Risk to ecosystem functions: Summary of two expert workshops.

Workshop 1:
CCLRMP/HPG Indicators
Vancouver, 26 June, 2002

[Readers should realise that the following report is based on an analysis of land condition/land use indicators as envisaged by the HPG Work Group as of June, 2002. Partly as the result of this exercise, some of the indicators have been modified since -- MC 22/04/03]

The workshop was convened by Michael Church and Nick Winfield at the Peter Wall Institute for Advanced Studies in the University of British Columbia. The purpose was to consider the suitability of proposed indicators for hydroriparian conditions and functions, and to construct risk curves for possible land management actions.

Participants were Gordon Butt (Principal, Madrone Consultants, Duncan); Dan Hogan (BC Ministry of Forests); Peter Lewis (BC Ministry of Sustainable Resource Development); Michael Miles (Principal, M.A.Miles and Assoc., Victoria); Kyle Young (Simon Fraser University); Kristie Trainor; Nick Winfield and Michael Church (HDT working Group). Representatives from DFO (other than Winfield) and from UBC Fisheries could not attend.

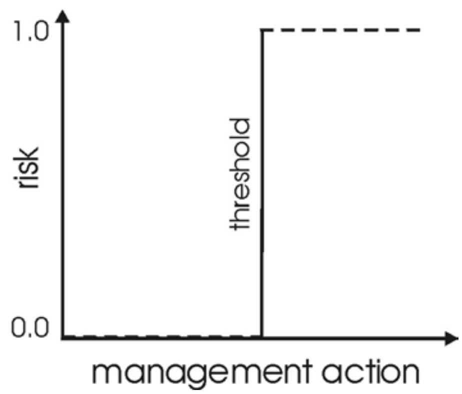
At the beginning of the meeting, a general discussion was held on the topic of indicators and risk assessment. Lewis reported that the strategy of indicator identification / risk assessment/ monitoring is currently under consideration by a wide range of groups. He presented a draft review document produced for the Ministry of Sustainable Resource Development (Monitoring Land Use Impacts on Fish Sustainability in Forest Environments, Gustavson Ecological Resource Consulting, Gabriola, BC, and Daryl Brown Associates, Inc., Victoria, for the Ministry of Sustainable Resource Development, Aquatic Information Branch, 15 March, 2002). Other known activities include Dobson Engineering for Riverside Forest Products; Canadian Forest Products (Peace River Divison); and a general directive from the premier's office to the Ministry of Sustainable Resource Development to develop the approach for land resource administration. This range of activities suggests that our results should perhaps eventually be coordinated with others. Lewis gave the opinion that our research on incorporating risk assessment is probably the most advanced exercise of the set.

The question was raised whether an approach requiring sophisticated (and possibly inexact) judgements can work in the field, where much of the work is done by personnel with limited training. The experience that is brought to judgements is important because regional and local conditions may affect judgements. For example, some degree of disturbance is beneficial for some ecosystem functions, and it will be important to appreciate that. Miles developed this theme, urging that a knowledge of landscape history (derivable from air photo and documentary records) is more important for projecting the future evolution of land surface and ecosystem conditions than synoptic assessment of indicators. The sensitivity of a watershed to current land management is often determined by the particular recent history (in particular, the history of sediment mobilisation).

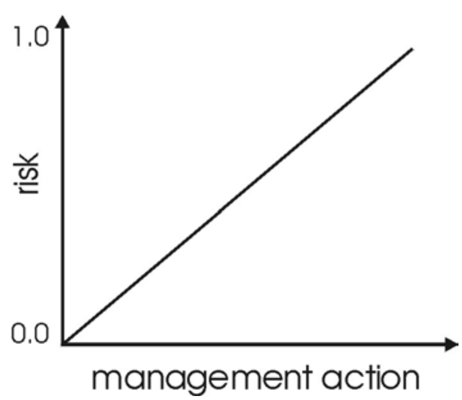
The related question was raised whether we are not setting out to replicate the history of development of watershed assessment, which has been continually simplified over the last decade in the attempt to arrive at a consistent and practical tool for field use. (The analogy is imperfect; CWAP is basically a retrospective exercise, whereas we are attempting to establish a planning procedure. But, at the least, we may learn some useful information about practical indicators from that exercise.)

Turning to indicators and to risk, it was emphasized that we must identify indicators that can be appraised synoptically, but that provide sensitive indications of long-term (20-50 year) effects. As to assignments of risk, it was agreed that, in most cases, our knowledge is sufficiently limited that we will generally be restricted to identifying one of three patterns:

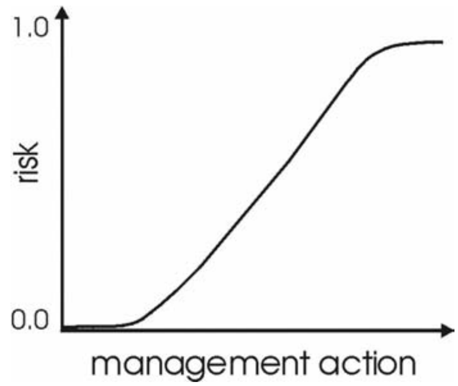
(i) Threshold effect;



(ii) Linear function (no knowledge to suppose anything more complex);



(iii) Sigmoidal effects (basically linear, but with a recognised zone of insensitivity at one or both ends of the scale)



In the course of discussion about individual indicators, it became clear that many of them have site-specific or historically conditioned elements. For example, the risk associated with riparian zone logging might be quite different in two superficially similar sites when one of the sites has a history of streambank instability and the other does not, and these two sites may occur within a few hundred metres of each other on the same stream. This is an example of site-scale effects that the Working Group identified. It appears to make larger scale assessment difficult.

To structure our discussion we considered "risk" in relation to each hydroriparian function identified by the HPG Working Group (e.g., risk to downed wood supply and function). Our risk curves were envisaged as expressing risk on the ordinate (on some indexed scale $0 \rightarrow 1$), and a proposed management action on the abscissa scale (e.g., percent of riparian forest cleared). This ties risk to proposed management action and makes the risk tool useful for planning.

It then became evident that many of the proposed (as of June, 2002) "indicators" are not suitable for risk assessment. For example, number or density of landslides (category "modifying morphology") is really a monitoring measure, not a risk assessment measure (because we don't plan to create landslides as a part of land management, though they may be an unwelcome consequence). Furthermore, for many "indicators", the question is not "how much", but how much land management may change them (with respect to landslides, for example, what increment is caused by land management). This cannot be known (on a watershed-specific basis) before forest development, hence does not provide a useful planning indicator. These considerations led the workshop group to reject some of the proposed indicators as risk assessment tools, though they may remain valuable as monitoring indicators.

