Testing the Hydroriparian Planning Guide

Report for the North Coast LRMP and Coastal Information Team

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Summary

This report describes a map-based test of the Hydroriparian Planning Guide designed to

- identify gaps, uncertainties and redundancies in the guide, and
- estimate the impact of precautionary guidelines on timber harvest in two North Coast watersheds.

Paril River (5,300 ha) has been harvested over the past decade; development of Chambers Creek (~ 9,000 ha) has recently started. The test uses existing maps (1:20,000) and databases to design hydroriparian ecosystem networks that meet the precautionary guidelines listed in the Hydroriparian Planning Guide.

The test clarified the guide in several places (see Section II):

- Terrain mapping (at least of fluvial units) is required to use the Hydroriparian Planning Guide.
- Mapping the transportation and deposition zones using terrain information plus a fixed-width buffer is preferable to the procedure listed in the guide.
- Not all colluvial cones should be included within the transportation zone.
- Stream morphology assessments should be performed by sub-basin.
- Site-level assessment will be important to classify small streams.

Identification of redundancies led to a simpler process to design the hydroriparian ecosystem network (see Section III):

- on a base map showing water features, contours and process zones,
  1. Reserve all terrain polygons classified as slope stability IV or V.
  2. Reserve all terrain polygons classified as active fluvial units (or as floodplains of unknown activity). Reserve all wetlands.
  3. Reserve buffers around all streams within the transportation and deposition zones.
  4. Determine if extra reserves are required to protect high-valued fish habitat.
  5. Reserve red-listed, blue-listed and other rare ecosystems.
  6. Calculate the area of each hydroriparian ecosystem to reserve. Add preliminary reserves as necessary, considering site series (or surrogate) representation.
  7. Select small stream reserves in source zone. Consider site series representation.
  8. Check that all site series are proportionally represented and modify as necessary.
  9. Check that requirements for corridors are met within the reserve system and modify as necessary.

Assessment of the effect of each guideline on the hydroriparian ecosystem networks (see Sections II and III) found that, in the two study watersheds,

- guidelines designed to maintain stream morphology, bank stability and downed wood addressed guidelines designed to protect high-valued fish habitat,
- guidelines designed to maintain stream morphology, bank stability and downed wood generally addressed guidelines designed to maintain biodiversity; exceptions, including

fans and high productivity riparian hemlock stands, required relatively little additional area to provide representation,

- relatively little additional area was required to provide continuous corridors along small streams.

The precautionary watershed-level hydroriparian ecosystem networks covered 56% (in Chambers Creek) and 64% (in Paril River) of operable forest, leaving 10 and 11% of each entire watershed available for harvest (see Section IV). Steps in the hydroriparian ecosystem network design with the biggest impact on operable forest included, in order,

- reserving Class IV terrain,
- reserving active fluvial units,
- buffering streams in the transportation zone.

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Introduction

A group of scientists and practitioners working for the Coastal Information Team have created a hydroriparian planning guide aiming to help planners, managers and others to design practices that are likely to maintain hydroriparian functions at a watershed scale during forest management. The North Coast technical team has expressed interest in using the guide to inform the North Coast Land and Resources Management Plan (NC LRMP). The procedures outlined in the guide, however, have not yet been tested. This document describes a map-based test of the Hydroriparian Planning Guide using two watersheds in the North Coast. The test has two aims: to identify gaps, uncertainties and redundancies in the planning guide; and to estimate the impact of precautionary recommendations, provided by the guide, on timber harvest in two North Coast watersheds.

Report Overview

This report has four sections. The first section briefly describes the study watersheds and databases used. The second section makes up the bulk of the report, discussing, in order, each step listed by the Hydroriparian Planning Guide. The section tabulates results for the two test watersheds, reviews each step and provides recommendations both for revisions to the guide and for people implementing the guide. Following the review, the third section offers a condensed list of steps needed to create a precautionary Hydroriparian Ecosystem Network. The final section discusses timber harvest impacts for the two study watersheds.

Project Scope

The Hydroriparian Planning Guide presents two options: precautionary guidelines and a risk-based assessment to be used when precautionary guidelines are not followed. This initial test focuses on precautionary guidelines. Managers will assess whether to move beyond precautionary guidelines after they have examined the ramifications of accepting the guidelines: hence testing the precautionary guidelines is paramount.

Although it considers sub-regional and landscape level context, the Hydroriparian Planning Guide concentrates on watershed-level planning, to be followed by site-level revision. This project tests only the watershed component of the guide. Although more detailed information on the study watersheds exists (e.g. Forest Development Plans, Triumph Timber's individual stream assessments), this test considers only information that would normally be available for watershed-level (i.e. 1:20,000) planning.

The hydroriparian ecosystem networks mapped in this report are not operational. They represent a paper exercise designed to test the steps of the Hydroriparian Planning Guide for feasibility and efficiency. As the project progressed, I learned better ways to define the networks. I did not always incorporate these changes into the plans (due to the time required for GIS processing) but instead listed them as recommendations.

Both study watersheds lie within the Outer Coast Mountains. Different concerns may arise in the Hecate Lowland.

Hydroriparian Definitions

The Hydroriparian Planning Guide defines and uses a variety of terms. Definitions are not always consistent or operational. I have used several terms within this report, with the following definitions. Within the Hydroriparian Planning Guide, ***hydroriparian ecosystems*** are defined as "aquatic ecosystems plus adjacent terrestrial ecosystems that are influenced by, or influence, the aquatic system". I adopt this definition in this report. Operationally, hydroriparian ecosystems include floodplains, fans, wetlands, lakes and streams (aquatic ecosystems, and terrestrial ecosystems that are influenced by the aquatic system) plus an adjacent ribbon as wide as one and a half tree heights (terrestrial ecosystems that influence the aquatic system). Floodplains, fans, wetlands, lakes and streams are derived from terrain information. I call these ***hydroriparian features***. ***Hydroriparian site series*** are site series described by the biogeoclimatic ecosystem classification system as associated with floodplains and fans. The planning guide also defines ***hydroriparian zones***. Because hydroriparian zones are operationally equivalent to hydroriparian ecosystems, I do not use this term in this report.

I. General Methods

Study Watersheds

With assistance from Jim Schwab (Prince Rupert Forest Region Research) I selected two study watersheds from the limited set of watersheds in the North Coast with existing high quality terrain mapping. Paril River lies at the south of the forest district between Ursula Channel and Alan Reach; Chambers Creek empties into Nass Bay in the north (Figure 1). The Paril River study watershed contains two mapped third-order watersheds covering a total of 5,300 ha. Chambers Creek includes a single third-order watershed of 8,911 ha.

Paril River has been harvested over the past decade; development of Chambers Creek has only recently started. The differing levels of development facilitate testing of different parts of the Hydroriparian Planning Guide. The harvesting in Paril River allows for testing of the precautionary guidelines and risk assessment; Chambers Creek, still mostly undeveloped, allows for creation of a hydroriparian ecosystem network with few constraints. Most of Paril River was harvested prior to 1995; practices have changed. I considered that comparing harvesting of a decade ago to the guidelines and risk curves provided in the guide might provide interesting insights.

Data

Initially, James Warren (Spatial Analyst, Ministry of Sustainable Resource Management) collected and compiled information from several spatial databases using ArcInfo (Table 1).

Table 1. Information used to test the Hydroriparian Planning Guide.

Data source	Information
TRIM	Contours, water features
Watershed Atlas	Watershed boundaries
Terrain Stability Mapping (Maynard 2001)	Terrain stability classes, terrain classification (floodplains, fans, gullies)
Forest Cover	Forest age, harvesting activity, inventory type group, site index
Rare Ecosystem Mapping (Ronalds and McLennan 2002)	Rare ecosystems (not available for Paril River)
NC LRMP	Known salmon-bearing systems
NC LRMP	Existing roads
NC LRMP	Timber harvesting landbase
ssPEM	Aggregated site series, modelled floodplain and fan ecosystems

Further GIS processing became necessary as the project developed. Dave Daust completed these analyses in ArcView. Due to processing time constraints, selected boundaries did not always match perfectly; hence area summaries are not precise. Cross-checks revealed no errors of greater than 5%. This level of precision seemed sufficient for the purposes of this report.

