Riparian Assessment and Prescription Procedures

Watershed Restoration Technical Circular No. 6

1999

BRITISH COLUMBIA

Funded by:

FOREST RENEWAL BC

Watershed Restoration Program

Ministry of Environment, Lands and Parks
and Ministry of Forests

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Riparian Assessment and Prescription Procedures

Compiled and edited by

C.W. Koning

Ministry of Environment, Lands and Parks, Watershed Restoration Program,
The University of British Columbia, 2204 Main Mall, Vancouver, British Columbia, Canada V6T 1Z4

Watershed Restoration Technical Circular No. 6

1999

Canadian Cataloguing in Publication Data
Main entry under title:
Riparian assessment and prescription procedures

(Watershed restoration technical circular ; no. 6)

Includes bibliographical references: p.

ISBN 0-7726-3885-3

1. Riparian areas – British Columbia – Management.
2. Wetlands – British Columbia – Management.
3. Forest management – British Columbia.
I. Koning, C. Wendell (Calvin Wendell), 1955– .
II. British Columbia. Watershed Restoration
Program. III. Series.

SD425.R56 1999 333.91'7'09711 C99-960165-2

Preface

This circular provides a procedure for conducting riparian assessments funded under the Watershed Restoration Program (WRP) of Forest Renewal BC.

The assessment procedure is based on identifying loss of riparian function due to past logging practices. Functions of riparian habitat include provision of streambank and channel stability; input of large woody debris and small organic debris to the stream; surface sediment filtering; stream shade and temperature buffering; and provision of wildlife trees, coarse woody debris and terrestrial forage materials.

The prescription part of the procedure involves developing a riparian restoration plan. The focus of the restoration plan is to create conditions that promote stable, diverse and healthy riparian vegetation communities which will perform the functions mentioned above. As riparian restoration is a relatively young science, small operational restoration trials will, in most cases, be the preferred method of gaining new knowledge and confidence. To promote a greater likelihood of restoration success, maintenance and monitoring activities should be designed into all projects.

Within the Watershed Restoration Program, riparian assessment is one component of a larger integrated program that includes hillslope, gully, channel and fish habitat assessment and restoration. To ensure a watershed-based approach to WRP projects, proponents should consult the other pertinent WRP publications.

Acknowledgements

This circular has adapted parts of the earlier (1995–97) draft procedures of D. McLennan, (Oikos Ecological Services Limited, Smithers) and T. Johnson (T. Johnson and Associates, Smithers) to whom we are greatly indebted. We also acknowledge the input of C. Harris (Aquafor Consulting Ltd, Prince George) in the assessment procedures and Level 1 field form. V. Poulin (V.A. Poulin and Associates, Vancouver) also provided input to the assessment procedures, and to the graphical illustrations. Format and introductory sections of the procedure were adapted from Johnston and Slaney (1996).

Additional input has been supplied over the past three years by many individuals within the consulting community, namely, B. Runciman, Silvatech Consulting, Salmon Arm; B. Bocking, S. Yazvenko, B. Murray, LGL, Sidney; B. Bancroft, Symmetree Consulting Group, Victoria; and G. Thomas, G3 Consulting, Richmond. Within provincial ministry circles, we acknowledge the input from Ministry of Environment, Lands and Parks personnel, namely P. Slaney, T. Johnston, H. Deal, D. Zaldokas, K. Baird, S. Crowley, D. Bate, M. Parker, T. Douglas, D. Donald, G. McKinnon, B. Morrison, K. Baird, M.J. Jojic and J. Standen; and Ministry of Forests personnel, namely, C. Rowan, B. McFarlane, N. Densmore, T. Nash, R. Meredith, M. Scott, B. Chapman, C. Bulmer, O. Steen and others. S. Mitchell, Dept. Forestry, UBC supplied valuable review comments.

K. Buschert was instrumental in compiling and organizing the materials for the earlier, March 1998 draft.

Contents

Introduction

The Watershed Restoration Program

There is an urgent need to renew the forest resources upon which an environmentally-sustainable British Columbia economy depends. Past land management practices have lessened the productive capacity of both forest lands and fish-producing waters. The Watershed Restoration Program (WRP) is a provincial initiative under Forest Renewal BC to restore the productive capacity of forest, fisheries and aquatic resources that have been adversely affected by past forest-harvest practices. The Watershed Restoration Program hastens the recovery of degraded environmental resources in logged watersheds by identifying the need for, the designing, and the implementing of projects to re-establish conditions more similar to those found in unaffected watersheds.

The **major goals** of the Watershed Restoration Program are:

- to restore and protect fisheries and aquatic resources in key watersheds throughout the province
- to increase knowledge, information and tools for restoration and management of watersheds
- to provide opportunities for community-based employment, training and stewardship.

An important goal of the WRP is to encourage working partnerships among local stakeholder groups to ensure that the whole range of logging-related resource impacts are identified and rehabilitated in a systematic, coordinated manner at the watershed level. Restoration activities funded under the Watershed Restoration Program should adopt a process-oriented approach that:

- reduces the generation and delivery of sediments from hillslopes to stream channels
- re-establishes natural drainage patterns and water quality
- replaces lost channel-structuring elements within streams to increase the amount and quality of fish habitat
- restores habitat within selected terrestrial, riparian and stream ecosystems towards pre-logging conditions.

The intent of restoration work should be to treat the causes of the adverse impacts rather than simply treating the symptoms. By altering the rates of processes that control the physical and biological structure of watersheds (by accelerating the natural restoration processes), we hope to re-establish more productive, and more normally-functioning ecosystems.

About This Circular

What Is the Purpose of This Circular?

This circular is one of a series of Technical Circulars designed to assist in planning watershed restoration projects. The purpose of this circular is to assist local groups (forest licensees, First Nations, community groups, stewardship organizations) to develop and implement integrated, effective, cost-efficient projects to rehabilitate or restore riparian resources that have been adversely affected by past forestry practices. The circular provides a standard framework for identifying the needs and opportunities for riparian habitat restoration through systematic assessment, and for prescribing and implementing effective activities to improve the riparian resources. The goal is not to “fix” nature, but to accelerate the natural restoration process.

Why Should You Use This Circular?

Watershed restoration deals with interconnected processes that often cannot be partitioned into independent components when devising effective corrective actions. Proponents of WRP projects should use the series of Technical Circulars available to ensure that their proposals consider all important aspects of watershed restoration, that they have planned their proposed activities in an efficient manner, and that their procedures and methods are technically sound. In particular the following related WRP manuals should be used:

- Guidelines for Planning Watershed Restoration Projects
- Channel Conditions and Prescriptions Assessment (CCPA)
- Fish Habitat Assessment Procedure (FHAP)
- Fish Habitat Rehabilitation Procedures (FHRP).

Note that the riparian, channel and fish habitat assessment procedures (WRP Technical Circulars 6–8) form an integrated set whose data collection should be combined wherever possible.

Background

Ecological Functions of Riparian Vegetation

Removal of the natural riparian vegetation through past forest harvest activities, in particular by clearcutting to the stream bank, can impair the functional role of the riparian zone in providing stable and diverse physical and biological conditions within the adjoining terrestrial and stream ecosystems. Ecological functions of the riparian vegetation include (Figure 1):

- regulation of the physical structure of the stream channel by determining the input and characteristics of large woody debris (LWD) which partly controls sediment storage and transport; local flow characteristics; and the creation of fish habitat
- maintenance of bank and channel stability by provision of solid root mass and ground cover
- regulation of stream temperature by providing shade

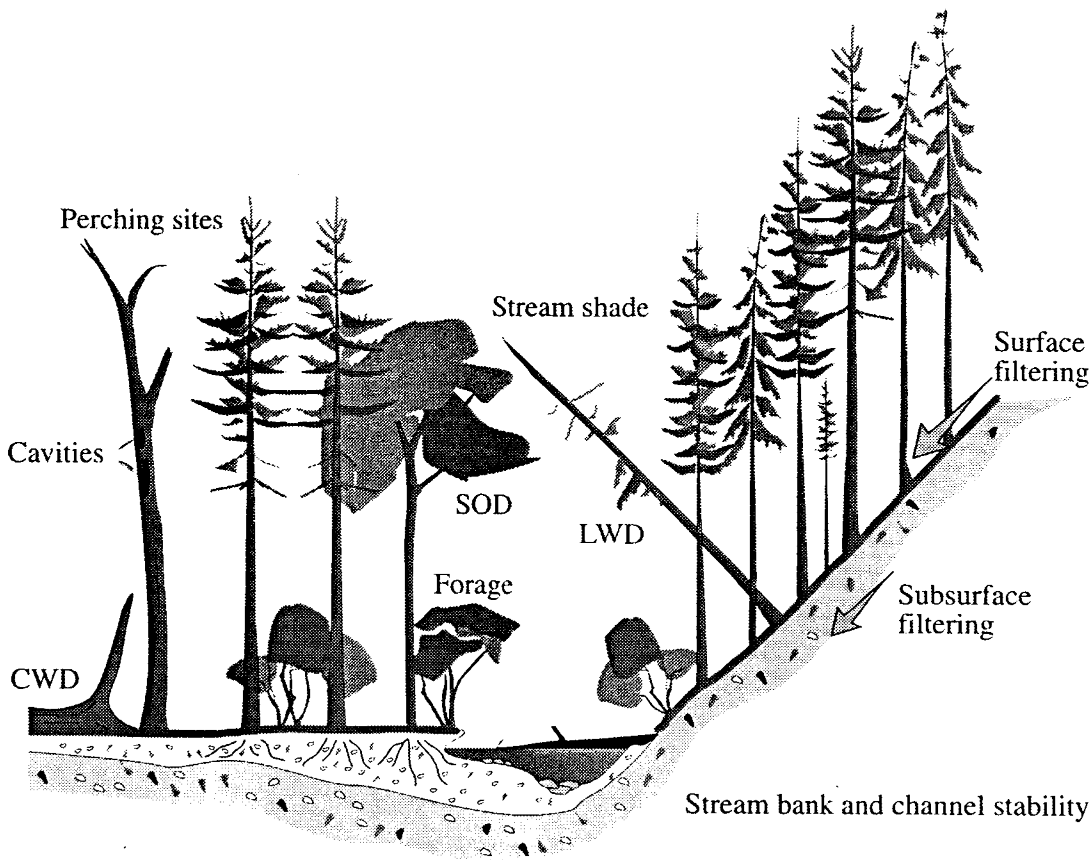


Figure 1. Ecological functions of riparian vegetation.

- regulation of instream biological production by determining the inputs of small organic debris (SOD) (leaves, detritus, terrestial insects, large woody debris, dissolved organic carbon) to the channel
- regulation of instream algal production by controlling the amount of sunlight (for photosynthesis) reaching the stream
- buffering the stream from fine sediments by intercepting surface flow
- provision of wildlife habitat features, including coarse woody debris (CWD), wildlife trees, nest and perch sites, and summer and winter dennings
- provision of summer and winter forage for terrestrial fauna.

