Review Comments for the Compendium entitled The Scientific Basis of Ecosystem-Based Management.

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General Comments

The Compendium document entitled "The Scientific Basis of Ecosystem-Based Management" is meant to provide a manageable summary of the rationale and scientific background to the Coast Information Team's approach to ecosystem-based management. In my view, it successfully summarizes relevant ecological theory and reflects the current state of thinking in this realm. The background technical reports (the ones that I had time to read carefully) provide thorough literature reviews and meet a high standard of analysis, particularly on the hydrological effects of forest harvest (HDT Technical Report #3), the effects of riparian zone logging (HDT Technical Report #4), the comparison of riparian protection approaches (HDT Technical Report #6), and the impacts of forest harvesting on terrestrial ecosystems of the Pacific Northwest (HDT Technical Report #7). The recommendations for management in each of these documents are clearly linked to an objective evaluation of information.

The background technical reports provide a good review of the data and information available to describe ecosystem elements and processes in the CIT region. More quantitative descriptions of these elements would be useful in the Compendium. See specific comments under Section 2.3 and throughout the review below.

Most importantly, the reports and the Compendium clearly delineate what is known about the BC coast from what is not known. The authors have identified what has been surmised about the CIT region from extrapolations of data collected in other areas (mostly coastal temperate rain forests from Oregon to Alaska). They have also distinguished information about the effects of harvesting based on empirical studies from information based on models. It is made clear that there are many unknowns and consequently, many uncertainties about how to maintain the complex suite of elements that comprise ecosystem integrity within the CIT area.

The Compendium provides a good review of the approaches used to deal with these uncertainties. The main approaches include the precautionary principle, risk assessment and adaptive management.

The precautionary principle is clearly explained. Logical arguments are presented to support the use of the precautionary principle It should also be mentioned that the

principle has been adopted nationally and internationally, in matters of resource management[1].

The Compendium clearly explains the benefits and transparency of using a risk assessment approach. Its application forms the basis for developing thresholds for managing the main ecosystem elements at the subregional to stand level scales. Overall, I am convinced that the approach is a reasonable way to set relative threshold values that will aid in decision-making. The specific details of the processes for developing the risk relationships are difficult to critique. My assessment is limited by the general difficulty of assigning causal relationships between factors and changes in complex ecosystems at multiple scales, and by my own lack of experience in modeling risk. The forms of the hydroriparian ecosystem risk curves are based on the ideas of experts who attended the two workshops. After reviewing the workshops' proceedings, I have greater confidence in the threshold values because, in most cases, data can be described to rationalize them. I am less confident that the shapes of the risk curves are correct[2]. I appreciate that confidence intervals can be placed around the curves to reflect the uncertainty in their shape and reflection points and suggest that perhaps this should be done on all of the curves presented to remind the reader of the uncertainty.

Adaptive management is described as the other main approach for dealing with uncertainty. The authors make it clear that adaptive management is an expensive commitment and a challenge (i.e., not always practical). This is not overstated. In my experience[3], applying an adaptive management and monitoring program is very difficult because resources, capacity and a clear understanding of how to proceed are elusive, especially when comparing management options beyond the stand level scale. The Compendium makes it clear that when management policies are not deliberately designed and implemented as experiments to enhance the rate of improvement, then the precautionary approach is recommended. It is likely true that an adaptive management approach is often suggested as an alternative for being cautious, without full appreciation of the commitment required to follow through the steps of adaptive management, particularly long-term monitoring and feedback into management decisions. The authors are also clear that greater uncertainty calls for greater precaution, especially in protecting

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[1] See Government of Canada 2001. A Canadian perspective on the precautionary approach/principle. Discussion document; Principle 15 of the Rio Declaration on Environment and Development, UNCED 1992; the Convention on Biological Diversity; Decision II/10 on conservation and sustainable use of marine and coastal biological diversity, adopted by the Conference of the Parties in Jakarta in November 1995; etc.

[2] The shapes of the curves are questionable based on the skepticism of some of the workshop participants and their inexperience in developing risk relationships. The workshop recorder (Terrestrial HPG Workshop #2) stresses that these curves should be considered working hypotheses.

[3] My experience includes setting up a monitoring program to assess the effectiveness of recommendations of the Clayoquot Sound Scientific Panel.

sensitive or valuable[4] elements. Thus, the precautionary principle limits adaptive management to options that are low risk. The Compendium is quite clear that the burden of proof should lie with proponents to prove no impact[5]. It is excellent to see power analyses and Bayesian statistics presented as essential tools for assessing the probability of impact and for allowing a shift in who bears the burden of proof.

