MoF had a forest health survey system. If this system is still in being in some form it should be mentioned.

Information on how the life cycle of the MPB and how the insect affects trees should be provided if reviewers of the Challenge Paper are to appreciate the beetle's effects and the specifications for a detection and assessment system.

(ix) Some missing background information is the apparent lack of coordination/collaboration between government agencies to support innovation towards solutions. Rather a bureaucratic quagmire of standards exists which do not reflect "results based" management but rather "rule based" management. The method by which results are achieved (i.e. beetle detection map) are more important than the quality and utility of the result.

The overlap of environmental/ecological stewardship responsibility between different government agencies and industry are not clear. Perhaps more background information on this aspect as to where the responsibilities lie will help to focus discussion as well.

The abbreviation for Background Statement is B.S. – fortunately I think you've done a good job in not making your B.S.'s a bunch of B.S.

Background Regarding Current Resource Inventory and Monitoring (1-13)

1. The change in provincial government in 2001 significantly changed mandates, organizational structures, roles and responsibilities, resourcing levels, and priorities which in turn have affected how resource information is collected, interpreted and reported. The government's natural resources-environmental portfolio and the formation of MSRM consolidated most of the land and resource information capacity at the provincial level with the aim to make it more consistent, corporate, integrated and accessible. Most, but not all, of the information staff and resources from the contributing ministries were united under MSRM.

(i) Not especially useful or relevant.

(ii) Even more important than the evolution of MSRM is the accompanying shifts in "New Era" forest policies that attempted to move critical hands-on stewardship responsibilities from ministries to licensees without providing sufficient incentives in the areas of inventory, G&Y and TSR. Inventories have been locked up in this policy stalemate.

(iii) It is still unclear to me as to what are the roles and responsibilities for inventory and G&Y between government and industry. Currently there is very little incentive for industry to adopt the inventory and G&Y programs and the government has significantly reduced staff resources necessary for VRI maintenance or the VRI roll-over. The Ministry should develop a comprehensive inventory strategy or address the problems with the current program delivery as part of this new initiative: e.g. better funding incentives, more cooperative approaches to developing standards, more acceptance by MSRM/MoF staff of new innovative inventory approaches, etc.

Because of reductions to staffing levels, the Ministry's approach has been to develop more prescriptive standards which have constrained inventory innovation. Whether by design or not, consultation with industry over standards development has been perfunctory at best, resulting in standard documents developed primarily by Ministry staff: e.g. dissemination of lengthy standards documents with unreasonable response times for review and inadequate solicitation of industry participants, etc., (e.g. MPB Inventory and Monitoring Strategy, PEM Draft Standards Revision, 2004).

Evidence of inflexible standards can be seen by the number of inventory projects designated as pilot projects by MSRM. For example, pilot project designation can be for something as minor as the collecting of additional data for the licensee (e.g. CMI - attributes recorded by quadrant) or plot modifications to an inventory standards (CMI – tags affixed a breast height instead of stump height, , top height collected in NE quadrant, etc.). While the Ministry rarely misses the opportunity to espouse the need for innovative thinking and design, it is extremely rare that better innovative approaches are ever adopted in the revision of a standard.

As well, Ministry reporting, data submission, data structure and data analysis requirements are onerous and costly because they are rarely, if ever, instep with changing technology. A classic example of an outdated MSRM analysis standard is with VRI Phase II adjustments. The MSRM TSR standard is to adjust only the leading species height, leading species age, and polygon volume. They don't allow for adjusting species composition (i.e. Species Volume), because they don't understand that these attributes can be adjusted with equal precision. If licensees wish to adjust species volume, basal area, storey height and snag frequency, this must be done separately at an additional cost to the licensee.

(iv) Clear line of responsibility for Corporate Base Mapping Standards.

(v) Yes, but then downsizing happened and expertise was let go, e.g., habitat expertise. Two consequences: 1) little expertise in SRM means they lose credibility and have to keep coming to us for priorities; 2) we lost GIS and systems capacity, SRM can't keep up to our needs (e.g., we need expertise to build and track WHAs under legislation) so we have to build capacity in our ministry – where is the dividing line between SRM provided services and doing it ourselves?

2. Land Information BC. Land Information BC is the flagship information service initiative of the MSRM[2]. It is a new vision for the effective delivery of integrated, science-based land, resource and geographic information in support of government's vision of economic development and a vibrant provincial economy, a sustainable environment and healthy communities. Key features include: (a) single window to the land and resource information, products and services for business, industry, academia, governments and the public; (b) delivery through partnerships, agreements and alliances with other businesses, industry and governments; (c) easy access to natural resource, land ownership and legal interest information to enable economic opportunity and development efforts, various levels of planning, First Nation opportunities and Treaty negotiations, business and citizens activities through e-services and the protection and stewardship of provincial resources; (d) broaden to enable integration of social and economic information over the long-term; (e) transformation of MSRM's business to a client focused service.

- This was news to me and is relevant. I hope that the end result is similar to State Clearinghouses or Spatial Data Warehouses in the US.

3. The Resource Information Branch was created within the Ministry of Sustainable Resource Management (MSRM) in 2003, with people and functions drawn together from a variety of inventory and information agencies. Today, it is one of seven components of Land Information BC. It is predominantly a headquarters branch, with one section (Forest Cover Update) located in Kamloops. In addition, there are Resource Information specialists located in various Contact Centres and the Kamloops Service Centre within the Business Solutions Branch (BSB). Business responsibilities and contributions by these BSB staff to the delivery of the resource information mandate are included in this business plan, within the appropriate section plans. The primary responsibility of the resource information business area is managing provincial natural resource and biophysical information.

(i) OK

(ii) The Resource Information Branch is also the recognized ministry custodian for orthorectified Landsat and SPOT satellite data.

[2] http://srmwww.gov.bc.ca/g/libcfacts.html

4. Forest Inventories have been conducted in BC since the turn of the century and have focused primarily on quantifying the standing green timber resource for harvesting purposes. In 1991, the Forest Resources Commission caused a change in focus of inventories to include other resource values and to use standardized methods as directed by the Resource Inventory Committee (RIC; now called Resource Information Standards Committee). RIC in turn established a Vegetation Inventory Working Group (VIWG) to develop the procedures and standards for the Vegetation Resources Inventory (VRI). Refer to Appendix 2 for a "Quick walk through of Forest History in BC."

(i) OK

(ii) … the Forest Resource Commission expanded the focus of inventories enabling inclusion of other resource values…

(iii) Supports the concept of multi-use product specifications.

5. Vegetation Resources Inventory. The VRI quantifies both the timber and non-timber vegetation forest resources. Providing stand level information based on mid-scale photography/digital imagery, VRI has two broad phases (a) photo interpretation of photographs or digital images to identify different forest stands and estimating the quantity and characteristics of different timber and non-timber attributes within the forest stand; and (b) ground sampling a portion of the stands identified within a management unit during the photo interpretation phase. The ground samples are used to develop a relationship between the photo interpreted polygon estimates and the ground samples. This relationship is used to adjust the photo interpreted polygon estimates and then to calculate a statistically valid estimate of any given attribute for the entire management unit.

Photo interpretation phase provides stand level estimates based upon general stand characteristics and not individual trees. The inventory file adjustment quantifies a specific attribute for the entire management unit and cannot be considered statistically valid for an individual stand nor should it be considered more accurate than the photo estimates for the same given stand.

The degree of disturbances (e.g., logging, fire, insect, disease, etc.) for a stand can be estimated during the photo interpretation phase and maintained in the inventory file.

(i) I note the emphasis on "stand level" identification and description of forest resources. I think that the definition of the level of spatial detail that is required will affect all subsequent decisions about how to approach the current challenge. I personally favor a stand level approach but it is important to begin the discussion with a debate about the spatial scale and precision of the objects that will be described.

(ii) It is also important to note that while VRI attempts to estimate stand level information, it is meant to be rolled up for strategic level reporting. Any strategy that depends on the information in the VRI being correct at the stand level will be unreliable.

(iii) Should identify that inventory was built for a wide range of values and that it can be refined for specific users (e.g., timber emphasis plots)

(iv) Middle para. re. accuracy: suggest you check this statement with Dr. Otukol.

(v) The VRI allows for the quantification of both timber and non-timber vegetation forest resources.

(vi) There is a reluctance on the part of industry to do anything more than the status quo until the Ministries start to truly evaluate initiatives for the science and affordability. Most inventory standards continue to be process driven, onerous and expensive, and poorly documented on the utility of the requirements. MSRM data requirements for Land and Resource Data Warehouse tend to be excessive and exceed what is required for a technical standard. MSRM continues to ignore these systemic problems.

As previously mentioned, the approval of pilot projects in forest inventory have been fairly widespread and should be an indication of the need for revision. As well, some of these science-based projects have taken up to two years to be approved by MSRM and rarely are these innovative ideas ever been adopted as a new standard. In my mind, this is not a progressive approach to forest inventory.

(vii) I would like more clarification on the use of digital imagery for VRI applications in B.C. – as far as I understand it the scope for digital imagery in B.C. is limited to a small number of 'obsolete' systems. I know that digital imagery is being used operationally in other jurisdictions in Canada.

(viii) Ya but – this is precisely the issue. While it can be done for disturbances the rigor with which it has been done in the past is poor and it is certainly not being done now to keep up with the MPB outbreak.

On a related point – I am by no means an expert but I have been told that the history layer needs to be linked to the polygon layer to get appropriate volumes for areas that have been disturbed. Presumably this is only the case for "natural" disturbances, not logging. If this is the case then everyone out there that uses the data needs to know about it.

6. The **VRI lifecycle** typically requires three (3) field seasons. During the first field season, acquisition of photos or digital images occurs with processing completed in the fall and delineation carried out in the winter and spring months. In the second field season, the photo interpretation fieldwork is completed with estimation of attributes and mapping completed in the fall and winter months. In the following spring, sampling design for the ground-sampling phase is carried out. In the third field season, ground sampling is completed with the adjustment factors developed and inventory file adjustments made in the winter months. Note — it may be possible to shorten this VRI life cycle by combining the photo acquisition and photo interpretation field seasons.

(i) OK

(ii) The lifecycle is fluid. Project timing depends on availability of photography, money etc. While the field work generally happens in the summer months, the delineation, classification etc can happen anytime depending in contractor availability funding etc. Also, at the moment the government is definitely not in the driver's seat when it comes to initiating or controlling VRI projects.

The Traditional VRI Lifecycle and Phase sequence needs to be rethought. Hopefully the new inventory can be done at lower cost and in a shorter time frame.

(iii) Often see Phase 2 done ahead of Phase 1

(iv) 3 to 4 years; some have taken 5.

(v) Volume of new aerial photography acquisition requests may have an impact on delivery times.

Photo delivery is progressive from date of photography. Deliverables are shipped to client as partial shipments from July – October

7. Currently, the VRI is implemented by industry at their discretion to meet their business needs. The Resource Information Branch's (MSRM) role is around standards and taking receipt of final, adjusted inventory.

(i) OK, useful background.

(ii) RIB also provides support, mentoring and guidance to industry, if they so request. RIB also maintains the inventory, updates it for depletion annually and projects it to current year.

(iii) Item 7 and 8 of the document talks about FIA and the VRI. The comment that I have is that FIA funding is available for licensees that VRI is the largest consistent expenditure of the FIA funding in the Land Base Investment Program.

Under th**e** FIA model there are a specific number of FIA activities where Licensees choose where and what to spend their FIA allocation on. Under the current model, Government is out of the decision making process of where and what those FIA funds are to be expended. Government's role is in standards and the data repositories of resource information. There is some control in place to ensure that correct standards are used.

(iv) MSRM also assists with project development and, in some cases, quality assurance. MSRM also takes receipt of interim data to ensure that it meets standards.

(v) VRI needs to be done in parks and PA's, as these areas contribute to SFM.

8. There is currently no inventory cycle in BC. The inventory cycle (a new inventory on a regular cycle) concept was introduced in the late 1980s and a number of inventories were done to pre-VRI standards. With the implementation of the VRI in the mid 1990s and the with loss of program control via Forest Renewal BC and now the Forest Investment Account, this concept is not in place. When the VRI was designed, it was assumed it would implement over the province within 10 or so years for the full suite of protocols. In reality, the province has (only) about 45 percent completed for VRI photo interpretation and about 30 percent for ground sampling. The VRI is predicated on using estimation techniques, and adjusting with a limited amount of measured ground data. The longevity of an adjustment has never been tested. There has been little interest by industry for anything but tree inventories (of the 4500 or so ground samples, fewer than 500 are installed to include the full suite of attributes (ecosystem attributes, CWD, etc.).

(i) I believe that there are some misconceptions regarding an inventory cycle and the capacity of a vegetation inventory and its detailed data collection requirements. The VRI is driven

by the licensee business drivers as it is essentially a FIA funded program. If the business driver is AAC then, unless there are issues with the management unit inventory, there is no real incentive to complete a VRI aside from the depletion update. If higher level plans do not require more detailed VRI inventories then there is no incentive for a licensee to implement or upgrade (beyond depletion update) a VRI inventory. The inventory cycle of the VRI is in the hands of the statutory decision makers (Chief Forester, Regional Executive Director etc.) and their perception of risk associated with the current inventory.

(ii) This information appears to me to be significant. It is important that there is no formal commitment to or design for ongoing systematic maintenance and update of forest inventory information. I would suggest, however, that there is an option other than the complete resurvey that is an underlying assumption of the inventory cycle approach. My suggestion is that continuous maintenance via a transactional update approach may be both easier to accomplish and more cost effective than adopting a cycle approach that involves complete resurvey on a repeating basis. I will elaborate on this idea in later comments.

(iii) The VRI is designed mainly for a living and growing forest. Projections are designed for Growth. In this case we require a stand decay model. We also require a way of separating dead pine from live pine in the inventory. We may have live and dead pine in the same polygon.

It must be remembered that government owns the land and is responsible for it. Industries interest is the trees. If government want inventory of other attributes they must be prepared to undertake and fund these.

(iv) Also alludes to this policy stalemate. A comparison of historic VRI implementation within TFLs/IFPAs vs. TSAs further illustrates the impact of incentives. "New Era" policies cut ministry capacities and simultaneously committed to reducing industry costs – leaving no incentives or resources for inventory in either camp. DFAM TSR policies had to settle for inventory/G&Y status quo.

(v) The first 3 sentences can be cleaned up. May not be clear what is meant by loss of control.

(vi) There is no information on VRI update in this document.

There is a group called the VRI update section that is managed by Rick Baker that is responsible for updating the VRI of the province and getting it ready for TSR.

There is a VRI update cycle. Update priorities are set based on the TSR schedule.

What can this group do to assist in the MPB? I think there is much they can do.

Is a new VRI required or will an update be sufficient for AAC determination? I tend to think that an updated VRI may be sufficient.

In certain MPB areas there may be a good VRI but it is out of date due to MPB. Do you need to do a complete new VRI or would it be suitable to have some other type of simpler scaled back VRI? What I am thinking of is that answer may lie in between the VRI update process and the VRI. It could be a VRI update followed up with some ground sampling in the MPB affected areas.

Aerial photography done to standard (BMGS) can be used for Forest Health and VRI. The mapping procedures are similar. Softcopy technology is used in both methods…However for VRI the photo interpreter must be VRI certified.

(vii) Add: For vegetated land in BC, about 60% has an inventory age more than 10 years old, and 17% more than 20 years old.

(viii) Habitat evaluation or modelling, ecosystem management and certification requirements would all benefit from ecosystem mapping, even if PEM.

(ix) True but some interest is specific to geographic location, e.g., SAR owing to occurrence, therefore, inventory doesn't have to be done "across the province", we can identify priorities.

9. There is a gap in good inventory information between the period of free-to-grow (10 to 20 years) to early to mid rotation. The "free-to-grow" label comes from the silviculture surveys. These polygons are not ground truthed until age 30 and even then, with very limited sampling. In short, the VRI is not addressing young second growth stands adequately. This needs to be addressed, regardless of the MPB event.

(i) The correct term is 'free-growing,' not 'free-to-grow.'

(ii) Notes the gap in VRI sampling within younger age stands. This is a function of the business drivers for the VRI and reflects its focus upon adjustment of net volumes. In a sampling sense it seeks a more stable (i.e. full occupancy) stand structure prior to sampling.

(iii) This information provides further support for the argument that forest inventory information would be more effective if it were to be based on an approach of continuous maintenance and transactional update.

(iv) The lack of inventory information on young stands is becoming a critical problem. We are seeing MPB infest young stands (age class 2) as the mature host is depleted. This will further draw down the mid-term timber supply forecast. Opportunities to undertake treatments on these stands will hinge on our ability to identify the stand attributes favorable for treatment, and the lack of information will hinder this effort.

(v) This is not clear to me what is meant that polygons are not ground truthed until age 30.

(vi) Makes assumption that we don't have a reinventory

(vii) This "gap" could be critical if forest managers need to know whether replacement stands have a correct label; are growing as the models say they are and whether new infestations are happening. We do not field check stands after free-to-grow with the exception of all-aged stands where regen. checks occur. Succession in these mixed stands will need to be monitored and we will need to see if our models can deal with Pl mortality.

(viii) Not related to MPB and should be removed.

(ix) I can only assume that when we have the discussion on the period from Free Growing to mid-rotation, the sub-topic of forest succession will be part of the debate.

(x) Yes, and corresponding habitat info.

(xi) The VRI is a strategic inventory that is designed to give general answers over a large area. It is a snapshot in time and longevity of a VRI is probably 20-30 years. The only stands that are significantly changed are the ones with disturbance. All other stands are just projected along the SI curves. Stands from 20- 80 years old are the ones we are most unsure about in the inventory. These thrifty stands change quickly and this change is not captured in a strategic inventory.

10. There are no Resource Information Standards Committee[3]-approved provincial forest inventory vegetation monitoring protocols in place, although there is interest in having them. There have been about a dozen monitoring pilots put in[4]. They typically install about 50 National Forest Inventory fixed area tree plots on a grid in selected young strata and use the data mainly to check TASS output. There is the assumption the plots will be re-measured to get growth data after five to ten years. VRI staff in government are wondering if this MPB strategy will result in a greater need and interest in this area. Whatever direction is taken, inventory monitoring needs to be either linked or embedded within the basic inventory design and be statistically reliable.

(i) Discusses the lack of management unit monitoring standards but notes that all management unit monitoring to date has been based upon the NFI/CMI standards. This program has the advantage of having existing standards and procedures for field measurement as well as digital field data capture (DR Systems TimVeg) and compilation software. If subcomponents of this program are to be used then the quality assurance, data capture and validation will need to be altered to accept this partial data.

(ii) SIGY is also working on a general (not MPB focused) G&Y monitoring paper due out March 31. I would be happy to discuss collaboration opportunities in this area. SIGY's report examines existing protocols, projects and incentives. There is interest in monitoring among licensees; SIGY members rank its investment potential as high. However, lack of incentives and resources remain a roadblock to investment, particularly for TSAs. Saying comparisons with TASS output is the main intended use of existing monitoring projects is slightly misleading. Small sample sizes (30-50 plots) will restrict comparisons to a few broad highly-aggregated managed stand yield curves and/or their component attribute averages (e.g., site index). Using this type of data in direct TASS validation is untested and would likely be more problematic and less meaningful.

(iii) The document needs to make it clear from the start what is meant by monitoring. Much discussion on growth and yield monitoring has occurred. (Why aren't J.S. Thrower and Associates (e.g.,. Eleanor McWilliams) included in dialogue challenge participants).

I'm ignorant on these pilots and the current NFI but it sounds odd to me using the term "National Forest Inventory" in terms of plots for pilot monitoring. I would assume that Thrower's pilots might be placed more intensely than what is used in the National Forest Inventory.

(iv) The standards manual is over 200 pages long! The plots are expensive, data collection is excessive, standards are inflexible, and there is no 'tree emphasis' plot. One NFI plot was

[3] Formerly the Resource Inventory Committee (RIC).
[4] Mainly by J.S. Thrower and Associates.

installed on TFL 52 by a 3 man field crew in 2 days. It is unlikely this would meet the Ministry's objective of 'extensive' decay sampling (i.e. Input Request 3.0.).

NFI Data collection example – 4 samples of forest floor/litter to be collected and analyzed for carbon and mineral content?

(v) *We absolutely have to get out on the ground and monitor the rate of kill as it proceeds. I do not think that we need to attach this activity to an onerous set of standards imposed by the needs of the National Forest Inventory.*

(vi) *Item number 10 is confusing. I suspect that it is simply incorrect.*

(vii) *Monitoring is the best way to get proper growth information for the new stands.*

(viii) *There is a need for info collection that is not used for "inventory", e.g., establishing an indicator for SFM may or may not need/want to follow RISC standard.*

11. National Forest Inventory. The VRI Section, MSRM is currently developing a proposal to seek federal funding to develop and implement an "enhanced" MPB NFI. The current NFI design will be stratified by large federal ecoregions. This will not meet the needs at the management unit level however.

(i) What's the point of this MPB-NFI then?

(ii) 11 notes that an intensified or enhanced NFI would not meet the needs at a management unit level. I believe that this needs to be reconsidered as the sample design integrates photo estimates and ground based sampling and it could provide an unbiased sample of the landbase while offering the potential to integrate and augment the existing national forest inventory information. This could better support an impact analysis that would gain the attention of the federal government.

(iii) I don't see the point in putting a lot of effort into NFI if it doesn't meet our needs.

(iv) I agree. As described the NFI is a parallel activity with a different focus and different methodology. It does not have the same "spatial footprint" requirements as the present challenge.

(v) A significant flaw in the NFI is the use of federal ecozones as strata. From a BC perspective, they are goofy. Ask anyone to divide the province into 5 classes that make sense from an ecological perspective and you would not get anything like the 5 ecozones for BC! (three boreal to deal with BWBS, SWB and northern AT; one coastal to deal with CDF, CWH, MH and coastal AT; and one ecozone to deal with the rest of the variation in forests and ecosystems from BG, PP, IDF, ICH, ESSF, MS, SBPS, SBS and interior AT).

(vi) The National Forest Inventory could also update their photo based plots to identify and map the portion of the photo based area killed by MPB. BC has a 1% landbase coverage under the NFI if updated for MPB would support this initiative. Secondly increasing NFI ground plots in the Central Interior definitely would provide improve monitoring the after effects of the MPB.

(vii) This item should be divided into: (a) NFI design; and (b) the enhanced NFI for MPB. Most discussion on this will be given in the project proposal.

(viii) #11a. Inventory/monitoring at regional/provincial/national levels, however, not for MPB.

#11b. The enhanced NFI design could meet TSR and MPB inventory and monitoring requirements at TSA level. For example, we could intensify the number of sample plots 2, 4, 6 or 10 times (or to the complete VRI coverage). The grid-based NFI design is flexible and robust and can be modified to accommodate various needs. More detail about this design will be available in the next a few weeks.

(ix) Background statement 11 needs additional explanation. A better description of National Forest Inventory (NFI) is required to allow readers to understand how an enhancement may be an appropriate strategy. The NFI is a monitoring protocol that expands on the VRI attributes. Specifically the purpose of the NFI is to assess and monitor the extent, state and sustainable development of Canada's forests in a timely and accurate manner. In addition to providing data for to support policy and national and international processes, the NFI should also provide a framework for collecting data for studying the factors affecting forest health and productivity. Finally the design is flexible that implementing agencies can integrate the design into their existing or planned inventories in a cost-effective manner.

The establishment of the NFI is 40% complete nationally and nearing completion provincially in BC.

The remeasurement strategy, developed in consultation with national and international expertise, will provide for annual change statistics based on current year re-measurements, and re-measurements from previous years updated for change and projected to the current year. Work plans have been developed to develop/test and deploy the re-measurement approach. Pilot projects will be established to test the ability to produce annual change statistics.

Much work has gone into the development and implementation of the NFI. We should try to build on existing activities to ensure solutions are integrated – that we are not creating one-off solutions.

All NFI documentation is freely available on the National Forest Inventory website.

(x) A change-monitoring program such as the NFI integrates inventory and monitoring. Clearly the sampling intensity of the NFI may not be sufficient to address the issue; however, intensifying the sampling intensity could offer a number of opportunities.

12. Site productivity is estimated from photo interpretation for each polygon using estimated age and site height (the term "top height" is not used). Ground sampling later adjusts the age and height and a new Site Index is calculated. If there is nothing to use but dead trees resulting from MPB, this method will have to be replaced, at least for standing volume of partially damaged/dying stands. For young stands with reasonable regeneration, other estimators can be used such as SIBEC or growth intercept methods. This area will need some examination.

(i) If stand is only partially damaged, we should still be able to determine site index. Also, historical information will still be available and can be used to estimate site index.

(ii) MoF Forest Practices Branch has a document on interpreting site index in the field which outlines assess site index through direct and indirect measurement. The methodology addresses when to use SIBEC, growth intercept and site curves. Site tools have integrated growth intercept information which requires a direct measurement. One concern that I have is that stands which are not harvested will have extensive dead overstory of pine. These dead standing trees could suppress regeneration by shading and they will affect the temporal availability of water. These stands may not realize the SIBEC site index potential as SIBEC was not based upon these stand structures and it is an indirect measure of site index. We need to consider whether these dead trees created an operational adjustment factor for the growth and yield model by occupying growing space both as standing and down (woody debris and mortality to regeneration) trees. Will these second growth stands achieve their potential site index or will they be affected by secondary pests such as needle casts and rusts.

(iii) I agree with these statements and find them useful.

(iv) It may still be possible to measure dead trees for age and height and get a better on-site estimate than other methods. SIBEC may be helpful, but is considered less precise than an on-site tree measurement. If SIBEC is to be used to any great extent, the application would benefit from additional inventory data (on-site site index with BEC classification). One big advantage of SIBEC may be in determining productivity of multi-aged and mixed species stands – a likely result in many MPB infested areas.

12 and 19b. Agree that this needs exploring. The VRI will continue to "grow" stands over time unless we can put something in the database to stop it. At the moment there isn't a way to capture that information in the VRI data model. It may be possible to put a field in the VRI for %live, or %dead that could be used to trigger VDYP and stop the projection from occurring in those stands. The hard part would be to populate that field. Doing a reinventory over the province is probably not realistic. Estimating % mortality will also be difficult.

(v) Of course, it's not the site index of the dead overstory we are interested in. We want to know the site index of the regen underneath. Our current site tools for regen are focused on plantations and we have been working to reduce estimates of years-to-breast-height (YTBH, etc). Unsalvaged conditions will likely create unique regen delay and YTBH conditions that will have to be determined. I somehow doubt our current second-growth site index adjustments will apply in unsalvaged stands. However, without fire, the new stand may grow better than the previous (dead) one if establishment densities are not as high. More research …..

(vi) I wouldn't rule out the ability to use dead trees for site index estimations. A dead tree can provide a reasonable age/height relationship. Beetle kill is relatively rapid process that likely hasn't affected past growth.

(vii) In the inventory program, we haven't used the term 'top height' for many years. It should be removed from the reference. (This is why we emphasized in the text that the term "top height" is no longer used. Ed.)

(viii) Can also get SI form the original stand. SIBEC and growth intercept methods provide a better SI in young stands than the traditional age/height relationship. It is actually required that an estimated SI be entered for stands less than 30 years old. This is for the situations where the age/height SI does not match the SI calculated from SIBEC or growth intercept.

13. Terrestrial Ecosystem Mapping and Predictive Ecosystem Mapping. Since the early to mid-1990s Terrestrial Ecosystem Map (TEM) involving the mapping of site series mainly at a 1: 15,840 – 1: 20,000 scale, has been undertaken on a number of forest areas in the province. Due largely to challenges with cost and rate of progress, Predictive Ecosystem Mapping was introduced as a more automated approach to TEM in the mid-late 1990s. Both field and polygon delineation processes with PEM have included a frequent use of some elements of the VRI process in different ways. At the same time, some VRI work has incorporated more ecological attributes and in some cases has tried to integrated forest cover mapping with ecosystem mapping. In the last few years, many of the first generation "overlay" PEM mapping approaches have moved to using more automated second generation approaches to predicting the distribution of site series and soil conditions. This new generation of PEM is realizing greater accuracy and has been made possible with improved mapping and modeling techniques and new data sources. This ability to map ecosystem conditions in a more automated manner and more accurately for large areas may provide important opportunities for new inventory and monitoring approaches, particularly where forest ecosystem features (understorey, moisture regime, soil materials, aspect, slope, etc.) need to be factored-in to an interpretation (e.g., the possible influence of site factors on shelf life).