The characteristics of the riparian vegetation thus can strongly influence the diversity and productivity of both the aquatic and terrestrial biota, and the physical stability of the streambank and channel. *(Additional details regarding riparian functions are provided in Appendix 1).*

Overview of the Riparian Assessment and Prescription Procedures

The WRP riparian assessment and prescription procedures (RAPP) attempts to identify opportunities and appropriate techniques to restore the aquatic and terrestrial functions of the riparian zone. The assessment provides a standard methodology for reviewing existing information, conducting field surveys, and interpreting the results.

The assessment and prescriptions **procedure** consists of the following steps:

1. Identification of harvested riparian areas within the project watershed (harvested before implementation of the provincial Forest Practices Code [Code]).
2. Prioritization of harvested sites for field visitation.
3. Collection of field data in priority riparian areas.
4. Evaluation of impaired riparian functions (dysfunctional stands) within the field-surveyed areas.
5. Identification of opportunities for riparian rehabilitation.
6. Development of riparian restoration prescriptions (alternatively called restoration plans).

There are three distinct **stages** in the procedure:

1. Office-based “**overview” assessment** of existing information from, for example, maps, air photos, forest data files.
2. Reconnaissance **“Level 1” field-based assessment.**

3. Detailed **“Level 2” field-based assessment**, where required, and **prescription development** stage.

The overview stage has the broadest geographical focus, with Level 1 likely reduced to a subset of the area assessed at the overview (priority sites only), and Level 2 likely a subset of the Level 1 sites.

The first step is to identify and delineate riparian areas that have been harvested in the past. It is assumed that these areas are most likely to contain impaired functions. Field visits are then carried out to these sites to determine their level of functionality and whether there is sufficient regeneration occurring on site. In most cases, this will require collecting data related to the overstorey vegetation (tree sizes, densities and dominant species), understorey vegetation (per cent cover and height of dominant shrubs, herbs and mosses) and a brief description of soil conditions. Those sites which are not providing sufficient aquatic and terrestrial functions, and have insufficient regeneration, are then recommended for further assessment (if required) and prescription development.

The riparian assessment procedures occur sequentially and include: identification of harvested riparian areas; field assessment and evaluation of level of impairment; identifying opportunities for restoration (e.g., tree thinning, planting, fencing); prioritizing sites for restoration, developing restoration plans; implementation of restoration works; followed by maintenance and monitoring.

Assumptions and Limitations

The procedure reported here for assessing riparian habitats and developing prescriptions is limited in scope and application. **First**, the procedure is limited to assessing impacts from past logging practices. **Second,** it is assumed that impacts are most prevalent in previously harvested areas and therefore assessments are limited to these areas. **Third**, the assessments will focus primarily on previously harvested riparian areas **adjacent to fish bearing streams** more than 1.5 m wide. **Fourth,** the focus will be on the riparian “reserve zone” of these fish bearing streams (see below for definitions and exceptions).

In the Code, fish bearing streams are divided into S1 to S4 streams (Table 1). An S1 stream has a channel width of ≥ 20 m; S2 from 5–20 m; S3 from 1.5–5 m and S4 ≤ 1.5 m. There are also S5 (>3 m wide) and S6 (<3 m) streams within the Code. S5 and S6 streams are not fish bearing.

Table 1. Key to stream riparian classification (from *Riparian Management Area Guidebook*, 1995)

Is stream a fish stream or in a community watershed?[a]			
Yes		**No**	
Avg channel width	**Riparian class**	**Stream width**	**Riparian class**
>20 m	S1	>3 m	S5
>5–20 m	S2	≤ 3 m	S6
1.5–5 m	S3		
<1.5 m	S4		

[a] To determine if a stream is within a community watershed and to locate watershed intakes, consult the *Community Watershed Guidebook* and contact the local BC Ministry of Environment, Lands and Parks, Regional Water Manager.

The riparian management area (RMA) is a designated term contained in the series of legal documents (Table 2). It is made up of the riparian management zone (RMZ), and, immediately adjacent to fish bearing streams of >1.5 m channel width (Wb), the riparian reserve zone (RRZ). Focusing assessments and restoration activities within the RRZ limits the degree of overlap with other forest management programs and thus increases efficiencies at implementing and completing restoration works.

Table 2. Stream classification

	S1[a]	**S1**	**S2**	**S3**	**S4**	**S5**[b]	**S6**[b]
Stream width (metres)	>100	20–100	5–20	1.5–5	<1.5	>1.5	<1.5
Riparian reserve zone width (RRZ)	0	50	30	20	0	0	0
Riparian management zone width (RMZ)	100	20	20	20	30	30	20
Riparian management area width (RMA)	100	70	50	40	30	30	20

The primary focus of WRP riparian assessments are streams with RRZs (i.e., S1–S3 streams).

[a] S1 large rivers may have a RRZ if designated by regional ministry staff.

[b] S5 and S6 streams are non-fish bearing.

The following **exceptions** apply to the limitations listed above: riparian assessments outside of the above stated RRZ, or at other than S1–S3 streams, and in riparian areas adjacent to wetlands or lakes can be of equal or more biological value. Issues such as the need to stabilize upstream channels, general biodiversity protection, and protection of endangered wildlife species may result in exceptions to our recommended focus, but these should only be undertaken upon the specific direction of the contracting agency. Where the fish-bearing status of a stream is unknown and there is no Code S1–S6 classification, assume that all streams with <20% gradient and >1.5 m Wb are acceptable for assessment. One other exception to the above is in collecting field data in old-growth riparian vegetation stands. This can be of much value in assessing the extent of impairment found in adjacent previously harvested stands and for subsequent use as restoration templates.

Finally, it is important to recognize that RAPP is a tool, and is not a replacement for training and experience.

Project Scope

Within the context of the larger WRP program, whole **watersheds** are the units for which restoration plans should be developed. The assessment procedures in WRP Technical Circulars No. 2–9 emphasize the potential impacts of forest harvest on aquatic resources. To assess the cumulative effects of forest harvest, the most usual first step is to complete the appropriate watershed assessment procedure, such as a Code coastal or interior watershed assessment procedure (CWAP, IWAP), or a similar review. Next, it is necessary to examine the state of roads, hillslopes, gullies, riparian areas, stream channels or fish habitat, as appropriate, to identify specific problems that may be treated through restoration projects (see WRP Technical Circular No. 1). Riparian assessment and prescription development should not be conducted without knowledge of upslope or upstream conditions and risks that may affect the project.

The appropriate spatial scale for applying the assessment and restoration procedures from Technical Circulars No. 2–9 is, third to fourth order basins on 1:50 000 national topographic series (NTS) maps. Watersheds of this size are sufficiently manageable for integrated restoration projects.

Related Assessment Procedures

The channel conditions, and fish habitat assessments (WRP Technical Circulars No. 7 and 8) provide information that is useful to the evaluation of riparian habitats. Where possible, all three assessments should be closely coordinated to ensure consistency in common methods, and the exchange of information to avoid duplication in field surveys. This is especially true for remote sites. Where possible, air photo analyses and field surveys should simultaneously gather data for all assessments that are indicated as necessary by the WRP contracting agency.

There are also many justified instances where the riparian assessment procedure may be exclusively carried out; for example, where fish habitat and channel assessments are already completed, or where the project proponent or project funding is limited to riparian works only.

Who Should Do the Assessments?

The riparian assessment procedure provides a standard methodology for reviewing existing information, conducting field surveys, and interpreting the results consistently to identify opportunities for effective riparian restoration projects. To use the methodology effectively, it is imperative to have a good knowledge of riparian vegetation and soil characteristics, and of fish and wildlife values. It is also essential to be familiar with standard field survey methods outlined in Ministry of Forests (MOF) and Code guides (see References section for sample references).

The riparian overview assessment and the Level 1 field assessment are intended to be done by experienced field technicians with an understanding of riparian vegetation and riparian habitat restoration options. Technical staff should work under the supervision of an experienced professional biologist or silvicultural specialist. Those involved in the overview assessment should also be experienced at air photo interpretation. Detailed Level 2 assessments and prescription development will usually be done by a silvicultural specialist experienced in riparian vegetation prescription development. Exceptions to the Level 2 expertise recommendation may be where the prescription is focused on, for example, streambank works (bioengineering), or some types of wildlife habitat restoration.

Riparian Assessment and Prescription Procedures

If a watershed assessment, for example, a CWAP or IWAP, a sediment source survey, a needs assessment, or a similar review of impacts of forest harvest in the watershed suggests potential impacts on riparian habitat, the RAPP can be undertaken to further identify the locations, nature and magnitude of impacts on riparian functions, and the opportunities for effective rehabilitation (i.e., the restoration of ecological funtion). **The assessment procedure (Figure 2) assumes that known or suspected riparian impacts resulting from past logging practices are present in the watershed.** The assessment addresses the following questions:

1. **What riparian habitat is impaired, where is it, and to what extent is it impaired?**
2. **What are possible restoration scenarios?**
3. **Which of the degraded riparian sites are the highest priority for restoration?**

In practice, the RAPP will be implemented as an iterative process. The first stage of RAPP is an **overview assessment** to identify areas of potential concern and to indicate the general nature of the disturbances. The second stage is more-detailed and quantitative **field assessments (Levels 1 and 2)** of particular areas of concern, leading to development of restoration prescriptions to improve the logging-impaired riparian habitats. Level 2 prescriptions should also include design of **maintenance** and **effectiveness monitoring** procedures to promote and evaluate the success of the restoration activities, and to allow for adaptive feedback, if required.