I used air photos (1992 series with terrain typing) to confirm or reject data when databases disagreed.

Steps

The hydroriparian planning guide lists the steps reproduced below. For this project, I focused on the watershed scale, and followed the steps highlighted in bold text.

1) **Define sub-region**
   a) **determine sub-region of interest**
   b) **describe natural disturbance regime for the sub-region**
   c) gather existing information about rare ecosystems and management zones
   d) assess current risk to rare hydroriparian ecosystems and note constraints to lower level planning
   e) plan adaptive management

2) Define landscape
   a) describe landscape character and condition and determine landscape of interest
   b) assess risk to rare ecosystems, biodiversity and stream morphology and note constraints to lower level planning

3) **Develop watershed plan**
   a) **develop interpretative maps of watershed character and condition, including delineation of hydroriparian zone**
   b) **define targets for reserves and development based on precautionary guidelines and/or risk assessment**

   c) **design and map reserves and identify potential harvestable area**
   d) develop monitoring plan

4) Develop site plan
   a) verify and/or revise mapped watershed reserves
   b) delineate more ecologically appropriate boundaries for hydroriparian ecosystem network, and other watershed reserves, as necessary
   c) design site level reserves, retention, and management zones
   d) delineate harvestable area, design harvest system components, specify site-level practices

5) Feed back information
   a) pass site-level information back to watershed-level plan and to monitoring and adaptive management plans
   b) enter specific information into hydroriparian database

I relied on terrain features (e.g. floodplains and fluvial fans) to delineate preliminary hydroriparian ecosystems. I then checked whether these hydrologically-derived boundaries needed to be expanded to include terrestrial hydroriparian ecosystems as defined by biogeoclimatic site series. Terrestrial Ecosystem Mapping is not available for the study watersheds. Preliminary investigation of ssPEM aggregated site series revealed some inconsistencies; hence I felt uncomfortable using it as a sole source. Instead, I used a combination of timber "Analysis Units" (created from inventory type group and site index) and ssPEM aggregated site series to delineate additional hydroriparian ecosystems. I classified terrestrial ecosystems as hydroriparian ecosystems only if they were listed as fluvial or fan site series in ssPEM (e.g. "FL" or "AS/AD(HD)" within the CWHvm1) *and* as high productivity analysis units.

The next section works through the Hydroriparian Planning Guide step by step, discussing methodological issues as they arise within each step.

II. Review of the Hydroriparian Planning Guide

1a) Define sub-region

Figure 2 of the guide illustrates the division into sub-regions.

Study Watershed Results

Watershed	Sub-region
Paril	Outer Coast Mountains – Kitimat Ranges
Chambers	Outer Coast Mountains – Boundary/Skeena Ranges

Review of Planning Step

Figure 2 of the Hydroriparian Planning Guide, mapping the eleven hydroriparian sub-regions, was adequate for the selected watersheds. From the figure provided, it may be difficult to classify watersheds in transitional areas. A GIS version of this map now exists, following watershed boundaries.

Currently, sub-regions have little impact on planning activities. A project defining natural disturbance patterns for each sub-region, will test the relevance of these divisions. In addition, sub-regions may prove useful in designing the adaptive management and monitoring projects required when practices exceed precautionary guidelines.

Recommendations

- Replace existing Figure 2 with GIS version.

1b) Describe natural disturbance regime

The guide provides an appendix listing preliminary natural disturbance regimes.

Study Watershed Results

Appendix 5 of the Hydroriparian Planning Guide estimates a return interval of 950 years for both watersheds, suggesting that a mean of 86% of unmanaged forest would be over 140 years old, and that 77% would be over 250 years.

Review of Planning Step

Appendix 5 will be revised in June based on an analysis of natural disturbance regimes of the coast and on recent literature reviews (Dorner and Wong 2002, 2003). The North Coast LRMP currently specifies return intervals for analysis units varying from 700 years for high productivity sites to over 2,000 years for low productivity cedar and hemlock sites and medium productivity cedar sites. Appendix 5 is based on an assumption of randomly-located stand-replacing disturbances—likely overestimating disturbance frequency in forests outside unstable terrain.

Recommendation

- Update Appendix 5 based on analyses.

1c) Gather information for sub-region

Study Watershed Results

No higher level plans exist. Some rare ecosystem mapping exists (primarily red-listed fluvial ecosystems) for some watersheds in the sub-region (Ronalds and McLennan 2001).

1d) Assess risk to rare hydroriparian ecosystems and note constraints

The guide calls for risk assessment based on provided curves.

Study Watershed Results

I did not analyse sub-regional patterns in rare ecosystems as part of this project. Ronalds and McLennan (2001) have identified and mapped rivers in the North Coast with significant components of red-listed floodplain ecosystems. They considered that Chambers Creek, but not Paril River, has significant rare ecosystems.

1e) Plan adaptive management

This step is not required for management that follows precautionary guidelines.

2) Define landscape

Landscape-level analysis was not possible within the time available for this project. Such analysis requires information for all watersheds surrounding the study watershed. Landscape-level planning primarily provides a context for the more detailed watershed-level plan and allows for trade-offs among watersheds.

3a) Develop interpretive maps of watershed

Terrain map

This map is not created for the planning guide, but should already exist.

Study Watershed Results

Good quality terrain maps exist for Paril River and Chambers Creek (Maynard 2001a,b). Existing terrain stability mapping does not divide Class IV terrain.

Review of Planning Step

Existing terrain mapping varies considerably in quality (Mike Church, personal communication), but floodplain and fan delineation should be sufficiently accurate to apply the guide in most cases (see discussion under Process zone map, below). Terrain mapping does not exist for parts of the North Coast. Management without terrain mapping, given current levels of understanding, is not sufficiently precautionary (Mike Church, personal communication).

Recommendations

- Terrain mapping is required for application of the Hydroriparian Planning Guide.

Process zone map

This map is created as part of the Hydroriparian Planning Guide. Appendix 7 of the guide lists methods.

Study Watershed Results

Transportation zones follow the valley-bottoms; source zones cover the hillslopes. Paril has no deposition zone. Chambers has a small deposition zone at the mouth. However, because this area was so small and because guidelines are the same for both transportation and deposition zones, I combined the two zones for simplicity (Figure 2).

Review of Planning Step

Appendix 7 of the Hydroriparian Planning Guide delineates process zones using landforms classified on the terrain map. Delineation of process zones is relatively straightforward on the terrain map, but requires complex queries to a GIS database because of the complexity of terrain symbols.

Basing the transportation zone purely on the location of floodplain and fan landforms results in patches of transportation zone within a source zone matrix and can miss areas that are influenced by water (e.g. extensive organic plains). Appendix 7 of the planning guide specifies that polygons with a terrain slope class of 2 – 3 (class 2 = 6 – 27%; class 3 = 28 – 49%; Kristie Trainor, personal communication) adjacent to floodplains and fans should also be included. This addition creates continuity, but can include areas that are not strictly within the transportation zone. In particular, when terrain mapping quality is deficient, adjacent zones may extend for a considerable distance away from hydroriparian ecosystems (Mike Church, personal communication). An alternative approach adds a fixed buffer (one and a half tree height default as described in the planning guide) to mapped floodplain and fan polygons, ignoring adjacent terrain polygons (both methods are subject to revision after field checking).

I delineated process zones in both ways ("adjacent polygon" vs. "fixed buffer" approach) to compare the approaches. The adjacent polygon approach resulted in a slightly larger transportation zone in Paril and slightly smaller zone in Chambers (1,059 ha vs. 917 ha in Paril; 1,016 ha vs. 1,033 ha in Chambers). In Paril, both methods included about 80% of hydroriparian site series as defined by the intersection of timber Analysis Units and ssPEM aggregated site series (see General Methods section) whereas the floodplain and fan terrain units alone excluded almost half of these hydroriparian ecosystems (Tables 2 and 3). In Chambers, both methods included over 85% of hydroriparian site series, while floodplain and fan units alone captured about three quarters. Overall, the two methods resulted in similar zoning for these particular watersheds. With the high quality of terrain mapping available for the study watersheds, this encouraging overlap between terrain units and terrestrial ecosystems is perhaps not surprising (Mike Church, personal communication).