Consideration of indicators: risk curves

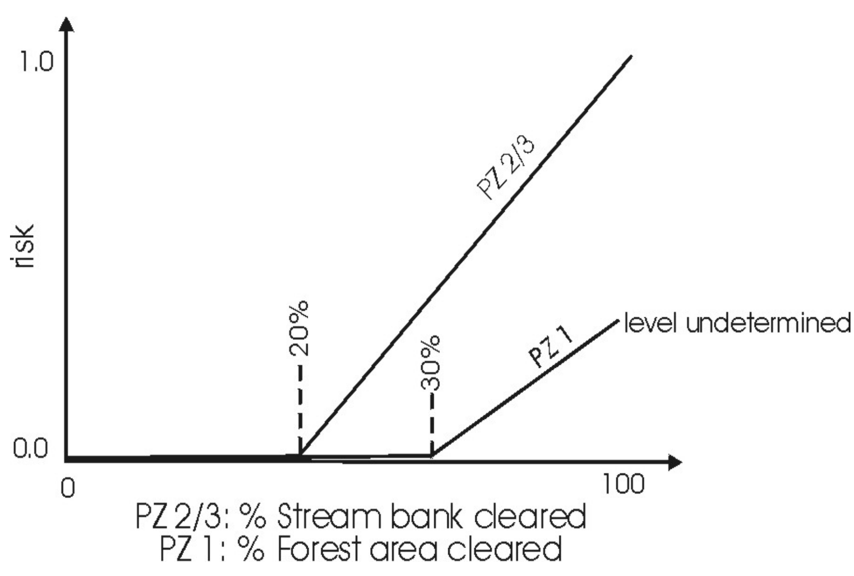
1. Downed wood

We considered that this category refers to "supply and function of downed wood in channels and on the floodplain". It was first considered that the specification of forest >250 years (DW1/DW3 -- *these are shortform codes for the list of indicators as of June, 2002; MC*) is inappropriate. The effectiveness of wood in a channel depends on the relative size of the wood and of the channel. In small channels, much younger wood may be effective. It was proposed, for example, that to be effective the length of pieces should be of the same order as channel width, and the diameter should be of the same order as channel depth. The key issue is by how much the supply of downed wood is changed as the result of forest harvest.

For DW1, it was proposed that, in process zone 1 (source zone), the percent of forest cleared is the appropriate indicator, since wood may be delivered downslope by mass wasting. What constitutes "forest" was not explicitly identified, but all stands capable of delivering wood that might be effective clearly are intended. Risk was considered to be negligible up to 30% clearance (or greater?), and to increase moderately thereafter. In process zones 2 and 3 (transport/deposition), it was proposed that the percent of stream bank(= 2x stream length) that is cleared was considered to be the best indicator. Age at which the bank would be considered reforested was not discussed. The risk curve was proposed to be flat (no sensitivity) to 20%, then to increase linearly to highest risk at complete clearance. It was pointed out that where banks are cleared (in relation to bank stability) may be important.

Identification of age or structure classes (DW2) was considered to be too complex and of dubious additional value. However, it was pointed out that the coniferous/deciduous distinction is important.

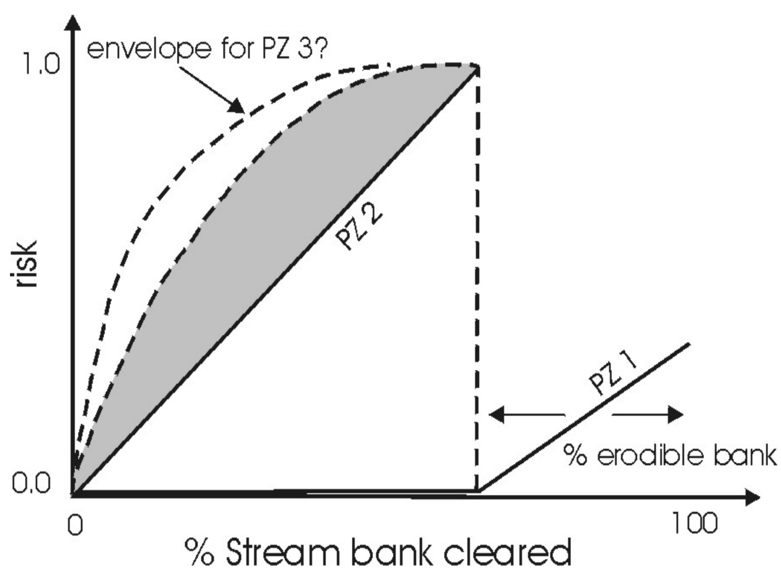
DW3 is considered covered under DW1.



2. Stabilising banks (filtering sediment, providing shade, moderating microclimate, providing organic material)

Both indicators under this heading refer to % riparian forest. Again, there was discussion whether the percent of stream bank cleared (as in downed wood) is not a better criterion. For process zone 1, a risk curve similar to that for downed wood was proposed where the onset of sensitivity would be defined by the proportion of stream bank that is erodible (many process zone 1 streams flow in gullies delimited by bedrock or other unerodible materials). In process zone 2 (banks largely alluvial), a linear function was proposed extending to maximum risk at (1-fraction of erodible banks). It was also considered that this function may actually be convex (possessing high sensitivity at small levels of forest removal) since bank erosion yields additional sediment to the stream channel which then forms deposits around which the stream must flow. In the process, additional attack and erosion of banks may occur. Process zone 3 (streambanks entirely alluvial) may be even more sensitive in this regard.

With respect to SFS02, age classes were again considered to represent undesirable complexity. With respect to streambank functions of shade and organic material, it was proposed that the width of the riparian forest strip relative to channel width is important. If width < 0.5 channel width, there is little effective function. If width > 2 channel width, functions approach undisturbed rates. These criteria are known to be deficient with respect to microclimate modification, but that factor was considered to be of low sensitivity in coast forests.