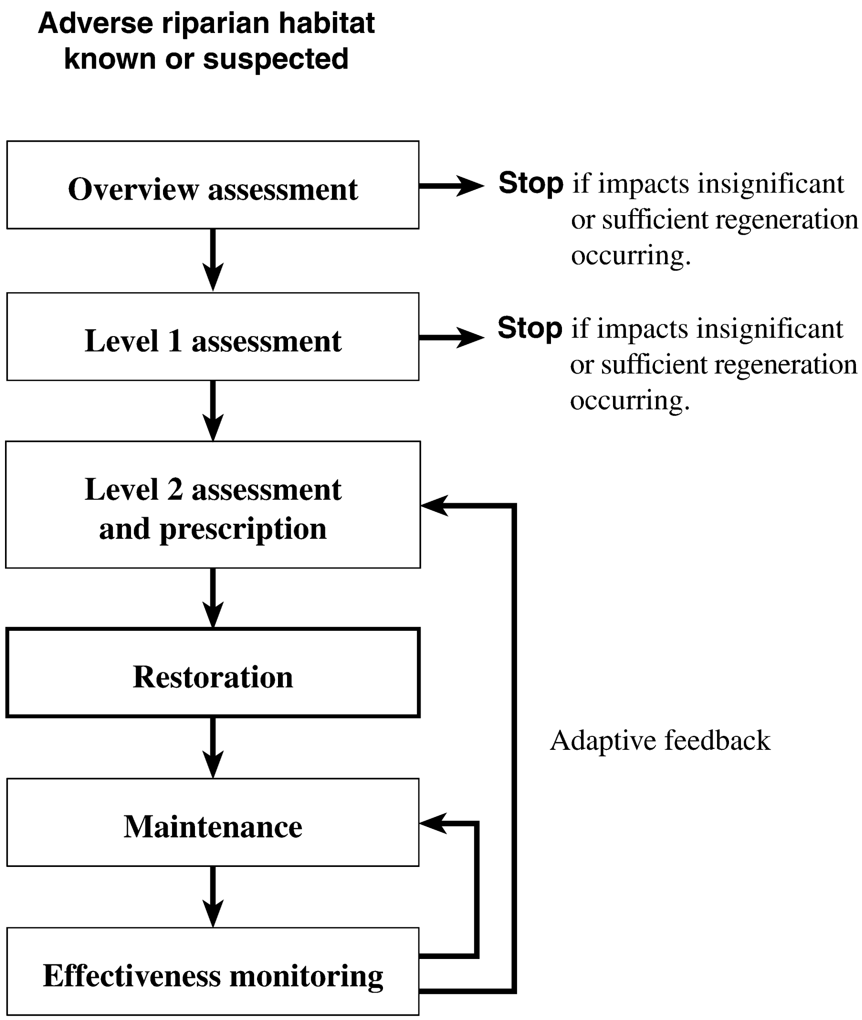


Figure 2. Flowchart of WRP riparian assessment and prescription procedures.

Overview Assessment

Aims of the Overview Assessment

The focus of the overview assessment is:

- to identify riparian areas that have been previously logged.

The **objectives** of the overview assessment are:

- to identify within the previously logged riparian areas, areas with known or suspected impaired functions
- to identify sites for Level 1 field assessment.

The overview assessment uses existing or easily obtained information to provide a *preliminary* indication of impaired riparian function at specific sites in the watershed. The results of the overview assessment will direct subsequent field surveys to those areas of the watershed where riparian function impairment may require restoration. If location of sites and extent of impairment are already known, you may be able to proceed very quickly to Level 1 field surveys after summarizing the existing data. Most overview assessments should only require from 2 to 10 person-days of effort, depending on the extent of area to be covered.

Note that the results of the initial watershed assessment procedure, the channel conditions and prescriptions assessment procedure (Technical Circular No. 7) and the fish habitat assessment procedure (Technical Circular No. 8), if already completed, may help identify areas of special concern in advance of the overview RAPP.

Steps in the Overview Assessment

The **steps** in the overview assessment are:

1. Identify and delineate the watershed of interest.
2. Assemble existing information. Materials to review include a combination of:
   - air photos (historic)
   - air photos, (recent), preferably low level 1:5000 scale and in colour, especially where access is limited
   - topographic maps
   - licensee files, forest cover and TRIM maps
   - other MOF maps/reports, opening files

- other WRP reports
- interviews with local MOF and MELP personnel, forest licensee personnel.

3. From the existing information, following the instructions for Form 1 (Appendix 7):

    i. Identify harvested areas, with primary focus being harvested areas near or adjacent to S1–S3 streams, unless directed otherwise by the contracting agency.

    ii. Categorize harvested areas by distinct riparian vegetation types, which at the overview stage will be based on stand structural stage and tree type (e.g., PSc, pole sapling – coniferous; MFm, mature forest-mixed conifer/deciduous; SH, shrub-herb) (also refer to glossary). Dominant species can be added if the data are available, but this will seldom occur at the overview stage.

    iii. Record past harvesting and restocking history and any other readily known or observable disturbances (e.g., erosion and slides).

    iv. Identify priority sites for Level 1 field assessment.

Overview Form 1 Instructions

Use the following instructions to complete Form 1 (also refer to completed form example in Appendix 7):

Watershed Name/Code: Identify the watershed by its gazetted name and hierarchical watershed code. Refer to the *Gazetteer of Canada for British Columbia* (Anonymous 1985) for official names. Obtain the watershed code from the MELP *Watershed Dictionary* (consult regional WRP staff). Note that sub-basins may have their own codes. If standard watershed codes have not been assigned to the stream, follow the guidelines in the *Fish-stream Identification Guidebook* to assign an interim locational point to the stream mouth.

NTS Map: Record index number of the NTS (1:50 000 scale) or BC Geographic Survey (BCGS 1:20 000 scale) map that depicts the downstream boundary of the stream reach or sampling site.

Air Photo: Record the flightline and air photo number that depicts the stream reach or sampling site.

Reach # (Reach number)**:** A reach is a relatively homogeneous section of stream having a repetitious sequence of physical characteristics and habitat types. Reach numbers are assigned in upstream ascending order starting from the mouth of the stream. Delineating reaches is optional if doing only a riparian assessment, but is strongly recommended if also completing a channel condition, or fish habitat assessment (WRP Tech. Circs. 7 and 8, respectively).

Polygon # (Polygon number)**:** A polygon is an area of vegetation that appears on air photos to be distinct from the adjacent vegetation. Using an omnichrome pen and mylar overlay, draw the boundaries of each polygon in the riparian zone of your study area.

Stand Structure: Identify and record the stand structure (SSt) within each polygon. Classification should include one of the following (see Glossary for more details):

INIT (initial succession) – earliest successional (developmental) stage (0–1 yr)

SH (shrub herb) – early successional stage (1–20 yr)

PS (pole sapling) – trees >10 m tall, densely stocked (10–40 yr, depending on species (e.g., alder is PS stage at 10–15 yr)

YF (young forest) – forest canopy forms distinct layers (30–80 yr)

MF (mature forest) – Canopy comprised of mature trees with second cycle of shade-tolerant trees establishing in understorey (80–250 yr)

OF (old forest) – old, structurally complex stands of mainly shade tolerant and regenerating trees (250+ yr).

If it is possible to pick out tree species and dominance from air photos and/or forest cover maps, record these in the same column. Otherwise, include only stand structure. If only 1:15 000 to 1:20 000 air photos are available, it may only be possible to identify stand structure and whether it is deciduous tree dominated (d) (>75% tree cover); coniferous tree dominated (c) (>75% tree cover); or mixed (m) deciduous/coniferous tree species (neither deciduous nor coniferous trees account for >75% cover) (e.g., *PSc* refers to a “conifer dominated pole-sapling stand).

Tentative RVT #: Based on stand structure as recorded in the previous column, assign a riparian vegetation type (RVT) number for each polygon, keeping in mind that several different polygons may contain the same RVT. At this time, the RVT numbers are tentative since they will likely be adjusted during the field visit at the Level 1 assessment, with the final RVT labels recorded on Form 3 (the Level 1 assessment summary form). The final RVT labels will be based on stand structure and tree species, and may also include a recognition of understorey vegetation types. One would also expect different RVT numbers in different BEC zones and subzones. The Overview stage, being an office-based assessment can only provide a broad-brush RVT description.

Stream Class: Identify the stream class (Code S1–S6 stream). A key to the riparian classification of streams was shown previously in Table 1.

Harvesting History: Using sources such as forest cover maps, silvicultural history (ISIS database from MOF), and local knowledge, record known harvesting history such as harvest date, age class, silviculture treatments, and year of site preparation or replanting.

Other Disturbances: If a major disturbance other than harvesting has occurred, record it. Disturbances include fire, insect or disease infestation, flooding, surface erosion, slope failure, overgrazing and presence of roads, bridges and culverts.

Priority for Level 1: Selection of sites recommended to proceed to a Level 1 field visit and assessment should be based on the following:

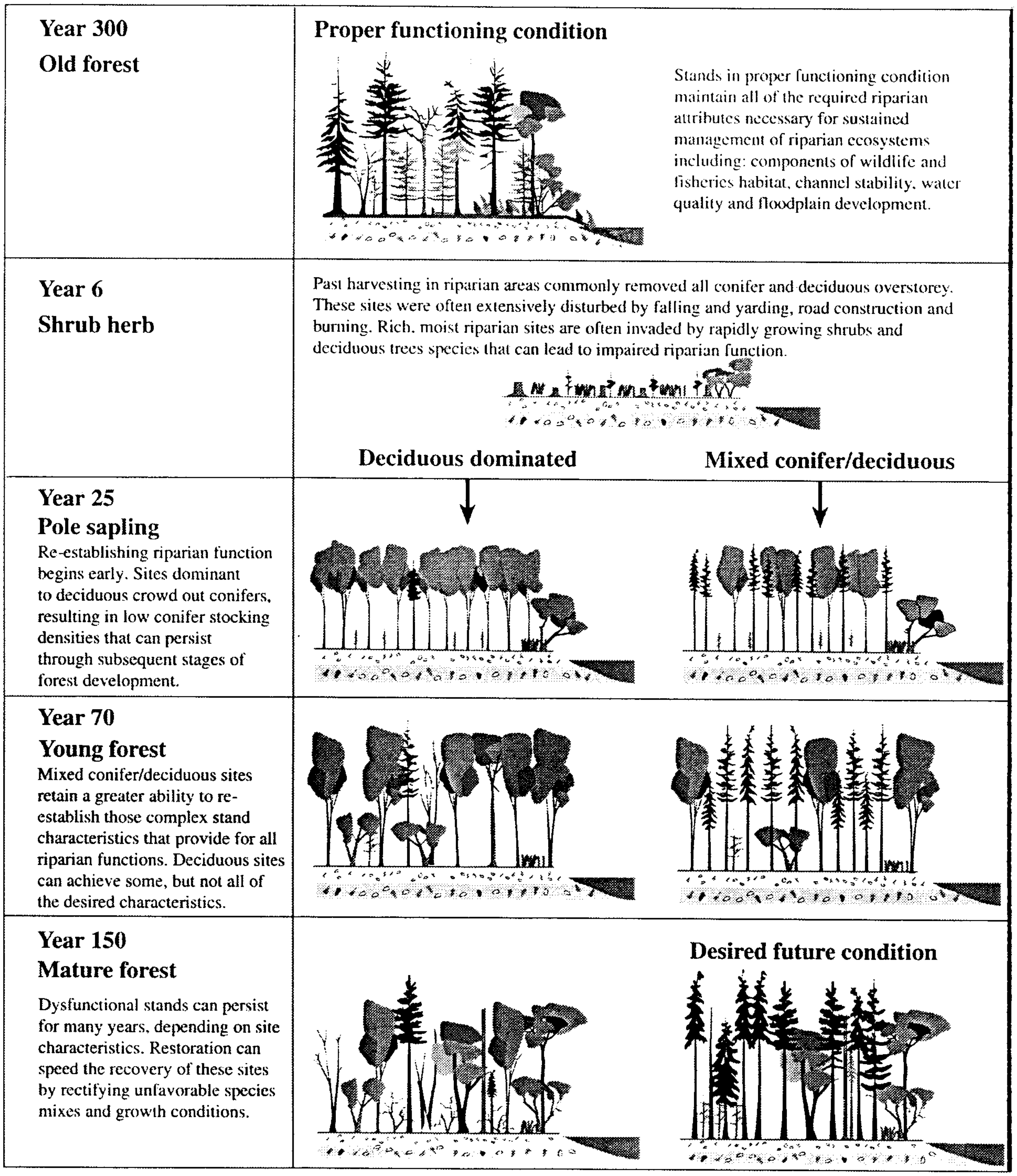
- information gathered on stand structure, harvest history and extent of proper functioning condition (Figure 3)
- other disturbances (e.g., fire, erosion, wind throw)
- high fisheries values
- expected level of benefit to the watershed, and likelihood of restoration success.