Table 2. Hydroriparian plant communities (defined as the intersection of analysis units and ssPEM aggregated ecosystems) represented by different approaches to delineating the transportation zone in Paril River watershed.

Analysis unit	ssPEM ecosystem	Total area (ha)	Adjacent polygon (% captured)	Fixed buffer (% captured)	Fans and floodplains alone (% captured)
Cedar High*	AS/AD(HD)**	18	86	86	82
Hemlock High	AS/AD(HD)	9	100	100	29
Hemlock High	FL	12	96	96	29
Spruce High	AS/AD(HD)	6	100	100	97
Spruce Medium	AS/AD(HD)	25	85	85	46
Spruce Medium	FL	49	73	72	61
All hydroriparian communities		119	83	83	57

* Spruce High = CWHvm1/09(08); others = CWHvm1/05/08 or CWHvm2/05/08 (Crosswalk tables A. Banner)
** AS/AD(HD) = CWHvm1/07/08(06); FL = CWHvm1/09/10/11 or CWHvh2/08/09/10 (ssPEM aggregated ecosystem table M. Eng)

Table 3. Hydroriparian plant communities (defined as the intersection of analysis units and ssPEM aggregated ecosystems) represented by different approaches to delineating the transportation zone in Chambers Creek watershed.

Analysis unit	ssPEM ecosystem	Total area (ha)	Adjacent polygon (% captured)	Fixed buffer (% captured)	Fans and floodplains alone (% captured)
Hemlock High	AS/AD(HD)	7	71	71	43
Spruce High	FL	13	100	100	92
Spruce Medium	AS/AD(HD)	68	79	90	68
Spruce Medium	FL	60	93	100	87
All hydroriparian communities		148	86	94	77

Some active fluvial landforms mapped for the study watersheds (e.g., active fluvial blanket and active fluvial veneer) are not included in the list of transportation zone landforms provided in Appendix 7 of the guide. Any terrain polygon with an "active" qualifier should be included within transportation or deposition zones (Mike Church, personal communication). Conversely, colluvial cones are included in the list of landforms, but perhaps should be excluded. Several units marked as colluvial cones identify talus aprons rather than hydroriparian ecosystems; others represent steep (>26%) debris flow fans on drainage lines (likely snow avalanche deposits; Mike Church, personal communication). I included all cones in Paril River, but removed talus aprons in Chambers Creek.

Although process zones generally include a deposition zone at the outlet of major watersheds, a transportation zone along valley bottoms, and a source zone on hillslopes, deposition and transportation pockets also exist within tributary systems. Some of these areas are visible on maps; others will be identified in the field. The current methodology does not identify wetlands as deposition zones. The planning guide should note that wetlands are included in a transportation or deposition zone and that the mapped process zones can include pockets of other zones. Site-level planning will revise the general outlines drawn at the watershed scale.

Terrain mapping does not exist for parts of the North Coast. No reliable procedures exist to map process zones for watersheds with no, or questionable, terrain mapping. Slope criteria could identify major floodplain units, but would lose pocket units, particularly fans, which could represent important habitat islands (Mike Church, personal communication). I tested the floodplain and fan model provided in ssPEM in Paril River. Unfortunately, this model has not been calibrated to the region, and relies on default values (Don Morgan, personal communication). For Paril River, the overlap between predicted ssPEM landforms and terrain landforms is poor for floodplains, and abysmal for fans (60% of ssPEM floodplain overlaps with terrain-classified floodplain; 17% of ssPEM fans overlap with terrain-classified fans; Table 4).

Table 4. Floodplain and fan units wrongly classified by ssPEM relative to terrain mapping in Paril River.

Landform	False negative (% of area classed as floodplain or fan by terrain mapping)	False positive (% of area classed as floodplain or fan by ssPEM)
Floodplain	67	40
Fan	89	83

Recommendations

- Do not use the current, uncalibrated version of ssPEM to define hydroriparian ecosystems.
- Use a terrain map in conjunction with GIS queries to delineate process zones. Do not include long linear colluvial cones (“Cc”) within the transportation zone.
- Use either adjacent polygon method or fixed buffer method to delineate transportation zone (but see Hydroriparian ecosystems, below). Further investigation is needed to determine when one method is preferred over another.
- Revise Appendix 7 to include all active fluvial polygons and to define slope class 2 – 3.
- Revise Process Zone mapping step to mention that pockets of one zone may exist within another (i.e. deposition zones may exist within the source zone).

Hydroriparian ecosystem map

This map is created as part of the Hydroriparian Planning Guide using existing information. Operationally, the map involves drawing a GIS buffer around water features and terrain-derived hydroriparian features.

Study Watershed Results

Existing data at the watershed scale (1:20,000) allow identification of floodplains, fans, wetlands, lakes and streams. Forty-five metres (one and a half tree heights) has been added to all hydroriparian features to delineate hydroriparian ecosystems (Figure 3).

It is only possible to discriminate among the three classes of small very steep streams (susceptible to debris flow, not susceptible to debris flow but with unique microclimate, others) in the field (most small streams are not even mapped at the watershed scale). For the purposes of this test, I divided streams into those steeper than 20% and those less steep. Air photo interpretation/verification would improve identification of hydroriparian ecosystems.

Because small streams cannot be identified at this scale, the guide asks for a calculation of the proportion of source zone harvested to estimate the proportion of small streams harvested. Ten percent of the source zone of Paril River has been harvested. Less than 1% of the source zone of Chambers Creek has been harvested.

Review of Planning Step

Appendix 3 of the guide provides a comprehensive list of hydroriparian ecosystems. Many of these ecosystems, however cannot be identified at the watershed scale. A simpler list might facilitate planning.

If the transportation zone is defined by floodplains and fans with a fixed buffer (as discussed above), this zone will be congruent with the floodplain and fan hydroriparian ecosystems. Such congruence simplifies planning, and suggests that, unless further investigation shows otherwise, the fixed buffer method might be preferable.

Good terrain mapping accurately identifies floodplain and fans landforms, while ssPEM does a very poor job (see Table 4 above). The Hydroriparian Planning Guide uses hydroriparian site series as well as landform to define hydroriparian ecosystems. I listed stands identified as both fluvial or fan communities in ssPEM aggregated ecosystems and as productive analysis units (Cedar High, Hemlock High, Spruce High, Spruce Medium) to determine whether the terrain-based hydroriparian ecosystems (including a 45-m buffer) needed further expansion. Polygons classified as FL or AS/AD(HD) *and* as high productivity only covered an additional 20 ha in Paril River and 8 ha in Chambers Creek (see Table 2 above). I did not add these small areas. More detailed work, including air photo interpretation would be necessary to decide whether to add any area to terrain-based ecosystems based on site series. Using plant community to define hydroriparian areas may become more critical when good terrain mapping is unavailable.

Because small streams cannot be identified at the watershed scale, this step asks for an estimate of the proportion of the source zone harvested to determine the proportion of small stream ecosystems harvested. However, because of the pattern of harvesting (relatively narrow bands running along the watershed), this calculation can underestimate the proportion of harvested streams. For example, over the entire Paril River watershed, although 10% of the source zone has been harvested, 43% of streams in the source zone have portions harvested. In one sub-basin with 13% of the source harvested, 73% of the streams in the source zone have portions harvested. This calculation seems out of place within a mapping step.