3. Modifying morphology/providing gravel

All of the candidate criteria (MM1-MM4) under this category were considered to be unsuitable as risk criteria for planning purposes, though they may all be recognised as appropriate monitoring criteria for purposes of adaptive management. Two alternate criteria were proposed:

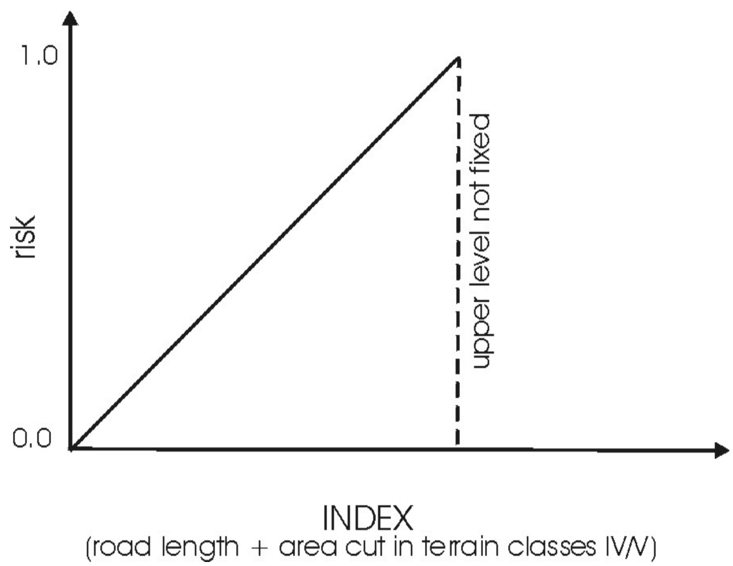
- (planned) length of road + area of forest cleared in classes 4 and 5 terrain;

- percent of streambank cleared in process zones 2 and 3.

The first criterion is intended to cover the likelihood of landslide initiation from roads (and reaching the riparian zone), while the second is intended to cover sediment derived from streambanks. Again, modification of the natural sedimentation regime – not the arrival of gravel in the channel *per se*, should be recognised as the concern.

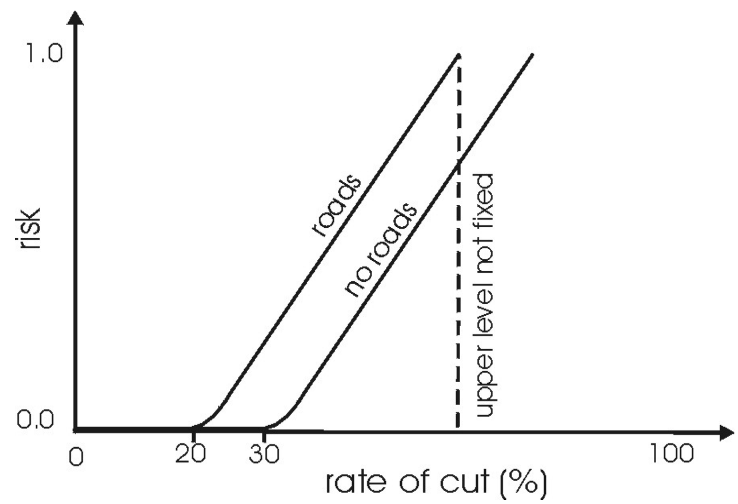
Considerable discussion was devoted to how best to operationalise the first criterion. Road density (road length/area in classes 4+5 may be a superior measure because it would then cover off the possibility of only a small area leading to a small road length. It was proposed that the two criteria (length of road and area cleared) be combined into one risk criterion, but how to achieve the combination was not discussed and there was no conclusion on combining the criteria. (However, reference was made to the index method used in CWAP -- *which was subsequently adopted; MC 22/04/03*.)

For each criterion, a linear risk curve was proposed, with the upper limit (prohibitive risk) somewhere below full clearance. No detailed thought was given to this curve since the problem of combining the criteria remained unresolved.



4. Transporting water

The expert group is sceptical of the value of this criterion. The general consensus within the group was that there is no reliably consistent relation demonstrated between forest clearance and extreme water flows (which were supposed to be the flows of concern). In any event, the group considered that the criteria should be reduced to a simple rate-of-cut criterion. A risk curve was sketched on this criterion that is insensitive out to 20% cleared (with roads) or 30% cleared (no roads), increasing thereafter to high risk for some level of clearance less than 100%, but not determined.



A fair summary of the workshop group's view perhaps is that sediment production, not water production, is the key issue and, by implication, that changes in water production do not independently affect sediment production strongly (the possible occurrence of severe storms during or following harvest needs to be discounted before water is considered as an independent agent of change.)

5. Changing ecosystem productivity

The workshop declined to consider this criterion since it considered that "ecosystem productivity" was not adequately defined.

The workshop adjourned at 4:30 pm so that participants could make travel connections.

Michael Church

Recorder

Workshop 2: Terrestrial Functions
July 10, 2002
Smithers BC

This document summarises a one-day workshop designed to gather expert opinion about risk to terrestrial hydroriparian function in the Central Coast, North Coast and Haida Gwaii. The team working on the Hydroriparian Decision Tool suggested appropriate experts to be invited to two risk workshops, one dealing with hydrological functions and fish concerns and one dealing with terrestrial functions. For the terrestrial workshop, upon confirmation of attendance, the appropriate experts were sent a document outlining the goals of the workshop and issues for discussion (see Appendix 1).

Participants: Jim Pojar (Ministry of Forests, Research; coastal ecosystem expert), Allen Banner (Ministry of Forests, Research; coastal ecosystem expert), Doug Steventon (Ministry of Forests, Research; risk expert, coastal vertebrate expert), Rachel Holt (Veridian Ecological Consulting; risk expert, ecosystem-based management expert), Laurie Kremsater (consultant; organiser/recorder), Karen Price (HDT Working Group; organiser/facilitator)

Workshop goals:

- *to use expert opinion to assess characteristics (importance, influence, landscape abundance, natural disturbance regimes) of each hydroriparian ecosystem*
- *to consider how retention affects recovery times for these ecosystems*
- *to use expert opinion to draw risk curves for indicators of hydroriparian function*
- *to discuss issues related to coastal hydroriparian risk*

Our workshop followed two days of presentations of preliminary results from the Environmental Risk Assessment for the North Coast LRMP. The North Coast team is assessing risk to coarse filter biodiversity, grizzly bears, marbled murrelets and mountain goats. Their analyses are further developed and more sophisticated than plans for the HDT, using formal modelling (a Bayesian belief network—Netica) to assess risk over the entire LRMP area over time based on current practices and on a variety of scenarios. Some of the methods used in the HDT workshop borrow heavily from the experience of the North Coast team, particularly from the approach to coarse filter biodiversity assessment developed by Rachel Holt and Glenn Sutherland[1].

We began our workshop with a general discussion about the merits and pitfalls of using a risk assessment approach. Two of the participants, Doug Steventon and Rachel Holt, have been immersed in thinking about risk for months in relation to their work for the North Coast. The approach is new and relatively untested. Potential benefits include separating science and policy (rather than combining them as in the Biodiversity Guidebook) and being able to present uncertain information more clearly. The latter benefit increases with the use of formal modelling, that explicitly incorporates probability

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[1] Holt R and Sutherland G (2002) Coarse filter risk model: a process for calibrating risk to ecosystems for the North Coast LRMP. Draft in progress. Also from discussions with Rachel Holt.

distributions with all parameters (not currently planned for the HDT). Allen Banner and Jim Pojar were generally sceptical, but sufficiently interested to be expert guinea pigs. Potential costs include adding complexity to management decisions and using insufficient rigour in developing methods (developing carefully considered indicators and reference points and calibrating curves locally takes time and thought). Scepticism was expressed about whether a new approach to analysis would influence management practices, but all agreed that allowing science to stand alone was useful.