Output from the Overview Assessment

Output from the overview assessment includes the following:

1. Brief discussion of methods used in the overview assessment.
2. Form 1 data (Appendix 7).
3. Mapping and map overlays of harvested riparian polygons in study area.
4. Identification of known or suspected impaired polygons.
5. A brief discussion of potential impairments.
6. Recommended sites for Level 1 field data collection.

In some cases, a recommendation for no further assessment may be made based on, for example, knowledge that sufficient regeneration is already occurring. However, confirmation of this would likely require a brief field reconnaissance by an experienced riparian vegetation specialist.



Year of structural stage varies with species of trees and between regions.

Figure 3. Stand structure stages on pathway to desired future condition.

Level 1 Field Assessment

Aims of the Level 1 Assessment

The primary **focus** of the Level 1 assessment will usually be:

- riparian areas that have been previously logged to the streambank, and within the RRZ adjacent to S1–S3 streams.

By using overview information, you can usually restrict the Level 1 field survey to a smaller portion of the watershed than the initial study area.

The **objectives** of the Level 1 assessment are:

- to confirm or revise the nature, location and extent of forest harvest impacts on riparian habitat
- to provide field data for use in prescription development
- to provide a preliminary list of restoration options for sites with impaired riparian functions
- to provide sufficient information to identify and prioritize impaired sites for Level 2 assessments and prescriptions.

The Level 1 assessment refines and builds upon the initial information from the overview assessment in identifying impaired riparian sites within the watershed. It does so by collecting further qualitative and quantitative information in field surveys. It also provides preliminary recommendations for restoration opportunities and prioritizes sites for the Level 2 assessment and prescription phase.

Scope of the Level 1 Assessment

The Level 1 riparian assessment is a field-based activity to survey current habitat conditions in selected riparian locations. It examines priority sites and evaluates the riparian level of functioning within those sites.

In particular, a site's level of functioning is based on its ability to supply the basic riparian functions of:

- LWD (especially from coniferous trees, which are more decay resistant), CWD and SOD
- stream shading
- stream bank and channel stability
- wildlife and general biodiversity attributes.

The level of functioning will be evaluated within a classification of low, moderate or high functionality. The Level 1 assessment uses several features to characterize riparian habitat conditions and identify priority sites for potential restoration. Habitat features of particular importance are:

- overstorey vegetation characteristics (tree species, densities and heights, % cover)
- understorey vegetation characteristics (shrub, herb and moss species, % cover and height)
- soil properties (horizon depths, textures, % coarse fragments)
- indicators of disturbances (e.g., slides, culverts, flooding)
- site gradient and aspect
- stream gradient and width.

To evaluate habitat conditions, the Level 1 assessment compares the values of the above habitat features within the reach to expected values in mature or old-growth forests. However, little in the way of published diagnostic data exists and, therefore, many of the evaluations will be based on general expected values at various successional stages of the riparian forest. For example, at the pole–sapling structural stage one would quite clearly evaluate provision of LWD as low (i.e., low functionality).

The field survey collects quantitative and qualitative information on the above features. Methods to obtain these data are described below.

Steps in the Level 1 Assessment

The **steps** in the Level 1 assessment are:

1. Develop a field visitation plan based on overview assessment recommendations and considering field logistics such as access and worker safety considerations.
2. Assemble field survey equipment:
   - field maps
   - air photos
   - field forms
   - pencil
   - field note book
   - plant identification field guides
   - MOF Handbook (see References, p. 39)
   - compass
   - measuring tools (e.g., tape, surveyors tape, foldable metre stick, surveyers rod, range finder)

- spade
- cable marked at 3.99 and 11.28 m (these sizes are used to provide a tree stems/ha count)
- flagging tape
- clinometer
- tree corer (increment bore; medium size)
- plant and soil sample bags
- GPS unit (if available)
- camera and film
- small white board and pen to identify location in photographs (optional)
- safety gear
- safety clothing (foot and head gear).

3. Gather and evaluate field data following the instructions for Form 2 (following section),

   i. confirm boundaries of priority riparian areas

   ii. select representative plot locations

   iii. gather quantitative data on site conditions, including overstorey and understorey vegetation from representative locations

   iv. gather descriptive data on soils, site disturbances and any other features that may influence site assessment and prescription development

   v. evaluate level of functioning within each polygon (high, moderate or low).

4. Identify priority sites recommended for the Level 2 assessment and prescription phase. As with the outcome from the overview phase, priorities are based on level of expected benefit to the watershed and where the likelihood of success is high. List or discuss possible restoration options for sites that are likely candidates for restoration projects. Typical harvested riparian sites and treatment scenarios are provided in Figure 4.

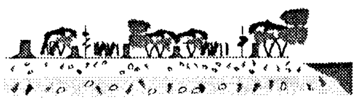
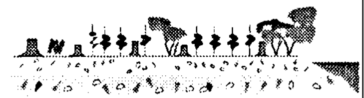
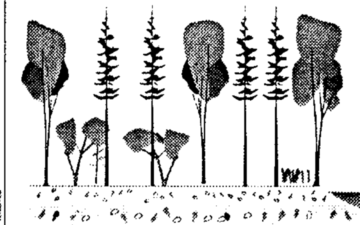
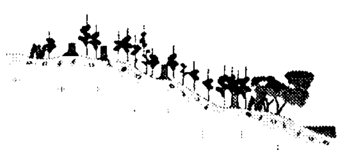
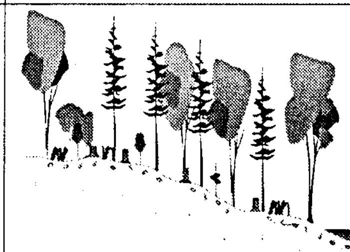
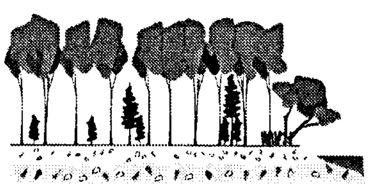
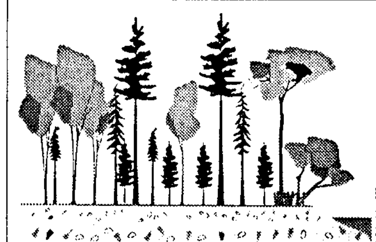
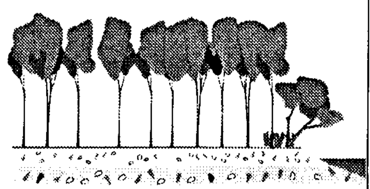
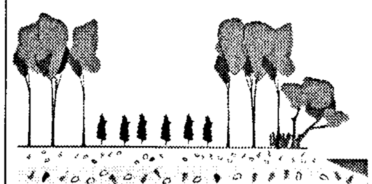
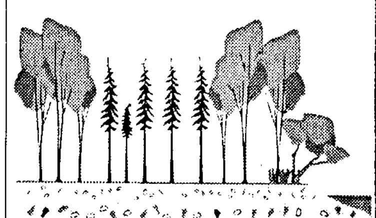
Scenario	RVT	Function impaired	Rehabilitation action/objective	Treatment	Desired future condition
1 Poorly stocked plantation on moist, rich site.		Large and small wood, shade, bank stability.	Cluster planting using large stock to increase conifer stocking on difficult sites.		
2 Overstocked plantation on mesic site.		Large wood, forage for wildlife, structural diversity, floodplain stability.	Juvenile spacing to focus growth on fewer trees and increase stand biodiversity.		
3 Overtopped conifers on moist, rich site.		Large wood, structural diversity, floodplain stability.	Release understorey conifers by directional felling of deciduous trees, space conifers to riparian densities.		
4 Deciduous pole sapling without conifers on moist, rich site.		Large wood, structural diversity, floodplain stability and bank stability.	Fell deciduous trees in groups and plant openings with conifers, follow by aggressive stand tending to ensure conifer survival; alternatively, manage as a deciduous stand.		

Figure 4. Examples of stand types that provide opportunities for riparian restoration and some options for restoration.

Level 1 Assessment Field Form Instructions

Use the following instructions to enter data in the Level 1 assessment field data form, **Form 2** (see completed form example in Appendix 7).

1. Preliminary Information

Polygon #: Transfer the polygon number from the overview assessment Form 1. All polygons should receive a unique number.

Plot #: A minimum of one plot per polygon needs to be completed.

SSt: Stand structure (SSt) within an RVT, previously identified during the overview assessment, should be confirmed in the field. Classification should include one of the following:

INIT – initial succession (bare ground or early herbs)

SH – shrub herb

PS – pole sapling

YF – young forest

MF – mature forest

OF – old forest.

Also include whether the stand structure is deciduous tree dominated (d) (>75% tree cover); coniferous dominated (c) (>75% tree cover); or mixed (m) deciduous–coniferous trees (neither deciduous nor coniferous tree species account for >75% cover).

Creek name: Transfer from the overview assessment Form 1, or distinguish as either the official name of the stream being surveyed as listed in the *Gazetteer of Canada for British Columbia*, or a local name.

Reach #: Transfer from the overview assessment Form 1, and refine if necessary. Delineating reaches is optional if doing only a riparian assessment, but should be consistent with reaches assigned if concurrently completing a fish habitat assessment or channel assessment.

Location: Record a concise description of the geographic location of the RVT surveyed referring to permanent or named features (e.g., *30 m upstream from main logging bridge*).

Creek aspect: The compass direction (N, S, E, W) the creek is facing.

BEC zone: To determine the biogeoclimatic ecosystem classification (BEC) zone, refer to a BEC map. The maps provide an initial identification of the biogeoclimatic unit for a particular area, and may be all that is necessary if the area falls well within a map polygon.