Recommendations

- Provide a simpler list of hydroriparian ecosystems (floodplains, fans, streams >20%, streams < 20%, wetlands, lakes) to be used at the watershed scale unless more detailed information exists.
- Use floodplains and fans as defined by terrain mapping plus a one-and-a-half tree ribbon to define the extent of these hydroriparian ecosystems and to define the transportation zone (i.e. “fixed buffer” rather than “adjacent polygon” approach).
- Until further work in a variety of watersheds shows that hydroriparian features plus the fixed buffer will include all hydroriparian site series, continue to examine site series and add area to the hydroriparian ecosystem map as necessary.
- The amount of source zone harvested can severely underestimate the proportion of streams with some harvesting. A better estimate would calculate the proportion of streams with more than a certain percentage cleared. Consider revising the guide to include more effective indicators. Consider moving this calculation out of the map step.

High-valued fish habitat map

This map is not created for the Hydroriparian Planning Guide, but relies on existing information. High-valued fish habitat includes critical spawning and rearing areas for anadromous and non-anadromous fish. These areas are "biological hotspots"—specific places within aquatic systems where aquatic animals concentrate their activities and numbers.

Study Watershed Results

Coarse maps based on Department of Fisheries and Oceans salmon escapement data have been created for the NC LRMP. These maps show known salmon-bearing systems, rather than mapping high-valued fish habitat and do not consider resident fish. They do, however, provide useful information at the watershed scale.

Review of Planning Step

Sources vary for high-valued fish habitat. Many small streams with valuable habitat do not show up at a 1:20,000 scale.

Forest age map

This map is not created for the Hydroriparian Planning Guide, but relies on existing information.

Study Watershed Results

Forest cover maps exist for the study watersheds (Figure 4).

Review of Planning Step

It is difficult to age forests in ecosystems dominated by gap-phase dynamics. Often, age class 9 (over 250 years) is underestimated.

Terrestrial ecosystem map

This map is not created for the Hydroriparian Planning Guide, but relies on existing information.

Study Watershed Results

Analysis unit maps exist for the study watersheds (Figure 5). ssPEM exists, but needs to be refined. For example, in Paril River, some cutblocks running along contour lines were classified as avalanches. Full-scale PEM may be preferable to ssPEM.

Review of Planning Step

ssPEM requires further testing and verification. A combination of analysis units and ssPEM serves to identify terrestrial hydroriparian ecosystems in the absence of PEM or TEM.

Rare ecosystem map

This map is generally not created for the Hydroriparian Planning Guide, but relies on existing information. However, before inventory is complete, an estimate may prove useful.

Study Watershed Results

Rare floodplain and fan ecosystems have been mapped in Chambers Creek, but not in Paril River (Ronalds and McLennan 2001). The mapping project only considered rivers with significant components of red-listed floodplain ecosystems. According to Ronalds and McLennan (2001), Chambers has a “good representation of fluvial/colluvial fan forest”, and contains “large wetlands near the drainage divide with Johnson Creek”. These large wetlands are not CDC-listed, but are rare and significant within the North Coast (Pojar 2002).

In the absence of rare ecosystem mapping for Paril River, I estimated rare ecosystem occurrence in Paril River based on Analysis Units, crosswalk tables that link site series to Analysis Units (created by Allen Banner for the North Coast LRMP) and slope position. I also checked ssPEM classification. According to the crosswalk tables, Spruce High analysis units are likely either CWHvm1/09 (red-listed) or CWHvm1/08 (blue-listed), with 09 occurring on flat ground and 08 on slopes. The single Spruce High stand in Paril River is on flat ground may be 09. Cedar High, Hemlock-Balsam High and Spruce Medium analysis units could be either 05 (not listed) or 08 (blue-listed) in the CWHvm1 or CWHvm2 with 05 occurring mid-slope and 08 on gentle receiving slopes. From their position, the Cedar High stand, one of the Hemlock High stands and all eight Spruce Medium stands in Paril River may be blue-listed. ssPEM classification has some inconsistencies, but matches reasonably well, classifying the Spruce High stand, the Cedar High stand, one of the Hemlock High stands and several of the Spruce Medium stands as possibly blue-listed ("AS/AD(HD)"), and portions of two Hemlock High stands and five Spruce Medium stands as possibly red-listed ("FL"). To increase my level of confidence in the estimation, I used stands that qualified as rare in *both* ssPEM and analysis units to represent rare ecosystems in Paril River.

Review of Planning Step

Rare ecosystem mapping is the only reliable way to identify rare ecosystems. The Hydroriparian Planning Guide assumes that rare hydroriparian ecosystems will be mapped as part of watershed planning.

Development map

This map is not created for the Hydroriparian Planning Guide, but relies on existing information.

Study Watershed Results

Forest cover and ssPEM list logging activity. Although ssPEM records recent logging not included in the forest cover database, the dates are inconsistent. I have used forest cover projected age classes for this test, recognising that there has been more recent harvesting.

Review of Planning Step

Existing databases often mis-classify old logging as natural disturbances (Audrey Pearson, unpublished data). The 70 – 80-year old stands in the floodplain of Paril River were potentially logged. These young stands match high productivity ecosystems precisely (the only Spruce High and Cedar High analysis units in the watershed) and are located along the edge of the river near its mouth.

Recommendation

- Include old harvesting in assessments. Use air photo interpretation to determine whether young stands, particularly near river mouths, have been mis-classified.

3b) Determine targets for reserves and development based on precautionary guidelines and/or risk assessment

This test of the planning guide uses precautionary guidelines rather than the risk procedures. Hence, there is no need to design an adaptive management plan or to consider the tables of importance and influence. This section follows the procedures in Appendix 6 of the planning guide, examining guidelines and risk for each a series of functions.

Because harvesting in Chambers Creek has begun only recently, no watershed-level guidelines have been exceeded. Hence, this section focuses on Paril River, comparing the current condition of the watershed with precautionary guidelines and risk curves. The precautionary guidelines will be applied to Chambers Creek in the design of a hydroriparian ecosystem network.

Maintaining hydrological regime

Precautionary Guideline

- Rate of cut should not exceed 1% per year of the forested area averaged over 20 years applied to every watershed and sub-basin over 1,000 ha. Stratify larger watersheds into sub-basins of approximately 1,000 – 3,000 ha. Use more conservative guidelines if a practitioner's experience indicates that a watershed may have a higher risk.

Study Watershed Results

The rate-of-cut in Paril River does not exceed the precautionary guideline for any sub-basin (Table 5).

Table 5. Forest area less than 20 years old within sub-basins of Paril River.

Sub-basin	Total area (ha)	% of forested area < 20 years old
Paril 1	1,216	17.5
Paril 2	1,194	14.9
Paril 3	2,890	11.8
Total	5,300	14.2

Review of Planning Step

Some watersheds, like Paril, divide sensibly into sub-drainages; others, like Chambers, do not. Long, narrow watersheds pose the greatest challenge. It is possible to leave semi-linear mainstem portions as a single large unit if it appears from physiography and terrain that similar features and potential problems occur everywhere (Mike Church, personal communication). I did not divide Chambers Creek into sub-drainages. A possible division would put the headwaters of Chambers Creek into one unit, several steep lateral drainages of similar character to the southwest into a second unit, and the remainder of the watershed into a third.

The hydrology indicator is simple to calculate and interpret. Because it considers only recent logging, it is insensitive to mis-classified old logging.

Because of the small operable area in the North Coast, the precautionary guidelines for hydrology will rarely be exceeded and there will be little impact on current practices.

Recommendations

- Revise planning guide to allow larger sub-basins if specified criteria are met.

Maintaining Stream Morphology

Precautionary Guidelines

- Do not harvest hillslopes in stability class IV, failure of which might cause sediments to be delivered to any steam channel.
- The entire wet floodplain and all wetlands are no work zones. Wet floodplains should be considered to be part of the active channel.
- Road crossings of the wet floodplain should be minimised; roads should avoid dry floodplains where possible; roads crossing active fans must be constructed such that they will not influence natural processes.

Study Watershed Results

In Paril River, 48 ha of Class IV and 0.6 ha of Class V terrain have been harvested, according to the 2001 terrain map and forest cover map. Fifty hectares of active floodplain ($F^{A}p$, $F^{A}b$ or $F^{A}v$) have been logged recently; 27 ha near the river mouth were potentially logged decades ago. Some roads cross active floodplains and fans ($F^{A}p$ and $F^{A}f$). This project is not designed to assess the impacts of these activities.