Specific comments below are organized to address points raised in each section of the Compendium in the order that they occur.

Specific Comments

Section 1.2 Definitions of Ecosystem-based Management

The Compendium document provides a thorough examination of the definition of ecosystem-based management by contrasting the way it has been defined in various land use processes and by academics. This treatment leaves no confusion[6] about the need to identify ecosystems as a priority for management in the CIT region. This point is translated clearly to the EBM Handbook in the principle "sustain cultures, communities and economies within the context of healthy ecosystems".

The Compendium explains that the crux of the debate is about what level of species and processes allow persistence of ecosystem integrity that support social and economic systems. A simple illustration of the connection between ecosystems and human well-being would be helpful, e.g., marine contaminants, traditional foods and human health of native peoples. The importance of using a long-term time frame is understated. Information on the long-term consequences to communities & economies of management decisions that did not use principles of ecological integrity would also help illustrate the point. Such examples may include soil degradation and lower productivity of plantation forests in Australia and New Zealand (Perry 1998 – see footnote 5 for reference).

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[4] The Compendium clarifies that only ecological values are addressed in these documents – leaving social & economic values to be determined by the planning table.

[5] Various scientists have argued that the burden of proof needs to be shifted away from practices that would change the management status quo and placed instead on practices that alter systems most dramatically (see Costanza 1993 and Henjum et al. 1994 cited in Perry, David A. 1998. The scientific basis of forestry. Annu. Rev. Ecol. Syst. 29:435-466.

[6] Part of the confusion comes from simple analogies such as the interlocking circles or the three-legged-stool, which give equal weight to social, economic and environmental components in discussions of sustainable development. See Dawe, N.K. and K.L. Ryan 2003. The Faulty Three-Legged-Stool Model of Sustainable Development. Conservation Biology 17(5) 1458-1460). The Compendium authors are wise in not using confusing analogies.

Section 2. The Ecological Integrity of the CIT Region

The Compendium synthesizes a clear definition of "ecological integrity" from a good range of sources, including the Parks Canada Panel 2000, which included a set of experts from across the country. The EBM Handbook definition (as it appears in the box) appears incomplete in following the definition. It does not explicitly describe the importance of maintaining conditions so that they are comparable to natural conditions of the region.

The Compendium accurately describes components of ecological integrity in the CIT Region, however all the information is qualitative. It is missing quantitative descriptions of attributes such as average and range of seasonal precipitation, temperature, wind speeds, the frequency of flooding, landslides and blowdown; range of slopes of mountains and the percent of area in steep terrain classes; the amount of biomass and the area of land within hydroriparian condition; and the frequency of watersheds in different size classes, etc. A summary of quantitative information would help the reader visualize the ecosystems in the CIT region and reinforce how much is known, and unknown, about natural conditions. I realize that details appear in background documents but there is a lot to sift through to find these values. As a part of the summary it would be helpful to see cross-references to where specific details appear in the background documents.

Two descriptions of the frequency of large estuaries are inconsistent. One statement: "There are many small, but few large, estuaries and floodplains, because watersheds are small and primarily rain fed" contradicts the other: "Large estuaries, fed by rivers, rain, glaciers and permanent snow are common". Both statements are cited from MacKenzie et al. 2000.

Species diversity is described in very broad categories. It is not clear whether the number of birds and invertebrates include strictly terrestrial or both terrestrial and marine species. If marine species are not included, why not? As indicated, a number of marine invertebrates (it would be useful to know how many) live in estuaries and near shore ecosystems and are affected by upland conditions.

The Compendium does well to recognize and explain the uniqueness of Haida Gwaii – its isolation, geological history, insular biota and the threat of introduced species. Do any other parts of the CIT region have distinct ecological qualities or conditions. Brooks Peninsula, for example, on the northwest coast of Vancouver Island is of significance as a glacial refugium. Are there others on the central and north coast that could be highlighted here?