Nonetheless, ***it should always be verified during the field visit***. The BEC zone should be one of the following:

AT – Alpine Tundra

BG – Bunchgrass

BWBS – Boreal White and Black Spruce

CDF – Coastal Douglas-fir

CWH – Coastal Western Hemlock

ESSF – Engelmann Spruce-Subalpine Fir

ICH – Interior Cedar-Hemlock

IDF – Interior Douglas-fir

MH – Mountain Hemlock

MS – Montane Spruce

PP – Ponderosa Pine

SBPS – Sub-Boreal Pine Spruce

SBS – Sub-Boreal Spruce

SWB – Spruce-Willow-Birch.

(For detailed descriptions of BEC zones, refer to Appendix 3).

Air photo: Transfer from the overview assessment Form 1, or record the flightline and air photo number that depicts the stream reach or sampling site (year of flight should be automatically included as part of the air photo number).

RVT slope: Use a clinometer or Abney level to measure the slope of the RVT. The slope can be measuring by looking from the edge of the streambank at right angles to the stream, out to the edge of the RVT.

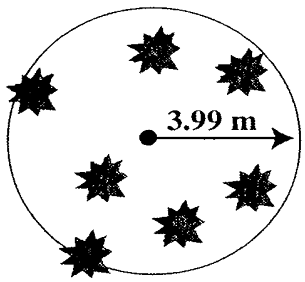
Stream gradient: Use a clinometer or Abney level to measure the gradient of the stream (± 0.5%) adjacent to the plot. Mark the surveyor’s rod at the eye level of the measurer. The rod man holds the surveyor’s rod vertical at the far boundary of the habitat unit while the measurer sights the clinometer on this mark to make the gradient measurement.

Map: Transfer from the overview assessment Form 1, or record index number of the NTS (1:50 000 scale) or BCGS (1:20 000 scale) map that depicts the downstream boundary of the stream reach or sampling site.

UTM: Using NTS maps or a GPS unit, record the UTM (Universal Transverse Mercator) number that identifies the location of the downstream boundary of the sampling site (e.g., 10.6975.58984).

Plot radius/Plot multiplier: Plots are created by measuring out a specific length (plot radius) from a centre point and surveying in a circle around the centre point (Figure 5). Plots should be large enough to tally an average of ***six live dominant trees per plot*** over the RVT, and they should be representative of the RVT. There are two standard lengths to measure based on the stem density within the plot. ***Use a 3.99 m radius in young stands, for older less dense stands, use 11.28 m instead.*** These radii are used since they can be conveniently multiplied to calculate stems per hectare. For a plot radius of 3.99 m, multiply by 200 (Figure 5). For a plot radius of 11.28 m, multiply by 25. For a plot radius of 5.64 m, used in some forest inventory activities, multiply trees counted within plot by 100 (i.e., a circle of 5.64 m radius is equal to 100 m^2 area).

Vegetation Plot



Determining stocking density

1. Area of 3.99 m plot equals 50 m^2
2. No. of trees/ha = number of trees in plot × 200

Example:
7 trees within plot × 200 = a stocking density of 1400 sph (stems per hectare)

Figure 5. Example of a 3.99 m radius field plot (submitted by V. Poulin, V. Poulin and Assoc., Vancouver).

Wb (bankfull channel width): Measure the bankfull channel width (Wb) in metres at a representative site as the horizontal distance perpendicular to the channel from rooted terrestrial vegetation to rooted terrestrial vegetation on opposite sides of the stream (often simply called channel width).

Stream width measurements should **not** be made near (within ≅ 20 m) of stream crossings, at unusually wide or narrow points, or in areas of atypically low gradient such as marshy or swampy areas, beaver ponds, or other impoundments. Do not include vegetated islands or bars. If multiple channels are separated by vegetated islands, sum the separate bankfull channel width measurements. Include unvegetated gravel bars in the bankfull channel width measurement. Refer to WRP Technical Circular 8 for more explanation if needed, or the appropriate Code guide.

Stream characteristics such as channel width and stream gradient can be used to give an indication of the potential value of fish habitat within the general area of the riparian field site (lower gradient streams are usually more valuable than high gradient streams), and help prioritize sites for riparian restoration.

Code stream class: Transfer from the overview assessment Form 1, or on the basis of previous definitions (Table 1) classify your stream as S1 to S6. *We recommend that the riparian assessment procedure focus on*

S1-S3 stream classes unless specifically designated otherwise by the contracting agency.

RMA, RRZ and RMZ: Based on the stream classification (S1–S6) (or lake or wetland), record the width of the RMA, RMZ and RRZ (see earlier definitions, Table 2).

Year of harvest: Transfer record (if any) of last harvest or restocking from the overview assessment Form 1, and if necessary refine based on field observations. A tree coring device can help provide site specific data.

2. Overstorey

For the purposes of this form, overstorey refers to all deciduous and coniferous tree species identified within a plot, regardless of size or age.

Layer: Layers of the overstorey are *based on the diameter of the trunk at breast height (dbh)*. The layers are:

1a: ≥ 22 cm (mature trees)

1b: 12.6–21.9 cm (mature trees)

2: 7.5–12.5 cm (poles)

3: 0.1–7.4 cm (saplings)

4: trees shorter than dbh (<1.3 m, regeneration layer).

Tree species stem tally: As species are identified, mark in the species code and the number of trees for each species in each layer within your chosen plot. There is room on the form for six species. See Glossary for tree species codes (e.g., Hw – western hemlock, Dr – red alder).

Total SPH: Stems per hectare (sph). Since it is impractical in riparian assessment to survey an entire hectare of vegetation, smaller plots are surveyed and hectare density is extrapolated. This number is calculated by *summing species tallied within each layer and multiplying by the plot multiplier*.

For a plot radius of 3.99 m:

layer 1a: (3 Hw + 1Cw) × 200 (plot multiplier) = 800 sph (also see Figure 5).

This number is used to calculate relative presence and abundance of the various species in each layer, and additionally to measure future sources of large woody debris (LWD). Sum coniferous and deciduous species separately.

Dominant species: Record the most abundant species for each layer as the dominant species.

Species hgt (height), **DBH:** Once the dominant species has been determined, select a representative example within the plot and record its height (visual estimate in m) and dbh (cm).

3. Understorey

The understorey is made up of species of shrubs, herbs and mosses. These are important indicators of site specific growing conditions, most typically related to soil moisture and nutrient conditions, and are commonly used to help establish the provincial BEC site series classifications.

Layer: Layers of the understorey ***are based on average height*** and can be divided up as follows:

Tall shrub: >2 m

Short shrub: <2 m

Herbs: predominant herbaceous (non-woody) growth

Moss: predominant moss species present on ground.

% cover: As it is not practical nor useful to do stem counts for the understorey, per cent cover is used as a measure of abundance. Estimate the amount of foliar coverage of a particular species within a given layer. For assistance in estimating cover, refer to the companion charts in Figure 6. It is not necessary that all the species of a layer add up to 100% cover.

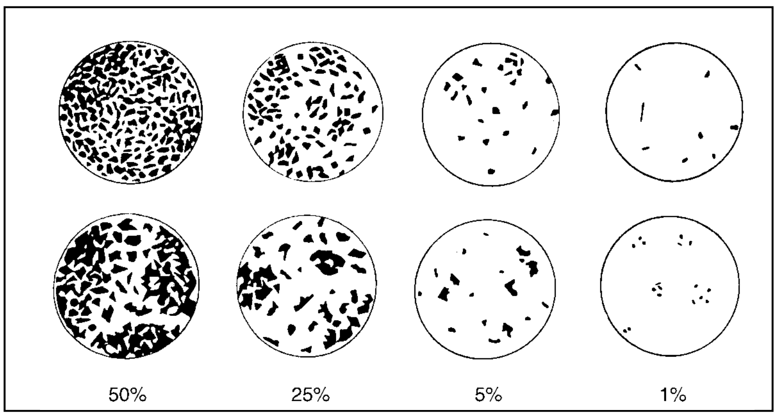


Figure 6. Comparison charts for estimation of foliage cover (after Luttmerding et al. 1990)

Species: There are no official species codes for shrubs, herbs and mosses. Instead, fill in the field form with either the latin or common name, or an acceptable abbreviation of the names. For example, salmonberry, *Rubus spectabilis* is commonly abbreviated as "Rusp;" (if using abbreviations, be sure to include the full names of the species on the field form). Record the three most abundant species in each layer. Should you wish to record the presence of more than three species, record them in the **Comments** section. If a species is unknown and cannot be quickly identified in the field, state whether it is a grass, forb, aquatic plant or moss under species column, and take a sample for identification later in the office or lab.

Height: Enter the height in metres to the nearest 0.1 m.

Mean height of dominant shrub layer: Estimate the average height of the understorey layer with the greatest total cover.

4. Plot Summary

Total % cover: Estimate the total per cent cover for both the overstorey and the understorey.

Total SPH: Sum the total stems per hectare (sph) for only layers 1a and 1b.

5. Snags

Snags are any standing dead trees and are valuable as wildlife trees and potential LWD (see BC classification of wildlife trees in Appendix 6).

Total/Plot: Add up all snags over 5 m in height within the plot.

DBH range: Estimate in centimetres the range in diameter (at dbh) of all snags over 5 m in height.

Species: Where it is still possible to identify the snags by species, record it. Otherwise, distinguish between coniferous and deciduous trees.

% LWD: Estimate the per cent of snags within the plot that may ultimately function as LWD (i.e., the percentage that is close enough to fall into the stream within the next 10 years – approximately).

Total/ha: Multiply the total snags per plot by the plot multiplier to calculate total snags per hectare.

6. Disturbance Indicators

Make note (yes or no) of the presence of any of the following disturbance indicators within an RVT:

Beaver activity	Flooding	Blow down
Fire	Surface erosion	Slide
Slope failure	Insect/disease	Bridge/Culvert
Grazing	Road	Other (e.g., herbicide).

C (comment): If a more detailed explanation of disturbances is desired, assign a number in the comment box and include a corresponding description in the comments section at the bottom of the form (referring back to the same number, e.g., C1, C2, C3).

7. Soil Horizons

Soil horizon can be defined as a layer of soil that is distinguished from adjacent layers by characteristic physical properties such as structure, colour or texture. **Humus** is the organic layer at the top that consists of decomposing plant material. **A** horizons are surface mineral horizons, and consist of two types. **Ae** horizons indicate strong leaching of organic matter and nutrients from upper mineral soil and are associated with nutrient-poor to nutrient-medium soils. **Ah** horizons indicate an accumulation of humus in the surface mineral soil, and are generally associated with nutrient-rich soils. Ae horizons are light greyish coloured (lighter than underlying soil) while Ah horizons are dark brown coloured (darker than underlying soil). (Refer to Appendix 4 for additional details).

Horizon: Classify as humus, Ae or Ah.