Risk to stream morphology for the entire watershed is low (Table 6). There is a potentially moderate impact on stream morphology in one sub-basin.

Table 6. Risk to stream morphology based on indicator given in Hydroriparian Planning Guide Appendix 6.

Sub-basin	Road length indicator (km/km2 of Class IV/V terrain)	Harvest indicator (% of Class IV/V terrain harvested)	Total score	Risk
Paril 1	0.1	9.2	1	Moderate
Paril 2	0.1	1.1	0.2	Low
Paril 3	0.1	3.3	0.4	Low
Total	0.1	4.4	0.5	Low

Using precautionary guidelines would have reduced past harvesting. Reserving all areas of Class IV terrain will reduce the harvestable area of a watershed. Floodplains are not necessarily reserved, but are treated cautiously—reserving all active floodplains may not change practices greatly.

Review of Planning Step

The indicators for stream morphology are not consistent with the risk assessment or precautionary guidelines. An indicator specifies the length of planned road, yet the risk assessment only covers roads in Class IV and V terrain and the precautionary guidelines only mention roads on floodplains and fans.

The precautionary guidelines related to harvesting are easy to apply. Those related to road building are difficult to define (e.g. what do “minimise” and “where possible” mean?) and/or more relevant to site-level planning (e.g. fan crossings).

Risk to stream morphology varies among sub-basins. The guide does not specify whether to apply the risk to sub-basins or to the entire drainage. Risky practices in sub-basins of more than 1,000 ha should be noticed by forest managers, but it might be useful to specify calculations within sub-basin (Mike Church, personal communication). Although the planning guide allows for higher risk management in some sub-basins provided that the entire watershed is managed to lower levels of risk, it requires equivalency of sub-basins. In Paril, the unharvested Class IV areas are different in character (i.e. higher elevation, lower productivity forest).

The risk assessment matches the methods of the Coastal Watershed Assessment Procedures (CWAP), and hence should not change current practices.

Recommendations

- Revise the guide to ensure consistency among indicators, guidelines and risk assessments.
- Revise the guide to recommend that assessment be performed by sub-basin.

Maintaining Bank Stability

Precautionary Guidelines

- In transportation and deposition zones, leave wind-firm buffers.

Study Watershed Results

Based on 1992 air photos, all but one stream within the transportation zone were not buffered.

In Paril River, risk to bank stability is moderate to high (Table 7).

Table 7. Risk to bank stability based on indicator given in Hydroriparian Planning Guide Appendix 6.

Area of forested hydroriparian ecosystems in transportation zone (ha)	Area < 20 years old	% deviation from natural proportion < 20 years	Risk (from planning guide)
917	220	22	Moderate – high

Review of Planning Step

At the watershed scale, it is not possible to delineate "wind-firm" buffers. Instead, this step uses the default buffer width (one and a half tree heights) delineated on the map of hydroriparian ecosystems. Site-level planning will revise buffer design. The unconfined nature of channels on floodplains and fans means that the entire floodplain and fan are considered; buffering only the stream channel is not a viable option (Wilford and Sakals 2002).

Recommendation

- Revise the guide to suggest that buffer width will be determined at the site level.

Providing Downed Wood

Precautionary Guidelines

- < 30% of forest should be younger than 30 years in the source zone
- < 20% deviation from natural riparian forest in the transportation and deposition zone

Study Watershed Results

In Paril River, 10% of the source zone is less than 20 years, 11% is less than 40 years. The riparian forest over 140 years in the transportation zone deviates by 17% from natural (estimated natural amount of forest over 140 years = 86%; currently, 71% over 140 years). Both criteria meet the precautionary guidelines.

Review of Planning Step

The indicator and risk assessment are simple to apply, but possibly redundant given other indicators. The precautionary guidelines listed under downed wood match the requirement for 1% rate-of-cut (under hydrology, above) and are pre-empted by the requirement for wind-firm buffers in the transportation and deposition zone (under bank stability, above).

Downed wood in the source zone is considered effective by 30 years old. Forest age is usually divided into 20-year classes. For this analysis, I used 20 and 40 years. In Paril River watershed, there is virtually no impact of changing from 20 to 40 years.

The guide does not specify the age of natural riparian forest to consider. For the purposes of downed wood, 140 years is a likely cut-off; 250 years could also be used.

Recommendation

- The guide should retain a section on downed wood for completeness, but should refer to guidelines under other sections to avoid redundancy.
- Consider revising the guide to change age from 30 to 40 years old. Examine impacts of such a change.

Maintaining High-valued Fish Habitat

Precautionary Guidelines

- Reserve all high-valued fish habitat and adjacent areas from development; adjacent refers to any land from which there may be direct impacts on the habitat as a result of development. Direct impacts refer to temperature, water quality, sedimentation and bank stability.

Study Watershed Results

In Paril River, forest has been harvested from land adjacent to high-valued fish habitat (Table 8). Old logging (decades ago) logged across the channel; recent logging has left a buffer next to the mainstem (visible on 1992 air photos). A road runs close to the habitat in several places and crosses the channel once; impacts are unknown.

Table 8. Harvesting and roads with potential impact on high-valued fish habitat within sub-basins of Paril River.

Sub-drainage	Length of valuable stream (km)	Length with adjacent harvesting (km)	Road crossings
P1	5.5	1 (0.5 old + 0.5 recent)	1
P2	0	n/a	n/a
P3	2.7	1.6 (old)	0
Total	8.2	2.6	1

Review of Planning Step

The Hydroriparian Planning Guide does not describe how to avoid direct impacts to high-valued fish habitat (beyond avoiding activities in these areas), but assumes that managers will refer to other documents (e.g. Fish Stream Crossing Guidebook).

Protection of fish habitat requires that all other hydroriparian functions be maintained. The step is included for the sake of completeness and to introduce guidelines for small drainage basins that are not covered adequately under other steps. For large (>1,000 ha) drainage basins, the guidelines included in the Hydroriparian Planning Guide represent current management direction.

Recommendations

- The guide should refer to other documents or should list further methods.

Maintaining Rare Ecosystems

Precautionary Guidelines

- <3% deviation from natural proportion of old riparian forest by rare site series

Study Watershed Results

In Paril River, I used the intersection of analysis units (potentially rare ecosystems identified by analysis unit, crosswalk tables and slope) and ssPEM aggregated ecosystems to estimate rare ecosystems. Because the two methods disagreed over whether ecosystems were red- or blue-listed, I combined the two classes. Estimates of natural disturbance suggest that about 77% of forest should be over 250 years.

All of the high productivity spruce, high productivity cedar and high productivity hemlock stands have been harvested in Paril River. Two of eight medium productivity spruce stands remain (one CWHvm1, one CWHvm2). Deviation from natural levels of old forest is 90%, exceeding the precautionary guidelines (Table 9).

Table 9. Deviation from natural old forest in rare ecosystems in Paril River.

Area of rare ecosystem (ha)	Area < 250 years	% < 250 years	Deviation from natural (%)
118	108	92	90

Review of Planning Step

The methods for identifying rare ecosystems in Paril River were not ideal, but do serve to illustrate the potential impact of this guideline. Current practices do not reserve rare ecosystems. With completed rare ecosystem mapping, this indicator and risk assessment are simple to perform.

In general, planning for rare hydroriparian ecosystems will be conducted at the same time as planning for rare upland ecosystems. In the North Coast, almost all listed ecosystems, and most other rare ecosystems, are hydroriparian.

Maintaining Biodiversity

Precautionary Guidelines

- Estuaries, karst ecosystems, small very steep streams with high susceptibility to debris flow or on unstable terrain: < 3% deviation from natural riparian forest
- Floodplains, fans, forested swamps, small very steep streams with low susceptibility to debris flow, but distinctive microclimate: < 10% deviation from natural riparian forest
- All other hydroriparian ecosystems: < 30% deviation from natural riparian forest
- In each hydroriparian ecosystem, determine areas for reserve and harvest by site series according to their representation in the watershed

Study Watershed Results

Table 10 lists the deviation from the natural amount of riparian forest for each hydroriparian ecosystem. All hydroriparian ecosystems fall within the precautionary guidelines except for fans. Based on the risk assessment curve, fans are at high risk for biodiversity in Paril River. All remaining unharvested fans become reserved in the hydroriparian ecosystem network; others are selected for restoration.