(i) My main area of activity in BC is in conducting "second generation" PEM mapping. I would contend that, if the assumption that Forest Cover or VRI information can be used as an input to predict ecological site types (Site Series) is widely accepted, then the reverse argument that PEM maps of ecological site types could be used to help predict forest stand characteristics (tree species, understory conditions, moisture regimes, energy regimes) is equally valid. Site factors influence the establishment and growth of forest vegetation just as forest vegetation can be used to predict site factors. It is unlikely that existing PEM maps will be feasible to use to support forest inventory and monitoring activities related to the current challenge due to issues related to incomplete PEM coverage and inconsistent or non-comparable PEM mapping approaches. I would argue that, if the province had a complete and consistent PEM coverage that this information could prove invaluable for addressing certain aspect of the challenge as described. I would also suggest, however, that acquisition of a complete and comprehensive PEM coverage for the entire area of interest is not likely to happen or to be feasible within the context of addressing the current challenge.

(ii) PEM would also allow you to better meet the objectives of challenge statement #2. PEM would allow for SIBEC application of productivity estimates over large areas. However, to be most useful, PEM needs to be a program – with appropriate infrastructure. PEM needs to be done in a more standard method than in the past. The 'learning' phase has narrowed the field of acceptable options and it would be most beneficial to the Province and resource managers at this time to use a proven approach and apply it over the large area requiring PEM. PEM using only FC1 and TRIM has not generally been sufficiently accurate.

The capture and assessment of other ecosystem or stand features will be very important in the near future. Shelf life will play an important role in determining salvage priority. There are opportunities to conduct a retrospective study on MPB infested areas that were

not harvested; there are areas that date to the mid-80"s outbreak available for evaluation. The TSR shows that significant volumes of dead pine will not be harvested before the assumed shelf life expires (some 17 – 23 million m^3 in the Quesnel TSA alone, of which 4 - 6 million m^3 will be in moderate to severely infested stands). This being the case, better information would allow for the strategic abandonment of this volume; for example, information on understory presence, density and condition would facilitate this and shorten the regeneration period for these areas.

(iii) I suspect eco-mapping will come in handy for a lot of things including shelf-life, future timber productivity, and production capacity for other values. Eco-mapping would also serve to demonstrate eco-based management principles are being used.

Background Regarding Related Inventory and Monitoring Initiatives and Changes (14-17)

(i) 14 to 17: There is no reference to the Defined Forest Area Management (DFAM) initiative. While the forest health aspect of this seems to have died, TSR and inventory are still alive and should be recognized in this paper. This strategic plan needs to align and support the DFAM TSR initiative if it continues.

(ii) ?? Forest Productivity Council

The issues around monitoring and stand growth projections are not new. It is important that government have in place structures that enable proactive initiatives rather than reactive. It's frustrating to see initiatives such as the development of this strategy that could and would have been addressed years earlier if a long term view is present.

I would note previous work such as the FPC Stand Level Working Group http://www.for.gov.bc.ca/hre/fpc/working/stand_level/priorities.pdf and probably other FPC recommendations.

(iii) Points 14-17. Example of Ministry excess and duplication:

- FRPA Legislation defining management strategies?
- FRPA Resource Evaluation Program?
- Biodiversity Monitoring and Reporting Strategy?
- Common Ground Initiative? Licensees already have certification: SFI, CSA, ISO, etc.

14. Under the new FRPA legislation, licensees have the responsibility for defining management strategies that will achieve the objectives set by government (results). The province in turn has taken on the responsibility for setting objectives (Objectives Set by Government) for 11 values and is now leading the development and testing of appropriate science-based C&I for their effectiveness evaluation framework and indicator protocol under the FRPA Resource Evaluation Program (FREP). Forest Stewardship Plans as they are introduced will be closely tied to the FREP initiative.

(i) Not sure what is meant by "FSPs will be … closely tied to FREP".

(ii) Being an outsider, I have to admit that this statement did not leave me any the wiser regarding what it was talking about. More elaboration is required if this statement is to prove useful.

(iii) FREP needs should also be considered in this strategy.

(iv) Should expand upon this.

(v) Science-based C&I: is FREP linked to inventory/gy requirements?

(vi) Industry defines management in the absence of clear indicators? How will industry know if the government's objectives are being realized?

15. A key challenge with FSPs is that industry requires timely access to key information in support of FSP development. Licensees are trying to obtain data in order to develop and submit their FSPs to meet FRPA requirements by December 2005. In order to do so, they need data now. There is an FSP information access Project Charter and Working Plan under development. Data needs to be collated locally as well as corporately (from the Land and Resource Data Warehouse), checked for currency and accuracy with any data QA issues or gaps noted, reviewed and signed-off and loaded for ready access. Much of this is data under the custodianship of the Resource Information Branch, MSRM.

(i) This statement may be leading up to something, but it doesn't get there within the body of the statement.

(ii) Urgency on may fronts. Immediate needs are just as important as the long-term needs. Another reason we shouldn't stop to re-invent any wheels we already have.

(iii) Data: RIB does not have TFL data on the LRDW. Currently, only FIA-funded TFL inventory work has a mandatory requirement to be loaded for public access. RIB has copies of 1990's TFL's but these have not been updated or projected and TFLs have requested the data not be released without their permission. This has created a data management head-ache.

(iv) While MSRM has custodial responsibilities identified in Item 15 including QA of the collected information, there is no compliance and enforcement mechanism within MSRM for 3r d party data collection. Current funding mechanisms and legislation put that in the hands of Price Waterhouse and the Ministry of Forests.

16. A Biodiversity Monitoring and Reporting (BM&R) Strategy has been developed by MWLAP under the guidance of a BM&R Strategy Working Group which involves head office and regional staff and other ministry representatives. The three "business"-related goals are: (1) to inform and support policy, practices and decisions (effectiveness monitoring); (2) to assess the state of risk-based biodiversity priorities; and (3) to assess general biodiversity trends and condition (ambient monitoring).

(i) Did not know that this existed – where do you see this strategy?

(ii) Still not very informative to me as an outsider.

(iii) (Again) this raises the issue of other resource values. Since they "constrain" timber supply, MPB may make them even more important to inventory and monitor. But trying to be everything to everybody is a recipe for failure, especially when time is of the essence.

(iv) WLAP monitoring: not linked to the provincial inventory; should it be so??

17. Key leaders from industry, government, and academia met in the spring of 2004 to begin to identify common ground for Sustainable Forest Management criteria and indicators initiatives — "Common Ground Initiative." The workshop was facilitated by FORREX with the support of the Forest Practices Board. The goal in the longer term is to see the collaborative development of common set of indicators and protocols among the parties. At a follow-up workshop held on February 17-18, 2005, with the benefit of several supporting studies since April, the group worked on moving the development ahead more substantively.

(i) Seems that different folk have different ideas about what this is all about – the FPB rep at the session expressed quite a different intended outcome than did other presenters and the Steering Committee rep.

(ii) This appears to me to be highly relevant and useful information. It might have been better to lead with this information as point 14 and to have the remaining points flow from it. It might also have proved useful to provide a bit more elaboration on how the decisions of these workshop impact on the need for information about forest resources, including stand level information about forest resources including tree species, age, height, diameter and other attributes. There is obviously a connection, but readers are left to infer this connection themselves and may do so incorrectly.

(iii) If we move toward monitoring, we should at least consider all it's other drivers, too, including C&I.

Adaptive management is another inventory/monitoring driver that hasn't been mentioned.

(iv) There is opportunity for sharing of data. This has always been done in the past.

What are the implications of MPB on Wildlife and Wildlife Habitat Mapping?

What are the implications of MPB on Terrain Stability?

What are the implications of MPB on Water Quality and Quantity?

(v) FORREX: I attended this workshop. Given that the criteria, in many cases, had not been carefully articulated it could take some time for this to gel. People are anxious to start work on supplying indicator data to criteria that have yet to be defined adequately.

Background Regarding Overview of Business Requirements for Timber Supply Analysis and AAC Determination (18-21)

18. First, it must be recognized that the current VRI Life Cycle was not designed with respect to information needs relative to the rapid and complex forest changes occurring due to the MPB epidemic:

a. The complexity of the current VRI procedure (75 attributes per polygon) and incompatibility of the VRI completion and TSA review cycle do not meet the needs of the forestry sector for infestation mapping and update (minimum of 1 year).

b. Albeit possibly sharing common data inputs (aerial photographs), the VRI and forest health detection and mapping employ different procedures, standards and time frames.

c. Any proposed approach must enable efficient sharing of both attribute data and a spatial database between various agencies, for a variety of resource management applications.

(i) The VRI has different business drivers and applications which provide information beyond the scope of a forest health survey which includes timber supply review. The VRI provides foundational information that supports Forest Health (FH) modelling (SELES) which directs the FH aerial overview assessments and ground surveys. FH surveys are purposeful in design and this will affect the capacity to apply these results to the landbase in an unbiased manner.

(ii) 18-20. See: Possible Scenarios

(iii) 18/21: Discussions that I haven't seen addressed so far include:

- Total area of MPB zone broken down by:

  Pure Pl stands where all trees will be killed

  As above with survivors—what will be left?

  Mixed species stands with varying % of Pl mortality

- What will these stands look like in:

  Two years

  Five years

  Ten+ years

- What are the assumptions around:

  What species replacement will occur?

  Are we going to be replacing beetle killed Pl stands with Pl?

  What proportion will be planting vs. natural regen. and will fire be required?

  Will we be harvesting Pl as fast as it is being killed? Is there going to be a huge backlog of beetle-killed stands and will we get to them all in a reasonable timeframe?

- What does all of this mean on management?

(iv) Clarification? TSR requirements (18-21) appear to reflect non-beetle analyses (status quo); I would like to see how TSR is going to change to deal with MPB.

(v) 18-21 are key - gives context for what is required.

A similar breakdown for habitat supply is required including:

- *Regeneration characteristics*
- *Shrub layer*
- *Snag status*
- *Snag and downed wood density estimates.*

(vi) "The complexity of the current VRI procedure….". This statement is not relevant. The complexity of the inventory ahs nothing to do with whether it can be updated or not. We are talking about a "strategic inventory", not an operational one. The VRI, and the FIP/FC1 before it, is not designed to handle these types of situations, except through the update process. If the update was funded properly, then it can do that. Please keep in mind that VRI and update are two separate things. The VRI is a snapshot of a management unit at a specific point in time. The update process makes changes to the VRI for disturbances.

The update process can be fast tracked to capture changes on an annual basis. All it takes is money. Need money to fly the areas every year with colour photography, create digital orthos, and delineate and track changes. More people need to be hired and trained, but it can easily be done by funding it to the level required. The update process we now have in place is not adequate. Satellite imagery will not provide the information needed. And currently MSRM has only 10-15 staff doing update. My opinion is that 1:30,000 colour orthos are the minimum needed. Anything else is not providing the level of detail necessary. A significant increase in staff or contractor capability will be necessary. The contractor route, with contracts managed by the current update group, would be the best approach.

(vii) This statement defines the advantages of using a single source for map data and mapping elements (aerial photography) - BMGS.

Supports the advantage of maintaining Corporate Standards that ensure multi-use products.

18a The complexity of the current VRI procedure (75 attributes per polygon) and incompatibility of the VRI completion and TSA review cycle do not meet the needs of the forestry sector for infestation mapping and update (minimum of 1 year).

(i) The background section should only state the facts, not judgment or conclusions. In order to say that VRI does not meet MPB requirements for TSR, it would require more

discussion and explanations which could be included in other sections (e.g. options, discussion, etc.)**.**

(ii) I would like clarification on the statement in Item 18a 'the needs of the forestry sector for infestation mapping and update (minimum of one year). Is this a reference to the forest health surveys which are for the most part reconnaissance and meet operational needs, or does this also refer to the update of the VRI maps for disturbances as well? If this includes the latter then we need to recognize the need for access to accurate source information such as air photos, appropriate resolution satellite imagery and ground survey information.

18b Albeit possibly sharing common data inputs (aerial photographs), the VRI and forest health detection and mapping employ different procedures, standards and time frames.

No specific comments.

18c Any proposed approach must enable efficient sharing of both attribute data and a spatial database between various agencies, for a variety of resource management applications.

No specific comments.

19. Information is needed to:

a. Define the area available for forest management and timber supply and to define those areas being managed for other resources and other objectives.

b. Project the growth and yield of existing and future stands with sufficient detail to provide adequate representation for mixed-species stands and mixed-stand conditions — e.g., partial beetle-killed stands.

c. Model management in the area including silviculture, harvesting, and non-timber objectives.

(i) This is missing the short-term information required for understanding shelf life and limiting timber supply falldown.

(ii) Section 19b; We must be cognisant of both mixed stand conditions as noted as well as secondary forest health issues which may be exacerbated by the MPB or post infestation management of these areas. Examples of this would include diseases and issues with some treatments such as rodent damage in fertilized stands.

(iii) Projection of attributes should not be for volume projections only. There are other attributes useful for investigating non-timber values e.g., standing and down tree attributes.

(iv) I agree.

(v) Another information need is residual (non pine) volume. This is another data need to support strategic abandonment of timber. Mitigate efforts are starting this coming year to help lessen the timber supply impacts of the MPB epidemic. Mid to late rotation fertilization is a key component of this effort and stand selection for treatment will focus on areas with significant residual volume that is expected to respond. Monitoring of these stand to quantify the response is also required.

(vi) Areas are managed for multiple objectives, very few are single objectives.

Habitat supply modeling is a big need, both for info to feed a model and for development of models under a strategic scope (Keith knows all about this).

20. To perform these tasks, the following steps need to be performed:

a. Characterize the current state of the land and forest (defining productive forest and the THLB, provide inputs for growth and yield projections) for forest management and other non-timber resources and objectives.

b. Define inputs for projecting growth of stands over time (site productivity, silvicultural regimes, stand structures).

c. Define management practices (reforestation, harvesting priorities, harvest types (clearcut, thinnings, selection cuts/partial cuts/variable retention systems) forest cover requirements for biodiversity, wildlife, visual quality, water quality, archaeological resources, etc.).

(i) The reality is that unless we get the required cold snap in the next 5 to 8 years most all of the Pl in the Province will be dead. Let's not tinker with the edges when the middle is collapsing.

(ii) I agree with these statements but recognize that some of them are getting a bit broad and ambitious and are not really likely to be achievable within the context of a program to monitor and map forest attributes in areas affected by Mountain Pine Beetle.

20a Characterize the current state of the land and forest (defining productive forest and the THLB, provide inputs for growth and yield projections) for forest management and other non-timber resources and objectives.

(i) The growth models will operate with varying levels and qualities of input information. The minimum to operate the model may not provide a reasonable prediction and so we should tie monitoring of these predictions into the strategy.

(ii) … and contribution of parks and PA's for non-timber, so timber areas can be managed more effectively.

20b Define inputs for projecting growth of stands over time (site productivity, silvicultural regimes, stand structures).

No specific comments.

20c Define management practices (reforestation, harvesting priorities, harvest types (clearcut, thinnings, selection cuts/partial cuts/variable retention systems) forest cover requirements for biodiversity, wildlife, visual quality, water quality, archaeological resources, etc.).

(i) In defining management practices we really need to regard the adequacy of funding to support intensive management. The funding to continue the current level of post harvest management and the capacity to provide resources such as contractors, genetically improved stock etc. needs to be evaluated in a realistic manner. If the focus and funding is shifted entirely to the MPB infested areas then the critical contribution of the non-MPB area to TSR may be overlooked.

(ii) Item 20 c will require the VRI inventory fraternity to develop an appropriate process to collect information and label mixed stands that are partially killed or harvested with partial cutting or variable retention prescriptions.

21. Some of the specific data needs are:

a. Current state of the forest stand by both stand averages as well as by individual species within mixed-species stands, tree size classes and tree condition classes (live, dead, etc.).

b. Good spatial location/boundary data for the forest stand:

- Land cover class – used in conjunction with site index, crown closure, management history and other information to define the productive forest (defined for timber supply analysis as the forest that can contribute to forest management objectives such as values for biodiversity and wildlife habitat).
- Tree species (all species occupying the site, and their proportionate contribution to volume)
- Tree heights (normally a "top" height is defined)
- Tree ages
- Site productivity (site index) – normally derived from inventory height and age; sometimes from field surveys
- Stand volumes – can be derived using yield models (inputs are height, age, crown closure, stocking class, decay factors)
- Stocking class (used to define merchantability)
- Crown closure (used to define merchantability)
- Basal area (for modeling growth and yield and different silvicultural systems, like variable retention)
- Number of stems per hectare

c. Characteristics of the land:

- Ownership
- Terrain (slope, sensitivity)
- Rivers, streams, lakes (usually from TRIM or other source)

- Environmental sensitivity (ESAs) – being replaced by specific classifications (terrain assessments, wildlife habitat, etc.)
- Roaded area
- Operability (harvest systems required)

d. Timber management

e. Silvicultural history and plans

f. Time when stand density management began (distinguish managed from non-managed stands)

g. Planned reforestation regimes (species, planting or natural density, spacing)

h. Fertilization

i. Use of improved seed (genetic worth)

j. Non-timber objectives (including good spatial location/boundary data for every landuse polygon and all spatial attributes):

- Biodiversity
- Wildlife
- Visual quality
- Recreation
- Water quality concerns (e.g., community watershed intakes)
- Archaeological
- Range
- Seismic

(i) Ditto a bit from above – way too much detail for the precision of our current data and timber supply modeling systems. This is a catastrophe like BC has not seen before – we need to address the issues now with what we know now or can provide reasonable estimates.

(ii) Is this a set of compulsory data requirements or is it a wish list? It is not clear. I am not sure how well the existing VRI maps presently meet these data requirements. Is it the intention of this exercise to propose methods that will produce forest stand information that improves upon the current VRI attribute data descriptions? Much of what I see under this number lies in the realm of forest management and records keeping. I transpose the requirements into an agricultural domain and I see similarities to the requirements met by spatially explicit farm management programs that collate and report information on site conditions and management practices at the level of individual fields. I see a similar need expressed here to collate, report and analyze information on forest site conditions and management practices at a stand level. I am not convinced that any inventory activity undertaken in response to the need to monitor MPB will provide all of the information listed here. What it may be able to provide is the spatial framework of stand level polygons to which this information could be added by others. It is important to define a consistent, continuous and meaningful spatial framework that can be used to collate and report information in site attributes and management practices. A transactionally updated map of forest stand polygons could well provide the ideal spatial framework for monitoring and reporting on management practices for many activities related to sustainable forest management.

(iii) Place a lot of emphasis on spatial accuracy. All of the attributes need to be redetermined.

NVAF Sampling as a tool to determine decay rates and possible shelf – life should be considered and investigated.

Specific data needs should include understory (density, spp and condition) and residual volume (volume, age, spp, live crown and condition) to support mitigation activities.

21a Current state of the forest stand by both stand averages as well as by individual species within mixed-species stands, tree size classes and tree condition classes (live, dead, etc.).

(i) Do we need to reinventory the areas the beetle has already moved through or just have a thorough update?

(ii) Seral stage development post-disturbance for habitat, especially where no management/ reforestation has happened.

21b Good spatial location/boundary data for the forest stand

(i) What about including wildlife tree recruitment?

(ii) Stands have site height not top height and stand age not tree age. Site productivity and stand volumes both have species as inputs. Crown closure defines merchantability but it also adjusts volumes as a surrogate for density/basal area.

(iii) Site productivity. Should add PEM/TEM/SIBEC approach to estimating site productivity. Given the appropriate stand characteristics, an on-site measurement is most accurate. If not available, then the SIBEC approach may provide as good, or better, an estimate of site productivity as inventory age and height. This is been shown to be most likely in pine stands that underwent repression, or in old stands (old-growth).

(iv) Land Cover class is no good for defining productive forest. The BCLCS is what should be used.

Site productivity… also include that all stands under 30 years of age have an estimated SI assigned that overrides the age/height SI.

Crown closure is used as a surrogate for density, not merchantability.

21c Characteristics of the land

No specific comments.

21d Timber management

(i) Why timber management? Do you mean a cut block coverage?

(ii) Section 21e; Silviculture plans should reflect the capacity to address these catastrophic changes to the landbase and not just extrapolate historical plans.

(iii) Why silviculture history and plans?

21e Silvicultural history and plans

No specific comments.

21f Time when stand density management began

No specific comments.

21g Planned reforestation regimes

(i) Should regard whether we will continue to favour pine monocultures at a time when MPB is attacking stands as young as 30 years and down to 7 cm diameter. Will pine provide the merchantable forests in the future or should we prefer mixed species for managed stands.

(ii) Reforestation and restoration and rehabilitation (latter two may not necessarily involve reforestation, however, reforestation is a form of restoration).

21h Fertilization

(i) As previously noted fertilization may have other issues such as rodent damage.

21i Use of improved seed

(i) The use of improved seed/genetic worth should regard the capacity to provide this seed.

21j Non-timber values

No specific comments.

Background Regarding MPB and Resource Information Needs (22)

22. Mountain Pine Beetle — A strategy regarding the resource information needs associated with implementation of the Mountain Pine Beetle Action Plan (2005-2010) is currently under development. The Action Plan identified seven strategies with objectives for each strategy. Resource information requirements are either explicitly stated or implied in each strategy. The resource information strategy should identify the questions to be answered and information required to do so. Resource information (in addition to the forest/vegetation information) needed in addressing the impacts of the Mountain Pine Beetle epidemic includes, but is not limited to:

- Vegetation Resources Inventory
- Wildlife and Wildlife Habitat
- Terrain Stability
- Water Quality
- Water Quantity
- Recreation/Tourism
- Biodiversity

(i) I understand government has received proposals from the private sector on what uses the dead pine might be used for. I would expect to see in any workshop some feedback from the Ministry of Forests regarding any promising uses for this material and what if any new resource inventory information may be needed.

(ii) This section (or more sections) needs to be expanded to clarify the why we want a strategic plan for forest inventory and monitoring in MPB areas. The need for the strategy is not clear in this background section. These needs should be from a variety of view points. It may be obvious to someone with the belief that "dead trees are useless unless harvested" but to someone who doesn't share that belief maybe the need is less obvious.

(iii) I agree with this list of important additional information needs. I note that elsewhere in the document arguments are made that it will be important to be able to assess the likely "shelf life" of dead standing timber and that such assessments will rely heavily on information about site conditions such as moisture regime, energy regime and ecological site type. I do not see PEM or other ecological information mentioned in the list provided here as being needed of likely utility for developing strategies for addressing problems that arise due to the MPB infestation.

(iv) Actually there are at least two strategic analyses currently happening around MPB. I believe the one you mention here is Marvin Eng's. Alan Wiensczyk (FORREX, PG) is conducting another focused specifically on research needs. His work should be referenced here too.

(v) A 5 year time horizon for a process which occurs over much longer cycles seems short sighted. I would hope that the recommendations of Dr. Terry Shore would be considered for creating a heterogenous landscape which is more resilient to large MPB outbreaks.

(vi) Add fish and fish habitat, as the list is almost inclusive and the absence of fish is noticeable.

(vii) Also missing in section 22, is a more detailed description of the key objectives of the Provincial MPB Action Plan and how inventory is vital to achieving them. The key objectives in my opinion that will drive priorities for inventory work relate to "Shelf Life" and the prioritization of rehabilitation. This MPB Action Plan represents government's current position on what it wants to do to lessen the negative impacts of the MPB outbreak and should be driving this MPB inventory strategy – not the other way around.

(viii) I have not seen the Action Plan since last September, however, at that time it did not contain any details regarding information requirements. As stated, the bullet does not provide any real information – just one of those "included but not limited to" lists of words. I suggest that this section of the background is critical to the second bullet in the key challenge and requires some detailed work.

INPUT REQUEST 2: EXPECTATIONS

- **What expectations do you have for this Challenge Dialogue (as in "I would consider this Dialogue a success if….")**
- **What expectations do you have for the face-to-face workshop (as in "I would consider the workshop a success if….")**
- **What suggestions do you have to make the workshop more effective?**

Challenge Dialogue: Expectations

(i) I would consider this Dialogue a success if: Government recognizes the serious nature of this Beetle infestation and that the appropriate commitment and resources for re-inventory and operational needs be provided to deal with the issues and that the expectations as outlined in this Challenge paper form the bases to do the work required.

(ii) Successful if people come away with the understanding that this is going to "swallow" us really soon and we need action plans and outcomes, not objectives and strategies.

(iii) I would consider this process a success if we:

- Had a better collective understanding of the impacts of the infestation is and will have on the BC environment and economy
- What kinds of decisions the public and private sector will be facing as a consequence of the infestation
- Identify what kind of information is required to meet the resource managers strategic and operational decision needs
- Identify what tools that are currently available:

  ID which tools will meet our needs

  ID which tools don't meet our needs

  ID what tools we need to develop if the existing tools don't meet our needs

- Identify some priorities for data capture
- Produce recommendations for a framework for getting this huge data collection process underway
- Get a commitment for Action with some associated time frames

(iv) Key expectations, looking for "buy-in" and commitment

It would be considered a success if a more diverse representation of industry / gov't / academia was involved

Not clear, what the consulting team's expectations would be around "ability to deal with highly dynamic phenomena".....it would be unrealistic to assume a solution to be achieved at this stage or is this an intended goal?

(v) I would consider the dialogue a success if it:

- identifies potential strategies that can be implemented in a timely manner within available government funding sources;
- is not intended to result in strategies that have been pre-decided by agency or consulting staff.

(vi) I would consider this Challenge Dialogue a success if it results in an explicit and comprehensive evaluation of inventory procedures for the full suite of timber resources in the interior BC pine forests, a statement of what is required in terms of the best 'science-based' and technical information upon which to base resource management decisions.

(vii) I would consider this Challenge Dialogue a success if it results in a clear identification and description of both the nature and magnitude of the MPB problem as it relates to inventory needs and if it produces a list of feasible and cost-effective responses to providing the forest inventory information needed to plan and implement effective responses to the problems as identified.

On a personal level, I would consider this Challenge Dialogue a success if ideas and suggestions that I had contributed were found to be useful in stimulating discussion and even more so if some of the ideas I contributed were identified as useful for possible implementation.

(viii) I would consider this Dialogue a success if everyone you sent it to actually reads it and provides valuable comments in terms of what information is important for their business.

(ix) I would consider the Challenge dialogue a success if we develop a plan which begins to update the provincial VRI inventory to carry MPB killed trees at the polygon level along with an indication when the trees were killed. Secondly if we decide to design a process to describe dead forests and begin data collection in order to track and model for decay.

(x) It is quite clear that the scope of the problem is well beyond anything that can be controlled, what we need to do is to assess how the resource base has changed and continues to change with time. We will be successful if we can come up with a methodology that will give us this information in a timely manner.

(xi) I would consider this dialogue as a success if the strategies developed from it lead to practical long-term solutions to "better characterize and monitor forest resource values in BC". This is one of the Consulting Team's Expectations, but I think the Key Challenges need to be modified in order to be consistent with this expectation.

(xii) I would consider the Challenge Dialogue a success if:

- the challenge provided a clear understanding of the information requirements (Business Needs) of government, industry and communities arising from the MPB outbreak;
- the plan addresses the information needs identified in both the short- and long-term. Current information sources should be extensively explored before initiating any new resource inventory collection programs.

(xiii) I would measure success if the challenge dialogue if it resulted in open, honest discussion about the implications of the MPB epidemic on all forest resources, and the presentation and discussion of innovative and visionary opportunities/solutions to the challenge of maintaining useful business oriented resource information in the face of a rapidly changing status.

(xiv) I want to learn what other think about these issues and have a chance to share my ideas and experiences with public-private partnership (3P) approaches. As such, SIGY would like to be an active partner in this effort and supports my involvement.

(xv) I would consider this Dialogue a success if [it results in]:

- A strategy that clearly identifies the business needs of MOF, licensees, and other agencies for forest inventory and monitoring of both timber and non-timber objectives.
- The implementation of a "structure/process" that enables a proactive approach to inventory and monitoring needs rather than a reactive.
- Improvements in the growth and yield projections of naturally disturbed stands for use in AAC determinations.

(xvi) Expectations for challenge dialogue success:

- Get clients to focus on business needs rather than trying to come up with technical solutions
- Get agreement on the process required to do this "correctly". The timeline for this is short yet it will take at least a year to get this worked out. We need to figure out just what and whether we need ad hoc interim solutions during this time.
- What is the consultant's role in defining new inventory and monitoring procedures? The strategy will be completed in April 05 but it will take a lot more effort to develop these procedures.

(xvii) My expectation for this process would be a clearly defined business needs for MPB inventory and monitoring. These needs have to be translated into detail and clear terms as what to be inventoried at what scale, frequency, and precision. These things will determine what kind of design is appropriate. Also some indication or estimates of real cost for implementing the strategy options (feasibility).

(xviii) I agree with the consulting team's expectations, especially #1.