Depth: Measure and record the average thickness of each soil layer in cm.

Texture (mineral layers only): To help identify soil type, crush a small handful of soil in the hand, and remove coarse fragments (particles greater than 2 mm in diameter). Gradually add water to the soil and work into a putty (not too moist or dry). Categorize the texture as either clay, silt or sand based on the following features:

Clay – feels smooth and very sticky,

Silt – feels slippery or soapy,

Sand – feels grainy.

% coarse fragments (mineral layers only): Per cent coarse fragments can be determined through estimating per cent by volume of ***mineral soil fragments greater than 2 mm in diameter***.

8. Level of Functioning

Levels can be briefly described as follows:

- Low (L) – riparian vegetation functioning poorly, improvement needed
- Medium (M) – functioning moderately, improvement may help
- High(H) – functioning well, improvement not needed.

These can be assessed by visually estimating the current extent of riparian functioning based on the potential level. The level for each ecological function will vary according to the structural stage of the vegetation (Table 3).

Table 3. Potential level of riparian functioning

Structural stage	LWD	SOD[a]	Stream shading	Surface sediment filtering	Bank & channel stability
Initial	L	L	L	L	L
Shrub herb	L	M – H	L – M	M	L
Pole sapling	L	H	L – M	M	L
Young forest	L	H	M – H	H	L – H
Mature forest	H	H	H	H	H
Old forest	H	H	H	H	H

[a] Small organic debris (e.g., leaf litter, twigs, falling insects)

Criteria for determining level of functioning (adapted from McLennan and Johnson 1997):

LWD/CWD: The primary factors for considering the level of functioning for LWD/CWD are the number of sph of the overstorey vegetation, the effective distance of potential LWD from stream, and the species of potential LWD.

To assess sph for LWD (Table 4), consider only coniferous tree species since their resistance to decay is much greater than that of deciduous species. The exception would be when assessing areas where coniferous species are naturally rare or absent.

Table 4. Assessing stems per hectare (sph) for potential level of LWD functioning

Overstorey layer	Coniferous sph		
	High (H)	Medium (M)	Low (L)
1a >22 cm	>150	50–150	<50
1b 12.6–21.9 cm	>100	50–100	<50
2 7.5–12.5 cm	>200	75–200	<75
3 0.1–7.4 cm	>400	200–400	<200
4 <1.3 m height	>600	300–600	<300

The effective distance for LWD is considered to be a slope distance of 25 m in BC coastal regions and 15 m in the interior.

SOD: For a general assessment of SOD, three factors should be considered. First, assess ***height and relative distance of the vegetation*** from the stream. The taller the vegetation, the further it can be from the stream and still be effective as SOD (Table 5).

Table 5. Effective distance for SOD and stream shading function

Dominant vegetation		Mean vegetation height (m)	Maximum effective distance (m)
Shrubs	Trees		
low	seedlings	<1	1.0
high	saplings	1–3	3.0
	trees	3–10	10.0
	trees	10–20	20.0
	trees	20–30	30.0
	trees	>30	35.0

Secondly, deciduous leaf litter is higher in nutrients, produced in larger quantities, and easier to decompose and digest than needle litter. Therefore, ***SOD which is deciduous in origin will be of higher quality than that which is coniferous.*** However, coniferous needles are shed year-round and therefore provide continuous supply of nutrients.

Lastly, the ***amount of cover will affect SOD input into the stream***. The more cover (regardless of tree/shrub, deciduous/coniferous, mature/early structural stage), the higher the input of SOD relative to little or no cover.

With these three factors in mind, determine the level of SOD functioning as either low, medium or high.

Stream shading: As with SOD, ***the height and distance of vegetation*** from the stream (as described in Table 5), and also ***the amount of cover should be considered for level of functioning***. In addition, the stream class, the BEC zone, elevation and the aspect of the stream segment are important factors for assessing stream shade.

Stream shading is likely to have the highest impact on streams which are small in size, south facing in aspect, and located in the dryer and warm BEC zones BG, IDF, PP, ICH and CDF.

Surface sediment filtering: The ability of the riparian area to intercept surface sediment deposition will depend on several factors: extent of vegetation cover, slope, micro-topography and upslope sediment sources. For example, minimal ground cover, high RVT slopes (>35%) and relatively smooth micro-topography (little mounding) will reduce the surface sediment filtering capacity at a site.

Bank and channel stability: Observe the amount of vegetative cover on the streambanks, and whether the banks are bare, undercut or actively eroding. Decide whether the streambanks in the area of your RVT are stable or unstable. If unstable, indicate whether of low or moderate functioning level.

Observe the channel size and patterns, and the channel substrate materials. Try to evaluate whether the channel is stable, aggrading or degrading. If either aggrading or degrading indicate whether of low or moderate functioning level. Refer to figures in WRP Technical Circular 7, *Channel Conditions and Prescriptions Assessment*, or the *Channel Assessment Procedures Guidebook* to assist in this evaluation. In cases where it is too difficult to assess (requiring input from a hydraulic or geomorphic specialist), indicate by placing a "u" (unknown) in the space provided.

Photos: Photo documentation (roll and frame number) should be included in the field form for easy reference. Ideally, two photos should be taken per plot, one of the RVT vegetation and the second of the soil pit. Include a measure of scale in each photo, for example, include a person or surveying rod in the RVT photo, and include an tape measure in the soil pit photo.

Other comments: The comments section can be used to explain any disturbance indicators in greater detail as well as any general comments on the site. In addition, since one plot per RVT in most cases does not fully describe a site, walk-through the RVT and make note of any additional tree species that were not included in the plot, and any other observations that might affect the outcome of the Level 1 assessment.

Finally, where possible, compare the functioning in the harvested sites to similar variables in adjacent mature forest, or **old-growth** forest sites.

Proper Functioning Condition

There are additional tools that can be used in the Level 1 field assessment stage. One method is the proper functioning condition (PFC) checklist-style assessment of the U.S. Bureau of Land Management (Prichard et al., 1998a, 1998b). This method requires a stream hydrologist, soils specialist, fish habitat biologist and riparian vegetation specialist to walk the stream together and make on-site evaluations based on their professional judgment (see Appendix 2 for sample questions). Some of the terminology used in the Code guide (e.g., desired future condition), are incorporated in Figure 3 (see earlier in text). To effectively use this method, consult the complete documentation of the Code method and the supporting scientific references.

Level 1 Data Summary

After completion of field data collection and function evaluation, return to the office and summarize the data. The summary will include:

- review of the field visits
- refinement of mapping materials

- tabulation of comparative data
- discussion of the results
- preliminary list of possible restoration activities per dysfunctional RVT polygon
- recommended priority locations to proceed to the Level 2 assessment and restoration prescriptions stage.

Level 1 Summary Form Instructions

Once data has been collected from the field sites, it is advisable to compare the sites to determine which are the best candidates to recommend for Level 2 assessment and prescription. This form **(Form 3)** is intended to make summaries and direct comparisons easier (also see sample of completed form in Appendix 7).

Reach no.: Identify the reach number (if simultaneously conducting fish habitat or channel conditions assessments). Transfer number from Forms 1 and 2.

Polygon no. and area (ha): Record the polygon number and calculated area based on the overview assessment and confirmed in the field visit. The area estimates (in hectares) can be quite crude since we are not yet at the prescription phase. For example, one can obtain a rough area measure by placing a grid system over the air photo polygons and counting the number of squares (of known area) from the grid which cover the polygon area. From the number of squares and based on knowing the scale of the air photo, one can use an appropriate conversion to obtain polygon area.

RVT no.: First determine the riparian vegetation type (RVT) labels (next column) and for each unique label, assign a number. If there are two sites that have the same label, they should also have the same RVT number.

An **RVT label** is created based on the stand structure and the overstorey species composition. Stand structure is identified in the first component. Composition makes up the second component and is determined by identifying the dominant species from the field form, with layer 1a and 1b. Where lower overstorey layers of seedlings and saplings are important and data are available, they will be the third component of the label. If a species is less than 20% volume in its layer, it can be included in brackets (Table 6).

Table 6. Examples of RVT labels (adapted from McLennan and Johnson 1997)

RVT Label	Description
PSd/Dr(Ss)/HwSs	A deciduous (d) pole sapling (PS) stand, 20–40 years old dominated by red alder (Dr) with scattered Sitka spruce (Ss) (<20%) in the overstorey; understorey has significant stocking of Hw and Ss.
PSc/HwCw(Dr)	A coniferous (c) pole sapling stand 20–40 years old where red alder (Dr) is a minor component (<20%) and western hemlock (Hw) and western redcedar (Cw) are dominant.
SHls/HwCw(Dr)	A low (ls) shrub (SH) regeneration stand between 1 and 20 years old where red alder (Dr) is a minor component (<20%) and western hemlock (Hw) and western redcedar (Cw) are dominant.
MFc/SsHwCw	A coniferous (c) dominated mature forest (MF) stand of Sitka spruce (Ss), western hemlock (Hw), and western redcedar (Cw).

RVT labels can also be designed whereby fewer tree species are part of the label, and instead, understorey vegetation species (shrubs and herbs) are added. Shrubs and herbs are indicators of site specific growing conditions and thus good RVT descriptors.

Level of functioning can be summarized by assigning numbers to the low, medium and high designations on the field form. For example, low becomes 1, medium – 3, high – 5. The numbers for each of the categories for a polygon can then be added in the **Summation** column. This method allows comparison of each individual category and overall level of functioning for different sites.

Note: Because of regional and site variations, it may be appropriate to assign stronger weightings to different functions, for example LWD and stream bank stability may be more important functions at some sites than provision of SOD or surface sediment filtering. It will be left to the judgment of those carrying out the assessment to use the system that suits their project best (most appropriate tool) such as retaining the existing ranking from Form 2 (L,M,H categories from the field data form), or creating their own weighting system.

Disturbance indicators: Record here any disturbance indicators that were noted during the site visit, particularly those that may affect future restoration efforts (e.g., site prone to flooding).

Priority and recommendations: The summary form for Level 1 is intended as a tool to compare the various RVTs that were field assessed and to determine which of those require the more detailed assessment and prescription development at Level 2.

For all sites for which restoration is a possibility, prioritize them for Level 2 activities, as high priority (H), medium (M), or low priority (L), based on benefit to the resource or watershed, and on factors such as accessibility, field logistics and costs. At the bottom right hand corner of Form 3 you can sum the total area (in hectares) for the three categories.

Output from the Level 1 Assessment

Output from the Level 1 assessment includes the following:

1. a brief discussion of methods used in the Level 1 assessment
2. Form 2 data (see Appendix 7)
3. mapping and map overlays of RVTs in study area
4. identification of known or suspected impaired polygons
5. a discussion of impairments and restoration options, desired future conditions; limitations to restoration;
6. recommended sites for the Level 2 phase.