Rachel and Doug discussed their views of risk assessment as more of a strategic than operational tool. They suggested that watershed planning was the most useful scale to consider, and felt that the HDT could play a very useful role as an assessment of management opportunities within a particular watershed.

Goal 1: to use expert opinion to assess characteristics of each hydroriparian ecosystem

Our first goal was to assess the relative importance of each hydroriparian ecosystem[2] within each physiographic sub-region[3] for maintaining terrestrial hydroriparian functions[4]. This goal is based on the assumption that risk varies among sub-regions and ecosystems.

Our ecosystem experts filled in the following columns for each ecosystem and sub-region:

- relative importance for maintaining hydroriparian functions[5]; Low (1), Medium (2), High (3), Very High (4);
- certainty of importance rating; 10-point scale from no confidence (0) to certain (10);
- influence on other hydroriparian ecosystems in a watershed; Low (1), Medium (2), High (3), Very High (4);
- certainty of influence rating; 10-poing scale from no confidence to certain;
- landscape abundance; Rare (1), Infrequent (2), Common (3), Abundant (4).

As we filled in each cell, we recorded the rationale for each rating. The values could be used in two ways in the HDT. First, they could be used to modify acceptable risk thresholds (e.g., a low level of risk might be acceptable for ecosystems with high importance and/or influence). Second, they could be used to adjust the risk curves up or down (e.g., loss of the same amount of an ecosystem with high importance for maintaining biodiversity and with high influence on other ecosystems would pose a higher risk than would loss of a less important or insular ecosystem).

[2] small steep streams, torrented gullies, small low gradient streams, fans, high-bench floodplains, low-bench floodplains, karst, forested swamps, sedge fens, bogs wetland ponds, lakes, shoreline forests, estuaries

[3] Hecate Lowland, Outer Coast Mountains, Inner Coast Mountains, Haida Gwaii

[4] contain diverse structure and vegetation (biodiversity), contain rare ecosystems, serve as corridors, provide downed wood, maintain characteristic ecosystem productivity

[5] Because it is difficult to separate ecosystem abundance from importance (e.g. an ecosystem may be more important to landscape-level biodiversity if it is rare or very abundant), we asked the experts to envision a similar unit of each ecosystem (e.g. 200 m along a stream) when filling in values. This method reduces the chances of double counting.

We also gathered information on natural disturbance frequency and type for each ecosystem, again noting the experts' level of certainty. This information will be important in establishing the range of natural variability. Currently, methods exist to estimate natural disturbance regimes by BEC variant but not to estimate regimes with hydroriparian ecosystems (particularly floodplains). Expert opinion could be used to modify the BEC variant calculations.

We divided Haida Gwaii into mountain and lowland sub-regions as suggested by Jim and Allen. Jim noted that the division into four physiographic regions matched the classes he suggested years ago. Table 1 shows the values provided for ecosystems in the Hecate Lowland and Haida Gwaii Lowlands. There are similar tables for the Outer Coast Mountains (and Haida Gwaii Mountains) and Inner Coast Mountains. Many pages of rationale accompany the tables.

Table 1. Importance, influence and abundance information and associated certainty for the Hecate Lowland.

Hydroriparian ecosystem	*Impt*[6]	*Cert*[7]	*Infl*[8]	*Cert*	*LS abund*[9]	*ND Cert*[10]
small steep streams	3	8	4	8	2	9
torrented gullies	3	8	4	8	1	9
small low gradient streams	4	10	2	9	4	10
fans	4	9	3	8	2	10
high floodplain	3	8	2	8	1	7
low floodplain	4	8	3	8	2	9
karst	4	10	4	8	1	
bogs	4	10	2	8	4	10
forested swamps	3	9	2	8	2	10
sedge fens	1	9	2	8	2	10
ponds	2	8	1	8	4	10
lakes	1	8	2	9	2	10
shoreline forests	2	8	2	7	2	10
estuaries	4	10	4	10	2	10

Goal 2: to consider how retention affects recovery times for these ecosystems

Our second goal was to assess whether we could develop a structural index (e.g., oldgrowth equivalency index) based on forest age and levels of structural retention. Such an index would be useful for several of the HDT indicators and would be particularly important for assessing the risks associated with different management options (e.g., variable retention, long rotation) in a relatively simple manner. The concept of a structural index was not fully explored and needs further discussion.

[6] Importance for maintaining hydroriparian functions (1 = Low; 4 = Very High)
[7] Certainty (1 = no certainty; 10 = very certain)
[8] Influence on other hydroriparian ecosystems (1 = Low; 4 = Very High)
[9] Landscape abundance within a physiographic region (1 = Rare; 4 = Abundant)
[10] Certainty associated with description of natural disturbance (no single value possible for disturbance)

Jim and Allen had already constructed recovery curves for structure, tree composition, understory vegetation, soil biota and epiphytes for ten analysis units (based on leading species and site index) within the BEC variants of the North Coast for Rachel and Glenn's model (see Appendix 2 for example curves). We looked at the recovery curves they had drawn for some sample analysis units chosen for the relevance to hydroriparian ecosystems (e.g., the spruce leading, high site index analysis unit is a floodplain ecosystem). Jim and Allen then drew recovery curves based on variable retention levels of 10%, 30% and 70%. They had time to complete curves for structure, understory vegetation and soil biota in two analysis units. Figure 1 shows an example in which oldgrowth structure on a productive floodplain recovers by 250 years following clearcutting and by 150 years following 70% retention. In general, forest attributes recovered more rapidly with higher levels of retention. Rachel and Glenn may be asking Jim and Allen to complete similar curves for North Coast scenario testing. For efficiency, HDT and NC ERA should work together on this task.