(xix) I would consider this Dialogue a success if the Strategy leads to cost effective resolution to Key Challenges.

(xx) I already consider it a success that there is an opportunity to provide feedback in this forum.

I would further consider it a success if this dialogue results in frank honest dialogue between people from different government agencies, academia, licensees and the forest consulting sector.

(xxi) I would consider this "Dialogue a success if…" – we produced a clear list of government priorities for inventory and an action plan (with roles and responsibilities defined) that addresses the objectives described in the Provincial MPB Action Plan.

(xxii) The Dialogue will be deemed a success if it leads to an objective evaluation of the strengths and weaknesses of existing inventory solutions to address the future business needs identified in the Challenge Statement.

(xxiii) The forest inventory as it currently exists is a Strategic level inventory. Those that wish to make it an operational inventory need to understand the implications and impacts of that decision. Decisions on changes to the inventory should be made in the Strategic context.

(xxiv) What does the last point in bullet 3 [of the Consulting Team's Expectations] *mean?*

(xxv) Inventory and monitoring strategy builds upon and integrates existing inventory and monitoring activities, and their associated information management systems.

(xxvi) I agreed to participate in this exercise in the hope that the input from myself and other participants could help BC to develop a better means for dealing with the MPB. Thus this Dialogue will be a success if BC emerges from the exercise with clearer direction on what needs to be done to best deal with the MPB.

(xxvii) A success if multi-sector and regional interests are included and reflected in the inventory. Including MSRM, MoF, Industry, WLAP, Regional research, CFS.

(xxviii) An impressive goal that requires stakeholders to "step outside the box"!

(xxix) Good expectations.

(xxx) Need a coordinated approach that is developed by involves ministries, licensees and decision makers.

Process should not end with the completion of this project, must be a process that is continued.

There are inherent problems with the whole issue of inventory; do not let the overall big picture prevent working on the MPB issue. (it may take awhile to fix the big picture, but let's make strides for MPB in the meantime).

Workshop: Expectations

(i) I would consider the workshop a success if it resulted in information that enables development of a comprehensive conceptual model of what is at issue: Who is involved or affected? In what ways? What are the general mechanisms of any impacts (that is, the connection between the beetle and different business areas)? All of this amounts to a listing of business needs associated with the infestation. If we focus on solutions, we'll get bogged down, since everyone will have their favorites. We're trying to offer people the opportunity to have input on the basis and need for the strategy, which can then be used to focus on applicable and appropriate solutions, not asking them to develop the strategy.

(ii) I would consider the face-to-face workshop a success if it:

- arrives at consensus on a strategy;
- concludes with sufficient detail about the strategy that there is no ambiguity about what it means.

(iii) I would consider the workshop a success if it produces consensus on one or more feasible and cost-effective approaches that have a strong likelihood of being able to provide the forest information needs specified under the heading "Consulting Team's Expectations".

(iv) The workshop will be a success if the project team gains a perspective of expectations for the plan from the various business areas and scopes out some potential ideas.

(v) The expectation for the face-to-face workshop is for open discussion and to find out who else shares similar interest.

(vi) I would consider the face-to-face workshop to be a success if there is clear identification of the need to distinguish short-term from long-term strategies.

(vii) My expectation for the workshop is the refinement of the opportunities/solutions into an action plan, supported by senior management and properly resourced, to details the short, medium and longer term actions to address the challenge statement. This is not the time to be faint of heart and conservative, but to take chances and risks to improve the information required to make sound management decisions. We can't afford to fall into "analysis paralysis". There is a need for rapid improvement in key information in the short term, recognizing that there are reliability/accuracy limitations, with a plan to improve these limitations over the mid to longer-term horizon.

(viii) The plan should have an adaptive management philosophy to allow early data collection combined with the ability to adjust on the fly as our knowledge improves.

(ix) It is well facilitated with clear, reachable goals and cooperative participants.

(x) The group recognizes and accepts the immediate solution can't and won't meet all possible needs. Time is of the essence; resources are limited. It can't be everything to everybody. It must be clear which priorities will drive the solution. What will have the final say?

(xi) The solution must be scientifically and technically sound and politically viable.

(xii) I would consider a face-to-face workshop a success if:

- A strategy implementation team (with members with the time and resources) is created and supported by the participants at the workshop. A desired proposed "team" or "process" is created that has the mandate and support for creating a strategy. A crude terms of reference for such a team or process should be drafted.

- If workshop participants can send a loud and clear message for the need and implementation of a strategy.

(xiii) Consensus on what needs to be done and that to do it we have to follow a business path starting with establishing the business needs. Given the short time for this, the workshop will have to be moderated tightly to get through the agenda.

(xiv) I would like to see an action plan come out of the workshop that articulates specifically what the information requirements are.

The action plan should also detail the cost of getting the information and who would be responsible for getting the information.

(xv) I would consider the workshop a success if cost effective approaches and common ground between business areas can lead to solutions to the challenge.

(xvi) Wish list is not the only thing to achieve from the workshop. It has to be associated with options and cost estimates. Agreed-upon and realistic wish list and strategy is the desire outcome of the workshop.

It is useless that we come up some strategy and design that is the best in world, but not feasible or not implementable.

(xvii) I would consider the whole process a success when results are more important than the process by which results are generated. Processes should of course be using the best available technology in a in a sound science based manner.

(xviii) A workshop would be successful if people understood where their pet interests lie within the scope of the Provincial MPB Action Plan objectives.

(xix) The workshop will be deemed a success if it can isolate the wants of the suppliers/custodians of information from the needs of the users of information.

(xx) Face-to-face a success if lots of brainstorming and general broad scale agreement on need and approach.

(xxi) Workshop has to have action plan with key people who are accountable (gee, that isn't too original, is it?!)

We all collectively own the resulting process; it isn't just an SRM responsibility.

Workshop: Suggestions to Make it More Effective

(i) Make sure that there are enough real-world operational types attend.

(ii) The workshop would be effective led by a facilitator, monitored by an agenda, freedom of speech for participants but focused on material at hand

(iii) I suggest asking proponents of different technical solutions to come to the workshop armed with concrete examples of how their approaches might look and work.

(iv) A dynamic facilitator with good knowledge of forest health issues is required to make the workshop successful.

(v) I am a little sceptical that a one day workshop can be successful unless the outcome is predetermined. I hope I am wrong on this point.

To be effective, participants must receive a synthesis of input from this questionnaire in advance of the workshop with sufficient time to review. If possible, a few recommended strategies to be debated should be identified rather than trying to cover off all the suggestions that are put forward.

(vi) I would consider the face-to-face workshop a success if agreement can be reached on a program of implementation and testing of innovative, integrated approaches to resource inventory, and who bears the responsibility for said inventories. It is important to have a good presentation and understanding of stakeholders' business needs but not all stakeholders are on the same playing field. Their business needs may be based more on lifestyle that a year's productivity.

(vii) You will need a good facilitator along with strong support staff. You should separate Inventory Strategy from Monitoring Strategy. You should have a couple MPB entomologist among the participants.

(viii) To make the workshop effective it will need to remain focused on the Key Challenge statements and not attempt to address all of the provinces current inventory problems in a single step.

(ix) This process will need to wrestle with the politics of stewardship responsibility in order to develop workable solutions. Policies/budgets will need to be modified. Are the right political players onside? This will have to go to Cabinet to get the proper policy and fiscal ducks in line. Are we in time to leverage MPB's pre-election political profile?

(x) To make the workshop effective

- you need the right participants. I see a need for those who have influence on resources, those who have needs, and those who can do the work. Each of these might have further subdivisions e.g., beetle experts vs forest inventory experts.

- the workshop should be structured such that general information is provided to all but such that (1) each of the 3 participants types can discuss amongst themselves and (2) there is sharing of ideas amongst the 3 types.

- you need a quick turn around summarizing what came from workshop and then you need a follow up workshop.

(xi) Well moderated, keep to agenda

(xii) For the workshop, I think it is vital that we have an explicit statement of meaningful and attainable objectives – let's set out to accomplish something concrete and not have leave too many items on the floor. If this requires reducing the focus of this Key Challenge (e.g., to deal just with dead wood), so be it.

(xiii) Suggest that workshop discussions be organized by topics and business areas to increase effectiveness.

(xiv) In the face to face workshop we need to be careful of other agendas. We need to identify:

- What specific information is needed?

- The cost of getting the information.

- When is the information needed?

- Who is responsible for collecting the information?

(xv) Additional Work Prior to Workshop

- The available government resources currently involved in forest inventory and monitoring should be summarized. This should include people (who is doing what) and money resources.

- Information from other jurisdictions that have suffered forest pest epidemics (e.g., spruce budworm). Were there lessons learned that we shouldn't be repeating.

(xxii) I hope the workshop program will include an opportunity to work in small multidisciplinary groups (breakout sessions of some sort to answer specific questions and report back to the larger group) to give people a chance to speak their mind with people from different agencies/organizations and perhaps break down some barriers which in a larger group usually stay intact.

(xxiii) I don't plan to attend the workshop. Given the diversity of background of those who are likely to be attending the workshop I suggest that it begin with presentations on the current inventory systems and existing sensors that could be used to track/monitor the MPB so that the participants appreciate the currently available tools. The descriptions provided are adequate for those with a forest inventory background but they likely do not provide the information required for others to appreciate them.

(xxiv) The workshop will be most effective if it uses break out groups and large group summaries.

(xxv) Clearly define before the workshop what will/will not be discussed – set the objectives for government and focus on solutions. Also, determine what government's position is on the following: Industry will clearly want government to invest in inventories that provide harvest prioritization and operational planning information that ultimately reduce their delivered log costs thus raising the spectre of industry subsidies. Is government willing to spend money on the type of inventories that do this?

Also, clearly define what time period we are looking for meeting specific objectives – i.e., retrospective (change detection)? after the outbreak is over? Rehab prioritization? Expedite the current VRI measurement cycle? Or more accurate descriptions of the annual changes to the outbreak?

Focus the discussion on inventories related directly to the MPB issue and not the more global issue of who/what/how the provincial inventory program will be carried out. This is a far bigger issue that will send any discussion into an endless loop. In my opinion, the problem is solved by having government take back the entire responsibility of doing inventories and properly resource them. The current system is completely inefficient and inadequate. You won't get anyone at a workshop to make such a decision unless they can speak on behalf of the Premier and his cabinet.

(xxvi) The workshop could be structured to focus on each of the three business needs identified in the Challenge Statement individually.

(xxvii)Need lots of communication as to what is happening and how folks can contribute in various places, ways, e.g., those who cannot attend the workshop and didn't fill in this feedback still need a way to provide input.

(xxviii) Need resources, not necessarily more ministry staff, but do resource this effort past the planning stage.

INPUT REQUEST 3: ASSUMPTIONS

- **Which assumptions require more clarification for you to understand?**
- **Do you strongly disagree with any of these assumptions?**
- **What assumptions, if any, would you add to the list?**

Assumptions

General Comments

(i) I think maybe it is better to put this Assumption section as the first, before the Background. It would help to understand the background activities.

(ii) Before committing to agreeing or not, there needs to be some more understanding of many of the statements – seem OK on first read, but again, lets not fetter on the edges when the centre is collapsing.

(iii) I left this section thinking that we're talking solutions before we really know the full scope of the problem. Maybe I'm wrong here, but I do believe it will be important to allow as many people as possible to have their say on how their business is affected by the infestation. A comprehensive idea of business needs will help to decide on which tools are most appropriate.

(iv) I operate a small remote sensing company that has been actively developing new technologies to monitor for MPB red attack detection since the beginning of the recent BC beetle population explosion in 1996. We develop and use geo-referenced high resolution digital cameras to provide locational information of damaged trees (and their species type). We incorporate new camera systems every year (as the newest high resolution cameras become available). I routinely acquire photographs with sub-meter resolution, typically at 20cm-50cm pixel size (adequate for single tree detection). The emphasis has always been on providing the government and foresters with beetle detection maps and georeferenced photos in an expeditious manner. That was until 2004…then the MSRM stated that only conventional aerial photography "TRIM standard aerial photography" was approved for government funding. The newly imposed standards are too rigorous, hampering a timely completion. For example, several forest districts are still waiting for their beetle detection maps (i.e. 100 Mile House District). Unfortunately, one step forward, several steps backwards.

With that in mind, I am doubtful that the government can explore alternative remote sensing capabilities, but I will participate nonetheless. The term alternative remote sensing should not even apply for digital aerial photography since it is not use remote sensing algorithms or sub-pixel analyses to detect beetle damage, but rather the damaged trees can be seen with the human eye similar to conventional aerial photography.

(v) Assume that we may not be able to meet requirements for all other resource values (e.g. VQO's, hydrology, wildlife, etc.).

The best option for future growth and reducing AAC inputs is to ensure harvest of the better sites and initiate managed stand silvicultural regimes as soon as possible.

VRI update/reinventory could address many of the issues once beetle has passed through an area. Harvest and silviculture records will provide adequate information for an update of those areas that are harvested, so we are really only talking about areas that don't get harvested. A retention plan could identify and prioritize those areas where an inventory update is required.

Aerial photo program for detection has not proven to be efficient, as demonstrated during the 2004 program to produce measle maps.

(vi) A good list of assumptions.

(vii) Assumptions to Add

- We are relying on more computer modelling for prediction of resources (e.g., forest stand dynamics, habitat supply, hydrological processes, …). While in certain situations, modelling may be used to provide "quick" fixes, modelling the complexities of a natural environment requires a long-term commitment of resources (people, monies, and institutions). Modelling is not completed in isolation of basic field research or data collection. Support for long-term research and data collection is required.

- Growth and yield modelling tools are sufficiently sophisticated to provide basic prediction information. However, these tools can be improved by further research and resources.

- Habitat supply modelling and population dynamics modelling in British Columbia is not very developed or well supported within government. Resources are needed in order to develop appropriate tools useful to practitioners.

(viii) Don't understand the detailed discussion on RS; it is premature. You need to establish the business drivers and then see which ones can be addressed by RS.

Disagree? Risk Management Environment indicates someone hasn't thought the process out. This is like saying we will collect some data and then figure out how to use it. Inventory standards are couched in statistics; the standards have to be developed, tested and then implemented—not the other way around. Also, suggest you avoid the term "Adaptive Management" which means nothing insofar as doing inventory/monitoring work. It is a term coined for saying we are going to do something, unsure what, but we will learn from the process. (personal vent)

Add to list? Stronger balance between role of RS and field work. We will need both. For the short term, possibly more RS with some shelf life sampling.

(ix) The statements and assumptions seem reasonable rather than provocative.

(x) This Section is poorly done. Assumptions should lead to hypotheses that can be rigorously tested.

Although the MPB is a complex problem, its resolution is a policy issue and is not the issue here. The issue is the lack of resource information in regards to mountain pine beetle damaged stands to help effect policy requirements.

The primary assumption is that the provincial inventory system is unable to accommodate large-scale disturbances that result in significant changes to forest cover.

Challenge that assumption by trying to use what has already been developed in BC and elsewhere.

Secondary assumptions would include:

- *The provincial growth & yield models cannot accommodate MPB damaged mixed wood stands.*
- *Not all trees in a MPB stand are dead and not all of the dead trees died at the same time.*
- *Site conditions (soil moisture, etc.) change with increased beetle mortality.*

It should be noted that the federal Mountain Pine Beetle Initiative has projects in place that are actively examining most of the "assumptions" identified including the Paprican project cited in the text. The remote sensing possibilities have been explored in depth.

(xi) All assumptions are relevant.

(xii) Need to avoid any assumptions that a single data source will act as a silver-bullet.

Need an explicit acknowledgement that there are trade-offs between image extent, resolution, availability, information content, etc.

Higher spatial/spectral resolution is not necessarily the solution. Need to work from a definition of information needs, then can act upon those with the most appropriate data source (remotely sensed or otherwise). See attached Wiart report[5].

Information needs should always determine data requirements.

(xiii) Points 7, 8 and 9 are NOT assumptions - #7 is an incomplete question; #8 is a question; #9 is a list of points.

(xiv) FPC/FRPA were not designed for a situation like the MPB outbreak; we should promote the non-legislated aspects of management rather than rely too much on the legislated tools.

Need to develop acceptable "overview" inventories that can be used to identify and rank the need for further inventory or treatments.

[5] R.G. Wiart & Associates. *Detecting and Mapping Mountain Pine Beetle Infestations: Defining the Role of Remote Sensing and Establishing Research Priorities*, June 26-27, 2003 Vancouver Airport Marriot, Vancouver, British Columbia. Workshop Summary Report, Mountain Pine Beetle Initiative.

Assumptions Related to Beetle Biology and Management (1-4)

General Comments

(i) How about some beetle biology and management assumptions not simply merchantable dead wood management?

1, 2, 3, 4: These 4 assumptions seem to have "given up" on our understanding beetle biology in order that we may modify the severity of beetle outbreaks. We need to take the opportunity of this large infestation to under beetle dynamics at lower infestation levels. We need to still explore different management strategies and develop tools to see if we can influence beetle dynamics.

(ii) 1 to 3. Agree.

1. The MPB outbreak will continue – current model outputs show up to 80% of merchantable pine will be affected over the next two decades. What happens after that remains to be seen. Some feel that if all the mature pine is not kill in this current outbreak then the next one will complete the job.

(i) Beetle mortality is not entirely mature/old trees; a significant component of immature trees is also being killed as are mixed stands.

(ii) If the assumption is that all (most) pine will die in the next few years, then the easiest short term re assessment is to just remove PL from the current inventory database?

(iii) I am not an expert on this. The assumption as detailed is clear and comprehensible. It is important for me to know that this is the general consensus with regard to the expectations about the MPB infestation.

(iv) Assumption 1 is basically correct given current technology.

- We need to prepare for the next epidemic with diagnostic methodologies
- We need to start now to see what we need to do to minimize the effects the next time around.
- One consideration is that with increasing temperatures that the next time around will be much sooner than the last time.

(v) The prediction that 80% of Merchantable pine will be affected over the next two decades is exactly that, a prediction. It is far for assured.

(vi) This should also include the evidence that MPB is impacting immature stands as well. Second growth stands 20 to 40 years old are starting to see significant losses, which will put a downward pressure on the mid-term timber supply.

(vii) Affected or killed?

(viii) A subsequent outbreak is not likely to be as severe as this one as the conditions which have sustained this outbreak thus far will have changed.

(ix) The SELES/MPB sim projections also show that there are some significant differences in impact if the outbreak ends early due to unknown causes or by weather events therefore the maximum mortality could be in the range of 50 to 65%, vs. 80%. What happens after? Historical records show beetle outbreak cycles have occurred over many decades as favourable weather events and stands grow into susceptible age classes in different areas (but none to the size of the current one). Clearly history will repeat itself as beetles return to kill survivors but not to the same severity as seen in the current outbreak. Forest Management has the opportunity to prevent this from happening in the next rotation if our reforestation practices minimize the size of continuous areas of pure pine.

(x) Replace the first two sentences with "Based on a model designed to provide a provincial-scale projection of the current outbreak it is expected that up to 80% of the merchantable and susceptible pine will be killed over the next 2 decades (http://www.for.gov.bc.ca/hre/bcmpb). While this conclusion is tenuous, there is considerably more uncertainty about what will happen after that."

The last sentence is pretty hard for me to swallow when stated in such a terse fashion. There is a LOT to the topic about the next outbreak.

2. Leading edge control seems to be ineffective thus far with respect to controlling spread.

(i) This is not an assumption, this is fact. "Leading edge control" is irrelevant if we continue to suppress wildfires as we do. These are successional forests reliant on natural disturbance processes. I suggest adding an assumption which is that successful management of the MPB in the longer term and at the broader level can be achieved through better landscape design and management – better range and distribution of age classes, stand types, etc.

(ii) This is important to know. Knowing this, it becomes clear that efforts to identify the extent of the infestation early and with high spatial precision in order to be able to implement control measures is not a high priority as control is not envisaged to be effective.

(iii) I am curious to know which "leading edge controls" are being applied. What I know so far is that there are two controls: controlled fire burns and a snap of cold whether lasting more than 2 weeks. Are there other controls we should know about? If so, may be we should beg a better description.

(iv) Leading edge control is also ineffective when the population is as large as it is. We are in a holding effort hoping for a natural event to stop the epidemic. Beetle proofing is limited to high value stands (e.g., superior provenance).

(v) Leading edge control should not be assumed ineffective in all situations. In some cases it has been assumed to be effective. We need to understand what has and what hasn't work.

Given the extent of the infestation, we may have opportunities to understand beetle dynamics under a wider range of conditions.

(vi) Agree, but what does "leading edge" involve? Presume means logging to save timber values.

(vii) Climate, Fire & a resilient landscape are the only true control measures. Forest management strategies have not had much success in slowing the rate of MPB spread.

(viii) Leading edge control – is not effective except on the periphery of the outbreak where the influence of the outbreak is less. This is particularly true in the NE (Dawson Ck. TSA) where severe weather limits beetle survival. Beetle spread and survival is also influenced by host distribution – the more widely dispersed, the more difficult they are to find resulting in higher beetle dispersal mortality.

(ix) Boy – talk about terse. I assume you will get a lot of feedback on this one. Here is what I wrote for Forum (ABCPF) and what Bob Clark and I "agreed" to:

- *Forest managers are engaged in an aggressive attempt to slow the outbreak. We model their management strategy, known as "leading edge attack" at a provincial scale given our current understanding of beetle biology and the observed behaviour of this outbreak. We find no evidence, virtually anywhere in the province, that the attempt to control the outbreak either slows its spread nor has any positive outcome with respect to the amount of live pine left on the landscape when the outbreak subsides. "Leading edge attack" may have had some success controlling previous outbreaks but the unprecedented size and aggressive nature of this outbreak appears to render it ineffective. However, there are hypotheses about beetle biology involving mechanisms that could slow or stop the outbreak, particularly at its periphery. If these hypotheses are correct some efforts at beetle control at the periphery of the outbreak may be warranted. Naturally, we would encourage you to read our report for a detailed discussion of assumptions and conclusions about beetle management (http://www.for.gov.bc.ca/hre/bcmpb).*

3. By and large, we are must now focus most of our attention on how best to deal with the consequences – i.e., salvage rates, shelf life and potential product usage. We need to plan for the future forest — life after the beetle. For example, we need to know about actual levels of mortality, natural regeneration possibilities in beetle killed wood (the nature of the understorey) and the shelf life of beetle killed wood for dimension lumber, pulp, OSB and power generation, etc.

(i) This assumption should have more emphasis on understanding and monitoring natural and managed succession, on stand and landscape regeneration and management, and on fuel load management, particularly in the millions of hectares of unsalvageable dead pine.

(ii) This is important to know and is critical information to consider in planning any inventory or information system that is meant to respond to the MPB infestation challenge. I note

there the importance of ecological site information as a key input for addressing most of the questions regarding regeneration and shelf life.

(iii) I agree with the notion that we need to focus on the future forest after beetle. We should not be focusing on what should be removed from the forest but rather focus on what we should leave. After we answer the question about what stands should remain we would also know what we could take.

(iv) I agree – life after the beetle should be the main focus – and the main tie to TSR.

(v) Agree, what about fire?

(vi) Yes. These are all critical questions that need to be addressed.

(vii) Take the waffling out of this point (delete "By and large" and "For example") and you have a pretty succinct summary of the information needs. Note that "potential product usage" is implicitly included in the concept of "shelf life".

(viii) *Strongly agree.*

(ix) Focus is on salvaging economic benefit from beetle killed trees. What about developing the value of the landscape? Forestry is not so much about what you take off the land but what you leave behind.

4. "The extreme range of sites and climates within which lodgepole pine is found in BC confounds shelf life of beetle-infested lodgepole pine. Paprican has utilized the Biogeoclimatic Ecosystem Classification System (BEC) information in association with intrinsic wood and fibre quality data and has shown that site quality factors can be used to predict both wood and fibre quality."[6] A Paprican project titled A Wood and Fibre Quality Deterioration Model for MPB Infested Trees by Biogeoclimatic Subzone (8-15)" will develop a preliminary model for predicting shelf life by Biogeoclimatic subzone across the lodgepole pine resource.

(i) Climate change should be treated as a background assumption; it is and will occur whether from human-caused global warming or natural processes.

(ii) This point simply repeats and reinforces the previous one with respect to how important it will be to marry ecological information with any information on forest cover and type and degree of pine beetle damage.

(iii) Shelf life is very important in helping determine salvage harvest priority. There is an opportunity to conduct a retrospective study of impacted stands to help predict shelf life. There are stands killed in the mid 80's as well as stands from the early period of the current outbreak that can be looked at to assess the nature and rate of degrade. The Paprican study is limited to the shelf life for pulp and paper use (pers. comm. with T. Trent). We need to look at a range of potential products, or describe the status of the standing dead to allow for as yet unknown products.

[6] Paul Watson, Paprican, Vancouver, BC — http://mpb.cfs.nrcan.gc.ca/research/Spring/8-15_e.html

(iv) Shelf-life is the recurring need expressed by SIGY's licensee members in the MPB area. There are other shelf-like studies besides PAPRICAN's . Extension is a real problem in this area – new information is hard to locate and the decay won't wait. There are diminishing returns when developing predictive models – at some point you say enough and move on.

(v) Haven't seen this.

(vi) Agree. How critical is the estimate of shelf life? Is the accuracy of the quality deterioration models being used known?

(vii) We think that deterioration in the form of checking and decay loss could be best handled with ground samples that were periodically remeasured. The remeasurement period would have to be fairly short and limited to attributes that would not be prone to a lot of measurement error. The tracking of the change over time in gross and net volume would be critical as well as trees economic condition in terms of log grade, caused by checking, decay, windfall and breakage. Stratification criteria should be something linked to soil moisture so BEC unit and site unit would be suitable. Likely an extensive network of small samples over the soil moisture gradient would be best; the NFI sample may or may not be suitable. Destructive sampling could be used to establish baseline factors for net volume adjustments but would have to be done apart from these monitoring plots. The deliverable could be a series of graphs showing volume and value (grade?) declines over time (months?) by BEC unit or site unit. This in turn would be used to guide the MOF for the priorization of the location of harvest.

(viii) Shelf-life Data Sampling Assumptions:

- Sampling across the range of attack ages by dry/intermediate/wet BEC subzones/variants

- Destructive sampling and stem analysis by crown/dbh class of wood decay, checking depth/orientation, decay, blue stain depth, spiral grain, etc..

Reasons for data collection (Shelf-life (decay) assumption):

1) Decay curves - % grade by decay year for each subzone/variant (Pure and mixed Pl inventory types)

2) Any trends in checking classes (depth, number, and orientation) and changes to log quality?

3) Any trends in terms of the amount and depth of checking over the tree lengths? first 5 meter log, second 5 meter log, etc.,

4) Any significant spiral checking?

5) Significant bark loss and changes to log quality?

6) Amount of checking by crown classes/dbhs?

7) Rough % of blue stain free lumber? Large diameter vs. small diameter?

8) Moisture content measurements

(ix) Why just Paul Watson here? Why is this here when there is a more extensive discussion of the topic in point 11?

(x) The Paprican and other ongoing studies should provide vital information to address the shelf life question.

Assumptions Related to Business Drivers (5-12)

(i) Re important contextual note: Expectations are that the three resource agencies will have to work cooperatively with each other for this initiative. There has been a significant amount of interagency jurisdictional fighting over the forest resource for the past few years. MPB initiative should start with a MOU between the three agencies outlining their roles, responsibilities, etc., before this initiative begins.

(ii) As noted before, the current business model of the delivery of inventory by voluntarily allowing industry to conduct the necessary surveys is a faulty model that needs to be fixed.

5. The average VRI lifecycle is 3 to 4 years. Any new standards will take time (and money) to develop, test, train contractors and build HQ infrastructure. It would seem practical that we try and use, as much as possible, what has already been developed. For example, VRI has a fixed area plot option that might be suited for monitoring as well as basic inventory.

(i) I agree that you should try to use existing information and methods as much as possible. I repeat that I can foresee using the spatial entities defined by existing forest inventories as the starting point for defining a spatial framework of stand level objects that you then monitor and update transactionally as they change. You would update any changes in the spatial extant and boundaries of stand level objects (e.g. polygons) and you would also update any changes in the attributes, descriptions or characteristics of defined spatial objects in response to observed changes in attributes within all, or part, of any given spatial object (e.g. stand).

(ii) Currently the VRI program is not being organized by government. Licensees control where inventories occur.

(iii) What is meant by the VRI having a life cycle of 3 to 4 years? Secondly, the VRI plot cluster suitable for establishing presence or absence of MPB or any pest in a sample polygon? For instance, if a sample polygon has a species composition of Pl60Ba40, but the species are not distributed uniformly, will the VRI cluster of plots be able to detect presence of Pl accurately if the cluster location is picked at random within the sample polygon?.