In some cases the recommendation may be that no further assessment is required. Reasons not to proceed with Level 2 for a given RVT are:

- the site is currently functioning well (stream banks and channels are stable, there is diverse mature vegetation that offers adequate LWD/CWD, shading, sediment filtering and nutrient inputs)
- the site is too prone to disturbance such as flooding, or for other reasons cannot support restoration efforts and success is unlikely.

Level 2 Assessment and Prescription

The final stage in the RAPP is prescription development – development of a restoration plan. To do so may or may not require additional field data. Whether to collect additional field data will depend on the nature of the prescription and the extent of data collected at the overview and Level 1 stages. Where restoration prescriptions involve detailed planting and stand tending, additional data requirements are likely. Where the prescriptions are relatively simple, for example involving only riparian fencing, additional data requirements are unlikely. This process is similar to that of Level 2 in the fish habitat assessment procedure, WRP Technical Circular 8.

Aims of the Level 2 Assessment

Level 2 field assessments are carried out where you require additional site-specific information to diagnose the nature of the riparian habitat impairment, and to identify or plan effective restoration prescriptions.

The **objectives** of Level 2 assessments are:

- to identify/confirm appropriate riparian restoration options and priorities
- to provide detailed site information needed to prepare restoration prescriptions.

Scope of the Level 2 Assessment

Level 2 field assessments are usually limited in scope to specific sites that the Level 1 assessment has identified as impaired (being of low to moderate levels of functioning), and where additional information is required to identify or to plan appropriate restoration activities. A Level 2 assessment usually consists of additional and more detailed field data to be obtained at particular sites within impaired RVTs. These data provide the specific information needed to develop appropriate riparian restoration prescriptions. For example, the project may require more accurate tree density estimates, site topography (microsite characteristics), or soil moisture and nutrient characteristics than provided by the Level 1 assessment. The decision whether additional data are needed will be made based on discussions with local MELP and MOF WRP staff involved in the project. Some of the more detailed restoration prescriptions may be quite similar in content to those in a silviculture prescription (SP) or stand management prescription (SMP) as outlined in provincial Code guides (see References section, and Glossary). Use the results of the Level 2 assessment to clarify the objectives and scope of restoration activities at specific locations, and to provide necessary detailed site information. Ensure that those doing the assessments have the training, experience and a sufficient understanding of the project scope and objectives to accurately document and correctly interpret site conditions and limitations, and to recommend suitable prescriptions for restoration.

Restoration Prescriptions

The prescriptive phase involves sufficiently identifying and evaluating habitat problems, and determining an appropriate course of action to address them. The recommended restoration prescriptions must be consistent with the objectives of other resource management plans for the area.

Typical restoration goals are:

- to increase surface sediment filtering by re-establishing ground cover
- to provide stream shade and SOD by restocking a variety of shrubs and trees
- to provide future high quality LWD and CWD by restocking (or spacing and releasing) conifer trees
- to increase bank stability by streambank plantings
- to re-establish channel stability by bar stabilization (working with fisheries biologists and geomorphologists), and long-term replanting schemes
- exclusion of source impacts by passive restoration (e.g., by streambank fencing in range areas, Kauffman et al. 1997).
- enhancement of critical wildlife habitat.

The ultimate goal is to create a healthy, diverse vegetation community in proper functioning condition. Where possible, follow the natural template specific to the area being restored.

Riparian restoration prescriptions must conform to current standards for the activities (e.g., with Code regulations); however, where tree stocking is recommended, the prescription may not necessarily follow the stocking densities and measures of success as outlined in regional guides such as the *Establishment to Free Growing Guidebooks*. In particular, any stocking prescriptions in the RRZ may vary from commercial forest prescriptions since the objective will be maximizing growth of diverse vegetation serving a variety of aquatic and wildlife purposes, rather than timber for future harvest. Stocking densities will likely be lower and more varied than those for commercial silviculture.

Typical prescriptions (restoration plans) may entail one or more of:

- various types of tree and shrub stocking
- cluster planting of conifers
- directional falling of deciduous canopy
- juvenile spacing to focus growth on fewer trees and increase stand biodiversity
- planting large stock trees to increase survival success, rather than the more conventional use of smaller stock
- manipulation of existing riparian trees to increase wind firmness and reduce potential for future wind-throw problems
- non-uniform planting and/or thinning to make more effective use of optimal micro-habitats
- brushing (manual brushing, brush mats)
- browse protection of young, palatable tree species (vexar tubing, fenced enclosures
- spot nutrient applications to key riparian trees (commercial fertilizers, dead fish carcasses, trace elements)
- streambank fencing
- streambank and gravel bar stabilization through willow and cottonwood tree plantings, or using bio-engineering techniques such as wattle fences (see Chapter 6, WRP Technical Circular 9; Donat 1995; and Polster 1998).

Summarize the necessary restoration work on a site-by-site basis in a concise format that indicates:

- the exact location of the site
- the boundaries of the work site
- the nature of the problem
- the precise objectives of the work
- the recommended prescription(s)
- site preparation and work sequencing priorities
- Workers' Compensation Board safe working practices, particularly where activities include tree falling, tree topping or girdling
- special concerns (environmental protection, timing, sources of native plant stock)
- labour and materials requirements
- estimated costs

- the expected benefits of the work
- post-works monitoring requirements.

There likely will be quite a variety of restoration plans since the riparian zone is made up of very diverse habitat. **As this is a relatively young science, small-scale operational trials are the preferred restoration method** (D. Karnes, district silviculturalist, United States Forest Service, Siuslaw National Forest, Oregon, personal communication). The results of the trials will be used over time to establish standard, proven treatment techniques. Restoration projects should ensure sufficient resources are available to evaluate the results.

Project Monitoring and Maintenance

Monitoring is essential for determining the biological, technical and cost effectiveness of the restoration works. Monitoring procedures should be designed to provide measures of restoration effectiveness and allow for adaptive feedback within the project and the wider WRP program.

Monitoring after tree planting or thinning, should include a combination of the following in test and control plots:

- measurements of tree, or shrub survival (% survival)
- increased tree vigour, and growth in target trees,
- tree height
- stem diameter at a specified height
- leader growth and bud sizes
- canopy cover (% diffuse light available)
- evidence of disease, animal damage and windthrow.

Design of **maintenance procedures** (brushing, pruning, thinning, watering, repairs) should be an integral part of all restoration plans. Restoration projects which do not include a formal inspection and maintenance procedure are more prone to failure in the longer term. Maintenance procedures should be specified on both a seasonal and annual basis.

References

References Cited

B.C. Ministry of Forests. 1998. Provincial seedling stock type selection and ordering guidelines. Victoria, BC.

Donat, M. 1995. Bioengineering techniques for streambank restoration: A review of central European practices. B.C. Min. Environ., Lands and Parks, Watershed Restor. Progr., Vancouver, BC. WRP Proj. Rep. No. 2.

Johnston, N.T. and P.A. Slaney. 1996. Fish habitat assessment procedures. B.C. Min. Environ., Lands and Parks and B.C. Min. For., Watershed Restor. Progr., Victoria, BC. Tech. Circ. No. 8 (rev. Apr. 1996).

Kauffman, J.B., R.L. Beschta, N. Otting and D. Lytjen. 1997. An ecological perspective on riparian and stream restoration in the western United States. Fisheries 22(5): 12–24.

Lutmerding, H.A., D.A. Demarchi, E.C. Lea, D.V. Meidinger and T. Vold (editors). 1990. Describing ecosystems in the field (second ed.). B.C. Min. Environ., Lands and Parks, Victoria, BC. Manual No. 11.

McLennan, D. and T. Johnson. 1997. Riparian assessment and prescription procedures field guide (first approximation). (Unpubl. draft, available from the WRP office. Superceded by the current Riparian Assessment and Prescription Procedures).

Polster, D. 1998. Soil bioengineering for forest land reclamation and stabilization. Course material for training professional and technical staff. B.C. Min. For., Victoria, BC.

Prichard, D., H. Barrett, J. Cagney, R. Clark, J. Fogg, K. Gebhardt, P.L. Hanson, B. Mitchell, D. Tippy. 1998a. Riparian area management: process for assessing proper functioning condition. U.S. Dept. Int., Bur. Land Manage., Denver, CO. TR1737-9.

Prichard, D., J. Anderson, C. Correll, J. Fogg, K. Gebhardt, R. Krapf, S. Leonard, B. Mitchell, J. Staats. 1998b. Riparian area management: A user guide for assessing proper functioning condition and the supporting science for lotic areas. U.S. Dept. Int., Bur. Land Manage., Denver, CO. TR1737-15.

Recommended References

Adams, M and I. Whyte. 1990. Fish habitat enhancement: A manual for freshwater, estuarine and marine habitats. (Chapter 4 & Appendix 3). Dep. Fish. and Oceans, Vancouver, BC.

Guy, S. 1997. Wildlife/Danger tree assessor's course workbook. B.C. Min. Environ., Lands and Parks, B.C. Min. For., and Worker's Compensation Board of British Columbia, Victoria, BC.

Meidinger, D. and J. Pojar. 1991. Ecosystems of British Columbia. B.C. Min. For., Victoria, BC. Spec. Rep. Series 6.

Plant Identification Guidebooks *(available from bookstores)*

Johnson, D., L. Kershaw, A. MacKinnon and J. Pojar. 1995. Plants of western boreal forest and aspen parkland. Lone Pine Publ., Vancouver, BC.

Klinka, K., V.J. Krajina, A. Ceska and A.M. Scagel. 1989. Indicator plants of coastal British Columbia. UBC Press, Vancouver, BC.

Parish, R., R. Coupé and D. Lloyd. 1996. Plants of southern interior British Columbia. Lone Pine Publ., Vancouver, BC.

Pojar, J. and A. MacKinnon. 1994. Plants of coastal British Columbia. Lone Pine Publ., Vancouver, BC.

_____. 1992. Plants of northern British Columbia. Lone Pine Publ., Vancouver, BC.

Ringius, G.S. and R.A. Sims. 1997. Indicator plant species in Canadian forests. Can. For. Serv., Nat. Res. Canada, Ottawa, ON.

Select Forest Practices Code Guidebooks *(available on the Internet at <http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/guidetoc.htm>)*

B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks. 1997. Biodiversity guidebook. Victoria, BC.

B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks. 1995. Establishment to free growing guidebooks (regional guides). Victoria, BC.

B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks. 1998. Fish-stream identification guidebook (regional guides). Victoria, BC.

B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks. 1995. Range management area guidebook. Victoria, BC.

B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks. 1995. Silviculture prescriptions guidebook. Victoria, BC.

B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks. 1995. Stand management prescription guidebook. Victoria, BC.