Section 3. Maintaining the Ecological Integrity of the CIT Region: the Concepts

This section provides a good review of concepts that are important in determining how to maintain ecological integrity. It is a mixture of ideas that are interconnected and the document presents them in an order that progresses from, first, defining the elements appropriate for assessment and planning, to, second, providing guidance on the appropriate amount, pattern and location of reserves, to, third, describing tools used to deal with uncertainty. The third group: 'tools used to deal with uncertainty' includes key

elements for understanding the rationale for allocating land to reserves. I suggest that these tools should be described earlier in the document. The notion of the precautionary approach clarifies why a variety of approaches are recommended to increase the probability of maintaining ecological integrity generally in the introduction, and more specifically why both reserves and variable retention strategies on managed forest are essential. The tradeoff between using the precautionary approach and using adaptive management to address risks should be more central to the introductory discussion on how to assign reserves to maintain landscape pattern, connectivity and effective corridors.

The literature cited as the basis for using a system of reserves, precautionary approaches to management, and restoration where appropriate includes FSC 2002 – a planning approach to B.C.'s regional certification standards, Noss and Cooperrider's 1994 book, and a paper by Lindenmayer et al. 2000. This combination of work spans regional to global authorities on the subject.

The criticism that the reserve concept is fundamentally opposed to an approach that acknowledges dynamism is not countered as rigorously as it should be on the grounds of effectiveness monitoring. Reserves have value when they are used as dynamic benchmarks for assessing the effectiveness of forest practices in managed forests. In fact, reserves are the best way to track changing conditions in naturally disturbed areas for comparison to humanly disturbed areas, especially at watershed or landscape scales. Several of the HDT Background Reports describe the importance of unmanaged areas for monitoring the effects of forest practices on hydrology. The Clayoquot Sound Scientific Panel (1995) cites other examples (see page 191 of Report 5).

Section 3.2. Managing at Different Spatial Scales

The definitions for different scales are clear and the practical reasons for setting a range of 1000 to 50,000 ha for watersheds is explained. It would be useful to know the distribution of watersheds that fall within different size classes. If there are numerous watersheds less than 1000 ha, greater details on how they will be managed at the site/stand level should be presented here (although I acknowledge that this information is presented in Section 4.5. Also, it would be useful to direct the reader to the discussion of this issue in the Background reports – especially HDT Report #3 and HDT Report #6.

Section 3.3 Coarse and Fine Filter Approaches

The distinction and requirement for coarse and fine filter approaches are explained clearly. The intention for applying the approach would be better described with more examples of fine filter candidate elements.

Section 3.4 Ecosystem Representation

This section describes the challenge of determining appropriate surrogates for determining whether ecosystem functions, processes and biodiversity are captured within a reserve network of representative units. The discussion about whether it is appropriate to group site series, and how to do so, is useful in that it sets out some of the uncertainty

and the need for cost-benefit analyses. The acknowledgement that rare site series are not captured well by remote sensing is very important.

The sub-section on hydroriparian representation is brief here, likely because it is covered in depth in Section 4.2.[7] The authors explain that there are shortfalls in the hydroriparian classification system. An example of some of the confusion over specific hydroriparian ecosystems within the CIT region would clarify the point.

Sections 3.5 and 3.6 Rare Ecosystems and Rare Species

It is excellent to see the inclusion of unlisted rare ecosystems and species, for which B.C. supports a significant part of the world population, as a focus for planning reserves at a fine filter level.

It is also worth noting that species at the northern end of their range may become more so our responsibility if climate change or practices in the Pacific Northwest cause declines in southern populations.

Section 3.7 Introduced Species

A good case is made for tracking introduced species and designing some system for control. The billions of dollars expended by New Zealand in their conservation efforts to combat the detrimental effects of introduced species provide a convincing lesson.

Section 3.8 Reserves

The discussion about determining how much to reserve is well supported with references to relevant literature. This discussion is well known because it has been central to conservation efforts for decades.

The three processes for selecting reserves are not as familiar and the Compendium describes them too briefly. For example, the line: " SITES is an automated site selection algorithm that attempts to maximize attaining conservation goals in a compact set of sites (Rumsey et al. 2003)" raises questions. What is meant by "a compact set of sites" – sites within a minimal area? Is the design criterion to maximize conservation goals per unit area? The "special elements approach" is not clearly distinguished from the other two approaches.