(iv) Yes! The use of fixed VRI plots for monitoring between updates is a must.

(v) I agree, let's work to make the existing tools work.

(vi) Agree; building standards cost big bucks and requires dedicated staff time. Note: we lost a lot of staff expertise from downsizing.

(vii) I agree with #5. I don't think new standards are needed. If they do I don't think they would take too much effort especially for VRI.

(viii) 5. and 6. Agree.

(ix) Data collection techniques are adequate for inventory and monitoring – what is inadequate is the amount of time it takes to generate the inventory.

(x) The reference to the VRI lifecycle is confusing. Typically a VRI will have a shelf life of 20-30 years before it has to be redone again. That is the experience we had with the FIP/FC1 inventories and I assume it will be the same with VRI. The 3-4 years that is mentioned here refers to the average amount of time it would take to complete a new VRI if one was initiated.

Monitoring procedures are probably the best way to get a handle on how the new forest is regenerating. A randomly selected set of samples, remeasured every 2-4 years will give good information on growth rates.

6. Current forest inventory data and the entire timber management system focuses on green/standing volumes and 'products' – now we must focus on primary versus secondary versus tertiary 'products' as related to applicable volumes and shelf life of MPB-killed timber.

(i) Yes, this does seem to represent a change in focus and philosophy that needs to be reflected in any new protocols that you develop for producing updated forest inventory information. Dead trees are now as important as live ones, perhaps more so.

(ii) Not sure what is meant by secondary versus tertiary products. If you mean that a dead tree has uses other than a "merchantable" use, I think that it is important to recognize. What is the value of a large area of dead trees for other organisms and their dynamics. Some species typically have a boom and bust existence.

(iii) I agree that we need to look beyond conventional forest products. Comments in 4 above apply. We also need to collect information on all layers in the impacted stands to determine if a stand is a candidate for strategic abandonment.

(iv) Yes, but I think VRI has many of the right building blocks. It is supposed to focus on the raw attributes rather than cultural values. We need to examine call grading's applicability for these other end uses. In this case some of these attributes are changing rapidly (i.e., shelf life) and we may need tweaks for that.

(v) Agree but this is related to use of dying forest; what about the new (replacement) forest?

(vi) The current focus on timber volume and the objective of maximizing it is a contributing factor to the situation we find ourselves in today. We need to think beyond timber volume if we are to be successful in the long term.

(vii) The wording of this point is very poor.

7. Current AAC/timber supply determination system vs monitoring of rapidly changing factors/ impacts/allowances for other resource values.

(i) Assumption 7 could use some clarification. If it means what I think it does, I'm not sure it's a AAC *versus* other values issue, at least I hope we could integrate other values into determining how much wood to harvest and where.

(ii) This is not an assumption. Could you please restate it as an assumption? This is not clearly written and is only a sentence fragment. Please elaborate. It appears to me to repeat the ideas and sentiments of the previous statement.

(iii) We certainly shouldn't entertain extending TSR intervals in light of MPB. Politics may drive a shorter interval. But I don't see the need for an entirely different process. That said, this should be an adaptive mgmt process with incremental improvements over time.

(iv) Note quite sure what it is getting at by comparing AAC determination system with monitoring of rapidly changing resource values. Is this trying to get at how such information can be captured during a TSR process that may take 2 years to complete?

(v) Needs more clarification as to what you are after.

(vi) This assumption is not clear, believe both AAC and monitoring of all resource values can be incorporated with minor revisions to current models.

(vii) What does this mean as a business driver?

8. Resource management trends – how will the information by which trends are determined going to be updated, monitored and reported?

(i) This is not an assumption. Could you please restate it as an assumption? I would imagine that the assumption is that there will be a need to change the way in which information trends are updated, monitored and reported for habitats, water resources, ecosystems and certification. Underlying this assumption is that all maps and databases must now become explicitly dynamic and that static representations of forest stands and their attributes are no longer sufficient or acceptable.

(ii) Some can be derived from VRI and G&Y projections; others will need their own inventories. What are the most threatened and valued resources?

(iii) Need more clarification on objectives (who for what) is using these trends.

(iv) Probably more than these four.

(v) Trends need to be monitored a strategic level and a least expensive modeling process from existing data sets needs to be developed.

(vi) We can't monitor everything under one protocol.

9. Resource information implications.

- Precision (forest cover type averages vs stand-level/polygon-level averages vs sub-polygon levels of information;
- Timing (multi-year, periodic inventory updates vs annual activity updates vs with-in year resource changes);
- Data capture cycles(precision, applications requirements);
- Accuracy/reliability (Provincial level, TSA level, forest cover types, polygon-level data, sub-polygon data);
- Data and information storage and archiving systems (date stamps/versions). We will have to have a system to address these requirements for intermediate and final levels of reporting and summarization as well as the raw data.

(i) These are not presented as assumptions. Could you please restate them as assumptions? There are some important assumptions contained in these statements but they are not presented as assumptions. To me they all boil down to the fact that it is now necessary to revisit and revise previous assumptions about the spatial and temporal resolution and precision required for forest inventory products and the procedures that produce them. You have the opportunity and the clear need to reconsider how frequently you need to update your forest resource information, how spatially precise the delineation of the objects that are to be updated need to be and how accurate your descriptions of the attributes of the spatial entities need to be. The final point implicitly includes a clear assumption that all spatial data will now have to be date-stamped and all spatial databases will now have to be dynamic rather than static.

(ii) Inventory precision can only be met at a low level of resolution and will generally mean little to a broad number of inventory users with differing views the data.

Timing might consider short term (1-5 years) and long-term (after majority of mortality has occurs) approaches. Timing might also vary depending geographical location as the outbreak is progressing at differing rates in different parts of the province.

(iii) Good issues; at what level do we need to make management decisions? Current VRI is by management unit and statistically valid to strata level—is this good enough?

(iv) A lot of different issues here. Polygon level data (VRI) still seems to be the best compromise. The cost of anything finer goes ballistic over such a large area. The utility of anything coarser is practically nil to a licensee and therefore to realized SFM. That said, MPB may warrant changes or expansion of spatial stand structure info captured at the polygon level, notably structural diversity (patch kill/salvage, etc).

(v) Bullet 3, appropriate information and ability to report and summarize is required between operational and strategic levels of resource information.

(vi) Should we assume the TSR level of requirements are the first and primary target for developing the MPB strategy? If so, does it have to be spatial (maps)? Any lower levels of inventory/monitoring (polygon or sub-polygon), while could be done locally, would be impossible to be implemented (statistically defensible) with current technology and resources at management unit level such as TSA's.

10. Detailed second growth inventories will be needed to assess things such as the potential for stand treatment. There will be big "holes" in LRSY down the road and options to accelerate growth, through fertilization and potentially other silvicultural practices, will need good inventories to locate candidate stands. Further, these stands will need to be monitored to ensure they are performing as to the model's expectation (link to Background Statement #9).

(i) Agree strongly.

(ii) Agree.

(iii) In addition to detailed second growth inventories we also need to ensure that our non-MPB areas have adequate inventories as their influence on the mid-term harvest flow is critical. As noted in response #2-1 regarding long term funding for long term data collection. An example of this is that site indices are referenced to 50 years breast height age and we need to sample at that age to validate the prediction.

(iv) Yes, this is an important point. You now need to monitor conditions within identified stands that are related to re-growth and/or to any changes in composition of characteristics within second growth stands. You also need to define a spatial framework for devising, applying and recording management strategies and practices within spatial management units that are likely to correspond to defined forest stands. (What is LRSY?)

(v) Second growth information is critical now that the large mature component is depleting at an accelerated rate. We need to be able to assess immature stands for treatment opportunities to either shorten the time to merchantability or to enhance the volume. We also need to get better information on other forest health issues; stems rusts are becoming a bigger problem in pre and post free growing stands, yet we have little information to guide response to this issue.

(vi) Second growth performance is not just an MPB issue. Let's leverage work and experience we already have in this area. Other than basic silviculture and genetics, I'm not convinced we have any other economically viable options within known intensive treatments. Regardless, we should be monitoring these stands against our expectations – they are indicative of the long-term wood supply.

(vii) Too much in this. Covers re-inventory, TSR, stand level silviculture, and monitoring. I would break it up into several areas. It would have separate bullet around mid-term timber supply fall down (LRSY is an inappropriate term in this case).

(viii) I am not familiar with LRSY[7] – perhaps a list of acronyms would be an idea to include in future documents.

[7] LRSY: long rub sustained yield (ed).

11. Shelf life (decay). Potentially the deterioration in the form of checking and decay loss could be best handled with ground samples that were periodically re-measured. The re-measurement period would have to be fairly short and limited to attributes that would not be prone to a lot of measurement error. The tracking of the change over time in gross and net volume would be critical as well as the trees economic condition in terms of log grade, caused by checking, decay, windfall and breakage. Stratification criteria should be something linked to soil moisture so BEC unit and site unit would be suitable. Likely an extensive network of small samples over the soil moisture gradient would be best; the National Forest Inventory sample may or may not be suitable. Destructive sampling could be used to establish baseline factors for net volume adjustments but would have to be done apart from these monitoring plots. The deliverable could be a series of graphs showing volume and value (grade?) declines over time (months?) by BEC unit or site unit. This in turn would be used to guide the MOF for the priorization of the location of harvest[8].

(i) Assumption is that the dead wood has the potential to be "wasted" because it is not being harvested….is the wood of use for non-timber resource values (such as species at risk).

(ii) Implies that MOF will be prioritizing harvest. Industry can probably do a better job of prioritizing than MOF provided they know the rules within which to operate (e.g. retention strategies, etc.).

(iii) If the proposed small network of samples across the moisture gradient is to be used you would have to ensure that these samples were unbiased and representative to allow extrapolation. You would also have to determine how to define the sample strata across the landbase, especially in the absence of PEM or TEM.

(iv) This is a big assumption. If it is accepted, it becomes almost mandatory that useful, reliable ecological information and maps be available to guide the assessment of relationships between deterioration of dead pine and site conditions. Is this feasible to contemplate?

(v) Personally the shelf life/decay model is the most important short-term project in which to invest resources. Information on how the shelf-life decay model can be linked to the Inventory is of interest to project declining volumes and value.

(vi) The salvage operations in the MPB stands will most likely be completed within the next 20 years. Is there an expectation that substantial decay of the dead Pl will have occurred during that short period?

(vii) Again a retrospective study may give information faster. One of the problems is that not all the stems die at the same time. The beetle tends to sweep through a stand in waves, taking the larger stems in one year and then returning in a second or third year to hit the lower profile. This makes shelf life status harder to determine; it is a continuum rather that a set stage with clear change points. There is also evidence of an Ips epidemic coming that would kill off any smaller diameter survivors of the MPB attack. This also has implications for immature stands (item 10 above).

(viii) Data needs for model building, including shelf-life, often differ from inventories. Inventories must to represent the current landbase, while models need to represent the potential range in biological conditions. Inventory-like random sampling is not an efficient

[8] These thoughts kindly provided by Will Smith (via Jon Vivian) Volume and Decay Sampling Officer, Resource Information Branch, MSRM.

way to capture the rare extremes which help define a realistic biological response surface in a model.

(ix) Shelf life – This research while focused on merchantable shelf life should also be looking at obtaining where feasible basic decay dynamic background that can be used for other objectives (e.g., understanding standing dead tree breakdown and resulting fauna/flora).

(x) Need to get appropriate knowledge base together (feds, province)

(xi) Agree. It may also be possible to sample the level of deterioration in standing dead trees based on time since death and soil moisture regime.

(xii) Shelf Life: This is a key issue and most likely is tied closely with BEC and age of death. Destructive sampling will provide little information here. I do not think that a monitoring approach would provide the information fast enough to use operationally. I would suggest an intensive sampling program using a matrix with BEC and age of disturbance as the factors. This is not my idea, it came out in discussions with other staff at Resources Information Branch. Will provide a plan of attack for the MOF based on BEC zone and age of hit. They could then priorize where they want to go first. The sampling could be completed in one field season.

12. Clearly the rapidly changing state of the forest condition in the MPB affected areas is having and will have a significant impact on various resource planning documents. Closely tied to the inventory and monitoring strategy will be the need to understand how these changes will affect previous plans and future planning processes.

(i) Yes, this is clearly stated assumption that will have to be acknowledged and addressed by any proposals that emerge from the Challenge Dialogue process.

(ii) 12 to 15. Agree.

(iii) Given all the dead standing grey and red attack trees in large areas, isn't it reasonable to assume there could be some major forest fire potential? This would impact the amount available to salvage. Also spatial information on dead standing could influence Fire centres fuel loading maps. I would think fire behaviour could be different in stands that are grey attacked (i.e. no needles on the trees) versus stands that are red attacked (with needles on the trees).

(iv) The impact on LUP's and LRMP's is significant. Can the goals and objectives be met in the face of rapid loss of mature and over-mature. Impacts on OGMA's and seral stage targets are significant and will have major impacts on the time frames to achieve these HLP objectives, and on the timber supply. Identification of candidate recruitment stands that survive the epidemic are crucial.

(v) *Strongly agree.*

Assumptions Related to Organizational and Resources Challenges (13-16)

General Comments

(i) On the assumptions related to organizational & resource challenges, an assumption is missing. Government agencies have been barred from planning or coordinating field data collection. There is an assumption that there will be legislated mandate to require licensee to plan & coordinate MPB data collection. If data collections are driven by business needs, licensees might not see a pressing need to collect the data. They might have other priorities. What will be the motivation to implement the strategy? What role will government staff have in planning and executing the strategies? Will new legislation be introduced to alter the status quo?

(ii) Agree, there is a sentiment that we are finished with these in some quarters.

(iii) Another assumption: Timeliness and objectivity are inherent in digital data sources and automated classification algorithms. Current mapping technologies employed in B.C are observer dependant and information does not reach forest managers in time to be of use in controlling the MPB epidemic. Remote sensing technology which involves the objective acquisition of spatially and temporally explicit data is superior to subjective "observer based" methods for at least three reasons: 1) complete coverage is guaranteed and a record for future reference is created, 2) several observers can verify the resultant products and if technology improves (a pretty sure bet) in the future the "old" imagery can be re-analyzed with new techniques to extract better information, 3) versatile product - imagery has multiple applications and the cost of acquisition can be spread over several govt agencies. Try convincing the ministry of Transportation to pay for beetle sketch maps – now try to convince them to cost share for up to date imagery of roads and highways under their jurisdiction.

Another assumption which is never addressed is the supposed cost effectiveness of heli-GPS surveys & sketch mapping surveys vs remotely sensed solutions. I have never seen the CBA which details this supposed "obvious fact". My feeling is that this CBA has never been carried out properly in that apples have not been compared with apples. The comparison has always been apples with oranges. The most recent example is the decision to use conventional aerial photography in 2004 for beetle detection. Many users of the end result are still waiting for the poor quality manually interpreted results.

13. In light of the complex and broad nature of the MPB problem, a multi-disciplinary and multi-organizational approach will be required to find a solution to the inventory and monitoring challenge and for its implementation. Options that are generated will probably need to consider a blend of conventional and new innovative approaches. Collaborative thinking and actions will be critical factors for achieving success quickly.

(i) You have talked about air photo (hardcopy) and digital photo products being used for VRI, etc. BMGS current Standards potentially limit this because they don't have standards for digital photography! There are digital photo systems that potentially will cover more area, at larger scales; while eliminating the need to scan photos; creating cost savings and turnaround of digital products at a faster rate that the conventional systems can achieve. If lack of a digital Standard by BMGS and or any lack of statements of why these systems should not be tested / used prevents access to materials that will help streamline inventory processes would be a shame; this needs to be addressed in the short term.

A variety of remote sensing technologies may be required to facilitate short and long term inventory needs around beetle and other inventories and new technologies should be looked at closely. The remote sensing (photo) contracting community's involvement at the start might be critical.

(ii) Motherhood statement, but true enough

(iii) Trying to meet the needs of all parties with a single solution could easily lead to something that very suboptimal outcome for all or, a very costly solution.

(iv) Agree, who will lead this?

(v) 13 is addressed by the Provincial MPB Action Plan.

14. While the fiscal situation has improved as of late, the government and industry nonetheless continue to operate in an environment of fiscal prudence. All options for a solution will need to carefully balance the benefits of any new protocols with financial realism and sustainability.

(i) True enough. I am wary of those who might take advantage of this situation to propose expensive and complex solutions that benefit themselves when much simpler and less costly approaches may well exist that would serve the information needs just as effectively or more effectively.

(ii) The issue regarding MPB shouldn't be viewed in context that sustainability is desirable. There is a vast resource that is deteriorating with declining value. For the province to attain the highest financial return is to salvage as much as quickly as it can. Time should be considered as a strong negative factor.

(iii) If there is not a lot of new money then don't expect much to happen. Currently, inventory work is initiated by industry using FIA dollars. This approach won't work for MPB.

(iv) The relative prices for coverage using different resolutions of data should be identified for comparison. The ability to share data based on the licensing restrictions should be an important measure in cost/benefit analysis.

(v) Cost/benefit estimates need to be developed so our approach to this challenge has some economic reality and work can proceed toward an optimal solution.

(vi) 14 is motherhood.

(vii) Has it?

15. It is possible that the inventory, monitoring and update protocols that are decided upon will venture into new somewhat uncharted territory each with their own set of inherent risks and while the "MPB clock" continues tick. This likely means that executives, managers and practitioners will need to embrace and manage these risks with due consideration of the reality of the circumstance. Staff charged with implementing these protocols will need to be open to operating within a "Risk Management Environment", learning and applying quickly what could be quite different methodologies. Rapid new skills training will probably be another important component of the whole solution.

(i) True enough. The world is always changing. It is just changing a little faster now with these new challenges. To me, this assumption states that the relevant people in positions of authority and decision making will have to be prepared to be flexible, innovative and ready to take calculated risks. You had better put in place systems that will encourage and reward such behaviors in government personnel as I would be surprised if such systems are presently in place and functioning.

(ii) We should not get overly caught up in the rush to get any information. If we proceed quickly (risk a lot) we may end-up getting nothing in the end.

(iii) Agree that this will happen. However, under a Risk Management Environment staff should also be assessing and willing to risk "not doing anything". Sometimes by doing something inappropriately we can cause harm to our ability to do something appropriately in the future.

(iv) Risk Management Environment: we are not resourced to do take this approach. Someone needs to take control across all agencies.

(v) The biggest bottleneck will likely be in the development / refinement / revision of the database. This will likely be the most time and money consuming portion of the exercise if significant changes are made to the attributes that are included in the data collection. Additionally, changes to the data validation routines will be time consuming and costly to ensure that valid, clean data is loaded to the data repository.

(vi) Need more training and help in risk management, and support from government.

16. It is anticipated that some solutions may necessarily require new and different kinds of partnerships with the forest and other sectors, technology firms and data suppliers such as those for some remote sensing platforms. Among many factors, flexibility, fairness, timeliness, data ownership, data sharing, and public access, will be important elements in defining these partnerships and for their success.

(i) Motherhood statement, but true. My vision of how I would approach addressing these challenges is not that expensive and would not impose any significant limitations with respect to data sharing or ownership, timeliness of public access. I agree with the need for flexibility, fairness and timeliness and believe my suggestions embrace these principals.

(ii) Existing partnerships, like COFI, SIGY and FORREX, should be examined to see where they best fit, or can be modified, before undertaking creation of new ones.

Some more assumptions and organizational challenges:

- Industry participants are difficult to engage in processes like this due to the unique nature of their job responsibilities, yet they have an important stake in delivery and deserve input opportunity. Engaging licensee org representatives (e.g., COFI, SIGY) can help bridge this issue.

- There clearly needs to be better clarification of roles and responsibilities for inventory and its associated monitoring and G&Y. Currently government and licensees are in a stalemate. Government moved decisively to reduce staff and its capacity to deliver these things on the ground, but has yet to provide licensees with clear strategies, policies and fiscal incentives to pick up the challenge. Industry cost reduction commitments have deterred government's use of regulatory imperatives. Fiscal incentives through increased FIA allocations or stumpage adjustments have yet to be realized. There is no strategy defining stewardship responsibilities, only ad-hoc lists of organizations abdicating responsibility. These are key issues that must be addressed before any technical solution can be successfully implemented.

(iii) Strongly agree.

(iv) While new data collection methods must be explored, there must be a commitment to meeting multi-use standards. A balance of cost verses usability must be met - a snapshot from a digital camera presenting an overview of infected areas vs. trying to map from same; acquiring a <u>few</u> aerial images using a metric mapping platform for use as an overview is not cost effective.

(v) A good role for ministries is to develop partnerships; WLAP has experience and has been successful.

Assumptions Related to Inventory and Monitoring Technology / Methodologies (17-19)

General Comments

(i) Various remote sensing techniques and methods are ideal for detection and mapping. Monitoring will require field plots and periodic remeasurements. A network of field plots, identification of remeasurement cycle, storage of data is missing.

(ii) I agree with #16.

(iii) Assumptions #17-19: Presupposes that remote sensing is a big part of the answer. This may or may not be true.

(iv) Agree, note: if there is an expectation that new data management systems can be built (like standards) in a few months they are way off base.

(v) Clearly remote sensing has a role in the development of a monitoring program over a large area. The specific tool and application should become clear once the goals and objectives of the monitoring program have been established.

Make sure that the tail (remote sensing tools) is not wagging the dog (strategy for forest inventory and monitoring).

17. A strategy to consider incorporating the monitoring activities of recent MPB activity into the inventory should focus on how to update the degree of disturbance attribute for a given stand without fieldwork. This strategy would reduce the inventory life cycle significantly (possibly to a year).

(i) I agree wholeheartedly. Field work should be done to validate and quantify estimates made using remote means. I envisage being able to provide updates on degree of disturbance that are updated at least yearly and perhaps even once a season (4 months).

(ii) MPB Detection Mapping which has been previously collected by Government and Industry should be specified in the assumption. Over the past 5-6 years MPB detection and mapping data has been collected and offers a potential source in which to update the inventory. The various surveys need to be investigated : methodology, accuracy , date and how and where they are stored.

(iii) Maybe we can use existing information and not have a short-term inventory cycle at all.

(iv) Monitoring is required to "adjust" inventory information between update cycles. This is especially critical since the status is changing rapidly. We need to capitalize on the field staff within government an industry to collect information in the course of their duties to help verify predicted changes.

(v) Clearly we can't afford annual field visits to every polygon, so something like this makes sense.

(vi) This statement presumes the business drivers are all known and someone (with an RS background) has figured out what the "focus" should be. This is premature.

(vii) Disagree if incorporation means permanent change to forest inventory data. Believe a re-inventory is the correct process to achieve such permanent changes. Incorporation of MPB monitoring activities into the inventory should only be via a modeling process, not an actual inventory change. Some fieldwork is required to ensure that the incorporation modeling is statistically valid i.e. the model has a basis in reality.

(viii) Again the life cycle is not relevant. It is possible to update the degree of disturbance without fieldwork. As I mentioned earlier, it will require a significant investment in aerial photography and colour ortho production.

(ix) Field work is needed to check the quality of the photo or satellite inventories.

18. Remote sensing tools are a good way to obtain data on features like extent, crown condition, etc., but will not address, in their entirety, a number of the issues identified in, for example Background Statement #11 and Assumption Statements #11 and #12.

(i) Agree, RS is but one approach in the strategy.

(ii) I agree with #18.

(iii) Agree.

(iv) Of course there are limitations to what can be achieved using remotely sensed data. The dame is equally true of what can be expected of ground sample or plot data or manual aerial surveys. Keeping this in mind, it may be useful to restate that it is unlikely that any single approach or data source will be able to address all needs fully.

(v) On assumptions 18 & 19, the most promising tool for broad mapping of MPB areas is infrared photography, either by satellite of by fixed wing aircraft. Other forms of photo-aided mapping might be useful, but extending the work into investigating the full range of the electro-magnetic spectrum will turn the exercise into endless research with limited benefits to the subject at hand.

(vi) Remote sensing is more than just conventional aerial photography. A brief "primer" on available technologies may help to broaden the understanding of remote sensing (I can help with this if required). Many inventory parameters can be directly captured from remote sensing: e.g. forest extent, crown condition, species, crown area by species, crown closure, vegetation greenness, moisture content, stem density, tree heights, spatial pattern (canopy openings OAF's).

(vii) No single data source will satisfy Background #11 or Assumptions #11 and #12. Rather, input data of various spatial resolutions and extents will be required for analysis.

(viii) This statement is not quite correct. Remote sensing refers to large scale air photos as well as satellite images. The quality of information you can get from these two extreme sources varies greatly.

19. Keeping Assumption #18 close in mind, following are some assumptions regarding the general "state of the remote sensing-related art".

(i) The discussion on use of remote sensing technologies and the use of digital products assumes that the appropriate standards are available to ensure the resulting mapping geometry fits the underlying TRIM base which we all use for resource mapping in BC. If emerging technologies are considered for the MPB affected areas we need to ensure that the resulting maps are spatially correct. Government and the private sector should work together to develop digital standards.

(ii) In recent years the interior has experience drought conditions that would induce moisture stress. We would need to ensure that this does not confound any selected remote sensing approach.

(iii) I do not possess an RS background or vocabulary. This appears to call for far more detailed information knowledge base than what is required for in the other questions/assumptions.

(iv) There is no remote sensing techniques operationally capable or feasible for MPB mapping and monitoring except conventional aerial photography. Any new remote sensing techniques to be used have to compare with the aerial photography for accuracy/precision and cost.

(v) The comments on the limitations of remote sensing approaches appear to apply mainly to an inability to detect green attach and early stage infestation of individual trees or a limited number of trees in a small stands. I refer you back to your own assumptions that all pine trees will eventually become infested and that there is no expectation of needing to provide information on early infestation in order to plan and implement control measures. Based on these assumptions, it appears to me that the role of remotely sensed imagery would be to provide information on the location and extent of large stands that included many dead or red attacked pine trees. These should show up quite readily on all manner of remotely sensed images over a wide variety of resolutions. I agree that you should investigate and evaluate a wide range of non-conventional remote sensing approaches. My personal belief is that the proposed inventory needs would be best addressed as a spatial database problem and not as a conventional remote sensing problem. I would plan a design that envisaged each spatial entity as a record in a relational database and would devise procedures to update both the spatial and not-spatial attributes of each in response to any observed changes. I would only record changes and I would time-stamp all changes so that the database only contained information on changes (spatial or attribute) and so that the database was truly dynamic and could be reconstituted to show conditions of spatial entities (forest stands) at any given time and could play back changes through time using animation techniques.

(vi) Given that the majority of the province is in salvage mode, there is little need to detect green-attack. The focus of inventory activities should be red and gray attack.

Remote sensing has been big on promise, poor on delivering on those promises in the province.

Timing should include a discussion on whether to wait until the outbreak is over for full re-inventory. Maybe carry-out short-term monitoring.

(vii) I have a few things to say about 19. Let's be careful about Remote Sensing. Remote Sensing is always searching for a problem to solve.

- There are enough currently operational remote sensing tools out there that can adequately map red attack.
- Aerial photography and the use of satellite imagery works.
- Any use of Remote Sensing should be practical, realistic and cost effective.

- Any new remote sensing tool being considered should be measured in terms of cost effectiveness with aerial photography.

- Aerial photography is tried and trued method of data collection. It is cost effective, easy to use and there are many people in BC that have the technical knowledge to use this technology.

- Remote Sensing has always had trouble from moving from a research to an operational environment.

(viii) Some of the assumptions do not entirely reflect the state-of-the-art on this topic, see below.

(ix) I am somewhat disappointed in this section. I am not sure what I expected but this leaves me no further ahead than when I started. I know that remote sensing technology of various kinds provides various amounts of information to natural resource managers the world over. I also know that it is among the most "undelivered" research that we fund. Finally, I know that various consultants continue to maintain that it "will revolutionize what we can do".

None of this helps me decide what to do in this case. I was hoping for some more focussed input from the consulting team – but it may be simply that I do not understand the Challenge Dialogue Process.

19a. Numerous research projects involving remote sensing in detecting and mapping of the state of forest health have been completed over the past two decades in British Columbia. Results are often inconclusive as few studies have been supported by field sampling and laboratory research[9,10]. In summary, using multi- and hyper-spectral airborne imagers was not successful for detecting green attack (vegetation stress detectable prior to discoloration of foliage). Recent studies at the Pacific Forestry Center and studies of anatomical evidence of damage symptoms in needles of red spruce from New Hampshire and Central Europe show some promise in early detection of the damage. Successful mapping of infested stands (by definition 10, or more red-attacked trees/ha) has been documented mostly by aerial photography, preferably color infrared, acquired at scales from 1:10–1:20,000.