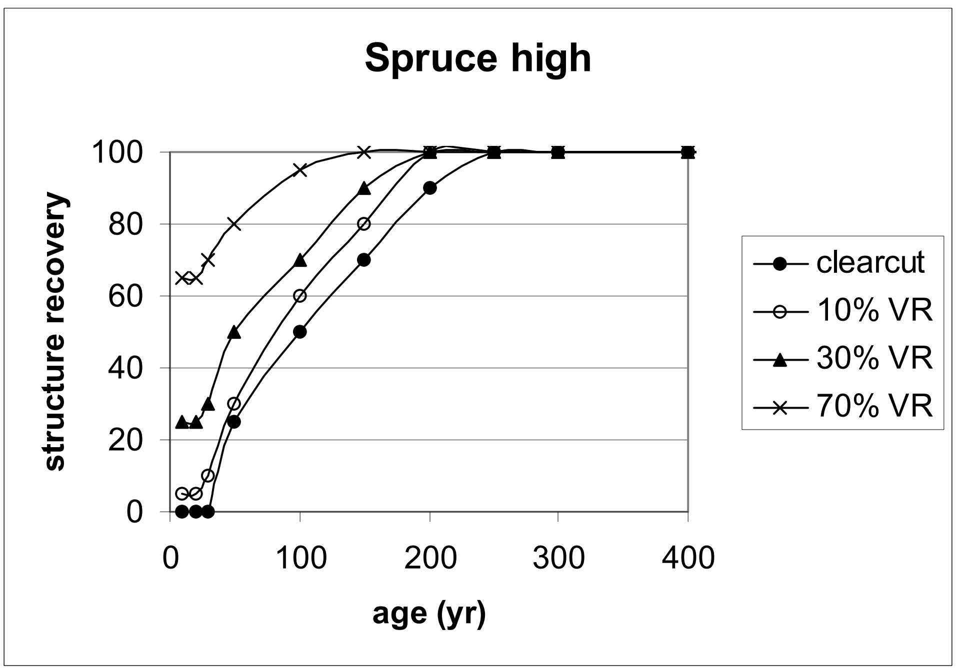


Figure 1. Expert-based recovery curves for structure in the spruce-leading, high site index (floodplain) analysis unit in the CWHvh2. Curves are based on initial management activities of clearcutting, 10%, 30% and 70% retention.

Goal 3: to use expert opinion to draw risk curves for indicators of hydroriparian function

Risk curves were based on published literature and modified for coastal ecosystems based on expert opinion gathered at the workshop. Experts discussed the risk to coarse filter biodiversity, rare ecosystems, corridors, downed wood and ecosystem productivity. Lack of time precluded complete discussion of all risk curves.

It is important to separate the different elements of risk to avoid double counting and to make calculations transparent. For the purposes of drawing curves, we considered risk as (1 – probability of maintaining a hydroriparian function) based on the HDT indicators. The elements described under goals 1 and 2 (importance, influence, abundance and ability to recover) can then be used to modify the risk curves or to set levels of acceptable risk.

We began by discussing the different possible shapes for risk curves (linear, sensitive, insensitive, sigmoidal). Initially, the group decided that sigmoidal curves make biological sense. Then Rachel pointed out that, with sigmoidal curves, it is critical to locate the inflexion point with reasonable certainty, particularly when converting curves to discrete risk categories; otherwise, a small change in an indicator value can change risk from one class to another too easily. As an aside, we agreed that converting sigmoidal curves to risk classes would generally use three classes (one for each of the relatively insensitive parts of the curve at the top and bottom of the "S", and one for the rapidly changing portion in the middle). Rachel also noted that with current levels of uncertainty, linear and sigmoidal curves with the same mid-point likely overlap and will not produce different risk classes. She suggested that we focus on which curves would be shifted one way or another (i.e. sensitive vs. insensitive) and use linear curves elsewhere. The group concurred with this approach, given their level of uncertainty in drawing curves.

Rather than the absolute values chosen for the X-axis by Mike Church's group (e.g. % forest cleared), the terrestrial group preferred a relative scale using natural variability as the reference point. Hence, we assessed risk on the Y-axis against the deviation from natural on the X-axis. Using natural disturbance as a reference point (or benchmark) is generally accepted in ecosystem-based management. This approach assumes that indicator values lying within the range of natural variability pose low risk. Although some members of the group were uncomfortable with using natural variability in regions with more variable disturbance regimes, all were comfortable with the benchmark in coastal ecosystems. We did not discuss what particular metric of natural disturbance to use (mean, 1 SD, range). North Coast analyses use a mean and SD. We need further investigation of appropriate metrics for hydroriparian ecosystems, particularly ecosystems with highly variable disturbance regimes (e.g. floodplains).

Rachel noted that we would need a small number of simple indicators if we wanted to model risk in a formal manner. Laurie noted that interpreting a whole suite of indicators would pose challenges for managers. We decided to limit consideration to current management practices (rather than considering the impacts of variable retention and other innovative options). We also decided to reduce the number of curves wherever possible.

We asked about ideas for integrating stand-level risks to a watershed level. After discussion with Rachel and Doug, we concluded that the HDT could create a watershed-level picture by presenting risks associated with each hydroriparian ecosystem (ideally combined into process zones) for a watershed. True integration, coming up with one value for watershed-level risk, is likely not possible, nor necessarily desirable. The influence and importance scores can then be used to assess priorities.

Biodiversity: containing diverse structure and function
We focused on indicator BD3 (% riparian forests by ecosystem by condition class). Although the group considered roads to be an important risk to biodiversity, they preferred to include the impacts of roads within the % riparian forest indicator (assuming current practices) rather than consider road density (indicator BD4) as a separate indicator.

We discussed whether to look at process zones (origin, transport, deposition) or hydroriparian ecosystems (small steep streams, high-bench floodplains etc). Although the group initially considered that using process zones might be easier (resulting in fewer curves), it became apparent as we progressed that the experts felt that risks varied by ecosystem within process zone.

We briefly discussed condition class (interior oldgrowth, oldgrowth equivalent, deciduous), but decided to focus initially on % riparian forest, using the deviation from natural amounts as discussed previously. Conceptually, it is easy to think about deviation from natural deciduous amounts and deviation from natural oldgrowth amounts. Practically, integrating the diversity of ecosystem types will be more difficult.

Doug commented that for biodiversity in general, and for certain species in particular (focus on birds and lichens), literature agrees on negative impacts (i.e. high risk) at habitat levels below 20% (range 10 – 30%) and little impact (i.e. low risk) at over 70% habitat, with a large area of uncertainty between. These values match the theoretical values derived from model landscapes and lead to a sigmoidal curve. However, because of lack of information on the middle of the curve, and because of potentially high overlap between linear and sigmoidal curves with current uncertainty (something Rachel and Glenn will be testing), the group agreed to use linear curves as starting points.

The experts felt that sufficiently certain to draw three classes of curves for the risk to biodiversity: linear, moderately sensitive and highly sensitive (Figure 2). (A larger set of curves was reduced to the three classes following discussion.) Estuaries, karst ecosystems, and roaded steep small streams and gullies follow a highly sensitive curve; fans, floodplains, heli-logged steep small streams and gullies follow a moderately sensitive curve; small low gradient streams, shoreline forests, bogs, sedge fens, ponds and lakes follow a linear curve. Where the experts felt uncertain, they placed ecosystems into the linear class—hence the uncertainty band around the linear curve is broader than around the sensitive curves. We did not explicitly draw uncertainty bands.