Table 10. Deviation from natural levels of old forest in each hydroriparian ecosystem in Paril River.

Hydroriparian ecosystem	Area in forested hydroriparian ecosystem (ha)	Area >140 years (ha)	% >140 years	Deviation from natural* (%)
Floodplain	478	397	83	3
Fan	430	213	50	42
Steep streams (>20%)	573	418	73	15
Steep streams on unstable terrain	286	266	93	0
Wetland	74	63	85	1
Lake	14	11	79	8

* Natural estimate is 86% greater than 140 years old.

The areas harvested within hydroriparian ecosystems are not representative. I analysed representation using timber Analysis Units which represent groups of site series. Within each hydroriparian ecosystem, harvest targets productive forest. Within hydroriparian ecosystems in the source zone (primarily streams) and transport zone (primarily floodplains and fans), all of the high productivity Analysis Units, 40 – 90% of the medium productivity units and none of the low productivity units have been logged (Figure 6).

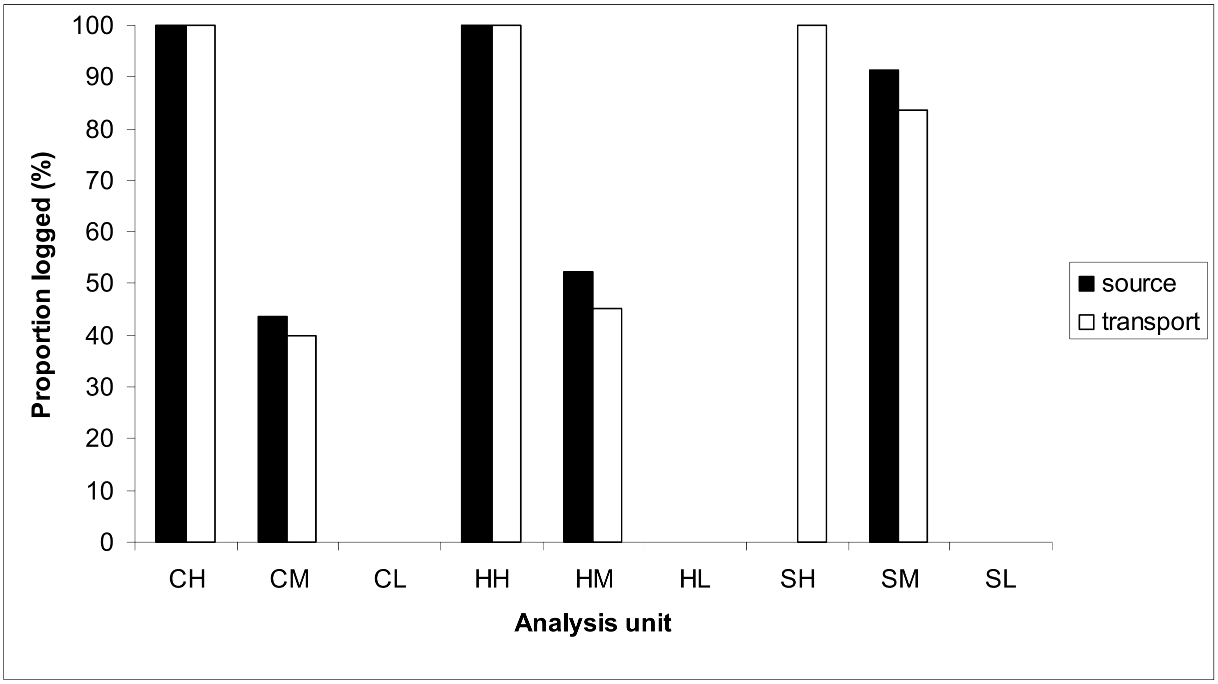

Figure 6. Percent of each analysis unit logged in the source and transport zones of Paril River. CH, CM, CL = Cedar High, Medium and Low, HH, HM, HL = Hemlock High, Medium and Low, SH, SM, SL = Spruce High, Medium and Low respectively.

Harvest area within hydroriparian ecosystems does not meet the precautionary guidelines for representation.

In Paril River, elements of biodiversity most impacted by harvesting are fans and high productivity hydroriparian ecosystems.

Review of Planning Step

The indicators and risk assessment are simple to perform. They clearly illustrate patterns in Paril River watershed. The planning guide does not describe how to analyse site series or Analysis Unit representation. Such guidance is probably not necessary. The adequacy of using Analysis Units as surrogates for site series should be evaluated further.

At the watershed scale, it is not possible to discriminate among types of small streams. I therefore included all small steep streams (>20%) in the low susceptibility to debris flow category. Guidelines to reserve all Class IV terrain will reserve small streams on unstable terrain. Field checking will identify streams with high susceptibility to debris flow and those with unique microclimates; these will be added to reserves.

It is important to note that guidelines are based on deviation from natural, not on percent of area harvested. With the estimates of natural disturbance used in this example, 20% of an ecosystem harvested translates into a 7% deviation from natural levels of forest over 140 years and no deviation from natural levels of forest over 250 years (given no natural disturbances in the same area). While this comparison conforms to most recent scientific standards, interpretation can be tricky.

Recommendation

- Revise the guide to specify that types of small steep streams will be identified during site-level planning.
- Revise the guide to include example of analysis of deviation from natural.

Maintaining Corridors

Precautionary Guidelines

- > 60% of streams within a process zone have natural levels of cover

Study Watershed Results

The guide does not specify how to count streams. For simplicity, in the source zone, I counted, by eye from a printed map, the total number of channels crossing the boundary between the source and transportation zone. (For this measurement, I used the transportation zone as defined by adjacent polygons of gentle slope.) These channels include first and second order streams with seasonal or perennial flow. In the transportation zone, I counted the number of channels joining the main channel. I then counted the number of these streams in each zone with more than 86% of their forested cover (estimated by eye) over 140 years old (based on the natural disturbance estimate used for this project).

In the source zone, 72% of streams have at least 86% cover (Table 11). Only in sub-basin 1 has the precautionary guideline been breached. Although 43% of streams in the source zone have been harvested on both sides at some point, first-pass harvest has affected only a short portion of the streams. In the transportation zone, however, only half of the streams had natural levels of cover. More than half (54%) of transportation zone streams also had road crossings. In watersheds with harvesting patterns designed based on the Hydroriparian Planning Guide, these streams would be buffered to protect bank stability.

Table 11. Percent of streams in source and transportation zones of Paril River with natural (i.e. at least 86%) levels of cover.

	Source zone		Transportation zone	
Sub-basin	Number of streams	% with natural levels of cover	Number of streams	% with natural levels of cover
1	26	58	24	29
2	31	87	26	42
3	72	71	63	63
Total	129	72	113	51

Review of Planning Step

This indicator is not easy to apply, but provides information about pattern lacking from many of the other indicators. Most source streams will not be marked on 1:20,000 maps in watersheds without harvesting history. Paril River, with a more extensive logging history, has many more streams mapped than Chambers Creek. Streams are difficult to count and vary tremendously in their character. However, a simple rule, counting the number of streams entering the transportation zone (and ignoring stream order or persistence), still provides novel information.

Apart from the valley-bottom, mainstem stream, the transportation zone generally contains short stream sections. Precautionary guidelines under bank stability require that these short portions will have wind-firm buffers—hence the indicator is redundant in the transportation zone if precautionary guidelines are followed. The indicator seems more suited to streams in the source zone.

The design of small-stream protection areas within a hydroriparian ecosystem network should provide corridors.

Recommendations

- Retain the indicator within the guide as the only indicator dealing with pattern (an important issue in coastal watersheds where logging is located in narrow bands along contour lines).
- Focus analysis on the source zone because guidelines will be redundant with other indicators in the transportation zone.