(i) Green attack detection is a waste of time. I did a graduate degree on the topic so I am well versed. There is simply too much complexity in the forest ecosystem to calibrate. Date of beetle flight and weather patterns (i.e. tree dessication) are dynamic variables…difficult to calibrate. Other factors such as nutrient status, moisture status, species competition, ecosystem variation, time of day, time of year differences all hinder hyperspectral / green attack detection.

(ii) Colour infrared film will NOT detect green attack MPB, that has been proven time and time again. Also CIR film is confusing for the "non-remote sensing specialists" and has limited usage to other users.

[9] A remote sensing strategic plan that was prepared for the Ministry of Forests in 2002 by Arthur Roberts and Jim Northrup, Department of Geography, Simon Fraser University, 34p

[10] Detecting and Mapping Mountain Pine Beetle Infestations: Defining the Role of Remote Sensing and Establishing Research Priorities. Workshop Summary Report, August 8, 2003. Workshop on June 26-27, 2003 in Vancouver facilitated by R.J. Wiart & Associates, 24p.

(iii) The extensive work done using CASI hyper-spectral airborne data needs to be referenced here. This work was also very inconclusive and costly.

(iv) SPOT5 satellite imagery has shown promise for landscape level mapping of red attack. Studies with Ikonos and Quickbird have also shown good results. From a cost perspective SPOT5 imagery is probably the best balance between level of detail, coverage and accuracy of the results.

(v) This year's 1:30,000 normal colour photography combined with Softcopy interpretation provided excellent results. Larger scale and infra red imagery, though nice, isn't necessary, particularly if you are trying to optimize the utility of the imagery.

In my opinion, government should fund conventional 1:20,000 colour photography over the most heavily attacked portions of the Lakes, Vanderhoof, Quesnel, and Central Cariboo since the outbreak has pretty well reached its peak. This imagery will be multi-purpose serving shelf life studies to TRIM and, if the project is large enough, will be very cost effective compared to other limited use imagery. Conventional photography could be conducted in other areas AFTER the outbreak has peaked as the purpose would be to "count the survivors". It is too expensive to be done annually or bi-annually.

(vi) Not clear what image resolution is being discussed, spatial or spectral. Issues related to logistical, operational, and science feasibility of green attack mapping must be considered. A remote sensing conundrum emerges with the pursuit of green attack, whereby large areas need to be surveyed with expensive data (as there is no need to fly where you already have red trees, as you know there are green stage trees there as well). With this need to fly large areas with expensive data, a primary driver for using remotely sensed data is lost. Below is from a report on MPB survey (See Wulder 2004, BC-X report below[11]: http://warehouse.pfc.forestry.ca/pfc/24986.pdf).

*(vii) **"Green stage":** Detecting green attack trees is a highly sought-after, yet elusive goal for remote sensing researchers. Water-stress of mass-attacked trees has been detected at the leaf-scale and at the branch scale (Murtha 1985; Ahern 1988; Rock et al. 1988). However, other studies have found low levels of detection where the data integrated foliage, branches, and other background objects (Puritch 1981).*

The key issue in mapping green attack is the subtle change in the spectral signal. In order to detect this change, the number of objects within a pixel must be minimized and the relative differences maximized; this requires a sensor with high spatial and spectral resolution (such as the Compact Airborne Spectrographic Imager). To objectively classify such data, training data must be precisely located and representative of the attack stage of interest. The spatial resolution must be sufficiently high that individual pixels represent only the sunlit foliage of a tree crown. In turn, the spectral resolution of the sensor must also be fine enough, with sensitive enough optics, to enable a unique spectral signature to emerge that represents the green attack stage. A survey intended to capture the green attack stage of mountain pine beetle attack must be timed accordingly; the field calibration, data acquisition and processing, product development, and delivery must all occur within a time period which enables the forest manager to act upon the information generated. Environmental aspects such as cloud cover, drought stress, or snow

[11] Michael A. Wulder, Caren C. Dymond, and Bob Erickson. 2004. *Detection and monitoring of the mountain pine beetle*. NRCan Information Report BC-X-398.

accumulations, will also hamper the identification of trees under mountain pine beetle attack. The rate at which the foliage of a tree crown exhibits a mountain pine beetle attack is also variable (across all stages, not only green stage). The earlier the detection of attack is attempted, the higher the omission rate of actual attacked trees is likely to be. The fading of the foliage in the crown of a tree infested with mountain pine beetle is not a consistent, linear process (Figure 2). Additional insights on the variability in fade rates and associated detection possibilities can be found in Roberts et al. (2003). Problems with any of the above elements will impact the ability to detect or map green attack using remote sensing instruments. The accuracy for green attack detection must be high for it to be useful in a management context. The costs must also be lower than established field techniques that are based upon associating surveyed red attacked trees with the presence of green attack.

An alternative to high spectral resolution data for maximizing the difference in spectral signal is to compare the same trees before and after attack. This image need translates into multi-temporal sets of high-resolution data. Because high-resolution imagery tends to cover small areas, these data are often collected only in areas of known infestations. This approach may not be feasible in an operational setting unless high-resolution imagery was already being collected in endemic and insipient areas for other purposes. "

(viii) By whose definition is an attacked stand one with 10 or more red attack trees per ha? What is the point of this definition? Why have a lower limit? We need to know about areas with very little attack if possible. Will 1:20 000 photos provide sufficient resolution?

(ix) Large scale colour photos are the best way to detect small patches of early attack.

(x) Who prefers infrared? No evidence of this in the Provincial Archive.

Nice scales (1:10-1:20K) if you can get it. 1:30 000 scale colour negative photography utilized successfully in 2004.

Actually utilized normal colour negative emulsion and produced "red-enhanced" prints & scans. Colour negative is a more stable emulsion (storage, handling, exposing, processing, and reproducing) than Infrared False-Colour film – and is more suitable as multi-use format.

19b. Information exchange between research and operational projects has not been particularly effective. Research on satellite, multi-spectral and hyper-spectral imagery applications has been carried out at the reconnaissance level (single date and change detection). Resolution is the main limiting factor of using satellite imagery. Large clusters of red-attacked and dead trees can be mapped, while infested stands cannot. Operationally, acquisition of infrared photography has been carried out at the stand level using traditional airborne surveys. Chlorophyll's reflectance in the infrared spectral range is greater than in the visible spectrum. This makes the infrared region more sensitive to changes in chlorophyll response to stress (e.g., red colour). Integration with field and laboratory measurements at the anatomic tree level is needed to design optimal spectral and spatial characteristics of imagery suitable for infestation detection and mapping.

(i) Again CIR film will NOT show MPB green attack, so it is a limiting, more expensive alternative to conventional colour film or digital aerial photography.

(ii) We need to be able to use any appropriate resolutions of data for a complete understanding of the MPB effect on forest inventory. This needs to be done in a cost efficient manner. What can be derived both spatially and attribution with 30 metre Landsat multispectral data? With multi-temporal scenes available, we should be able to accurately map the red attack areas down to small groups of trees. As this is the least expensive remote sensing data available, we should extract as much information as possible from this source. What additional needed information can be contributed by higher resolution sensors? What is the increase in spatial and attribute information and at what cost.

(iii) The slow pace of research in B.C. is related to research agendas at both provincial and federal levels where the discovery of a solution would result in a loss of funding. Rather than stimulating researchers and rewarding them for transferring successful technologies to the private sector the opposite is achieved with current funding models. The public pays taxes and at some point the public should accrue a benefit in the form of significant technological advances in science based management of forest resources. With respect to remote sensing and the MPB outbreak in B.C I am not convinced the public has received their benefit.

(iv) I certainly agree with statement 19b that, "information exchange between research and operational projects has not been particularly effective".

(v) Landsat is certainly good enough to show patches of red attack to the resolution necessary for defining harvesting priorities based on shelf life criteria. Higher resolution imagery, though nice, isn't necessary. Recommend for Lakes, Vanderhoof, Quesnel, Central Cariboo that change detection analysis of Landsat imagery from 1999 to 2004 be done to more accurately map out the beetle attack by year which will then be used to calibrate the provincial SELES/MPB sim projections that have been used by the Chief Forester to determine the outcome of the current outbreak.

(vi) Depends on what you want in terms of the information remote sensing can offer. Spatial resolution impacts the scale of what you can detect (stands [Landsat], trees [QuickBird]. Resolution, per se is not the main limiting factor, it is the linking of the desired spatial resolution with the attributes of interest (i.e. if you wanted trees and used Landsat, you will likely be disappointed). Additionally, the operational use of particular attributes, or attack stages, must be kept in mind. For instance, with green attack stage, operational considerations as indicated above.

Infested stands can and have been mapped (i.e. Franklin et al; Skakun et al, [ref details in following paper], Also see Wulder et al 2005[12], where the RS mapping has been done as well as integrated with the forest inventory). Clusters of infested trees have been mapped (See White et al 2005[13]).

[12] Wulder, M.A, R.S. Skakun, S.E. Franklin, J.C. White. 2005. *Enhancing forest inventories with mountain pine beetle infestation information*. Forestry Chronicle, Jane/Feb 2005, Vol. 81:1.

[13] White, J.C., W.A. Wulder, D. Brooks, R. Reich, and R.D. Wheate. 2004. *Mapping mountain pine beetle infestation with high spatial resolution satellite imagery*. Forestry Chronicle, Nov/Dec 2004, Vol. 80:6.

(vii) Who did the infrared? We could acquire for provincial aerial photography archive if corporate standards are satisfied.

19c. Remote sensing technologies other than more conventional forms are not well utilized in BC at this time to support operational resource inventories and monitoring. Jurisdictions in the US, Europe, Australia and elsewhere are using these technologies operationally to decrease costs and increase the currency, quality and speed of acquiring data. Some of these approaches might be adopted or adapted for BC's situation.

(i) I think BC would benefit from using digital based aerial photography, since it is less expensive and has a faster turnaround time. Many other jurisdictions (example Asian Tsunami disaster) are utilizing digital only technology (satellite and digital aerial photography), not conventional film. Unfortunately, the MSRM has a strict mandate not permitting anything except conventional aerial photography. Too bad for BC!

(ii) Somewhat agree, but these techniques need to be compared in a cost/benefit analysis with our current processes that may adequately meet needs in a cost effective manner.

(iii) I couldn't agree more. Well said. I am shocked at how far behind the leading edge B.C. finds itself with respect to remote sensing technology.

(iv) Little detail is provided in regard to the experience of other jurisdictions (statement 19c.) with the MPB or other pests that have similar effects. For example, an outbreak of MPB in southwestern Alberta was fairly successfully combated in the early 1980s. The key to success was the use of medium-scale, colour aerial photography for the detection and mapping of MPB damage.

(v) True in some cases regarding speed (and sometimes, cost) of acquiring data; but other technologies do not improve on the quality of aerial photography data.

Other jurisdictions often operate on much smaller land bases than BC, including the US where states are smaller, etc.

Practical application of the other remote sensing technologies over areas as large as ours (large photo blocks).

19d. Predictive mapping, including some approaches being use for PEM in BC, is capitalizing increasingly on the use of multiple data sources, both vector and raster, for modelling and predicting ecosystem features for large areas with acceptable accuracies at more affordable prices. These techniques, which have moved beyond the realm of research, can generate new kinds of interpretive products increase our ability to delineate and characterize forest and ecosystem features in greater detail and with greater resolution than was previously possible[14].

[14] Personal communication — Bob MacMillan, LandMapper Environmental Solutions Inc., Edmonton

(i) How does this relate to bark beetle?

(ii) PEM relies heavily on its inputs, of which forest cover is one.

(iii) PEM is reliant on the quality of the base input information to the model so PEM in and of itself without a good understanding of the quality of the input data sets is problematic.

(iv) Will anybody from MSRM's PEM group be able to give more details on the state of the art PEM mapping (i.e. Colleen Jones)??

(v) 19d and 19f. These seem like advertisements for Bob. I am not sure why they are included.

(vi) More information on predictive mapping techniques (statement 19d.), a potentially very useful tool, would also be helpful.

(vii) What is going to be predicted? MPB will continue to move into PL dominated stands.

19e. There is a move towards the greater use of multi-temporal data sets and often data sets of differing spatial resolutions. Multi-temporal data is becoming increasingly available and more affordable. Multi-temporal imagery offers promising capabilities for looking at patterns of change in reflection throughout the entire growing cycle which can significantly help with the identification of different land covers and land uses[14].

(i) Believe acquiring multi-temporal data throughout the entire growing cycle will have a very high cost with limited return. This is more of a pure research proposal that may have some sampling benefit but will not be able to achieve large area coverage.

19f. LiDAR (Light Detection and Ranging) will revolutionize what we can do with such profile data once it becomes ubiquitous, affordable and clean which it is rapidly working towards. It can provide highly accurate data on tree heights and shapes, canopy structure, and bare ground shape and context that will dramatically increase our ability to quantitatively describe and classify objects on the surface. There remain challenges with interpreting the data and with data volumes (e.g., e.g., 1,000 to 10,000 times the data volumes we are accustomed to)[14].

(i) Lidar is still expensive and not well developed for forest inventory, so short term applications are limited. Requires digital photo draped over for any visual assessments.

(ii) How would LIDAR help with the MPB situation? Agree that it gives good information on height and surface etc, but it can it identify dead trees? Probably not.

(iii) Lidar is an excellent tool, but is way too expensive. Lidar cannot be used to detect or monitor for MPB, so it is essentially unrelated to the topic of MPB. It can be used to get a more accurate inventory (maybe).

(iv) LiDAR – Being a pessimist in this case, I wouldn't say that it will revolutionize but hopefully will become useful tool.

(v) LIDAR does a few things well, but it does not answer the whole picture. If LIDAR is being considered, then you need to compare it with traditional information acquisition costs. Why would one need highly accurate tree heights and shapes, canopy structure and bare ground shape? What would that information be used for? Is a TRIM DEM and a VRI or photo interpreted tree heights sufficient?

(vi) Strongly disagree with the assumption that LiDAR may be of use in the MPB issue. LiDAR can give very accurate tree heights and ground elevation information but what is the improvement over current height and stand information in our forest inventory. Is the increase in accuracy needed, and at what cost? Suspect LiDAR may have applicability as a sampling tool in forest inventory and is a cost effective tool for applications such as road construction. For MPB, suspect LiDAR would add very little useful information.

(vii) LiDAR can also significantly improve the reliability of forest inventory parameters related to the vertical component of forest structure.

(viii) LiDAR may have great utility in stratification of salvage stand rehab by surveying understory regeneration. It probably is excellent at defining dead vs. live crowns and could be used to sub-sample the LANDSAT derived beetle kill history maps. This technology needs to be explored. Costs/ha need to be determined and compared to other sensor cost/benefits.

(ix) I'm not convinced of the utility of LIDAR. The benefits and revolutionary properties of LIDAR have been touted for many years with no significant product or service being delivered.

(x) LIDAR provides information regarding inventory attributes, providing an excellent source of measurement for vertically distributed elements of forest structure. If the focus is on collecting forest inventory and structural attributes, lidar can augment current data streams. If compilation of traditional photo interpretation based forest inventory information is too expensive, then lidar will likely be too costly. Opportunities may exist using lidar as a sample data source to characterize large areas, not to replicate a polygon based forest inventory. With regards to MPB, lidar would occupy a specialized niche, one that might only be considered satisfying when more immediate issues are addressed.

(xi) LiDAR may prove to be a useful tool but its cost may be prohibitive given the budgetary situation mentioned in statement 14. SPOT, IKONOS and Quick Bird are other sensors worth noting.

(xii) The volume of data will not only be difficult to interpret in a time frame, there must be a realistic method of storage and timely retrieval. Is DIM up to this challenge?

19g. Recent advances in digital aerial imaging using manned and unmanned vehicles and may hold promise in the acquisition of digital infrared imagery at a resolution allowing individual tree detection (sub-meter pixel size). These images allow reliable detection and mapping of red attack and die-back. Cost/benefit advantage of these techniques over sketch mapping may lie in the greater value of the imagery for a multiple applications.

(i) I almost rolled off my seat laughing at this assumption. Sorry to be so sarcastic, but the idea of unmanned "drones" to monitor the BC forests for MPB is not feasible. As a pilot, I am well aware of Transport Canada restrictions. I have a difficult enough time making minor airframe modifications (such as a hole in the aircraft belly) in my commercially licensed Cessna aircraft for aerial photographic reconnaissance. The idea of unmanned (or GPS autopiloted) aircraft are better left to the cold war arms race, drug smuggling, or for attacking oil-laden middle eastern countries. The use of unmanned drone aircraft will be experimental and highly restrictive (if at allowed at all). On the positive side, it is refreshing to see the government entertaining new ideas for combating the beetle problem, but I think that we should focus on more attainable solutions for the planned strategy meeting, such as allowing detection methods from presently legal commercially licensed aircraft. Fixed wing aircraft are safe and inexpensive. Fixed wing commercial aircraft are only $225 - $450 / hour, while helicopters are $850 + / hour. Unmanned aircraft may have lower operating costs, but development will be costly and they will have serious liability issues.

Digital aerial photography is a useful, proven tool for beetle detection. It is cost effective since developing, scanning and photo cataloging is not required for digital imagery. The question is not if digital aerial photography will replace conventional film aerial photography, but when will digital imagery replace analog film. If the government of BC wants to take a pro-active approach to managing MPB, it should abandon its present method dictating how detection should be conducted. The government should live up to its claim of results-based by allowing and encouraging private industry innovation.

(ii) Can't disagree with holding promises but again it is another tool with its benefits and problems.

(iii) Agree.

(iv) Infrared: while it might help with identification of beetle, would be limited for other inventory uses around VRI, TEM, etc. mapping and much other operational use. So infrared imagery would be single use for beetle and you have stated elsewhere in this document a need for multi purpose imagery.

(v) Disagree with this approach based on cost effectiveness. Aerial imaging using digital cameras is comparable to current scanning of analogue aerial photographs. Are these digital cameras calibrated to ensure the quality of images and the repeatability of process? Large area coverage is typically problematic with many of these systems due to the small camera format.

(vi) In general I agree with the last part of the assumption that remotely sensed data in the form of imagery or LiDAR has more value than the subjectively acquired sketchmaps from wither fixed wing aircraft and helicopters. I think this assumption needs to be expanded to a separate assumption.

(vii) Digital aerial imaging may provide wonderful benefits in improving accurate mapping of beetle attack over sketch mapping but for the cost and turnaround time, this imagery is not viable unless the purpose is to replace heli-GPS detailed aerial surveys. Getting adequate standards from BMGS is an issue if FIA funding is being pursued for such image acquisition. MOF is no longer supporting the use of digital cameras for suppression BMU surveys because of BMGS's restrictions on digital photography.

(viii) Logistics? Not sure a RPV (with its own unique issues) would have much cost savings over established and reliable aircraft based data streams. Again, information needs must drive the selection of data sources.

Sketch mapping satisfies a certain information need - sub-metre pixel imagery would satisfy a very different information need and therefore it may not be fair to compare the two. Especially when the low costs for sketch mapping are considered, no digital remote sensing source with equivalent information content can compete. This year's measle mapping work is an example of efficient photo collection and interpretation for red attack.

(ix) I think this is getting too costly for the incremental value of the information.

(x) Small/medium format digital cameras are less efficient than conventional format systems for coverage of large areas due to increased number of images required by smaller formats.

Good to see reference to value of "multiple applications"!

INPUT REQUEST 4: INITIAL IDEAS and SCENARIOS to STIMULATE the DIALOGUE

- **What questions, concerns, and opportunities do these items raise in your mind?**
- **What new ideas do they suggest to you that need to be addressed?**
- **What additional work do you think should be done to flesh out these ideas (perhaps ahead of the workshop so we are further prepared with resources for a productive face-to-face workshop session)?**

Key Questions

General Comments

(i) Keep strategy strategic. Creation of overlay of dead vs live areas could be used as a minimum. This would avoid the situation in 4. To try and populate this information on the polygon/stand level doesn't seem possible within the timeframe needed. You may need to keep the strategic level separate from existing inventories, but make sure whatever is done is "integratable" in the future.

(ii) Additional questions:

- categorization of "shelf life" of dead wood should include non-timber uses such as habitat for species at risk;
- what is the relative effects on hydrology of beetle killed stands being left vs harvested beetle killed stands?
- different type or phases of inventory could have different cycle times, for example, 'harvest' updates could be done annually from satellite images and be semi-automated and not require ground truthing, while stand composition updates may need to be done less frequent;
- rehabilitation, what to do with the stands of non-merchantable;

(iii) Under Key Questions we need to come to some understanding about what is Update of the VRI, versus Monitoring of the VRI, and when to we need to replace the VRI. Do we need to identify some trigger points that will say this inventory no longer meets our operational and strategic needs? In some cases we may be able to model the change to the stands as a result of the MPB attack (netting down the stands for pine content and driving a new label). This will need to be tested with field work to provide feedback to the model.

(iv) These are all good questions, and likely more will arise in the face-to-face meeting. Some of the comments I made earlier relate to questions I have in assessing possible responses to the epidemic. In 1996, the Quesnel TSA had a 70 year supply of mature/over-mature timber. In the face of this vast resource, the impact of forest management treatments to enhance growth and yield or reduce losses to forest health vectors were over shadowed by the fact that the average harvest age significantly exceeded the rotation age. The world is different now and any treatments to improve mid-term timber quantity and quality will be embraced by the impacted communities.

(v) BC will have over 300 million m^3 of beetle-killed pine by 2010. Markets will not allow this volume of additional material (live or dead) to be processed into standard wood products. A better question could be:

- *How would one best incorporate decay and fall down rates within impacted MPB stands to project CWD and fuel management concerns or to model stand structure/habitat progression?*

(vi) From my perspective, it is not the best use of time and resources to do a full inventory of green and red attack areas – they're going to be gone within a year, two at the most. If you want to have a quick, non-corporate reconnaissance with generalized 'polygons' to indicate where these areas are, that would be the most effort that should be put in (from my perspective.)

The biggest bang-for-buck would be figuring out and corporately mapping where the damage has occurred after the beetle has run-course. Attributes in the inventory could be altered to focus on the dead trees and possibly look at the understory component. A monitoring (inventory or forest health, I'm not sure yet) program should be implemented to gauge the shelf-life and start evaluating what's coming in under the dead trees (maybe there's an understory component on many of these stands already.)

(vii) It seems to me that you have asked (question 1) and answered (question 2). Unfortunately you seem to mix the issues of beetle control (suppression and containment areas) with the completely different issue of salvage operations (and shelf life). To me, issues about salvage and shelf life fit much more reasonably in 2B.

(viii) Given the multi-party reality need for data sharing amongst participants. If government owns and pursues a cost recovery model then there is little incentive for other parties to contribute or participate. Need for flexibility in how data and information is shared and used.

Comments on Specific Key Questions (1-14)

1. To what extent is this challenge a forest vegetation inventory challenge versus a monitoring of a forest health problem, or both? What are the data collection, information management and resource information product (output) implications (pros and cons) when taking an inventory, monitoring or "both" perspective?

(i) Perhaps we need to get away from the idea that inventory needs to be to the same standards that we are used to. That is, we don't need a Cadillac.

(ii) This challenge is more than both forest vegetation inventory and monitoring forest health problems. It potentially threatens the existence of communities. You need to get a handle on the loss (change) associated with loss of pine at a detail that will allow for informed decision making. Higher investment VRI inventory processes to do this right is more important than short term political approaches. VRI Standards don't have to mean all VRI attributes being reassessed. The 2004 Beetle flying / measle mapping in the southern interior; where is this at; is it being looked at as an update /re-inventory tool right now to assess its use to update the inventory?; to determine if this is a suitable tool and start scheduling more photo (digital??) this summer. If the beetle epidemic is to peek in the next few years; then this is more a Veg. Reinventory issue than forest health monitoring issue.

(iii) The scope of Monitoring should exceed the bounds of a forest health issue. Along with quantifying what has occurred on the landbase and providing data on trends it should provide information on performance and sustainability.

A Monitoring Framework which will act as a warning system for other pest agents, other natural unpredicted events would be beneficial to incorporate at this time. So worth discussing at the workshop.

(iv) Debate the issue of whether this is a VRI or Monitoring issue is premature until we know what the information requirement are of the key players.

(v) It is an inventory question at minimum, but the rapid nature of change (in the short-term) suggests a more dynamic inventory than "normal" – something with monitoring capabilities. Most of the pros and cons involve cost trade-offs.

(vi) Challenge is both an inventory and a health monitoring problem. This will require a data model that supports temporal change components. Information must be easily added to the system over time, and must allow for easy reporting between time periods for monitoring.

(vii) The MPB epidemic is, in my opinion, the greatest forest resource management challenge we have ever faced in BC, a multi-faceted challenge which is providing us with some incredible opportunities for innovation, visionary thinking and action, and inclusive decision-making:

- It is vital that we have a very good inventory of the MPB-killed pine if we are to promote a salvage harvesting economy for shorter periods of time in our resource-dependent communities. This inventory must include information on wood quality as well as processing capabilities, and, of course, the dynamics of decay.

- It is vital that we have a very good inventory of advanced regeneration, natural regeneration, succession of mixed wood stands, mixed stands, success of improved seed/stock, forest health, and understory responses if we are to develop and implement successful silviculture strategies to manage the Pl landscapes into the future.

- It is vital that we have a very good inventory of regenerating plantations so that we can manage for stability and well-being in these plantations. Many regenerating pine areas

are experiencing problems with diseases and other pests which thrive on pure pine stands.

- It is vital that we have a good inventory of wildlife and wildlife habitat, fish and fish habitat, particularly the endangered and threatened species as they might be impacted by the scale of the beetle disturbance and the subsequent harvesting disturbance. It is also vital to have good inventories of our watershed and water resources.

- It is vital that we have a good inventory of the remainder of the forest resources because there is widespread reliance on subsistence industries (e.g., hunting trapping, guide-outfitting, fishing), and outdoor recreation and tourism industries (e.g., eco-tourism, fishing camps/lodges, campgrounds, skiing, hiking, snowmobiling).

Thus, this is not just an inventory challenge – it is a resource management challenge involving the environmental, economic and social components in the equation.

Two other items come to mind at this time:

- The importance of monitoring – Monitoring what we do is necessary and vital to our success. Monitoring is also very expensive (cost and time) so that we need to be very careful as to what criteria and/or indicators we want to monitor.

- The importance of having a good inventory system (or integrated procedures) – the time is ripe for innovation, leadership, and stewardship.

We must also understand that the MPB is not the only bark beetle in epidemic proportions in central BC. The spruce bark beetle, Douglas-fir bark beetle and the western balsam bark beetle are also epidemic in the north-central interior. Since forest health is driving our harvesting programs, we had better not be exclusive in dealing with this Key Challenge.

(viii) Inventory vs. forest health problem?: it is both and with any luck will pull forest health back into the inventory framework. Output implications? The term "inventory" suggests a non-dynamic, point in time counting of trees largely for planning (TSR) purposes. Currently, that is a correct assumption. The VRI could be modified to include monitoring but that would require govt' to impose standards and procedures that would not benefit industry for just TSR. VRI ground sampling is designed to minimize cost to adjust strata for TSR purposes. If ground samples were to be installed for both adjustment and monitoring we might chose to put them out on a grid. The net result might result in wider sampling errors for adjustment but would provide for a framework for plot re-visitation to monitor across the landbase—not just the strata for adjustment. Further, VRI sampling is based on point sampling. Our investigations indicate that monitoring is performed using fixed radius plots which would be inefficient (more costly) for adjustment (only). Possibly it will take the MPB issue to resolve this. Also, the forest health staff indicated they didn't want to be involved (train) VRI field samplers with pest identification. There would be contract staff training requirements. Of bigger issue, are we developing a new inventory system to make up for the shortfalls of the current system? If so, expect a lot of work.

(ix) The challenge is both a forest vegetation inventory challenge and monitoring a forest health problem.

- I think we need to scope out what exactly has to be done.

- What is really needed?
- What are the real information requirements?
- When is the information needed?
- How much is it going to cost to get the information?

(x) In a simplistic look, at the need simply being to identify what is impacted and what it will look like in 10-100 years, I don't really think that it is a technical forest inventory or forest health monitoring challenge. The tools and methods are there if we wish to make decisions at the current level we do. It is a resourcing problem to get basic inventory information and projections. However, if we want improved information for decision making and for improving how we manage resources (knowing decisions are going to get more difficult as we have an AAC falldown) we are going to require more refined inventory, monitoring and prediction tools and information.

(xi) Unfortunately, I do not think that one can not divide the forest into the two categories you suggest. The infestation is continues to damage forests long after the peak year and there are places where the infestation is still building rapidly that need to be salvaged.