Section 3.9 Ecological Benchmarks: Range of Natural Variability

The Compendium clearly explains how the concept of natural range of variation can be theoretically applied to conserve forests. It also addresses the challenges of applying the concept: "the lack of historical data, difficulties in interpreting historical data, the possibility that future conditions may be without precedent and the difficulty of synthesizing over appropriate multiple spatial and temporal scales." Another point needs to be made in this discussion. There are practical reasons why close emulation of natural

[7] In general there is repetition of information given in Sections 3 and 4. I think Section 4 provides the crux of the matter and should contain the bulk of the information. It is, however, challenging to grasp the concepts in Section 3 without some examples.

disturbance patterns is not feasible even when we know the sizes of forest openings and expect a low rate of natural disturbance to continue. The area of land affected per unit of timber extracted and transported would be far too large and thus, there would be negative ecological (and economic) consequences, especially if the impact of roads is greater than the impact of habitat alteration. These ideas are germane to the concept of applying RONV and should be mentioned in this section as well as later (section 4.4.4 – page 75).

Section 3.10 Natural Disturbance

The estimated return intervals for stand-replacing disturbances presented in Table 4 (page 37) provides a convincing case about the need to stratify areas. The variant or sub-regional scale of stratification is likely not fine enough to capture the variability in natural disturbance rates. For example, within the CWH vh1, the frequency of larger scale blowdown is much greater for HwBa than for CwHw stands[8]. The EBM Handbook should reflect the idea that a combination of levels of variable retention and rotation periods will be applied variably over the landbase according to site-specific ranges of natural variation, vulnerability and risk.

It would be helpful if a reference were provided to support the statement "predicted changes in future climate will likely increase the incidence and or severity of most disturbance agents."

Section 3.11 Landscape Pattern

The questions about whether island biogeography theory applies to forested landscape, specifically whether area and distance effects occur, are clearly explained. It would be useful to discuss the circumstances of the few studies that found these effects in contrast to those that did not (i.e., was the matrix less hospitable to species studied in the former? was the overall landscape more heavily altered?).

There is a very limited discussion of the evidence for or against managing for interior forest condition (defined by a conservative estimate of 100-150m). The CSSP cites Chen et al. 1995 to support their recommendation that 20% of the forests in late successional stage (age classes 8 and 9) of a watershed-level planning unit should constitute forest-interior conditions. The background reports (Young 2001 and Price and McLennan 2001) explore the literature extensively. More of the discussion from these reports should be presented in the Compendium.

There is no explicit rationale given to support the EBM Handbook box about protecting groups of small streams. Again, I recommend that more of the discussion from the HDT Background Reports be included, specifically from Church and Eaton (2001) who are candid about the impracticality of protecting small intermittent streams. Their argument that reserves would fragment the watershed is relevant here.

[8] Scott, R. 2001. Variable retention windthrow monitoring report: block summaries for Interfor West Coast Operations. Long Beach Model Forest Report.

Section 3.12 The Managed Forest

The Compendium provides a clear rationale for maintaining biodiversity within the managed land base through variable retention. The factors that influence retention and the attributes to be retained are covered thoroughly in the Background documents by Bunnell et al. (1999) and Bunnell et al. (2003).

The temporal component of stand based management should be discussed more explicitly throughout this section. Longer rotations could be mentioned as a means of recovery in cases when low retention levels are applied (Perry 1998 - see footnote 5 for reference).

Section 3.12.4 Access

This section provides a good review of the negative effects of roads and the tradeoff between dispersing small cuts versus reducing the density of roads needed to access the same volume of timber. There should be an explicit connection made to the discussion of of natural gap dynamics.

Section 3.12.3 Management Practices

There is no rationale given for the assumption that ecosystem-based management will be achieved if Best Management Practices are applied everywhere within the managed forest of the CIT. An alternative idea was suggested by Zielke and Bancroft (Technical Report #6) when they proposed a clear blueprint for achieving desired stand structure within the RMZ. The Compendium does provide more comprehensive guidance for stand level management practices based on the background reports of Bunnell et al. 1999 and Bunnell et al. 2003, among others, in Section 4. Some of the points raised in that discussion could be developed here.

Section 3.13 Restoration

The section on Restoration explains the general principles well. An explicit description of the elements that need to be restored and an example of the site series under- represented at late seral stages would provide clarity.

Sections 3.14 – 3.17 Risk Assessment, Precautionary Principle, Analysis Techniques, Adaptive Management and Monitoring

These sections of the Compendium describe concepts used to deal with uncertainty such as risk assessment, the precautionary principle, considerations for statistical analyses, and adaptive management and monitoring. I have discussed the use of these approaches in my general comments. In terms of organization, I recommend moving these sections to the beginning of Section 3 because they are central to the discussions in earlier subsections. As well, I suggest adding some examples to demonstrate how power analyses and Bayesian approaches have been applied in the background analyses. Examples would aid the understanding of these important tools.