3c) Design and reserves and identify potential harvestable area

This step maps “hydroriparian ecosystem networks”, a system of hydroriparian reserves, using the interpretive maps created in step 3a) and the precautionary guidelines listed in step 3b). I designed hydroriparian ecosystem networks using Appendix 6, step 3c and Table 1 of the Hydroriparian Planning Guide (Figure 7).

Recommendations for step 3c) as a whole are included at the end of the step.

Sub-regional information and constraints

Not available for this project.

Landscape context

Not available for this project.

List and map constraints for hydroriparian ecosystem functions 1 through 4

This step is designed to map the results of step 3b. Hydrology guidelines do not provide mappable constraints. Stream morphology guidelines call for no harvesting in Class IV or V terrain and for no activity within wet floodplains or wetlands. Road constraints are not mappable. Bank stability guidelines require windfirm buffers in the transportation and deposition zone. Downed wood guidelines will be covered by the windfirm buffers.

Review of Planning Step

Reserving Class IV and V terrain is simple—maps are already prepared. The guidelines state to "not harvest hillslopes in stability class IV, failure of which might cause sediments to be delivered to any stream channel". In some cases, for example hummocky terrain in the Hecate Lowland, streams may be buffered. In most cases, however, the precautionary approach requires that all Class IV terrain be reserved at the watershed scale. If accurate, more detailed classification exists, a subset could be reserved. I mapped and reserved all Class IV and V terrain.

Reserving wet floodplains and wetlands is less obvious. Any terrain unit with an active fluvial qualifier should be reserved (including F^Ap, F^Av, F^Af, F^Ab). It is often difficult to interpret whether floodplains are active or not, especially away from major river channels. Hence, at the watershed level, the precautionary approach should also identify all floodplains as active (i.e. Fp as well as F^Ap) until site-level assessment shows otherwise (Mike Church, personal communication).

Mapping windfirm buffers in the transportation and deposition zones cannot be completed at the watershed level. Instead, the default buffers of one and a half tree heights already mapped suffice.

Recommendations

- Revise the guide to stipulate that reserving active floodplain as no-work zones includes any fluvial terrain unit with an active qualifier and also all floodplain units.

Reserve areas of high-valued fish habitat and determine locations for watershed refugia

This step adds reserves as necessary to protect high-valued fish habitat. In the study watersheds, mapped salmonid habitat is within already-reserved portions of the transportation zone.

Review of Planning Step

The guide does not provide specific instructions to protect high-valued fish habitat beyond avoiding activities in these areas. The guide assumes that, in most cases, protecting stream function addresses fish habitat protection requirements. The results in the study watersheds support this assumption.

Biodiversity for transport and deposition zones

Floodplains and wetland ecosystems are sufficiently reserved under guidelines designed to protect stream morphology and bank stability. Portions of streams within the transportation zone are buffered to maintain bank stability and downed wood. Fans, however, require additional reserves.

In Paril River, I reserved all remaining unlogged, and some harvested, fans.

Review of Planning Step

Language in this step is inconsistent with language and directions in the precautionary guidelines and risk assessment in Appendix 6 of the planning guide. The precautionary guidelines require less than a certain deviation from natural old forest on each hydroriparian ecosystem.

The description of the "entire valley bottom" is misleading. These words refer to floodplain and terrace units which are already reserved through guidelines to protect stream morphology.

Sensitive terrain

These have already been mapped.

Review of Planning Step

This step is redundant.

Biodiversity for source zone

This step focuses on small streams. In Paril River, very few areas of small streams remain unlogged. I included those that are unlogged as small stream reserves. Other, likely more important areas (e.g. tributaries of fish streams) should be reserved for restoration over the long term.

Review of Planning Step

The biodiversity step is inconsistent with the precautionary guidelines and risk assessment in Appendix 6 of the planning guide. There seems no need to separate planning for source and transportation zone biodiversity. The guidelines do not divide hydroriparian ecosystems by zone.

Rare ecosystems

Rare ecosystems are included in the network.

Review of Planning Step

This step is simple.

Riparian corridors

Small stream reserves allow for unbroken corridors.

Review of Planning Step

This step requires analysis after initial hydroriparian ecosystem network design.

Ecosystem productivity

Included under other steps.

Review of Planning Step

This step is redundant with planning for biodiversity.

Recommendations for step 3c

- Revise the guide to ensure that steps 3b and 3c are consistent.
- Examine biodiversity by hydroriparian ecosystem rather than by process zone.
- Provide a simplified set of steps to design a precautionary hydroriparian ecosystem network. The next section of this report outlines such a procedure.

III. Suggested Steps for Creating a Precautionary Hydroriparian Ecosystem Network

This section provides my suggestion for a simple procedure to design a precautionary hydroriparian ecosystem network (i.e. one based on the watershed-level precautionary guidelines). After working through the two study watersheds, and because of my familiarity with the Hydroriparian Planning Guide, I was able to boil down the steps provided into a simple list. On a base map showing water features, contours and process zones,

1. Reserve all terrain polygons classified as slope stability IV or V.
2. Reserve all terrain polygons classified as active fluvial units (including F^Ap, F^Av, F^Ab, F^Aj, F^Af) or as floodplain of unknown activity (Fp). Reserve all wetlands.
3. Reserve buffers (one and a half tree heights wide) around all streams within the transportation and deposition zones.
4. Determine if extra reserves are required to protect high-valued fish habitat (this step may require checking other sources).
5. Reserve red-listed and blue-listed ecosystems (and other rare ecosystems as necessary).
6. Calculate the area of each hydroriparian ecosystem (floodplains, fans, steep streams, other streams, wetlands, lakes) to reserve (based on allowable deviation from natural). Add preliminary reserves as necessary, considering ecosystem representation.
7. Select small stream reserves to protect the required area of source zone streams. Consider ecosystem representation in designing areas.
8. Check that all site series (or their surrogates) are proportionally represented and modify as necessary.
9. Check that requirements for corridors are met within the reserve system and modify as necessary.

The first five steps are spatially constrained and provide the backbone of the hydroriparian ecosystem network, protecting stream morphology, bank stability, downed wood and rare ecosystems. The remaining steps are flexible in location, though constrained to meet representation requirements, and focus on maintaining biodiversity.

The entire procedure takes about a day to complete for a 5,000 – 10,000 ha watershed, once all data are collated into a usable format and process zones have been defined. I used a combination of paper maps and GIS databases.

This process will delineate a precautionary watershed-level hydroriparian ecosystem network. Site-level assessment will revise boundaries. Risk assessment procedures can be used to move beyond the precautionary guidelines for any or all of the hydroriparian functions examined in the planning guide.

Paril Hydroriparian Ecosystem Network

An initial hydroriparian ecosystem network designed to meet spatially constraining guidelines (steps 1 to 5 above), and reserving all remaining unlogged fans (as required by biodiversity guidelines) resulted in a reserve network reasonably representing hydroriparian ecosystems and site series. Representation analysis of hydroriparian ecosystems called for an extra 56 ha of fans, 14 ha of floodplain, 1 ha of lake and 16 ha of steep streams. Representation by Analysis Unit showed insufficient Hemlock High units relative to other ecosystems. I added an already harvested hemlock stand and increased the area of fans in the network. I considered additions of less than 20 ha insufficient to warrant further attention at this scale. In Paril River, some old forest targets could not be met.

Chambers Hydroriparian Ecosystem Network

Steps 1 to 5 reserved sufficient proportions of every hydroriparian ecosystem except for fans (144 ha still needed to meet precautionary guidelines). Representation by Analysis Unit within each hydroriparian ecosystem was adequate for all but Hemlock High units around steep streams and within floodplains (only tiny amounts of this analysis unit exist in the watershed). I included several fans and a small stream protection area, including inoperable Hemlock High communities, to the network. The small stream protection area also created several corridors within the hydroriparian ecosystem network. Overall, very few modifications were necessary once the spatially constrained areas had been reserved.