I suggest that more useful dichotomy would be inventory attributes that change:

- *Rapidly with respect to normal inventory cycles – amounts of pine killed and the shelf-life of dead pine*
- *Slowly with respect to normal inventory cycles – state of regeneration of beetle killed stands.*

(xii) In my opinion both an inventory and monitoring program are required; an inventory to establish a baseline, an update program to maintain the baseline, and remeasurement to assess change. Too much focus is placed on separating these into components rather than linking these activities into an integrated program.

(xiii) The MPB provides both an inventory and a monitoring challenge.

(xiv) The focus should be on forests that have already been MPB modified.

(xv) Regular, more frequent updates are called for.

(xvi) The challenge is both a forest vegetation inventory challenge and a forest health monitory problem. VRI collects various forest health attributes on the ground. Dead and live tree volumes are also calculated, providing necessary data for timber supply.

(xvii) The challenge is actually monitoring change – need a baseline and targets so we know when we reach a critical point.

2. Are we not dealing with at least two lines of questions regarding inventory and monitoring of these MPB affected areas?

(i) There is little need to identify green attack as the fight against the beetle is lost. So there is no need to panic over a short-term inventory solution for green-attack.

(ii) The question of when to do inventory up-dates should consider a delay of up to 10 years (wait until the beetle has run its course).

(iii) This is about short-term vs. long-term management issues. Attack detection, salvage scheduling and other short-term issues which seem to mortality focused. Vs. the long-term implications including residual stand characteristics, stand replacement and growth, which tend to be green tree focused. These two aspects probably don't need to be monitored (updated) at the same frequency but they need to be compatible with the same inventory file.

(iv) 1 and 2. VRI vs. FH monitoring – are two distinctly different "challenges" from an inventory perspective. (2B). VRI, particularly if you the focus is on timber, needs to be done when the outbreak is over to provide TSR the most stable estimate of the growing stock. In most of the beetle damaged areas, the infestation will continue for another 5 to 10 years so the priorities should be to inventory the areas where the "change" is over or nearly over. In contrast, (2A) FH monitoring, particularly in the "blown out" areas is done quickly and cheaply using the overview sketch mapping survey. From a strategic FH perspective, we don't need really detailed severity and positional data unless we plan to do something like direct small patch harvesting or single tree treatments. Industry, on the other hand, needs more precise information to do operational planning but, of course, would prefer government to pay for the survey data acquisition. Operational costs are addressed by the appraisal system. Government should avoid subsidizing industry whenever possible. FH monitoring is ongoing and funded and is not an issue from the MOF's perspective.

There are a number of other objectives that fall in between these two major objectives that require "special inventories". Rehab planning is one use that requires interim data to facilitate the planning of silviculture activities (i.e., sowing requests, funding, etc.). "Shelf life" priorization – one could debate that this is something government or industry should be doing solely – needs both more accurate mapping of damage by time of death (than provided by the provincial overview survey) and ground sampling of areas to determine wood quality in relation to site factors.

(v) The amount of pine that has been killed (at any point in time) is important to the categorization of Beetle Management Units into the categories of monitor, suppression, containment or salvage. However, large areas of the province are already categorized as "salvage" (http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/maps/ebbma/Ebbma_Jan05.pdf) and this area will increase rapidly. As more and more of the province is categorized as "beyond the leading edge". We still need to know how much pine has been and is being killed. That inventory has to be provincial in scope in areas that are lightly and heavily infested. We need the information in order to project the infestation with better surety and to accurately estimate short-term timber supply impacts in areas where the infestation has largely subsided.

We need information about shelf-lie more-or-less independently of the infestation. We need to know how it will vary with biophysical factors. This information would ideally be available prior to the outbreak occurring in an area.

Information on regeneration should be accumulated as quickly as possible but I see this as a long term problem that we can deal with in the long term.

(vi) *There is an on-going need to describe the current state and geographical extent of the forestland affected by the MPB and to predict the future state of both the currently affected forest and that forest that will be affected in the future.*

2A and 2B must be coordinated.

(vii) *2 C. This category should be added – 'Data should be collected to determine possible future geographic areas of attack. This is important to predict future impacts on timber supply.'*

(viii) *Rank from overviews and local knowledge.*

2A. The need to describe the current state and geographical extent of **forest areas that are under infestation** and monitor their state and geographical extent over time? The inventory and monitoring efforts would be directed at forest stands that are under green or red attack, and recently dead. Current MoF infestation categories are described as either: (i) containment areas - large infested areas currently harvested; and, (ii) suppression areas - small patches of red attack where sanitation measures are possible.

- These data would need to be collected and analysed within a very short time frame in order to guide salvage operations and may help answer questions regarding the estimated shelf life of dead trees on different sites (i.e., how many years are remaining for obtaining a marketable forest product — a key factor in Timber Supply Analysis).

(i) Statement A is where forest health operates. The current spread of beetle infestation is a monitoring and ongoing process. Quick assessments on the state of the inventory at a particular time as the infestation evolves should come from modeling scenarios, operational assessment by licensees, etc. to facilitate the day to day operations required.

(ii) Sketch mapping is probably adequate.

(iii) I am not clear about the need for 2A as the earlier assumptions stated that containment and control were not seen as viable options and should not be the focus of the proposed inventory design. I personally do not see the urgency of mapping green attack. I believe that a single monitoring system (see below) could monitor the spread of dead trees and those under red attack. So, from my perspective, I can accept viewing this as a single problem in which the need is to continuously monitor and update the condition and spatial boundaries of forest objects that are equivalent in size and concept to a forest stand. I do not differentiate between the time scales or data needs associated with red attack or dead trees.

(iv) Attack issues: this will all be a moot point in a few years if we are expecting all pine to be dead within the next few years. This is why we need to partition this into short vs. long

term inventory needs. We might need something "quick and dirty" for the former and a longer, "monitoring component" for the future.

(v) Too late to monitor forests under infestation.

2B. The need to describe the current state and geographical extent of **forest areas that have been already severely damaged** and for which the MPB has already peaked. .

- These data would be used to update existing inventory information. This activity would need to occur within a reasonable amount of time like, say 2-4 years (i.e., not conventional VRI cycles), so that new timber supply and growing stock estimates can be calculated and new forest plans can be prepared and acted upon for timber and other forest values.

(i) Agree.

(ii) Extent and Inventory cycle: agree, however, after 2 to 4 years what are we expecting to be dealing with? Huge areas of dead and standing; partially cut stands; newly regenerated stands—most likely a mix of the above. The current VRI implementation (industry's call for their own business needs) is probably not the best way to do this. Inventories will need to be planned for large landscape areas that cross tenure borders including TFLs.

(iii) Statement B is where veg. Inventory can operate. Reinventory or update addresses a more detailed snapshot of the inventory at a particular time and requires more time to complete.

(iv) The risks associated with B depend on the shelf life and timelines to salvage log these areas. Data should be used to model the inventory for AAC, not update the inventory directly. Re-inventory of the MPB areas should occur when these areas of infestation are at the free-to-grow stage.

(v) Get rid of the reference to the VRI cycle. Again, this is an update issue which can be fixed if it is funded adequately.

3. How will different time frames for activities 2A and 2B be coordinated?

(i) The 2 activities are different in that current infestation (A) should be monitored by forest health, licensees people, with some inventory types; while (B) should be mostly re-inventory work.

(ii) I propose a system that would address the time frames of both needs.

(iii) Coordinated? By returning the control for doing inventories back to gov't with appropriate funding.

(iv) Satellite imagery for attack ages.

(v) The inventories described in 2A are already funded and coordinated by Forest Practices Branch as they are a key driver for the province's allocation of bark beetle management funding. For 2B, these should be coordinated by MSRM's Resources Inventory Branch and MOF's Forest Analysis Branch.

(vi) Need to develop an update cycle to capture annual changes to forest cover with in impacted areas so that a reasonable management approach can occur.

(vii) 2B can be done on an annual basis. The shelf life issue can be sampled early and quickly. The growth rate of regenerated stands can be done over a longer period of time.

(viii) 2A later timing, concentrate on heavy hit areas for salvage and treatment, including parks and PA's.

4. With reference to question 2B above, how do we handle the problem of updating the information when the new information (about the pine damaged areas) does not jibe with the previous inventory polygon information which may indicate there was no pine present?

(i) As the MPB business drivers, sample design and standards are different from VRI the data should be maintained separately from the VRI to avoid compromising the VRI inventory. The VRI update cycle could capture these changes as per Section 2b. The attribute information would be incorporated into the VRI at free to grow like other managed stands.

(ii) A part of the VRI process is to develop Vegetation Strategic Inventory Plans (VSIP). This is a required component for any new inventories. Perhaps an assessment of the state of the inventory (Pine Beetle specific VSIP) should be developed for TSA's (this summer) identified as critical for MPB loss. Proper inventory planning may ID problems such as incorrect polygon species ID and make recommendations for more detailed needs in any re-inventory. There may also be areas ID'ed with dead pine that the current inventory does not indicate any pine. This could also be a small problem, as you potentially will be changing whole line work with the pine component dead.

(iii) No different than any other inventory update. Use best available information. This points to a problem with inventories in general.

(iv) I have a design and a proposal for how to transactionally update the data that define the spatial extent and boundaries of the objects that are being monitored and described (forest stands). I do not have the time or the inclination to describe that approach here. Suffice it to say that it is a database centred approach and that database records are only updated for the spatial component of the data if a change in the boundaries of a defined object (e.g. a forest stand) is indicted and observed. My design also contains elements of the design adopted to define a robust and invariant spatial referencing system for the National Forest Inventory and could be made compatible with it. I believe that his issue is eminently solvable and should not be a major issue to deal with.

(v) Species irregularities are not a new problem.

(vi) Updating issue: this is a technical issue that can be resolved later. People need to understand that inventory labels are correct for the leading species about 50 to 60% of the time. For minor species' components, much less.

(vii) If we have confidence with new information that conflicts with the existing inventory, we should revise the stand attributes, metadata should describe the reason for the change, the data source and accuracy of these changes at the stand level.

(viii) If the information does not jibe…one can go back to the inventory document photos that were initially used to create the inventory and take another photo interpreted look.

(ix) Composite coverage of PEM polygons and FC polygons to identify possible errors in Pl forest cover (e.g. PEM - soil moisture modeling, materials mapping (coarse soils), site series, aspect, slope position, etc.).

(x) It means that the either the previous inventory was wrong so I would use the most current data.

(xi) Fix the inventory data?? This question seems a little picayune to be number 4. There will be a lot of details that will come up during the process. Hopefully, we can use this as an opportunity to generally improve the inventory.

(xii) Inventories are never 100% accurate. Their level of detail must also be appreciated. An inventory based on medium-scale aerial photography at a scale of 1:15,000 can't be expected to accurately describe the presence of every pine tree. If that information is critical to management inventory specifications will have to be modified.

(xiii) It does not matter if the old does not match the new.

(xiv) New info should be more accurate shouldn't it?

(xv) The correct species identification of Leading Species can vary between units. On an average the leading species can be 75% correct. Many decisions have been based on this figure, however the decision can be only as good as the inventory.

5. Do we need to consider how other forest health-specific inventories and surveys would be integrated to with a new/re-inventory, monitoring of MPB affected areas and Timber Supply Analysis?

A. The ad hoc forest health survey/mapping (sketch) activities conducted by MOF.
B. The MPB infestation mapping initiative.
C. Independent mapping efforts conducted by licensees using largely private contactors.
D. Standards and procedures used to incorporate the state of forest health into existing Timber Supply Analysis.

(i) The incidence of stem rusts in increasing (related to climate change?) and we need to be able to predict and respond to this emerging issue. Climate change will also influence reforestation decisions around species suitability. Reforestation of salvage areas and the rehabilitation of abandoned strands will require better site information to ensure we build

flexibility and resilience into the future crops. The worst scenario is to set up for a repeat by reforesting with another sea of pine when there are other options open to us.

(ii) Other Forest Health specific inventories need to be considered.

(iii) Yes.

(iv) We do need to consider the integration of current MPB data sources as they might hold may answers to short-term information needs.

(v) YES, but they shouldn't override the process. They may be useful for calibration or validation data.

(vi) What this strategy really emphasizes is the need for a continuous inventory cycle and monitoring program. We shouldn't just be trying to capture the flavour of the day.

(vii) Survey integration: agree, it's about time. Put everyone on a common grid for a start.

(viii) Yes, you would need to look at the accuracies of these methods.

(ix) Integration should be via modeling approach. Appropriate measurable results of all approaches should be a requirement. Co-ordination to prevent duplication of effort between groups is required. We need to know what is mapped and what the level of accuracy is, then gaps in the data required can be identified.

(x) Good forest health component in VRI Phase II sampling.

(xi) Question 5 about integrating forest health surveys and other data collection processes has been tried in the past but there was strong push back because of conflicting objectives, increased costs (collecting species, age and height), and expediency. If this is a desirable outcome all parties need to buy into this process.

(xii) Yes.

5A The forest health survey is not really "ad-hoc". It is a reasonably well defined annual survey that has some significant utility. Unless the optimism about resources for inventory bear fruit it will be all we have. It should represent the fall back position. It should be strengthened and improved as much as possible in order to keep up with all the other forest health problems that are cropping up (because of climate change in my opinion).

5B would that be the work done to map suppression areas??

5C I doubt if this is going to help. They don't seem to think they have to give us the data, even if it is paid for by FIA. In any case; the resulting piece meal coverages probably would not justify the effort of putting it all together.

5D this is completely different issue that has to do with modeling methodology not inventory.

(xiii) Definitely the integration of various surveys and inventories must be integrated. Methods to successfully achieve integration in a cost-effective manner must be implemented.

(xiv) A. "the ad hoc forest health survey" – is NOT ad hoc. It uses a survey method that was developed and implemented by CFS since the 70's and has a RIC approved survey and data standard. There are known limitations to the survey and many of them are highlighted by users of the data who were not the original clients (i.e., modelers, FAB, etc.). Inconsistencies in applying the standards have also been a problem mainly due to differences in surveyor skills and interpretation. These issues are being dealt with through QA procedures, training and improved methods. The overview is still a key survey to monitor the progress of the beetle outbreak over time and provide early reporting of the magnitude of the infestation and update strategies.

B. The MPB infestation mapping initiative – will likely not continue as the suppression area where it was being applied is now too fragmented and heli-GPS surveys are more operationally suitable (wider weather window and fast turnaround time). The survey data will not be useful to the majority of the heavily damaged areas since they were not flown (not in suppression BMUs).

C. Independent mapping efforts – usually are only focussed on individual licensee areas of interest for harvest planning or are those funded by FIA for DFAM. The resulting surveys, up to 2003, used multiple standards and methods to identify small red attacked spots in suppression BMUs. FPB has most of this data archived from 2000 to 2003. FIA only funded suppression BMUs. Until FIA eligibility criteria were set, these were the truly ad hoc surveys but the positional accuracy is likely better than the overview survey.

D. Standards and procedures for FH into TSR? I'm sure there is room for improvement but I'm not an expert in this field.

(xv) Yes , Forest Health has always done a lot of inventories and they should somehow be incorporated into the forest inventory.

(xvi) Needs coordination. Lead licensee concept might work or using a large "inventory" consulting firm as coordination.

6. What features needs to be detected and mapped for situation 2A and 2B?

Clear definitions are needed to establish standards. For example, what is a hot spot? How are its boundaries defined? What is the definition of severity levels? What other attributes are needed?

(i) Agree.

(ii) The MPB infestation mapping initiative. If this is the 2004 Beetle photo measle mapping, much of this mapping is done and digital orthos are being made for much of this project. Softcopy data (3D digital) could be obtained (cost approx. $150 per map) if required to assess the potential of this work to update the inventory database around infestation.

(iii) OK, but I refer again to my comments that you have previously indicated that no actions can be taken to save trees so that early detection is not really that important and you should not be spending a lot of money to achieve early detection.

(iv) Technical issue to be sorted out later.

(v) All good questions, but too much detail to resolve before Mar 31. Another good question is attack age.

(vi) For 2A, the overview survey standards including LRDW data model are all available and on the web (see: http://www.for.gov.bc.ca/hfp/forsite/overview/overview.htm). There are also detailed aerial survey standards for heli-GPS and measlemapping: http://www.for.gov.bc.ca/hfp/forsite/fhdata/detailed_digital_stds.htm

For 2B, the VRI data collection standards are also set and available on the web.

It's not a matter of standards, it is a matter of funding, resourcing and prioritizing the high cost, ground based inventory work. Perhaps remote sensing could be used to do more stratification of stand types thereby reducing the number of plots and expediting delivery of results.

(vii) Please do not take a categorical approach. In so far as possible we need definitions of kill that are based on absolute magnitude of timber volume. All the rest, percent killed, severity classes, area affected, can be inferred or calculated.

(viii) Part of the process of reviewing current inventory procedures must include the development of clear definitions based on management information needs and budget realities.

7. Which remote sensing techniques hold the most potential to become operational?

Understanding of all major operational limitations should be considered. These include:

- Detection limitations, single data set and repeatable
- Mapping accuracy
- Cost
- Availability
- Processing effort and cost
- Use for other applications
- Technology transfer
- Residual value (aerial sketch vs. image)

(i) Questions 7, 8, 9 would support a provincial Remote Sensing Strategy which would fit into a Partnership process. MSRM experience shows that when one agency purchases remote sensing products all other users want access to this product. This shows the multi-purpose use of the remote sensing products. If we pursue a partnership (even if only within government) we need to work on licensing issues with the vendors of the remote sensing products.

(ii) The present method sketch-mapping has been watered down by the provincial government to the point that it is not accurate enough to be reliably used. The process of sketch-mapping has some benefits that aerial photography, satellite, GPS heli mapping do not share. Sketch-mapping is the most cost effective means for red attack detection, and providing that the sketch-mappers are skilled, the results are quite accurate. Also, the turn around time is very short, since the sketched maps can be used immediately following the

flight. Unfortunately, sketch-mapping is often too difficult in heavily infested areas. In these areas, one of the sketch-mapping alternatives should be used.

I think that we should include digital colour aerial photography as best operational beetle detection tool. Here are my reasons:

- Digital imagery has excellent spatial resolution (50cm pixel size or finer), much higher resolution than any satellite.
- Cost effective! It is a fraction of the cost of high resolution satellite imagery, GPS heli-mapping, or conventional aerial photography.
- All the imagery can be seamlessly mosaicked together and orthorectified (easily integrated into G.I.S. systems).
- Since the imagery is digital, there are no costs associated with film purchase, developing, scanning, or photo cataloging as compared to conventional analog aerial photography.
- Much faster turnaround time than TRIM standards aerial photography, scanning, etc.
- Quality photographs can be taken in two weather conditions: sunny weather (with no clouds), or in bright overcast (high, thin cloud only) conditions. Overcast conditions are common in B.C. therefore enabling us more survey days than satellites or conventional aerial photography companies.
- Digitizing is conducted "on screen" the same as conventional aerial photography (after it has been scanned).
- Several digital aerial photography companies presently offer the following service for **$14 / km**^{2}. The package includes the following: 1) aircraft costs, 2) photo acquisition, 3) mosaicking and orthorectification of the photographs into seamless mosaics, 4) duplicate imagery enhanced to better display the beetle damage, 5) digitization of the bark beetle damage, 6) integration of the digitized results into the MOF beetle tracking system, and 7) plotted maps of the beetle damage.

The digital photographs can be easily printed off and given to field crews. Beetle probers find these enhanced photographs as the best "map" available. The printed imagery is even better than Heli-GPS maps because the image displays a current snapshot of the area rather than an arbitrary-shaped polygon draped over the forest cover map. The high resolution imagery avoids confusion and is a valuable time saver for beetle probers and salvage crews.

(iii) Concerned about this one. Have spent the last 5 years listening to sales pitches that say we are almost there, and that one more year will solve the problems. This hasn't happened.

(iv) See my proposal attached[15]. I believe that much of what you wish to achieve can be achieved using currently available FREE MODIS data supplemented with higher resolution satellite imagery (LandSat, IRS, QuickBird) as required (to update the boundaries of spatial

[15] Attached at end of this compilation document (ed).

entities mainly). I believe that my proposal is both extremely cost effective and highly likely to be able to address the main questions of interest.

(v) Using statistical sampling methodology to assign a strategic level percentage dead to the pine stands? From what I've seen the bug killed stands are quite salt and pepper so it can't be assumed that a 100% pine stand is necessarily 100% dead. And as discussed previously, the VRI is not 100% accurate at the stand level.

(vi) Using Landsat change detection methodology for example, the very dead stands could be identified. Estimating the %mortality however would be very difficult and may not be possible. I was involved in a very small test area using Landsat change detection. The results were not ground truthed, but when visually comparing 1:15000 colour photos to the change detection results, red patches >5ha corresponded quite closely between the two sources. We thought it would be easy enough to have a photo interpreter draw polygons around "dead" stands. The definition of "dead" and what constituted that turned out to be much harder than it seemed. Also, ideas like, do you use the existing VRI as a starting point from which to try and estimate the 5%dead within each VRI polygon, or do you only go with what is on the photo? Using the VRI has the problem of what if the attribution is incorrect? Needs more investigation.

(vii) I have seen examples of spot multispectral imagery that shows bug infestations quite clearly. Cost is definitely a factor however for obtaining SPOT over large areas.

Some licensees purchasing spot data for salvage activities. If this is their business, then perhaps that requirement is partly looked after. For TSR it could be possible to use an overlay comprised of multi-temporal change detection, sketch mapping etc since TSR is strategic in nature and the information is rolled up anyways. Not important for TSR that individual stand data be available.

(viii) Need to look at fusion of multisource data. Each dataset will yield different information. The type and resolution will govern the level of detail that can be extracted.

(ix) Yes, agree.

(x) RS potential: don't know—figure out the business needs first.

(xi) As detection of the location and severity of changes caused by the MPB infestation in the forest is the critical issue, multi-temporal change detection using two dates of imagery seams the best approach. For very large areas, Landsat will provide some of the strategic levels of information needed. For areas of high risk and for operational levels of information, higher resolutions of data may be required. This approach will allow for an optimal balance between information requirements and costs.

(xii) Different approaches will apply at different scales – the aggregation of tree/stand level information up to the Provincial level would be too time consuming. Likely a "quick and dirty" approach to gain a broad understanding of the state of the forest at the Province/Regional will need to be implemented as well as a detailed approach at the tree/stand level.

(xiii) Yes.

(xiv) Remote sensing methods that are close to being operational:

- ***LANDSAT** – change detection to determine areas of red attack by year (operational now)*

- ***SPOT 5 / Quickbird / IKONOS**– orthorectified imagery (if panchromatic and colour infrared imagery are fused) can detect red tree crowns. Operational but only suitable for harvest planning by licensees and BCTS. Overkill for MOF's beetle strategy updates and planning and not suitable to detect single tree treatment sites for suppression BMUs. Imagery licensing limits distribution thereby limits the value to the crown as a multi-use tool.*

- ***Conventional colour photography with Softcopy "measle mapping"** – operational but requires a large area to be cost-effective. Unlikely that this will be carried out again by MOF as the suppression areas in the province are smaller and more scattered.*

- ***LiDAR** – for sub-sampling areas of heavily damaged timber to obtain grey/green/red volumes, tree heights, species, and density of regeneration. The technology needs to be tested.*

(xv) Timeliness is particularly important in the context of MPB. There's a specific bio-window. It is not operationally possible to collect data for the whole province, or even sub-areas, with a single sensor [that has the information detail desired], simultaneously. Trade-offs between spatial extent, resolutions, cost, etc. need to be taken into account.

(xvi) Don't know – Malcolm Gray does? Mike Lodin does??

(xvii) The most useful product for a variety of uses would be colour orthos made from 1:30,000 photography.

(xviii) Conventional aerial photography (multi-use product),

Provincial Aerial Photography Program

8. How will the added value of digital imagery over sketch mapping be assessed in strategic and tactical planning?

(i) Added value will depend on cost, timeliness, and lifespan of the data.

(ii) Digital imagery should be compared and assessed by the front line people involved in MPB detection and monitoring *not* by Victoria. The Forest Entomologists, Forest Health staff, and forest licensees should conduct cost benefit analyses to determine the best method. These tests have been conducted in the past, with a favourable showing, but Victoria (the MSRM) will not fund any form of satellite or digital aerial photography…hence progress is stalled.

Digital aerial photography is a cost effective alternative with the additional benefit of having current photographs that can be used for other projects. For example, I have seen my photos being used to show recent landslide damage, compliance and enforcement, riparian monitoring, fire hazard rating, etc.

(iii) Digital imagery needs to be contrasted with regard to cost, timeliness, spatial integrity, modelling capacity (i.e. detection using spectral analysis).

(iv) Do a cost-benefit analysis supported by on ground field evaluations.

(v) Advantage of digital imagery is that it is repeatable and consistent. We can judge the accuracy and we can generate consistent year to year reporting. Imagery is much cheaper and turn around is much quicker than manual methods. We are not dependant on the competency of a small number of individuals.

(vi) I think you have to look at the spatial accuracies as well as the interpreted accuracies.

(vii) Digital imagery (satellite, digital airborne, scanned photographic) will be assessed based on its ability to deliver needed information within the time constraints of the tactical and strategic operations.

(viii) Re: 8 & 9 – Coordination between stakeholders to maximize the value of digital imagery will result in far more value than the cost to each stakeholder. Cost is only an issue in the absence of value. The demonstration of the value of digital imagery is severely hampered in B.C. by the "rules based" paradigm currently in place.

(ix) The added value of digital imagery (vs. sketch mapping) must be put in context with the turnaround time and cost. Sketch map data is compiled and available for viewing as early as the first week of October for over 80% of the entire provincial forested landbase for a cost of <.005 $/ha. Its purpose is to summarize the general forest health conditions across the landbase and be comparable to past data.

(x) Information needs must drive data choices.

(xi) Based on obvious factors such as need, level of detail achievable, cost, accuracy, etc.

(xii) Digital orthos are the way to go. Can be used for a variety of other purposes as well.

9. Would newly acquired imagery be used for other resource management applications and if so, for what, and to what extent? If shared across programs and applications, specifications of the imagery would be designed to meet these applications. For example, if imagery would be shared by VRI and TRIM, optimal scale, stereo coverage and photography specifications will be determined by combining the needs of these programs. Presumably this creates a stronger business case for these investments.

(i) Would use aerial photos and orthos subject to (8) above.

(ii) Scale, resolution, colour or B&W and format (hard copy / digital) of newly acquired imagery will influence its use to other resource management applications. For VRI ,TEM etc. photography scales equal to or larger than 1:20,000 are preferred for most areas and colour not infrared. There are claims that Spot 5 / ICONUS, etc. imagery can do VRI, etc. It is not proven yet!; however it may have a place for monitoring, but costs and actual results need to be tested further. Proprietary issues with licensing also.

(iii) Digital aerial photography could be used as a supplement to the existing TRIM program…not as a replacement. That way, the strengths of each approach are utilized. A thorough management plan might have conventional aerial photographs acquired every three years (made into TRIM orthophoto mapsheets) and use digital aerial photography in between those years as a cost effective detection tool with the added beneficial possibility of being utilized for other projects.

(iv) My proposal envisaged acquiring and processing FREE imagery of low spatial and high temporal resolution. Analysis of this imagery could be useful for a large number of other potential applications but the FREE cost precludes having to justify the cost of acquisition and processing of this imagery by associating it with other potential inventory uses. I can see how the imagery could be used to maintain a database of forest cut block entities and fire affected areas. It could be used to assess local climatic conditions such as frost pocket locations. It could be used to monitor, in near real time, instantaneous status of forest stands with respect to relative dryness or wetness of forest stands with a view to assessing forest fire risk. These are just a view of the potential other applications.

(v) New imagery will be needed to make stewardship decisions around the potential relocation of OGMA's and other biodiversity reserves.

(vi) Imagery: agree on need to share but someone needs to set standards on what each type serves which purpose: Landsat vs. Lidar.

(vii) If new aerial photography and or satellite imagery is acquired these photos can be used for other projects. This data could be used for VRI , VRI update, TEM, TSM, orthophotos, TRIM and TRIM update. Data is freely shared across government.

(viii) The use of newly acquired imagery for other resource management applications will depend on the applicability of the data to the application. The value of these types of imagery versus sketch mapping is that these data sets can be used in a multitude of other applications and archived for future use in monitoring changes.

(ix) Multiple use imagery is the only way to go. Current FIA eligibility criteria ensures BMGS's standards are followed.