Section 4. Targets and Thresholds

This section provides the crux of the scientific basis for the EBM Handbook. Overall, the systematic organization of information under the seven headings (definition, importance, impacts of harvesting, indicators, risks and thresholds, uncertainty and questions for

adaptive management) is effective in conveying the scientific basis for ecosystem-based management of each element. Specific comments follow for each subsection.

4.1 Representative Ecosystems

4.1.5 Risks

The authors are clear about the limitations in the scientific literature to provide information for setting reliable risk thresholds for amounts of representative ecosystems to be maintained in old seral condition. They explain that we lack long term studies and measurements of biological responses (i.e., more than presence or abundance parameters) to habitat loss at any scale. They also emphasize the variation among species and ecosystems (and their interactions). The compendium makes use of the best available information (Dykstra 2003 and HDT Background documents) and provides a convincing case for setting thresholds of old seral condition at different levels for each scale (e.g., 30% at the watershed level, 70% at the subregion level).

There is less rationale presented for maintaining less than 50% of each site series in mid seral condition (at watershed and landscape scales). There are two cases to consider: areas with conventional harvesting (e.g., watersheds that have already been clear cut) and areas that will be harvested with variable retention. The background documents clarify that risk curves are based on what is known from the effects of forest removal through clearcutting. Further discussion of the other case is needed.

4.17 Questions for Adaptive Management

The authors convincingly argue for a precautionary approach rather than adaptive management at the landscape scale given the complexity of the questions and the enormous logistic hurdles, commitment and funding required for the latter.

[Small typos on page 57 of the document – “at least at” “range of assumptions”]

4.2 Representative Hydroriparian Ecosystems

4.2.2 Importance

The importance of hydroriparian ecosystems in supplying and transporting wood within streams is described well. It is also important to acknowledge that drift wood from riparian sources is transported by streams to the ocean where it provides a critically important source of habitat and food for the marine ecosystem, including estuaries, beaches and the deep-sea floor[9]. Questions about the effect of harvesting on the role of wood to the ocean ecosystems could be mentioned here and suggested for research and adaptive management.

[9] Maser, C. and J.R. Sedell. 1994. From the Forest to the Sea. The ecology of wood in streams, rivers, estuaries and oceans. St. Lucie Press, Florida.

4.2.3 Impacts of Harvesting

Recent literature[10] on the importance and impacts of harvesting to small streams should be explored.

Another potential side-effect of the fact that harvesting increases storm runoff has received recent attention in Clayoquot and Barkley Sounds where high fecal contamination in near shore areas caused closures of shellfish harvesting in 2001. The source of fecal contamination was believed, by Environment Canada, to be hinterland drainage; that is fecal matter from wildlife accumulating on the foreshore and hinterland, being washed into the intertidal zone with rainfall (Holmes 2001 cited in Kingzett and Paltzat 2002[11]). Increased fecal coliform levels are found after major rainfall events. The suggestion is that the greater discharges of water from logged watersheds may lead to higher levels of hinterland drainage and thus, higher levels of fecal contamination. How much evidence exists to support these connections? As is the case for so many interactions between the land and sea, we have very little information, but the possible impacts should not be ignored.

4.2.5 Risks

I will briefly comment on whether the explanations for each threshold adequately reflects information provided in the HDT background documents.

There appears to be evidence and conformity for the threshold rate of cut at >1% per year (averaged over 20 years) to maintain hydrology. The EBM Handbook excerpt does not specify a rate of cut. It says 20% effective clearcut area. Why not recommend a rate? Surely there is a greater effect if the forest is removed all at once rather than 1% ever year for 20 years? Church and Eaton (2001) recommend different rates based on watershed size.

The correlation between landslides and harvesting on unstable terrain is well documented in the literature. The precautionary guideline that accepts zero risk is appropriate especially considering the severity of the potential damage and the difficulty of re-stabilizing and re-vegetating slopes if landslides occur. Likewise, accepting zero risk of destabilizing stream banks is appropriate given the potential impacts of sedimentation and canalization. The guideline for streams within the source zone is less precautious because the risk is lower, although the uncertainty is very high considering the lack of data available on small headwater streams. Given that the first signs of effects occur when 50% of standing forest along streamside is removed, a more precautious recommendation would be to retain 25 to 50% (and complete retention on steep streams

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[10] The UBC Symposium on Small Streams was mentioned in some of the background reports but the papers had not been released at the time of writing. Canadian Journal of Forest Research Vol. 33 No. 8, August 2003 includes some papers from the Symposium.