IV. Impacts on Timber Harvesting Landbase

Following the simple steps listed above to design a precautionary watershed-level hydroriparian ecosystem network, I investigated the impact of the designed hydroriparian ecosystem networks on the timber harvesting landbase in both watersheds. I considered all units not classified as "inoperable" to be operable, including marginal ground, and heli-logging.

This sample of two watersheds should not be considered representative of the North Coast. A hydroriparian ecosystem network designed for the Hecate Lowland will likely look quite different, and larger and smaller watersheds will pose their own challenges.

Paril

The hydroriparian ecosystem network covers 1,823 ha of forest, of which 902 ha are operable. Of operable forest, 578 ha are older than 140 years; most of the remainder has been logged. Most of the old forest is low or medium productivity cedar or hemlock forest (Table 12).

Table 12. Area of old operable forest in hydroriparian ecosystem network in Paril River.

Analysis Unit	Area (ha) of operable forest > 140 years in hydroriparian ecosystem network
Cedar Low	128
Cedar Medium	101
Hemlock Low	203
Hemlock Medium	135
Spruce Medium	11
Total	578

The hydroriparian ecosystem network based on precautionary guidelines covers 64% of the 1,419 ha of operable forest in the Paril River watershed. There are 517 ha of operable forest remaining, constituting 10% of the entire watershed (Figure 8a).

I compared the area of operable forest reserved in each step of the process to determine which functions had the greatest impact. Many steps reserved overlapping polygons. The steps in the Hydroriparian Planning Guide reserve areas first for hydrological and sedimentological functions and then for ecological functions. This order seems sensible. Reserves designed to maintain stream morphology and bank stability have the highest impact (Table 13).

Table 13. Area of hydroriparian ecosystem network added to maintain each hydroriparian function in Paril River.

Step	Function	Area of operable forest in hydroriparian ecosystem network (ha)	Incremental area of operable forest (ha)	Incremental % of operable forest in watershed
Class IV/V terrain	Stream morphology	330	330	23
Active fluvial units	Stream morphology	172	172	12
Wetlands	Stream morphology	9	9	<1
Streams in transportation zone	Bank stability, downed wood	281	162	11
High-valued fish habitat	Fish	unknown	0	0
Rare ecosystems	Rare ecosystems	74	35	2
Floodplains	Biodiversity	263	53	4
Fans	Biodiversity	251	48	3
Streams >20%	Biodiversity	153	11	<1
Streams <20%	Biodiversity	259	17	1
Lakes	Biodiversity	5	0	0
Wetlands	Biodiversity	9	0	0
Small stream reserves	Biodiversity, corridors	70	27	2
Representation	Biodiversity	61	36	3
Total		n/a	900 ha	63%*

* Representing the total percent of operable forest within the hydroriparian ecosystem network.

Reserving Class IV/V terrain removes the headwaters of most steep streams from the harvesting landbase. Reserving active floodplain and fans and buffering streams in the transportation zone cover most requirements for high-valued fish habitat and valley-bottom biodiversity. A surprisingly small area needs to be added to reach the precautionary guidelines for small steep streams. Over time, as the watershed is further developed, harvest might be further limited because of concern over corridors.

The precautionary hydroriparian ecosystem network designed here would be subject to modification at the site level. In particular, small streams with high potential for debris flow would be added and buffers around streams in the transportation zone would be modified for wind-firmness.

Chambers

The hydroriparian ecosystem network covers 2,737 ha of forest, of which 1,249 ha are operable. Almost all of the operable forest within the network (1,235 ha) is over 140 years old. Most of the forest is low productivity hemlock forest (Table 14) matching the pattern in the entire watershed.

Table 14. Area of each analysis unit within operable area of hydroriparian ecosystem network.

Analysis Unit	Area (ha) of operable forest in hydroriparian ecosystem network
Cedar Low	217
Cedar Medium	28
Hemlock Low	630
Hemlock Medium	150
Spruce Low	65
Spruce Medium	145
Spruce High	14
Total	1,249

The hydroriparian ecosystem network based on precautionary guidelines covers 56% of the 2,238 ha of operable forest in the Chambers Creek watershed. There are 989 ha of operable forest remaining, constituting 11% of the entire watershed (Figure 8b).

Again, elements of the network overlap. Reserves designed to maintain stream morphology (unstable terrain and active floodplains and fans) have the highest impact (Table 15), removing almost half of the operable forest. Reserving Class IV terrain from harvest overlaps the least with other elements of the network (306 ha are removed solely because they are unstable); most other elements overlap. In particular, areas reserved to maintain biodiversity, with the possible exception of fans, overlap almost completely with areas reserved to maintain stream morphology. Small additional areas including patches of small streams have a small relative impact.

Table 15. Area of hydroriparian ecosystem network added to maintain each hydroriparian function in Chambers Creek.

Step	Function	Area of operable forest in hydroriparian ecosystem network (ha)	Incremental area of operable forest (ha)	Incremental % of operable forest in watershed
Class IV/V terrain	Stream morphology	745	745	33
Active fluvial units	Stream morphology	338	338	15
Wetlands	Stream morphology	45	29	1
Streams in transportation and deposition zone	Bank stability, downed wood	383	98	4
High-valued fish habitat	Fish	unknown	0	0
Rare ecosystems	Rare ecosystems	65	1	0
Floodplains	Biodiversity	447	12	1
Fans	Biodiversity	194	25	1
Streams >20%	Biodiversity	179	4	0
Streams <20%	Biodiversity	264	1	0
Lakes	Biodiversity	0	0	0
Wetlands	Biodiversity	45	0	0
Small stream reserves	Biodiversity, corridors	21	19	1
Representation	Biodiversity	0	0	0
Total		n/a	1,272* ha	56%

* There are 23 ha of unaccounted overlap within this total (total network is 1,249 ha).

Conclusions

Applying the watershed-scale precautionary guidelines provided by the Hydroriparian Planning Guide is not as onerous as first appears from reading the guide, provided that adequate terrain mapping exists. For watersheds of 5,000 to 10,000 ha, it is quite possible to design and refine an initial hydroriparian ecosystem network in one or two days once data and maps are assembled. One of the main successes of this report was to produce the simplified list of steps needed to design a precautionary watershed-level hydroriparian ecosystem network.

This exercise found and clarified several inconsistencies, gaps and redundancies within the planning guide. These issues can be corrected in the next revision of the guide, due July 2003.

In the two Outer Coast Mountains watersheds examined, the hydroriparian ecosystem network covered 56% and 64% of the operable forest in the watershed, leaving about 10% of the entire watershed available for harvest. Most of the reduction in operable area was due to reserves designed to maintain stream morphology, including guidelines to avoid unstable (Class IV) terrain and active fluvial areas, and to leave windfirm buffers around streams in the transportation zone. The reserves designed to protect stream morphology also protected fish habitat. In addition, they generally included sufficient representative area of each hydroriparian ecosystem to meet the biodiversity guidelines. Fans were an exception in both watersheds. Small stream protection zones, while requiring little additional area reserved, served to capture missing ecosystem types and to provide corridors with continuous cover. Hydroriparian ecosystem networks designed in the Hecate Lowland would likely have a different composition; with less unstable terrain, it might be necessary to reserve more area in small stream protection zones. Hence, biodiversity guidelines may have a higher impact elsewhere.

Precautionary hydroriparian ecosystem networks designed at the watershed scale provide useful planning information. After examining and analysing a network, managers can decide whether the benefits of exceeding the precautionary guidelines for any particular element are sufficient to warrant the commitment to monitoring and adaptive management linked with the risk-based approach.

The boundaries drawn at the watershed scale will be revised after site-level assessment. Three site-level assessments will be particularly important. Site assessment of mapped Class IV terrain might change the area reserved due to instability. Small stream protection areas might be moved to protect special types of small steep streams unidentifiable at the watershed scale. Buffers around streams in the transportation zone may be modified to match micro-site conditions.

I was unable to invent any means for generalising impacts over the entire North Coast because terrain mapping seems the only reliable way of delineating active floodplains and fans. In essence, applying the hydroriparian planning guide requires that floodplains, fans and unstable terrain be mapped adequately.

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