(x) I don't think we want to do this. We must have a multi-temporal inventory to assess the progression of the infestation and shelf life. It has to be done rapidly over large areas. To me that means it has to be cheap on a per hectare basis and that means that imposition of a bunch of standards that would make it all things to all people is completely out of the question. We already had an experience last year where photography that would have been useful to MPB suppression efforts was not flown because it would not have met cloud cover standards for "generic" aerial photography.

(xi) Potentially any imagery acquired for MPB use could be used for other purposes. The application would depend on what type of imagery was selected. Other uses might help fund the MPB program. However, decisions on which imagery to use should be driven by other uses to the extent that MPB information needs are not addressed.

(xii) Scales smaller than 1:30,000 are not good for VRI.

(xiii) Stereo coverage is not an issue (provincial standard!). This is a requirement for all Provincial and FIA funded aerial photography projects as per CBMAC.

Cost-share potential.

1:30 000 scale photography available.

10. Growth and yield - what will be the role for:

- Existing PSPs in these stands? Do we need to identify them, classify by attack stage and remeasure?
- New PSPs: will we need these and if so do they need to be stratified by things like dry vs. wet sites?
- Models: do we need to develop modules to address the changing stand profile?
- The MOF Research Branch and their researchers (e.g., the TASS model, Experimental Plot data, site productivity models and information, etc.)?

(i) PSP's will need to be identified as they will be resource features for research under the MoF General Actions Regulation. We need to investigate the opportunity to assess changes to stand dynamics in response to MPB for partially affected stands or we could compare the second growth managed stand characteristics with those of the previous stand as measured by the PSP. This will require the development of a forest health matrix in conjunction with MoF and MSRM. PSP's are purposeful samples covering a range of stand conditions but they are not monitoring samples as a function of this sample establishment design. If you want to monitor stands you would need to have an unbiased sample design but you would need to ensure a broad range of stand conditions were included if you wish to use these for model calibration. Although some models may address complex stand structures they are not adequately calibrated for these MPB selection harvest stands with standing dead trees. The strategy should incorporate the collection of sample information and model development to address the growth and yield of regeneration in stands with standing dead trees.

(ii) Yes!

(iii) GY information will be needed to connect stand level impacts to remote sensing information.

We need information on stand succession following attack for a variety of stand types so we can priorize harvest in those that will not recover easily.

Was this document sent to MoF Research Branch for their input?

(iv) PSP's will play an important role in monitoring and assessing the growth of residual volumes, advanced regeneration in strategically abandoned stands, and treatment responses to enhance mid-term timber supply (fertilization and density control of stands at various stages of development).

(v) G&Y: Existing PSPs may have some utility but I expect attack dating issues will be a problem for some applications. If new PSPs are needed, we should consider the monitoring standard for dual purpose. But I also have some concerns about plot size and

capturing the MPB stand structure mosaic. We must have clear business needs before proceeding. Consider both short-term (mortality, shelf-life) and long-term needs (regen, growth modelling). PSPs are a logical project for a G&Y Co-op, with proper incentives.

We are lucky that growth model development has emphasized complex stands for some years already (TASS and Prognosis), but we still have a ways to go. Much of the current G&Y research and modelling (FIA-FSP) is either focused on, or directly applicable to MPB issues. Some thought also needs to be given to VDYPs future role in unsalvaged stands. Regen in unsalvaged stands seems to be the main unique MPB G&Y issue. We should encourage development of MPB regen models that are compatible with all our existing G&Y models. Old PSPs might be a source of post-MPB regen data. Early indications suggest unsalvaged regen is still slow to non-existent. The current outbreak clearly can't give us any quick long-term data. What about previous attacks? Attack dating will be an issue.

G&Y staff in MSRM and MoF-RB need to be engaged in this exercise early on. Collecting data that won't interface with G&Y tools would be a costly mistake (again). We should consider TASS as a TSR yield curve generator for unsalvaged mosaics, similar to its current use in Variable Retention. We'll what some research support for the G&Y of species alternatives. What about the lack of realized genetic gain trails for spruce? If we have fires, high pine densities could become a problem. We should not let old research areas get ignored just because they don't have MPB in their title – it's all the same basic biology.

(vi) G&Y: these were my bullets so won't comment other than when we turned PSPs over to industry, they, for the most part, stopped doing the work. Managing and maintaining a PSP Program requires dedicated staff and dollars. Also, if we decide we need new PSPs could we install them for joint purposes such as addressing both growth and monitoring needs?

(vii) Growth and yield – Existing plot data will be valuable to document the impact of overstory mortality on regeneration response. Rehab decisions require some projection of the yield in damaged stands to determine if it is beneficial to rehabilitate stands. PSP data is vital. Few models predict the response of understory regeneration following various degrees of overstory mortality. This will be a common G&Y issue throughout the beetle kill area.

(viii) The potential short- and long-term utility of PSPs (existing and new) and various models should be assessed as part of this review.

11. There is presently a limited contractor community. Many have been laying off staff rather than building up their personnel. Will this be a factor with some strategic options?

(i) #11 is not relevant to this process and not a factor.

(ii) True. Yes this could be a factor.

(iii) I laid off eight full-time staff when the MSRM refused to approve digital based aerial photography as a detection tool. Now, most of my work is urban photography.

(iv) Should not worry about contractor community availability as they will respond to opportunities that present themselves.

(v) Capacity is always an issue. To the extent capacity just shifts between gov't, consulting or industry, it didn't disappear. But there has been significant retirement and migration too. Increasing demand will help.

(vi) Contracting resources: could be an issue if a lot of work is supposed to occur in a hurry.

(vii) Obviously time frames and the amount of work required might be limited by what is left of the VRI contracting community. Staff are not just being laid off; they are retiring. Some contractors still around may be involved with other VRI work and not available at times for beetle re-inventories? There is also a government VRI community that while busy may be under utilized with respect to their field of expertise because of government policy.

(viii) Consultant capacity and skill levels could be a significant issue. We would need to ensure that suitable training and certification opportunities are made available. This ties directly in to the long term funding for a long term strategy. The cyclical nature of VRI activities and funding has not provided support to maintain the skilled personnel and we should investigate how those participating in the short term assessments could move to the long term monitoring program.

(ix) Very likely. If you design a "big" solution it will take time and money to assemble the required teams of contractors. I believe that I have designed a "small" solution that could be implemented quickly and easily using one or two people at a very low cost. My suggestions presuppose a limited budget and a limited resource base.

(x) If there is a market for services the contractor community will react far quicker than government.

(xi) Build it and they will come … but only if there is some assurance that government is investing for the long-term.

(xii) With the budget down-sizing over the past four years, the contractor capacity has been diminished. It would probably take a year or two to start bringing back the capacity of the contracting community. Funds would also need to be allocated to refresh the existing training program or modify / develop the training to accommodate the 'new' inventory program.

(xiii) Obviously in-house and contractor capabilities will have to be considered in this review.

(xiv) Availability of contractors will be a major issue. Or, if work is there, companies will find staff.

What will be the availability of <u>trained</u> government staff in 3 years, 5 years? Without properly trained staff, a tenfold increase in the MPB budget will mean little.

(xv) The big factor seems to be the availability of a constant funding source. Contractors can usually change their expertise very quickly if money is available.

(xvi) Work out a 5-year plan and communicate so private sector can ramp up and provide services. Have multi-year contracts.

12. Is there a need to factor in any considerations for forest fires? Some say it will not be an issue; but what about the seemingly wild swings we are seeing with weather patterns?

(i) Forest Fires. I think protection needs quick turn around with imagery and inventory / assessment of fire damage. Digital photography offers opportunity here but Digital Standards are not in place with BMGS. For Inventory, fires can be updated into the database as available, satellite imagery is an alternative source at the end of the season; something that protection can not afford to wait for.

(ii) I would think so.

(iii) The significant fuel load, backlog of salvage harvest and recent drought conditions should all be significant issues for consideration as we need to manage for outcomes of the MPB.

(iv) Yes! In my mind, the design should be one that attempts to monitor and map ALL changes in forest land use/land cover. One of these changes is that which arises from loss of forest cover due to forest fires. This is just another type of change in forest cover and the design for the inventory and monitoring system should be able to identify and record this change along with any changes that are due to insect infestation and tree kill.

(v) This is very important. With limited resources, Protection is seeking to value rank areas to assist in the deployment of suppression activities (currently life and property, and all else). There is also a need to identify natural fire breaks or barriers, and link these with manipulated barriers (increased acceptance of deciduous) to create positions to either start suppression actions from, or to establish barriers for allowing the re-introduction of fire onto the landscape. There is also a social need to assist rural and remote communities struggling to locate insurance coverage for their properties. Fire Management Plans will address some of the concerns of the insurance community.

(vi) Fire in MPB mortality should be a big concern, but it just creates another large-scale disturbance that would have to be captured by inventory. Another reason to design a dynamic system now. I think we should at least consider fire in the design. It would make it transferable to non-MPB fires, as well. Climate change may also support a dynamic inventory design.

(vii) If we are going to have lots of dead trees out there for some time and estimates of both dead and standing trees and CWD may require detailed ground survey info.

(viii) Forest fires may be the biggest threat to successfully salvaging MPB areas and may variably impact reforestation. If large MPB infestation areas are struck with lightning, some of these areas may be engulfed in fire storms that severely damage the soils and forest ecosystems. In other areas, fires may result in massive pine seed release resulting in new even aged stands that are greatly overstocked. The rapid response of fire crews to areas with the potential for fire storms may be a critical issue, especially in populated interface areas.

(ix) A shorter fire return interval (closer to 60 rather than 100 years) will aid in maintaining a MPB resilient landscape.

(x) Fires. Protection Branch has a good handle on fire inventory. FAB includes fires in their LRSY calculations.

(xi) Yes – the new inventory paradigm that should come out of all this must adequately address all disturbances that occur – not just logging and mpb.

(xii) Forest protection effects of MPB activities must be considered.

(xiii) Yes, forest fires will be a large issue with the future amount of decadent stands.

13. What are the pros/cons regarding Area based vs. volume-based AAC in terms of timber supply calculations and allocations, and with respect to the development and monitoring of operational and forest stewardship plans?

(i) Q. 13 & 14: Leave this question to Timber Supply specialists to answer.

(ii) Area vs. volume based AAC: don't know, what are the expectations of DFAMs?

(iii) Not really sure what the link is – would it be easier or more appropriate to determine AACs on an area or volume basis in MPB areas? There would be some issues in beetle areas given the amount of non-pine volume that's involved (any harvest of non-pine eats into the mid-term timber supply). Area-based AACs might create some problems in that context, but implementation of volume-based AACs can also be difficult for the same reason.

I wonder about the possibility of allocating total volumes of wood (together with some kind of practices requirements) rather than trying to figure out an AAC, which requires shelf life estimates.

It seems to me that harvest level determination in the context of the beetle involves determining where the damaged wood is; determining where the industry can operate economically; minimizing "collateral" harvest of non-pine timber; deciding on what to do to protect environmental values. More information about post-disturbance dynamics would help determine what longer-term implications might be. I wonder if information on what remains post-attack could help to develop treatment priorities. For instance, if there's a pretty good understory left, it may make sense to leave the stand alone rather than log and reforest.

(iv) Area-based AACs may not look so good (flat) with an MPB uplift in place. I'm not convinced they would streamline the TSR process. A lot of complex forest modeling still has to occur for the other forest values. They don't change the fundamental need for resource inventories, although some might feel they further shift the responsibility away from gov't.

(v) Area based AAC could reduce need for inventory update.

(vi) The determination of AAC is founded on certain harvest flow assumptions such as conversion to PHR (regenerated managed stand analysis units with higher productivity),

removal of older stands (potentially stands at risk such as Pl or stands declining in productivity and volume). This current MPB infestation has altered our consideration of AAC as a management tool and the issue is how to best preserve the economic and other resource and environmental values of the landbase.

(vii) I think the pros of an area based system far outweigh the cons.

(viii) Let's leave this one for a later date!

(ix) These must be considered as part of this review. This questionnaire doesn't provide an adequate platform for such a review.

14. Tenure impacts – tenures will be unevenly impacted. How will this be handled; what information will be needed?

(i) It's a natural disaster; the affected parties need special treatment (aid) of some sort.

(ii) I believe this is outside scope of this project.

(iii) Tenures will be unevenly impacted both in the short and long term. Harvest rates, and cut profiles and markets for these products will not be constant.

(iv) Clearly this is true. This is an area outside my expertise. Even so, it is clear that you will need to know what forest stands are impacted, where and how severely if you want to address issues related to uneven impact on different tenures. The system I propose will allow you to identify where and how severely different stands are impacted and to use this information to address tenure issues.

(v) Of course tenures will be unevenly impacted –the implication is that industry will have to be compensated for this….tricky business.

(vi) An assessment of MPB effects on tenure must be conducted at some future point. How those effects are handled will likely be a political decision.

Possible Scenarios

General Comments

(i) We need to bring the resource users into partnership with the MSRM provincial Remote Sensing Strategy. This would ensure a broader coordination of acquisition of the data. Licensing issues with the vendors will need to be resolved in order to deal with access to and distribution of the data.

(ii) Scenarios are driven by remote sensing requirements. Our inventory is calibrated at a stand level and it is difficult to envision how and MPB strategy could address tree level information given the budget, technology and time constraints.

(iii) Scenarios 1 and 2 do not seem to relate well to the Key Challenge Statement. Possible the following approach would be more successful at meeting the challenge:

- Short-term – Use forest health information or a modification of this information to meet short-term information needs.
- Carry out VRI after infestation has run its course.

(iv) **NEW IDEA:** What can be learned from the 1980s outbreak in the Williams Lake TSA with regard to what kind of information should be collected and when? Inventory information has been collected on attacked stands in the Chilcotin and was incorporated into Timber-Supply. A great deal of experience might be available here.

(v) There are several business decision points that need to be factored into these scenarios.

Short Term:

Forest Health and forest operations need timely access (usually by September / October) information on MPB infestations in order to move on forest harvesting strategies etc. As pointed out in the discussion on remote sensing (items 17 though 19) not all remote sensing products can meet the detection standards and be used in forest planning activities.

Different sensors can provide different timelines (i.e. regular predicable orbits when imaging can take place such as LANDSAT, or order specific oriented data acquisition such as SPOT products.) Many of the products are dependant on the weather so there is no guarantee that you will get a useful product.

Using remote sensing products for forest operations and forest health issues in the timelines they need will be a vigorous discussion.

Mid to Long Term:

Having said that, good quality, medium resolution imagery is already being used by the Resource Information Branch, Vegetation Update Section to help update the VRI for disturbances. LANDSAT 7 or better digital products are used to map disturbances directly into the VRI. The major issues remain mapping partial disturbances. With access to good quality images and linking into the RESULTS data base the spatial portion of the update of the VRI could move quickly to meeting an annual maintenance cycle. Issues such as attaching attribution to the disturbances would need more work.

(vi) 1 through 3: just don't know; why are we discussing this prior to figuring out the business needs? All of this will get dealt with in the next level of discussions (after the strategy is completed) by the technical people. If you get into discussions such as these during the workshops you will not complete figuring out what are the business drivers.

(vii) All 3 scenarios are good. Scenario 1 and 3 are short term whereas Scenario 2 is long term. It is important to have both a short and long term strategy.

(viii) The possible scenarios could incorporate much of the data already collected in terms of spatial/temporal models of beetle spread inside stands and across landscapes. The GPS linked spatial patterns of disturbance could be tied to a PEM type product based on existing inventories.

(ix) Scenarios need to be built around the information that is needed and the time frame it is needed in – not the technology that is available. From an inventory perspective I think we need to know:

- *how much pine is being killed over time and space. We need this information now to accurately project the course of the infestation and to assess short term timber supply impacts.*
- *what is the shelf-life of beetle killed wood for a variety of products. We do not need anything like the kind of detail that industry requires on this topic but we need basic information and we need it now.*
- *how will beetle killed stands regenerate under a variety of starting conditions (biological and physical) and management (no management, prescribed fire, logging, etc.). I think we can wait for this information until after the infestation has passed in a given area.*

Items 2 And 3 do not benefit from "remote sensing" technology except perhaps during the sample design phase. You have to go out there and measure things that you can only "sense" from up close.

Item 1 requires some remote sensing technology to do properly. It is my sincere hope that the remote sensing community can deliver on a program. Given the multi-temporal nature of the problem the solution is going to be expensive. The trick (aside from actually getting the information out of remotely sensed data) will be designing a program that costs as little as possible and still provides the needed information. I do not think we should look at this a being expensive and therefore it should have to provide a generally useable product. I think we have all been burned in the past by programs that tried to develop products for the "anonymous user". They take a LONG time, they become MORE expensive than people estimate and none of the "real users" are particularly happy with the results.

That does not preclude collecting some of the data in a way that it would be useable for other applications.

(x) Isn't this too early to be making such decisions? I expect that a combination of satellite imagery for detection and aerial photography for mapping, with some ground sampling and monitoring, will be the recommendation. Defining the appropriate combination will have to consider available resources and the value the BC Government and forest industry place upon the data and information.

Scenario 1: Enhancement of current inventory and update models with some improvements

This scenario would involve reliance on low resolution satellite imagery for reconnaissance, selected aerial surveys for stand level data and cruise information for tree-level data. It would address the following basic needs:

- Temporal discrepancies between currency of existing inventories and the need for current information on infestations.
- Maintaining inventory at stand level and insect damage at polygon level.
- Developing standards, procedures and metadata for mapping of infested stands.
- Reliance on sketch mapping will be reduced.
- Integration (update) of infestation information into existing inventory (VRI).
- Data inputs and outputs will be specific to forest health information.

(i) Low resolution inventory to meet immediately political needs! Certainly has some use.

(ii) The spatial and attribute resolution and collection standards would not favour integration of MPB infestation survey data directly into the VRI as this would compromise the integrity of the inventory. Information could be collected on a resource layer and used for analysis. This would avoid any mismatch of VRI and survey polygonal information. The majority of MPB management should be clearcut harvest and the depletion could be treated like any other depletion and integrate into the VRI at free to grow. For MPB selection harvest the impact could be modelled in the interim and verified as a photo interpreted update. I am not sure what they mean by maintain inventory at a stand level and insect damage at a polygonal level.

(iii) Scenario 1 is a good long term goal but won't provide information in the short term.

(iv) Scenario 1 appears to be the most cost effective approach. For the fifth bullet, strongly advise that the integration process be a modeled approach.

(v) Sketch mapping develops a unique product that is inexpensive, swiftly developed, and useful. No remote sensing data source can compete with the aerial overview survey, as the sketched data has large attack and small attack areas [equivalent of multiple spatial resolution], differing intensities of attack [areal generalization], multiple pathogens, etc. This sketch data is very useful for characterization of large areas. The sketch data may be augmented with satellite image backgrounds to aid in positioning of attack boundaries. A fruitful use of the sketch data is to consider it as the first level in an information hierarchy, that can guide the collection of more detailed (and expensive data) where necessary based upon management objectives. Integrate other RS options where appropriate - scenarios may be developed so that information needs are being met by the appropriate data source. Any plausible scenario should be tied directly to information requirement and not to proprietary sensors or data sources. Technological advancements will constantly occur, providing greater possibility to meet these information needs.

Polygon decomposition can be used to easily integrate information into existing inventory data (See Wulder et al 2005).

(vi) My ideal scenario for kill rate information is very close to your Scenario 1.

- *Get satellite imagery at as high a spectral and spatial resolution as we can afford for the entire area of interest. Ideally this would be the entire province. I am trying to look to future applications such as updating all harvesting on the coast and updating for the spruce bark beetle outbreak that is just around the corner. I am not too sure but I don't think we have to get much in the way of retrospective data – we might be able live with starting in 2004.*

- *Get a well-formed sample of aerial photography of the satellite imagery. This has to be multi-temporal. Build on the work that FPB did last year for the southern part of the province – but we need samples in the hard hit areas as well.*

- *Get a well-formed ground sample of the aerial photography. This is going to require a lot of plots – to start with at least. We need to ensure that the plot work is focussed on kill levels only in order to get a large sample efficiently. I don't know much about it but I think that a set of prism plots at each location, identifying species and kill class (grey, red, or green attack) is all that is needed. There will be a tendency to try and collect a bunch of stuff at each plot (shelf-life and regen). This other data needs different sampling regimes. We should resist the tendency to create multi-purpose plots.*

Scenario 2: Strong reliance on aerial photography, some hyperspectral sub-sampling and cruising

- Planning of acquisition of aerial photography will be coordinated with the needs of other applications (e.g., VRI). Specific needs of VRI (stereo imagery), not essential for forest health surveys, will be accommodated.
- Optimal type and resolution of imagery (e.g., colour infrared 1:15,000, or finer) will satisfy the needs for current operational inventory programs in BC.
- Hyperspectral sampling will help to assess spectral characteristics of outbreak

(i) **Proven technology that can meet the needs of a host of inventories, operation and other uses. Need to get BMGS motivated in assessment of new digital technologies.

(ii) As both VRI and base mapping can be achieved using a scale of ~ 1:30,000 in soft copy systems, the expressed need for 1:15,000 is overkill. Cost/benefit analysis of these two scales of imagery will confirm.

(iii) Colour infrared photography, regardless of scale, is pretty much single-use imagery. Also difficult for reproduction. Perhaps for this type of remote sensing, digital sensors may be more cost effective. Is this part of the CBMAC umbrella? Is the mapping of diseased trees part of Base Mapping? Part of the PBA?

Provincial aerial photography specifies stereo imagery for all applications (multi-use product!)

1:15 000 or 1:30 000 scale colour negative photography!

(iv) I like scenario 2 as being a pragmatic balance between what is available and operationally feasible at present. The unknown utility of satellite imagery for inventory applications and other applications make the use of digital aerial photography & LiDAR obvious choices for a transition to more innovative, objective and cost effective solutions to the forest management challenges facing B.C.

Scenario 3: Full multi-scale, multi-source approach involving satellite imagery

Examples for this scenario might include Landsat, Aster, Hyperion, SPOT; airborne drone- or manned- infrared and hyperspectral. It would involve full use of existing and newly acquired field data.

- Most complete and complex option.
- Significant technology transfer and training component.
- Will enable incorporation of summaries of mortality by location, species, causal agent and severity into existing inventory.

(i) Not proven and doesn't (at this time) meet the needs for VRI, etc. Some elements should be utilized over time to assess potential and further develop.

(ii) Scenario 3 points:

- Landsat 7 stopped communicating in 2003.
- Hyperion is still only 30m resolution, insufficient for single tree detection.
- Higher resolution satellites are more effective at resolving beetle detection (Spot, Quickbird, and Ikonos). Unfortunately, Ikonos and Quickbird are more expensive than digital aerial photography. SPOT is limited by a 10m multispectral sensor. SPOT imagery cannot be used for single tree detection.
- Infrared (whether film or digital) does not show green attack. Infrared imaging does not offer additional information.
- Hyperspectral imaging cannot detect green attack. It is a complex costly alternative to conventional aerial photography (analog or digital).
- Forest health surveys do not need to be conducted in stereo. The detection of a red tree can be easily seen and identified by a "non VRI person" from a photograph or digital aerial photo. Most forest health government staff, entomologists, and forest health consultants are not VRI trained, but they have years of experience conducting forest health surveys (sketchmapping, Heli-GPS mapping, photo interpreting, etc). The idea of having only VRI approved technicians conducting forest health surveys discounts significant expertise. Forest health surveying in stereo also takes longer to perform, hence delaying results.

(iii) Scenario 3 is complex if it tries to provide information at the polygon level. As a strategic overlay, it could be a possibility.

Scenario X: What other scenarios can you envision?

(i) Additional scenarios:

1. Develop retention plans. Identify what won't be logged. Prioritize for inventory update once the beetle has passed through. We have some time with the current AAC uplifts that are in place and don't have to have the updates done until the beetle has moved through and condition stabilized to point that uplift not required. For logged areas, we can rely on the normal update cycle through harvest/silvicultural reporting.

2. Continue reliance on sketch mapping and licensee surveys to provide operational data.

3. Use aerial photos for VRI update purposes, but not for detection.

4. Don't invest heavily in remote sensing unless able to deal with some of the other issues such as shelf life, location of green attack, etc.

(ii) Inventories and Inputs needed:

- Thematic map of attack ages. i) Satellite Imagery 1998? -2005 - used to determine the age of attack for the Quesnel TSA for use in decay sampling. ii) Colour Infrared orthophotos* - used for the % of live, green Pl trees or other species within attacked FC polygons. Planning maps indicating levels of attack (i.e. % unattacked Pl volume). Ground truthing done by beetle probing to annually update polygon information.

- Reinventory of VRI focusing on immature Pl and Non–Pl stands using orthophoto or colour infrared.

- Site productivity information for developing harvesting and silviculture strategies. PEM inventory using Land Mapper model, (Inventory Inputs: TRIM, DEM, Materials Mapping, Big BEC).

- Pl shelf-life information. VRI fixed plot sampling ages of attack by BEC subzone/variant (Dry, Intermediate, Wet) to develop decay curves. Shelf-life sampling can also provide information on natural regeneration by subzone/variant/site series.

- All of the Quesnel TSA is currently designated for Pl salvage. Level of attack will only be useful in cases where forest cover has been misclassified – e.g. Pl mixed stands. Planning maps of attack levels will be more useful for TSAs with aggressive and containment strategies.

Analysis Scenario

- Use Ministry Type II Forest Level Silviculture Strategy to do the analysis.

- Pl coverage with decay information

- New VRI with a better immature stand inventory

- Silviculture scenarios (Genetic gains, fertilization, CT/Fert, rehab Pl, alternate planting densities, alternate species plant, natural regeneration, etc.)

- A linear programming model Woodstock is used to apply each silviculture treatment scenario to the land base. Comparisons are made of the harvest forecast and financial viability (NPV) of each treatment to the base case.

- Development of Preferred Silviculture Strategy scenario made up of treatments with significant positive impact on the land base

- Use linear program Woodstock with Stanley (Spatial) to produce 1:50,000 maps of areas to harvest/treat under PSS scenario.

(iii) Scenario X – for 2A. Continue monitoring beetle damage conditions annually with the provincial aerial overview survey. For refinement, use change detection of past and recent LANDSAT imagery to confirm location and relative severity of overview surveyed polygons in salvage and holding BMUs. Heli-GPS data documenting the location and severity of spot infestations will continue in the remaining suppression BMUs. For areas where the beetle outbreak is largely completed, begin a full inventory starting with a large colour photography project using directed FIA funding cleaved off the top of the FIA budget and carried out by MOF/MSRM. Ground based inventories could be carried out by industry – like forest health suppression activities – by using directed funding. Licensees could supplement the inventory efforts by contributing individually through FIA LBIP funding. This inventory would begin with multi-use conventional colour photography suitable for all planning and base mapping.

Licensees should be encouraged to purchase SPOT 5 imagery to optimize their harvest by cutting only recently killed timber and minimize non-pine volume in holding action BMUs and recently declared salvage BMUs. MOF isn't too interested in purchasing such imagery for beetle management although BCTS would probably want to obtain it for operational planning.

Use LiDAR to sub-sample salvage areas where non-recoverable losses will be highest (i.e., not yet developed, young stands, etc.) to determine the rehabilitation priorities. Licensee should also be encouraged to utilize LiDAR as a means of identifying the proportions of live vs. dead vs. recently killed volumes although this data could also be derived from other less data intensive means.

(iv) Short term scenario:

- *It would be useful to re-measure some of the existing VRI Phase II samples in Lodgepole Pine stands to determine the timber supply impact. These samples are randomly located and could determine statistically the beetle impact. One place to start would be the re-measurement of the Vanderhoof samples.*

Long term scenario:

- *Establish random VRI Phase II samples in non infested areas.*

What questions, concerns, and opportunities do these items raise in your mind?

(i) The bark beetle problem is a serious epidemic that is extremely damaging to the BC interior forestry communities. I would like to see the government focus on results based MPB detection products. Forestry officials in Victoria have been changing their minds year after year as to which is the preferred beetle detection product. They used to say that only sketch-mapping was approved, then there was significant interest in CASI hyperspectral imagery, then Landsat was to be the ultimate tool. Last year they stopped funding to everything except conventional aerial photography. This year, I heard that they *may* be interested in alternatives because the conventional aerial photography was not cost effective or timely. Their indecisiveness is unfair to forest health contractors.

The recent decision by the BC forest service to allow the MSRM to impose and facilitate their rigorous mapping standards for MPB red attack detection has backfired. The MSRM hired a Quebec company to conduct the entire provincial photographic beetle detection contract (leaving all local provincial contractors without work), and mandated that all of the beetle detection was to be performed by VRI specialists only (in stereo). Unfortunately, most of the VRI specialists work for large photogrammetric companies, thus again ignoring the expertise of local consultants / contractors forest health staff, etc. The government should respect the communities that they represent and hire utilize present expertise. The government should also live up to their mandate of results based forestry and set out a list of criteria that needs to be achieved for beetle detection contracts. Finally, the BC Forest Service should not allow the MSRM to control beetle detection surveys. The mandate of the MSRM is to provide accurate spatial data, they have **no** interest in products better suited for beetle detection.