There was considerable discussion about the impacts of management on bogs (including removal of all adjacent cedar, compaction from tracked vehicles, increased access, changed water table, and ultimately a shift from forest to heath). Initially, the group thought that management around small low gradient streams could be less sensitive in the Outer and Inner Coast Mountains (relative to the Hecate Lowland), but they fell back on the linear curve due to uncertainty. Similarly, deposition wetlands were initially considered relatively insensitive until 20% deviation from natural, but then included in the linear risk category. Our final set of curves did not vary by sub-region; differences in natural disturbance regimes may, however, lead to different deviations from natural, and hence different risks.

The group found it difficult to separate terrestrial and aquatic systems in considering impacts to biodiversity (particularly when thinking about mixed media ecosystems like bogs). We tried to concentrate on terrestrial biodiversity, but Jim, in particular, would have preferred a more holistic approach.

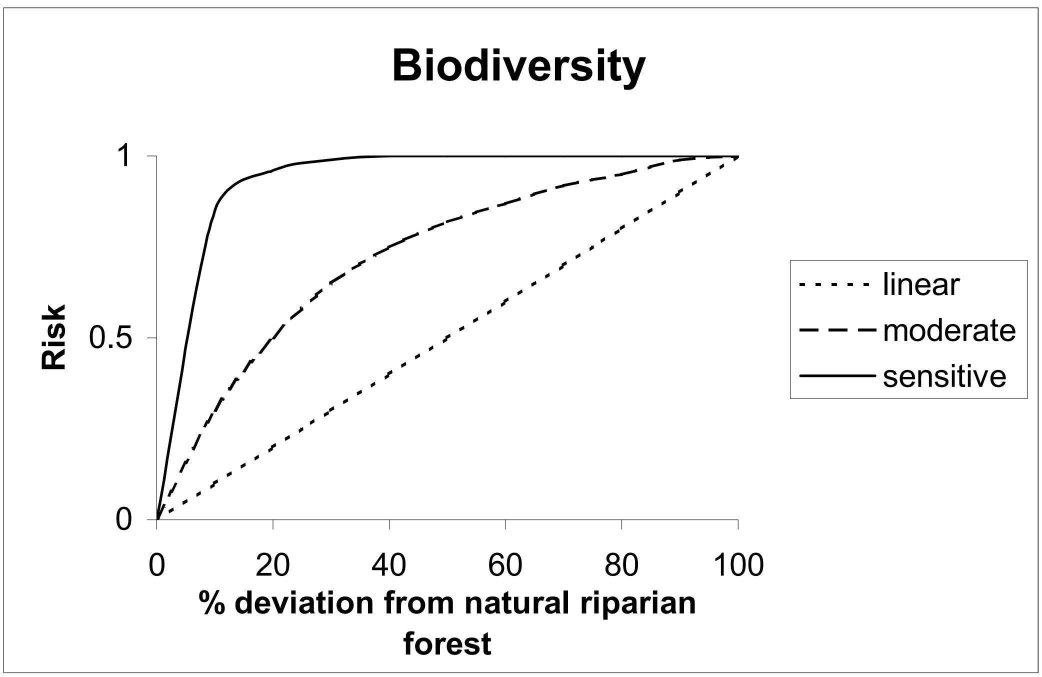


Figure 2. Risk curves for biodiversity. Estuaries, karst ecosystems and roaded small steep streams and gullies follow the sensitive curve. Floodplains, fans, forested swamps and unroaded small steep streams and gullies follow the moderate curve. Small low gradient streams, shoreline forests and wetlands (lakes, ponds, sedge fens, bogs) follow the linear curve.

Rare Ecosystems
We focussed on indicator RE1 (% of each listed ecosystem in old structural class).

The group changed the X-axis of RE1 to be consistent with the indicator of coarse filter biodiversity: deviation from natural % riparian forest. Instead of developing separate curves for each rare ecosystem based on their sensitivity, the group decided that, because of rarity and importance to biodiversity, rare ecosystems should follow the highly sensitive curve drawn for coarse filter biodiversity (Figure 2, sensitive curve). Because the rare ecosystem curve already includes estimates of importance and landscape abundance, it should not be shifted upwards later in the model.

Rachel felt that RE2 was not necessary due to the mathematical properties of calculating % deviation from % natural. Hence, we did not consider RE2 further. However, this does not include effects of small size.

We asked the experts which listed, and non-listed, ecosystems are of greatest concern. Jim has completed a report for the North Coast LRMP on rare ecosystems. He suggests that we start there. Completing a similar report for the Central Coast and Haida Gwaii would entail considerable work.

Corridors
We focussed on indicator C5 (% streams with connected cover from head to mouth). The North Coast ERA has already analysed upland forest (C4; % forest > 250 years) and we did not want to spend time duplicating effort. Concern was expressed whether C3 (diversity of ecosystem types) related to corridor use.

The indicator needed refining. Because natural levels of connected cover vary across the coast (e.g. Skidegate Plateau had streams with naturally connected forest from head to mouth; whereas mainland streams usually cross avalanche tracks, bogs and other non-forested ecosystems), we changed the indicator to deviation from natural levels of cover. We agreed to use process zone as the appropriate scale of measurement. The group had no reason to consider shapes beyond linearity for the corridor indicator due to uncertainty (Figure 2, linear curve).

Downed Wood
We had insufficient time to consider the relative merits of DW1, DW2 and DW3 adequately. However, the group felt that using % deviation from natural riparian forest as the X-axis was appropriate. For its importance to terrestrial functions (e.g. habitat for tree seedlings, other plants and animals, underground conduits), the group considered old forest to be a necessary part of the indicator (as opposed to Mike Church's group considering hydrological functions).

The group suggested a linear risk curve beginning at 20% deviation from natural (Figure 3). Although the X-axes differ, this shape is almost identical to the curve developed by Mike's group.