[11] Kingzett, B. and D. Palzat. 2002. Results of shellfish growing water sampling programs in Barkley and Clayoquot Sounds. Report prepared for the BC Shellfish Growers Association.

& gullies with high susceptibility to windthrow), until the results of adaptive management experiments can verify the slope of the risk relationship.

With the history of clearcutting to the edges of streams in coastal B.C., we have little evidence to be used to build the risk curve to downed wood with increased deviation from natural riparian forest. However, the agreement of two independent expert workshops gives credibility to the risk curve for the transportation and deposition zones. The argument for the source zone is incomplete. I found the line "small pieces of wood may be effective" (section 4.2.5) unclear. I surmised that one would expect detrimental change to occur at a higher level of forest removal within the source zone because wood comes primarily from mass wasting events (to the best of our knowledge) rather than from riparian areas and small streams function well without large woody debris. The authors need to clarify whether this is what they meant. It would be good to remind the reader again that risk curves do not include the costs (seriousness of the effect) of detrimental change, rather the probability that detrimental change will occur.

Precautionary guidelines for biodiversity within riparian ecosystems follow the three risk curves drawn on the basis of susceptibility to debris flow or distinct microclimates that would be affected by deviation from natural riparian forest. There may be other factors such as the importance of litter input or inherent edge habitat (between lakes and forested edges, for example) that could be considered in drawing the curve if there were evidence of their influence. The HDT Background Reports identify key influences on biodiversity from the available literature but admit that relationships to biodiversity are not well known.

4.2.6 Uncertainty

I agree with the two general themes that run throughout this section. First, the uniqueness of coastal hydroriparian ecosystems and the biogeoclimatic conditions that shape them makes it critical to have data collected from the CIT area to inform decisions. Second, the lack of data, natural variability, confounded studies and short-term studies support setting precautious thresholds.

The challenges of addressing the uncertainties using adaptive management are clearly explained.

4.3 Rare Ecosystems

Between this section and section 3.5 the Compendium clearly defines and describes the reasons for protecting rare ecosystems (at old and young seral stages). I agree that red-listed and regionally rare ecosystems should be 100% protected in reserves. I wonder whether reserves for 70% of the blue-listed ecosystems are sufficiently precautionary. I would suggest that a further assessment of these ecosystems be made to consider which are most valuable in the context of the CIT region. Those that are most diverse, most productive or have sensitive soils should be considered for higher levels of protection.

It would be useful to map some examples of red-listed and regionally rare ecosystems in the Compendium. This would clearly illustrate the need for site level assessment and the importance of distinguishing naturally rare from created rare ecosystems.

4.4 Inblock Retention

The Compendium makes a well-supported case for flexible retention options. The available evidence suggests that 30% retention provides a higher likelihood of lifeboating organisms than 15%. The use of 15% as the high risk threshold in the EBM Handbook is not justified on the basis of best available science for maintaining species at a stand level scale.

[Holt and Sutherland's paper is cited as 2004 instead of 2003].

4.5 Fish Habitat

This section supports the guidelines to prevent impacts of forest development on highly valued fish habitats. The precautionary steps suggested are supported by the comprehensive review of the literature in the background report by Young (2001). The recommended measures to limit disturbance to 10% of the forest area averaged over 3 years in small watersheds (<1000 ha) running directly to the sea is more limiting than what Church and Eaton (2001) recommended for the purpose of protecting the hydrology of small watersheds.

The special focus on fish raises questions about other species and ecosystem processes that may be affected by forestry disturbance in small basins that run directly to the sea. There should be an explicit acknowledgement of these unknowns, especially at the land-ocean interface.

4.6 Hydroriparian Process Zones

This section presents clear definitions for the source, transportation and deposition zones and a straight forward procedure for delineating them using terrain mapping. Justification for protecting all streams within transportation and deposition zones was provided in the section on representative hydroriparian ecosystems.

4.7 Riparian Corridors

An illustration would be very helpful in defining a riparian corridor. Rationale for the precautionary guideline is based on a high level of uncertainty and a risk curve drawn by an expert group. It is unclear whether there is a rationale for choosing 60%, rather than 50% or 70% as the low risk threshold. The authors clearly state that there is little known about the effectiveness of riparian strips in managed landscapes as corridors and about the impacts to biodiversity of management around small streams. Answers to the questions outlined under adaptive management are very important to determining the best way to manage the landscape pattern of harvest around small streams.