(ii) VRI database could be expanded NOW to include attributes for future monitoring. This doesn't mean the data has to be collected right now, but it will at least provide a place to put the attributes at a later date as inventories are collected. This may not help in the short term, but would help with monitoring in the long term. There is an opportunity to change the VRI database within the next 6 months probably. After that it will be very difficult to make changes. Please keep that in mind.

(iii) There is a cost associated with all of the potential action plans that may fall out of this work – who pays – will the government accept that it is their resource and their resource that is losing asset value the longer we wait after mortality?

Community impacts – we talk about this in the Key Challenge Statement and then seem to not address it much after.

(iv) It is not yet clear what our attributes of interest are.

- Are we interested in the intensity or extent of the beetle attack?
- Are we looking to quantify the amount of dead wood volume made available by the beetles?

- Are we looking to determine at what rate the attack is spreading to other areas?
- Are we looking for information on what will happen after the dead trees are burned or harvested?
- Are we looking for information that will allow us to forecast future attacks by beetles?
- Are we looking for ways to prevent such attacks by beetles or other pests?

A choice of which of the question above we would like to have answered will allow us to define specific objectives to address data needs for the applicable questions. It is difficult to evaluate the scope of what should be done without nailing down the objectives specifically.

(v) I'm not sure this is an inventory issue, but it will be important to think about how to deal with some of the uncertainties. For instance, what do we do in the face of uncertainty about "shelf life"? How do we set harvest levels in the face of that uncertainty? Should harvest levels be annual or simply provide a total volume that is available to the licence holder, leaving it up to the private sector on how quickly the volume should be harvested? How do we outline practices requirements the are consistent with any harvest levels we set? As applied scientists, foresters appear often to want resolution to uncertainties before acting. That's not going to be possible here. We may need to consider a mechanism to communicate on the limited ability to resolve all uncertainties and get people working on management and decision making processes that function in this uncertain environment.

(vi) Need to be able to collect attributes for longer term monitoring for resources and collection of live versus dead information for example which is not presently available. For the short term, at least provide strategic level information for TSR projection netdowns and aid in salvage area identification.

(vii) Stand quality before fertilizing? For example, low density Pl stands with bad taper and large branches and the potential of exacerbating low quality lumber production by fertilizing.

Setting harvesting priorities: harvest stands with high potential SI first.

What new ideas do they suggest to you that need to be addressed?

(i) An indication of how we hope to use monitoring data should be discussed. On the issue of quantifying of amount of dead wood, it is clear how the data can be used in TSR. But how do we hope to use monitoring data? Specifics on this, prior to completing the strategy would be helpful.

Are existing data collection methodologies suitable for collecting pest infestation information? Is it possible to explore alternative methodologies that are not consistent with the conventional techniques aimed at just determining the amount of timber volume?

(ii) As the dead timber declines in value will the type of data/information requirements also change? Will the business drivers from say a bio-energy industry be different for a stud mill or OSB plant?

What additional work do you think should be done to flesh out these ideas?

(perhaps ahead of the workshop so we are further prepared with resources for a productive face-to-face workshop session)

(i) Would a quick study to review literature on similar infestations outside of BC be useful prior to developing the strategy?

Would a summary documentation and analysis of past beetle attacks in BC be useful?

(ii) Mitigation – I am sure this will be addressed as the discussion heads to G&Y etc in some places – but maybe mitigation against timber supply impacts is a section on its own – may want this for funding leverage with Ottawa.

(iii) Need to consider assessment of forest resources based on new approaches to inventory and data management. Assessment needs to have a much increased frequency based on the increased magnitude of short termed changes – need to consider something between inventory and monitoring with respect to frequency of update.

(iv) Questions that need to be addressed at the start of the workshop:

- *Is the funding mechanism/delivery model being discussed? (it is currently a big part of the problem);*
- *What time frame are we looking at? Short/quick answers vs. longer, more accurate data? This will determine which route we take in image/data acquisition. "Quick and dirty" will open the door for non-traditional remote sensing tools while more conventional means will answer the more detailed questions.*

New ideas suggested:

- *Looking at alternative funding and delivery models.*

Additional work:

- *Need to have cost/benefits of LiDAR presented as well as its capabilities (and drawbacks) and expected time to be operational.*
- *Communicate what the most current Provincial MPB Action Plan objectives are (tied to the public announcement).*
- *Clarify government's position on funding data collection that reduces the cost burden on industry and improves their bottom-line vs. what is collected to benefit the province as a whole. Yes, this outbreak is a natural catastrophe but at the same time industry is making large profits because they are paying minimum stumpage. Shouldn't they be responsible for paying for determining where they can make the most profit or is government taking the position that they are willing to assist industry in any way they can?*

INPUT REQUEST 5: ANY OTHER COMMENTS YOU WOULD LIKE TO MAKE?

(i) Great idea – lets get on with it!

(ii) I welcome the opportunity to participate in this dialog. I hope that the results of this strategy session are beneficial and bring all parties together. Furthermore, this collaboration will be useful since it will condense ideas and hopefully come up with practical effective methodologies.

(iii) I was disappointed that this strategy did not regard the need to collect data and upgrade our growth and yield models (VDYP, TASS-TIPSY) to address the stand structures (standing dead pine with regeneration, selection or standing dead pine in complex stands) resulting from MPB infestation and management. I feel that this is a significant issue as we expect these models to project the stands and support operational models (SELES), strategic plans and timber supply review.

(iv) I would suggest that to make this Dialogue complete we need to engage some of the forestry conversion plant managers so:

- That the land managers have a sense of the emerging technologies and how the conversion plants may respond to the MPB issue to-day and in the future. Particularly on the kind of information the plant managers will need for investment strategies.

- That the conversion plant managers understand what the future inventory will look like so that they can respond to the changes taking place on the land base.

(v) Agree with the concept and would like to be a part of the process. Thank you for the opportunity to provide feedback in this regard.

(vi) I think this strategy is long over due and that projects such as the measle mapping could be being assessed right now for potential inventory uses while this Beetle Strategy is being developed.

BMGS should be included, as imagery may be an important component for any inventory work. We could be laying out potential photo requests right now, so that they are in place if any meaningful work is to occur this fiscal. They (BMGS) should also be requested to be prepared to deal with digital imagery if it is requested; start looking at what will be an acceptable digital standard for photos.

A start on VSIP's for critical TSA's to assess the current inventory. The Quesnel TSA is currently on the VRI priority lists for a VSIP; just need the funding to do.

You may have to just start doing some inventory work and see how it evolves concerning the Beetle Inventory Strategy and make adjustments as you go. Pick a bad TSA and run with a new VRI???

(vii) This is a very ambitious but worthwhile exercise. I hope you are able to obtain clear business objectives from the different user communities.

(viii) Nuf sed earlier. Thanks for the opportunity.

(ix) This initiative was needed two years ago, but it is better late than never. I hope this is not an exercise to develop a plan that languishes in the absence of senior support and resources to implement; there have been too many of these in the past.

(x) Just to reiterate I'd be happy to collaborate further, particularly on the G&Y and monitoring side. MPB is a priority for SIGY too.

(xi) Many thanks for soliciting my input which I hope is not too biased in any direction. If I can make any final statement if is this:

Hold the reins on technical solutions, particularly RS types, until you have figured out your business drivers. In other words, establish the criteria first, and then deal with the indicators.

(xii) Thanks for the opportunity to participate. I look forward to the results and also I would like to participate in the up coming workshop.

(xiii) RIC standards have been an impediment to innovative, cost effective ways of completing inventories. An example is the roadblocks that were thrown up to the DFAM groups when it came to using digital photography (e.g. Terrasauras).

(xiv) Should the strategy be focused simply on MPB or should we be considering other "natural disturbances"?

Is strategy simply reactive to MPB attack areas or is there some advance monitoring of non-MPB areas.

Should information such as Marvin Eng's report be noted?

(xv) Things to Address

- We have great concerns about the loss of timber supply due to MPB infestation. However, little has been given to looking at the natural dynamics of such an infestation and the potential benefits of not salvaging.

- We need to look at this outbreak as an opportunity for understanding MPB biology and dynamics. It appears to me (in my small world) that we are not putting enough resources into understanding what is happening. We seem to be spending a lot of resources trying to put out fires (i.e., salvage dead wood) rather than looking ahead in 60 years.

(xvi) An observation on the stakeholders invited to comment thus far in the process. I find it interesting to note that there are a limited number of licensees, lots from the Provincial Government and no First Nations representatives or members of the BC Community Forestry Association.

(xvii) I look forward to further dialogue and participating in this process.

(xviii) A critical piece of information that will need to be dealt with is the immature pine inventory in age class 5 and 6.

(xix) Looking forward to seeing what comes out of this!

(xx) This issue should be divided up into three different projects

1. *Map the infestation. It is a simple update process that can be done if it is funded appropriately. Fly new photos every year, create orthos and update the infestation codes. Satellite imagery is not useful for the detail that is going to be needed.*

2. *Sampling project to determine shelf life of dead standing timber. Sample on a matrix based on BEC and years since disturbance.*

3. *Establish a monitoring program to keep track of growth rates in the disturbed stands. Need it in both the plantations and the natural stands regenerating after infestation.*

Good Luck sifting through all the input. I know you will get lots of conflicting information.

Thanks for the opportunity to comment.

Appendix 1: A Generic Design for a System for Monitoring Changes in Land Use or Land Cover

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1.1 Introduction

The challenge of how to create, maintain and update spatial databases that provide information on changes in patterns of land use and land cover across very large areas is one that has interested me for some time.

I began thinking abut this challenge quite seriously in about 2000. My interest at this time was in devising a mostly automated system that could recognize, classify and map changes in agricultural land use for an entire province in a manner that was technically feasible, accurate, efficient, and affordable. To my mind, a spatially explicit database of land use was perhaps the single most important spatial database that was not available in any reasonable form for Alberta, or for that matter for any other Canadian province.

The design I initially conceptualized for that database addressed many of the same needs and challenges that are encountered in designing a spatial database to track changes in forest vegetative cover at the level of either cut blocks versus forest stands or healthy versus diseased forested stands.

In December, 2004, I was asked if I could provide any ideas for a system that would enable the province of Alberta to automatically recognize and extract forest cut blocks in order to automate the process of developing and maintaining a spatial database of changes in forest cover due to harvesting, human disturbance and fire activity.

In my view, the problem of identifying and mapping the spatial extent of areas affected by Mountain Pine Beetle is not terribly different from the problem of monitoring change in forest cover from forested to non-forested cut blocks or fire scars. There is a difference in degree of difference where forest to non-forest is virtually a binary operation from dark (forest) to white (non-forest) while pine beetle damage is somewhat more subtle, but otherwise the problems are conceptually similar.

I provide below a short description of a generic design for addressing the challenge of monitoring and transactionally updating a spatially explicit data base of information on forest cover status.

1.2 Problem Analysis

The main features of the problem can be identified as follows:

Firstly, the problem requires an ability to assess land cover and/or land use over very large areas up to an entire province in extent. The requirement for continuous coverage over a very large area

imposes a number of significant challenges in terms of simply acquiring and processing very large volumes of information. It has proven very difficult to produce cloud-free mosaics of satellite imagery for entire provinces even when images could be selected from archives that stretched over several years. Obtaining cloud-free high resolution imagery for an entire province for two or more time periods of similar dates in a single year is likely to be highly problematic. Even if two or more cloud free composite images could be produced for an entire for two different time periods in a single year, the volume of data processing might well prove to be prohibitive in terms of costs and time requirements.

Secondly, the problem of detecting the presence of areas affected by Mountain Pine Beetle and, more generally, of detecting changes in the health and vigor of forest stands affected by Mountain Pine Beetle is complex and is not likely to be well served by analysis of just two different image mosaics produced by compositing multiple images taken at different dates and different times of day and under different lighting conditions and different stages of seasonal growth. Relying on an analysis of differences in simple reflectance values between two images taken at two different dates (or more likely taken over a series of dates in two different seasons) is fraught with hazards. Pixel by pixel comparisons are subject to error caused by registration errors and displacement of pixels in space from their true position so that observed differences arise as much from comparing two different locations as from detecting change in forest cover condition at the same location. Comparisons of change in pixel values between only two dates is likely to be sub-optimal as significant changes may not be readily obvious for all locations at exactly the same two dates. The types of changes that are of interest are far more likely to be discernable in terms of yearly patterns of growth and reflectance for each site than in terms of a simple difference in reflectance values between two dates.

Thirdly, it is important to conceptualize and identify the size, scale and attributes of the object that is of interest for monitoring and change detection. If the object of interest is an individual tree and the desire is to be able to monitor the forest across the entire province to detect and identify individual trees that have been attacked by Mountain Pine Beetle, then the solution must target the recognition of objects as small as individual trees. While this may be a legitimate desire, it is unlikely that anything this ambitious would be feasible to accomplish given limitations of time, budget and available technology. One then has to ask what other objects might be profitably identified and monitored that are feasible and cost-effective to recognize. I would argue that a suitable object to identify and monitor might be defined as a forest stand, or a defined portion of a forest stand. A forest stand can be compared to a farm field. It can be thought of as displaying a relatively uniform composition in terms of type and pattern (density, age, height) of forest cover. Forest stands tend to behave similarly (e.g. age at a similar rate, be attacked by pests at the same time, etc). Forest stands also have the desirable attribute of being relatively large. Let us assume that most forest stands have horizontal dimensions of at least 500 m by 500 m and more commonly are up to 1 km by 1 km in size. If such stands can be identified and spatially located once, they can then form the basis for relatively large objects whose behavior over time can be monitored quite affordably using lower spatial resolution but high temporal resolution imagery.

In analyzing the problem, it is important to consider the utility and cost of using relatively coarse resolution cloud-free multi-temporal imagery that can be obtained frequently, on a short repeat cycle and at low cost versus using higher resolution imagery for which it may be difficult to obtain cloud free images for more than one or two periods of several months duration during a given year. Lower resolution, multi-date imagery, such as MODIS, has several distinct advantages as a data source for monitoring and detecting change in vegetation or other land uses at the scale of interest to the Mountain Pine Beetle problem.

To begin with, MODIS imagery is compiled and distributed at very low cost as 8 and 16 day composites of daily images selected in such a way as to minimize the amount of cloud cover in each 8 or 16 day composite image. An image mosaic can be constructed for an entire province of relatively cloud free images that are all taken within a short 8-16 day interval. The relatively large footprint of MODIS imagery (250 m) means that is it both feasible and affordable to obtain and process MODIS imagery for an entire province on a weekly, or perhaps bi-weekly, cycle. The ground footprint of a MODIS image (250 m) represents a reasonable trade-off between spatial detail and processing volume. If we accept that the target objects of interest are forest stands, and that forest stands are typically at least 500 m by 500 m in horizontal dimensions, MODIS imagery at 250 m footprint will provide a reasonable measure of aggregated surface cover characteristics within most forest stands of interest.

Next, one MOSID imagery product that is distributed is a Normalized Difference Vegetation Index (NDVI) that can be interpreted as a measure of relative "greenness" of the objects that occur within each MODIS pixel. The specific problem of identifying forest stands that are potentially affected by Mountain Pine Beetle, as well as more general problem of identifying changes in type and density of forest cover, are well served by analysis of multi-date images of "greenness index". One can consider that, for example, 12 monthly images of "greenness index" can be thought of as defining a characteristic graph or curve that identifies a yearly cycle of relative "greenness" for each object. This annual greenness graph can be interpreted in terms of kind of ground cover, vigor or health of the ground cover and density of the vegetative ground cover. Over a complete cycle of one year, a relatively treeless forest cut block will display a very different temporal pattern of "greenness" than will a thick healthy forest stand. Similarly, a forest stand whose health and vigor were adversely impacted by infestation by Mountain Pine Beetle would be expected to exhibit a different annual cycle of variation in "greenness index" than a healthy stand. Since the objects we are interested in monitoring are conceptualized as forest stands, the annual cycle of greenness values can be computed for each identified forest stand by computing mean values for greenness index rolled up for each stand at each image date. These mean greenness index values taken together over a yearly cycle form a characteristic curve that describes the cycle of variation in greenness within the object of interest over a year. These curves can be used in a manner that is similar to signature libraries used to identify organic compounds. The yearly greenness curve for any given object can be compared with a library of curves that represent typical cycles of greenness for different cover types. The cover type whose curve in the library most closely resembles the curve observed for a given object will be identified as the most likely cover type for that object. It should be intuitively obvious that a forest cut block will exhibit a different temporal sequence of greenness values than will a mature forest stand. Likewise a stand infested with Mountain Pine Beetle is expected to exhibit a different temporal pattern than a healthy stand.

A key advantage of using multi-temporal image data sets is that the analysis is flexible enough to deal with differences in dates and rates at which greenness (growth) occurs at different locations. Differences in the greenness value observed at different locations with the same cover type at the same date can arise due to differences in climate (temperature and moisture), latitude, longitude, sun angle and illumination and many other factors. Use of an approach that compares the yearly cycle in variation in greenness to a library of reference standards means that different locations can have very different greenness values at similar times and still be recognized as having a similar cover type, if both display graphs of variation in greenness that have similar shapes. The shapes of the graphs can be offset in the time dimension (horizontal axis) or in the vertical dimension (absolute value of greenness) but they can still be judged to be similar and to represent the same cover type, with differences in time due to differences in timing at which growth

becomes active and differences in absolute value due perhaps to illumination, shading or even relative vigor of the vegetation.

The problem of detecting and mapping changes in forest cover (or forest health) can be broken down into three main sub-problems. In the first instance, it is necessary to identify and spatially locate objects that one wishes to monitor for change. In the second instance, it is necessary to monitor these objects to identify when they exhibit a marked change in cover pattern, which we here recommend be identified using analysis of low resolution, multi-date imagery. In the third instance, it is necessary to confirm (or reject) the existence of an anticipated change and to update the boundaries of any objects of interest (forest stands, cut blocks) that have been confirmed to have undergone a change in cover type in part or in whole. These problems are not all well addressed by the same data sets.

The first requirement is to identify the objects that are to be monitored for change. The objects can be as simple as a single pixel in an image dataset. For various reasons, it is recommended that detection of change not be attempted on an individual cell basis. For one thing, there is the problem of spatial off-set due to image registration errors. For another, cell by cell comparisons create inordinately high volumes of data and increase processing time. For another, it is the characteristics and behavior of the larger objects of interest (e.g. forest stands, cut blocks) that is of importance for this problem and not that of individual cells. Working with pixel data aggregated within larger object areas equivalent to forest stands provides some leeway for accommodating errors due to mis-registration of images. It also greatly reduces the volumes of data that have to be stored, processed and interpreted. The actual process of identifying, outlining and classifying the spatial objects of interest is time consuming, may require a significant amount of manual human interpretation and will certainly require the use of high spatial resolution imagery. The good news is that this process of identifying initial objects for classification and monitoring only has to be done once. After the initial objects are defined, all subsequent efforts are directed at transactionally updating the object data base by identifying only locations where there has been a change in the character of the object and updating the spatial extent and attribute classification of the changed object. In the case of BC, it may well be feasible to use existing vector data on forest cover (FC or VRI) as an initial starting point for identifying forest stands, non-forest areas, cut-blocks and other spatial entities that will define the objects to be monitored. Existing manually interpreted spatial databases may be supplemented, or revised, through the use of automated techniques for identifying and extracting features or objects from image data (as per e-Cognition).

Once the objects that are to be monitored are defined, mapped and in place, the second part of the equation is to devise an effective and cost-efficient mechanism for monitoring those objects to identify if they have undergone a significant change in cover type or in the characteristics (health and vigor) of the cover type. This part of the problem can best be addressed using high temporal frequency, low spatial resolution image data such as MODIS. It is simply not feasible to acquire, process and interpret moderate to high spatial resolution image data for an entire province on a repeat cycle of several images per year. It is sub-optimum to attempt meaningful change detection using only one or two difference images per year of moderate to fine spatial resolution image data. Finally, it is not necessary, for the purposes of detecting change in objects the size of forest stands, to process moderate to high spatial resolution imagery for each object for each time period. All of these reasons argue for adoption of a monitoring methodology that makes use of lower resolution image data that can be obtained and processed at a high temporal frequency. The point of the monitoring data sets is not to identify the boundaries or extent of changes in land cover precisely, it is only to identify whether a significant change has occurred within a defined spatial object (e.g. a forest stand) that may indicate a significant change in health, condition or

cover type. The monitoring acts as a screening mechanism to raise flags for locations where a defined and mapped object has demonstrated a likely change in cover density, type or pattern. Once the broad brush monitoring has raised a red flag, the areas of concern need to be reviewed using higher resolution imagery to determine if a significant change has occurred and, if so, the nature and spatial extent of the change.

The third main sub-problem is that of transactionally updating the database of spatial objects to reflect any changes in cover type, pattern, health or other attributes that are identified by the screening process described above. Objects whose cover type has significantly changed need to be reviewed. New boundaries need to be drawn to partition an original object into two or more new objects if the observed change has only affected part of the previously defined object (e.g. part of a previously healthy forest stand is now infested with Mountain Pine Beetle and part remains unaffected or part of a forest stand has been harvested and pert remains). If the entire object has undergone a uniform change, then only the attributes recorded for the object need to be updated. In order to conserve space and in order to make it easier to track and identify changes in the object data base, it is recommended that only changes to the spatial object data base be recorded for any given time interval. All locations that have not been associated with a change do not need to record updated spatial information. Only those locations where an object has changed its boundaries are recorded, along with the date and nature of the change and the identity of the new spatial object that the location now belongs to. This time-stamped spatial database should be fairly easy to query to identify and display changes in status of the forest between any two dates or to display the current status of the forest at any current date. Since the spatial database consists of a series of relatively large spatial objects (forest stands and the like) it will be smaller and more feasible to manipulate and display than a pixel database of billions of cells. Attribute data need only be maintained for larger spatial objects and not for the individual pixel elements that make up each object.

1.3 Implementation details

1. You need to first define, delineate and attribute spatial objects that are not single pixels but are rather something closer in concept to the objects that you want to monitor for change. In the forest environment, the objects of interest are:

a) Forested stands
b) Cut Blocks
c) Fire Scars
d) Non-forested exception areas (urban, water, roads, rock, etc. - all pretty easy to isolate once and they stay that class thereafter).
e) Pine Beetle affected stands

2. To define these objects, you can certainly avail yourself of existing vector data sources such as VRI, FC and AVI (in Alberta). You probably need to verify these visually against a backdrop of background imagery. This is a big job and might be time consuming and costly but it can be done. JMJ has done manual on-screen recognition and digitizing of readily visible objects for me for pennies a hectare (< 3 cents per hectare). This job could theoretically be automated but it may not be cheaper or faster to look for automated methods of feature identification and extraction.

Where manually interpreted vector maps do not already exist, you can certainly look to using automated feature extraction or object recognition software to automatically recognize and extract spatial objects that exhibit a characteristic spatial pattern in image data. Many people are now

familiar with the concept of object extraction from imagery as performed by e-Cognition software. The idea here is to draw boundaries around known or obviously visible areas of non-forest (cut blocks or fire scars) so that you know which areas are in forest (and so can practically change from forest to non-forest in the case of monitoring harvesting activity or from healthy forest into pine beetle affected forest in the case of monitoring Mountain Pine Beetle activity.

3. Once you have these initial objects recognized, extracted and attributed the problem becomes one of monitoring the remaining areas that are designated as forested (at the level of forest stands and not individual trees) to check for dramatic changes in the spectral pattern within the mapped forested entities. In the reverse sense, you can also monitor the non-forest areas to look for dramatic changes that may indicate a return to forest cover from non-forest status. In your case, the problem is a bit more difficult since the changes may not be as dramatic as from forest to non-forest or vice versa. Still, the key is to define the objects first in any case as these objects become the things that you monitor for change (and not the individual pixels in a satellite image).

4. My suggestion here in Alberta (and it would be the same for you) would be to set up a monitoring program that made extensive use of lower resolution, multi-date imagery such as MODIS rather than to try to acquire, process and interpret the many hundreds of satellite imagery scenes that would be required to cover all of BC (or Alberta) periodically. The MODIS ground footprint is only 250 m as opposed to 20-30 for satellite imagery. However, most of the spatial objects that Alberta is interested in monitoring (cut blocks) are larger than 250 m in both directions, 500 m to 1 km would be about normal. So a MODIS image can have its digital values (NDVI greenness level values in the case of MODIS) rolled up to compute a sum within the bounds of each polygonal entity quite effectively. MODIS is cheap to acquire. You can get weekly mean value MODIS images that have been created using the parts of daily images that have the least cloud cover to create a weekly composite "cloud-free" greenness image. Because the images have 250 m ground footprints you can affordably process a composite image for the entire province in a few minutes to perhaps an hour. At this rate you can process images weekly throughout the year in a way that is both feasible and affordable. You cannot hope to do this with any finer resolution imagery (satellite or airborne).

5. Because you roll up the weekly values within mapped polygons, the exercise becomes one of looking for significant (or dramatic) changes in values within any given polygon. Because you have acquired and processed weekly data sets, the process also becomes one of looking at temporal patterns that can be equated to "signatures" that are characteristic of the phonological behavior of the ground cover through time (e.g. through a full year growing cycle). In the case of cut blocks, the yearly greenness pattern is very characteristic with white snow reflected in the winter, rapid and strong greenness in the initial spring flush and then rapid senescence to a brown cover by perhaps August. Forest stands will show a very different greenness curve. I can imagine that a healthy forest stand will have a very different temporal curve than an un-healthy stand affected by Mountain Pine Beetle. These signatures and patterns are observed and recorded at the level of the spatial objects (such as stands or cut blocks) and not at the level of an individual pixel or tree. This makes it feasible to go for province wide coverage on a weekly (or bi-weekly) basis. The temporal signature concept also allows for relative classifications and comparisons such that the shape of the curve is of greater importance in comparing like objects than the absolute values of the digital numbers. This makes the process much less sensitive to variations in image quality, climate induced differences in growth rates and dates and other elements that will cause confusion if single date satellite imagery is used for change detection.

6. Your MODIS NDVI multi-temporal analysis becomes your tool for screening the entire area (province) to pick out indications of locations where a change may be occurring. It may not be of

sufficient spatial resolution to let you map the change, but it may well be enough to tell you a change is occurring within a particular defined polygonal entity. If your screening sends out a red flag that tells you a change may be happening within an object you have defined (e.g. a stand or a cut-block) now is the time to obtain finer resolution imagery for this particular location and use it to examine and verify or reject the postulated change. If a change has occurred, you then need to transactionally update your data base of objects that define stands, cut-blocks, fire scars, etc to break the previous object (e.g. a stand) down into its new components (e.g. a stand and a cut-block or perhaps a healthy stand and an infected stand). You then go back to your weekly monitoring for change with the new objects entered in your database along with their spectral and temporal signature patterns.

7. A fairly efficient way to store changes for only for those areas that experience a change in cover pattern is needed. So, instead of having to maintain maps of cover type at every time for every pixel, you only maintain a record of 2 things. One is the rolled up value within each object which is stored as a data base record tied to the object for a particular date. The second is a database of grid cells that have changed from being associated with one object to another. Only grid cells that change assignment are recorded with the date the change was implemented and the nature of the change (from polygon N of type forest to polygon X of type cut-block). This makes it quite feasible to maintain a very reasonably sized data base of temporally changing conditions.

1.4 Conclusions

The above design is quite generic and could be applied to monitor, for example, changes in agricultural land use of types such as permanent pasture, forages, cereal crops, oilseed crops, crop-fallow rotations, continuous cropping, no till versus minimum till, etc. All of these are patterns that apply to objects (here farm fields) and that can only be recognized through reference to temporal variation in land cover patterns within these objects (and not within individual pixels). This issue is of great interest for monitoring land use practices for conformance to Kyoto agreements. I fully expect to see something like this become required to monitor for conformance to Kyoto agreements.

From the point of view of forest cover mapping and monitoring, you want to flag locations where changes in the previously mapped condition of the forest has occurred. Once flagged, you want to go to the locations of potential change and review the latest image information to compare it to previous image information for the same location. If a change can be verified, you need to record the kind of change and the extent of the new area that it applies to. In this way, you create a time-stamped map and record of what changes have occurred in the forest cover, when they occurred and where they occurred. This time-stamped spatial data base can be queried to create multi-temporal maps that depict change through time.

You might like to visit the web page for TimeMap (www.Timemap.net) to get an impression of what a temporally variable map can look like.