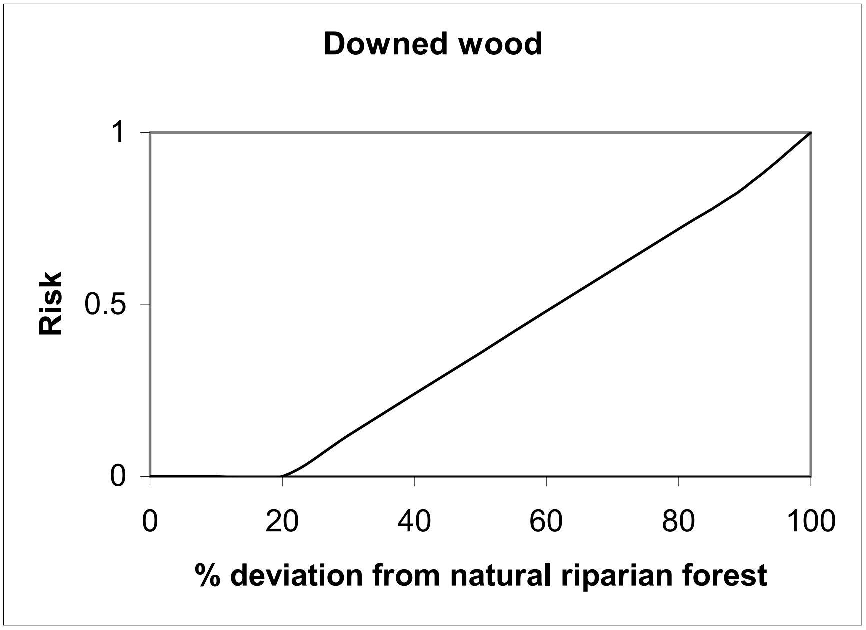


Figure 3. Risk to downed wood functions with % deviation from natural riparian forest.

Ecosystem productivity
We focussed on indicator EP4 (% of ecosystem modified by modification class).

The terrestrial group had no difficulty with the definition of ecosystem productivity (unlike the hydrology group), but did have trouble relating % modified to deviation from natural. For example, the area covered by road could be calculated, but the area influenced would depend on road location. The group felt that the detail in indicator EP4 (different modification classes) was too operational to be considered at this more strategic level. They concluded that the biodiversity curves, reflecting current practices (including access), would apply equally to ecosystem productivity (Figure 2).

The group discussed roads briefly. They stated that, relative to upland ecosystems, productivity in all hydroriparian ecosystems is sensitive to degradation by roads, and drew a highly sensitive curve relating risk and road density. We had insufficient time to develop this graph fully—in particular, we did not set the density at which risks became very high. Although not our mandate, the group voiced concerns about roads, particularly those crossing hydroriparian ecosystems on steep ground, leading to sedimentation.

Appendix 1. Information sent to participants in advance of workshop.

Workshop goals

- *to use expert opinion to assess characteristics of each hydroriparian ecosystem*
- *to consider how retention affects recovery times for these ecosystems*
- *to use expert opinion to draw risk curves for indicators of hydroriparian function*
- *to discuss issues related to coastal hydroriparian risk*

You may not be (probably will not be) comfortable developing risk curves in the absence of information. That's OK—I'd like to learn what we can and can't do, where the discomfort lies, how to reduce discomfort, and, of course, what are the implications of all of the above.

Background
Concern over forestry-related impacts to hydroriparian function in coastal BC led to the concept of a Hydroriparian Decision Tool (HDT). The Coastal Information Team (and formerly, the Joint Solutions Project) gathered a group of practitioners and scientists to develop a HDT, one component of an ecosystem-based management framework, for potential use at LRMP and forest management levels.

The CIT recently directed the HDT working group to follow an Environmental Risk Assessment approach rather than simply presenting management guidelines. Benefits of a risk approach include explicit statements of assumptions and levels of uncertainty. Costs can include increased time and effort for the same end result.

The working group has chosen indicators to represent hydroriparian functions (see "Indicators for Workshop" file). The next task—this workshop—is to assess levels of risk to each function. Very few data exist; expert opinion is critical. A combination of data and expert opinion on risks and uncertainties will form *a priori* beliefs for potential inclusion in the decision tool, in formal risk modelling (such as the Bayesian Belief Networks being used for the North Coast LRMP) and in adaptive management experiments. Any modelling would occur during a subsequent project - the current project focuses on developing the conceptual tool.

Scope

We will consider selected terrestrial functions of hydroriparian ecosystems in four physiographic units on the coast:
geographic extent: North Coast, Central Coast and Haida Gwaii/QCI;
physiographic sub-regions: Hecate Lowland, Outer Coast Mountains, Inner Coast Mountains, Haida Gwaii (from Pojar et al. 1999 and hydrological analysis in Trainor 2000);
hydroriparian ecosystems (although the distinction between upland and wetland is unclear on the wet coast, the tool is limited to those areas of land that influence, or are influenced by, water): small steep streams, torrented gullies, small low gradient streams, fans, high-bench floodplains, low-bench floodplains, karst, forested swamps, sedge fens, bogs, wetland ponds, lakes, shoreline forests, estuaries

terrestrial functions of hydroriparian ecosystems (hydrological and aquatic functions were considered at a separate workshop):

contain diverse structure and vegetation (important for biodiversity),
contain rare ecosystems,
serve as corridors,
provide downed wood,
maintain characteristic ecosystem productivity,
moderate microclimate

Central questions/tasks

- ***For goal 1: to use expert opinion to assess characteristics of each hydroriparian ecosystem***
    - Assess relative importance and influence of each hydroriparian ecosystem for maintaining hydroriparian functions.
    - Document how common or rare each hydroriparian ecosystem is in each physiographic unit
    - Explore what is known about rates of natural disturbance in each hydroriparian ecosystem

- ***For goal 2: to consider how retention affects recovery times for these ecosystems***
    - Can we develop a structural index (e.g. old growth equivalency index) based on forest age and retention? We'll discuss recovery curves for a few example ecosystems. Are there any generalities that can be drawn regarding old growth equivalency depending on retention amount? or is it different in each ecosystem? What are our assumptions and levels of certainty?

- ***For goal 3: to use expert opinion to draw risk curves for indicators of hydroriparian function***
    - Can we describe general shapes for each indicator (linear, insensitive, sensitive, S-shaped)? What are our assumptions and levels of certainty?
    - Are there thresholds? What are our assumptions and levels of certainty?
    - Do curves shift for physiographic units? Do they shift for different hydroriparin ecosystems? What are our assumptions and levels of certainty?
    - What indicators/risk curves need further investigation through adaptive management?

- ***For goal 4: to discuss issues related to coastal hydroriparian risk*** *(Many of these may be discussed as we go through the first 3 goals)*

    - *Integration issues:*
        - Can we assess risk at a watershed level? How can we integrate stand-level risks?

    - *Natural disturbance issues:*
        - How can we deal with watersheds/ecosystems with different disturbance regimes? (for hydroriparian ecosystems, we can't assume—as Rachel Holt has

for upland ecosystems—that oldgrowth is the natural state, but we don't know disturbance regimes)

- Does probability of maintaining hydroriparian function differ with proportion or amount of ecosystem (e.g. some watersheds may have 10% old forest on floodplains; others may have 60%—is maintenance of half of this amount equivalent? or is old forest more valuable in the floodplain in which it is naturally rare; or is old forest more valuable in the floodplain in which it is common because the ecosystems there have adapted to the high level)

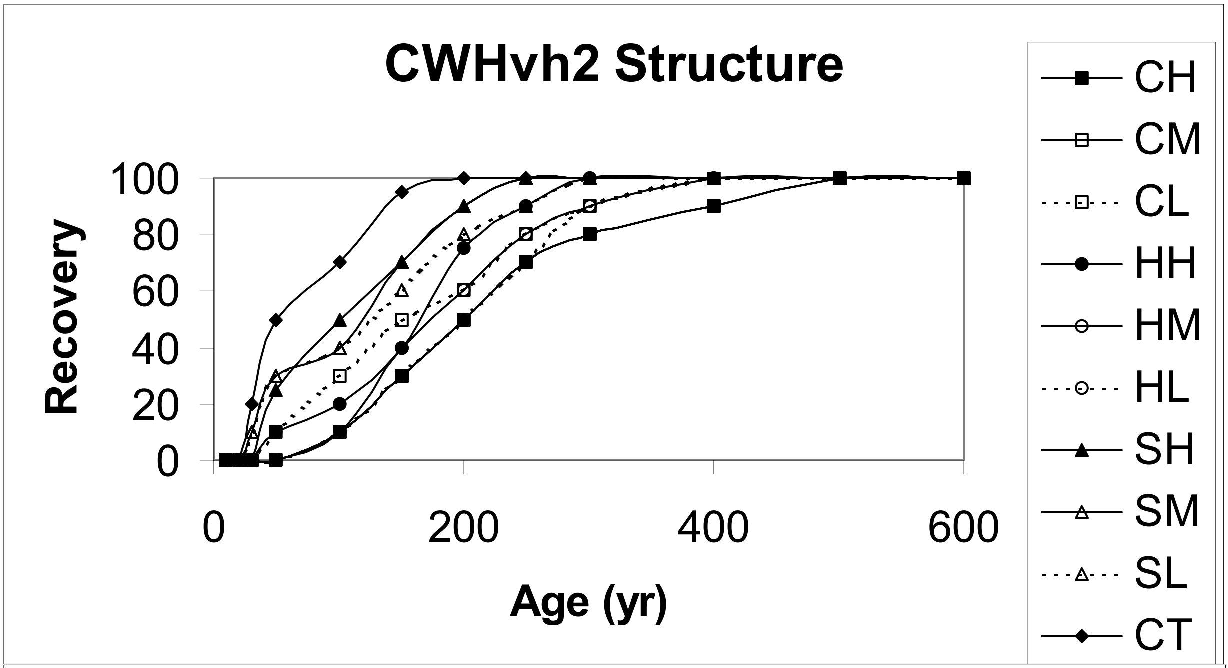
- *Recovery issues:*
  - Can we assume that recovery of other organisms is a function of structure, vegetation and soil?
  - Have you seen ecosystems that have not recovered after disturbance due to isolation or lack of seed source?

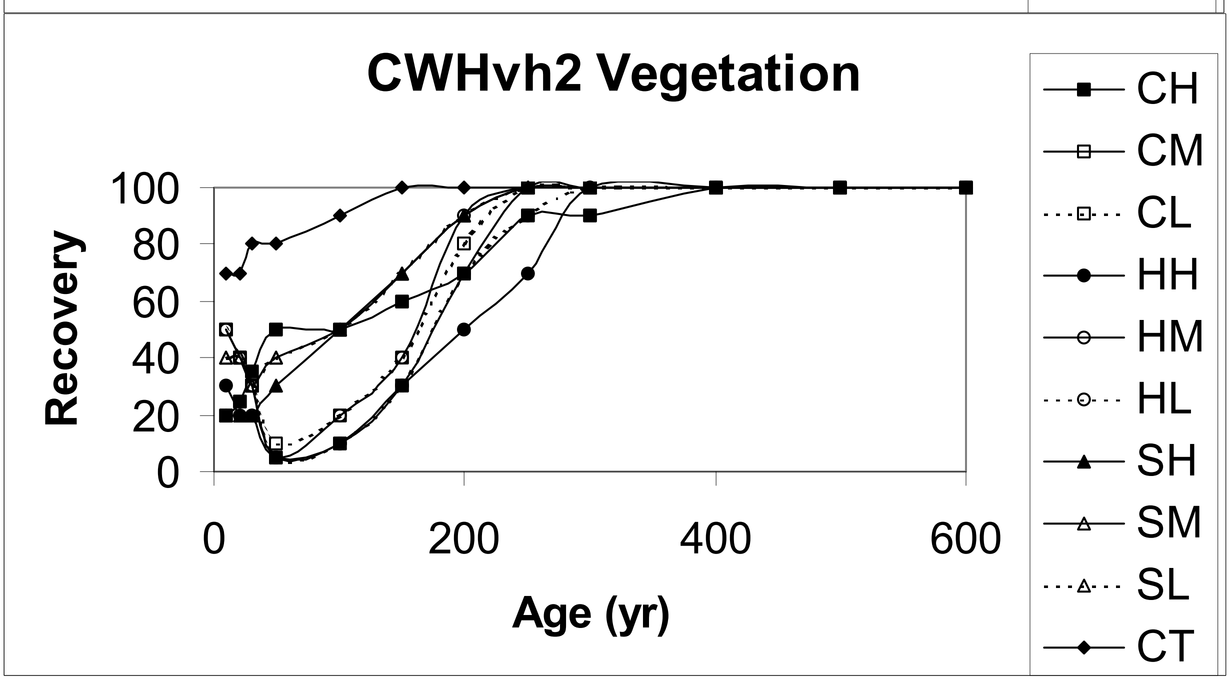
- *Rare ecosystems issues*
  - Do we need to consider each rare ecosystem separately? Or can we develop a general curve that applies to several?
  - What listed ecosystems are of greatest concern?
  - What rare, but not CDC-listed, ecosystems are important?

- *Productivity issues:*
  - Do roads change floodplain productivity?
  - Does Hyp3 give any guidance about bogs? Are there better indicators?

- *Corridor issues:*
  - Given that hydroriparian corridors in unmanaged landscapes are openings in an old forest matrix, and, in managed landscapes, are old forested strips in a young matrix, can we conclude anything about corridor use in natural systems?
  - Is interior oldgrowth important in riparian corridors?

Appendix 2. Examples of recovery curves developed by Jim Pojar and Allen Banner for North Coast Environmental Risk Assessment[11]. The two graphs show recovery of structure and understory vegetation for 10 analysis units (leading species and site index combinations) in the Hecate Lowland.





[11] Methods in Holt and Sutherland (2002).