B.C. Ministry of Forests, Field Guides for Site Identification and Interpretation *(regional field guides for site assessment to the "site series" level) (available from Crown Publications)*

Banner, A., W. MacKenzie, S. Haeussler, S. Thomson, J. Pojar and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 26.

Braumandl, T. and M.P. Curran. 1992. A field guide to site identification and interpretation for the Nelson Forest Region. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 20.

DeLong, C., A. MacKinnon and L. Jang. 1994. A field guide to site identification and interpretation for the southeastern portion of the Prince George Forest Region. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 24.

_____. 1994. A field guide to site identification and interpretation for the northern rockies portion of the Prince George Forest Region. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 29.

Green, R.N., and K. Klinka. 1994. A field guide to site identification and interpretation for the Vancouver Forest Region. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 28.

Lloyd, D., K. Angrove, G. Hope and C. Thompson. 1990. A field guide to site identification and interpretation for the Kamloops Forest Region. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 23.

MacKinnon, A., C. DeLong and D. Meidinger. 1990. A field guide to site identification and interpretation of the ecosystems of the northwest portion of the Prince George Forest Region. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 21.

Steen, O.A. and R.A. Coupé. 1997. A field guide to forest site identification and interpretation for the Cariboo Forest Region. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 39.

Abbreviations

CAP – channel assessment procedure

CCPA – channel conditions and prescriptions assessment

CWAP – coastal watershed assessment procedure

CWD – coarse woody debris

DBH – diameter at breast height

DFO –Department of Fisheries and Oceans, Canada

FHAP – fish habitat asessment procedure

Code – Forest Practices Code

IWAP – interior watershed assessment procedure

LWD – large woody debris

MELP – B.C. Ministry of Environment, Lands and Parks

MOF – B.C. Ministry of Forests

RAPP – riparian assessment and prescription procedures

RMA – riparian management area

RMZ – riparian management zone

RRZ – riparian reserve zone

RVT – riparian vegetation type

SMP – stand management prescription

SOD – small organic debris

SP – silviculture prescriptions

SPH – stems per hectare

Tree Species Abbreviations/Codes: see end of Glossary.

Glossary

adaptive management feedback – the ability to generate meaningful effectiveness monitoring data and use it to make ongoing project and program adjustments where required.

alluvial – (see fluvial).

biogeoclimatic classification – a hierarchical classification system of ecosystems that: integrates regional, local, chronological factors, and combines climatic, vegetation, and site factors (Meidinger and Pojar 1991).

biogeoclimatic zone – a large geographic area with a broadly homogeneous macroclimate. It has characteristic webs of energy flow and nutrient cycling and typical patterns of vegetation and soil (Meidinger and Pojar 1991). *Refer to Appendix 3 for biogeoclimatic zones of BC.*

channel – a waterway of discernible extent that continuously or periodically contains moving water, and has a defined bed and banks.

climax community – the final and relatively stable stage in plant succession for a given environment where the species present perpetuate themselves in the absence of disturbance.

coarse woody debris (CWD) – sound and rotting logs and stumps that provide habitat for small terrestrial animals and their predators. Large woody debris is one type of CWD, but with a primarily aquatic rather than terrestrial influence.

canopy – the overhead branches and leaves of vegetation.

fish habitat – spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes. Habitat can be located instream (main river or stream system) or off-channel (small tributaries or wet areas; includes off-channel and instream habitat).

floodplain – areas of flat land bordering a watercourse. They are frequently at or near the same elevation as the top of the streambanks and are subject to flooding.

fluvial – refers to materials transported and deposited by running water.

Forest Practices Code (Code) – specifies planning and operational guidelines for each phase of timber harvesting operations around streams, lakes and wetlands in the province of British Columbia.

free growing – a term used to describe a stand of trees that has grown sufficiently above the grass and shrub level, ensuring its survival (and free growth) against competition from other vegetation.

gully – a long, linear depression incised into steep hillslopes, where the overall gradient is at least 25%, with a channel confined in a V-notch ravine with banks higher than 3 m, sideslopes steeper than 40%, and an overall length greater than 100 m.

intermittent stream – stream with a defined channel, but dry for periods of the year, usually the late summer and fall period of low precipitation and no snowmelt.

large woody debris (LWD) – pieces of dead wood, having a diameter of 10 cm or larger over a minimum 2 m length, that intrudes into the stream channel; important for providing fish habitat and in influencing channel morphology.

mesic – intermediate or medium moisture conditions; that is, neither very wet nor very dry. The term refers to habitats that have neither an excess nor a shortage of water, relative to the existing extremes in a given area.

nurse-tree shelterwood – a nurse-tree shelterwood system manages different species in two different layers. The tree canopy shelters and provides a more suitable environment for establishment and juvenile growth of the young regeneration. The overstorey can be gradually removed, or removed all at once when the regeneration is developed enough to withstand open site conditions. Where applicable, this system enables shade-intolerant and shade-tolerant tree species to be managed on the same site for a period of time. An example of this is the managing of a redcedar understorey with a cottonwood or alder overstorey.

overstorey – all trees growing in a forested ecosystem, regardless of height or trunk size.

perennial stream – a stream that has flowing water all year.

rehabilitation – returning to a state of health and useful activity. In this manual, rehabilitation means producing conditions more favourable to particular groups of organisms, especially the economically-valuable or aesthetically-desired components of the native flora and fauna, without necessarily returning the system to its undisturbed condition.

restoration – bringing back to a former or original condition (e.g., the pre-logging state). In this manual the term restoration is meant to include rehabilitation.

riparian area – an area of land adjacent to a stream, river, lake or wetland, containing vegetation that, due to the presence of water, is distinctly different from the vegetation of adjacent upland areas.

riparian management areas (RMA) – areas around streams and wetlands that consist of a riparian management zone, and where required by the regulations, a reserve zone within which constraints to forest practices are applied. Its width is determined by the class of stream or wetland. Refer to tables 1 and 2 in the *Riparian Management Area Guidebook.*

riparian management zone (RMZ) – the zone within the RMA and outside the riparian reserve zone where limited harvesting is permitted. As with the RRZ, its width is determined by the class of stream or wetland. Refer to tables 1 and 2 in the *Riparian Management Area Guidebook.*

riparian reserve zone (RRZ) – the zone within the RMA immediately bordering the stream or wetland where no timber harvesting is permitted. Its width is determined by the class of stream or wetland. Refer to tables 1 and 2 in the *Riparian Management Area Guidebook.*

riparian vegetation type (RVT) – classification of vegetation based on stand structure and species composition.

riparian zone – land adjacent to the normal high water line in a stream, river, lake or pond and extending to the portion of land influenced by the presence of the adjacent ponded or channeled water.

silviculture – managing forest vegetation by controlling stand establishment, growth, composition, quality and structure, for the full range of forest resource objectives.

silviculture prescription (SP) – a site-specific plan that describes the forest management objectives for an area. SPs must be consistent with any higher level plan that encompasses the area to which the prescription applies. The SP prescribes the method for harvesting the exisiting forest stand, and a series of silviculture treatments that will be carried out to establish a free growing (above brushline) crop of trees in a manner that accommodates other resource values identified. Subsequent documents, including cutting authorities and logging plans, must follow the intent and meet the standards stated in the SPs.

site series – a method of site classification defined by using late seral or climax vegetation within a biogeoclimatic subzone. Each site series is given a two-digit numeric code that relates to its position on the relative moisture and nutrient scales. This term forms the basis of much of the MOF field guides for site identification and interpretation in forest regions (see MOF Land Management Handbook references in References section).

small organic debris (SOD) – organic material such as leaves, detritus, terrestrial insects, twigs that enter the stream and become part of the aquatic food chain.

snags – standing dead trees that provide essential habitat for wildlife.

soil horizon – a layer of soil that is distinguished from adjacent layers by characteristic physical properties such as structure, colour or texture.

The letters A, B and C are used to designate soil horizons. The A horizon is the upper part (usually organic) and is the zone of leaching minerals and nutrients. The B horizon lies under the A and consists of weathered material with accumulated minerals and nutrients. The C horizon under the B is the layer of unconsolidated, weathered parent material. Not all horizons are present in all soils.

stand management prescription (SMP) – a site-specific plan describing the nature and extent of silviculture activities planned for a free growing stand of trees to facilitate the achievement of specified or identified social, economic and environmental objectives. An SMP was created under the Code to complement the silvilculture prescription by specifying a full-rotation plan or strand strategy for an individual stand.

stand structure – the vertical arrangement and stocking of trees within individual crown classes (canopy layers) in a stand.

Stand structure descriptions:

INIT: Initial stage – as per shrub-herb below, but the very initial stage after disturbance. Bryophytes, lichens and herbaceous plants are dominant.

SH: Shrub-herb – this stage develops after a disturbance in which the forest canopy is completely or significantly removed (e.g., after clearcut logging or a severe fire) and typically lasts up to 15–20 years, although it may persist much longer. The vegetation is characterized by the dominance of shrubs and herbs; young trees are also abundant, although not dominant. Establishment is the primary process; biomass increases rapidly and floristic diversity is often high. This stage is also often referred to as the regeneration stage.

PS: Pole-sapling – this stage typically begins 5 to 15 years after a disturbance, depending on the tree species, when the young trees overtop the shrubby or herbaceous vegetation. Saplings are the earlier stage, poles the later. It usually lasts for up to 30 to 40 years, but may persist indefinitely – as in the case of some lodgepole pine stands in the interior. Trees at this stage are characterized by their vigourous growth and lack of dead lower branches. Stands are more or less even-aged, having been planted or established naturally within a relatively short time. Establishment remains the dominant process, with stand biomass continuing to increase. Understorey biomass declines as the canopy closes in. Note, in some text books the pole stage is the young forest stage.

YF: Young forest – this stage begins when self thinning becomes evident. A second cycle of trees begin to show a significant presence in the ground layer by the end of this stage. Differentiation of the initial tree species into dominant, co-dominant and suppressed layers, and self-thinning, low stand diversity and increasing biomass through rapid height growth are characteristic of this stage. Understorey development is often limited by the dense forest canopy. This stage usually starts about 30 to 40 years after a succession-initiating disturbance and lasts for up to 50 years. In open forests where self-thinning may not be evident and a second cycle of trees is lacking, this stage will be characterized more by the vigourous growth of the trees.

MF: Mature forest – this stage extends until the initial trees mature, height growth slows, and some of the initial trees begin to die. A second cycle of trees may show a significant presence in the lower tree layers. In some cases, the first cycle of trees may begin to die from old age before significant development of a replacement layer begins; in other cases, the next cycle of trees may be well developed before significant mortality of the initial trees occurs. Generally, the even age distribution typical of early stages changes as new trees become established and older trees begin to die. Gap phase replacement may begin to be important at this stage. The understorey re-develops as the canopy opens.

OG: Old growth – old-growth stands generally have an all-age class distribution. Growth slows and volume is lost through rot. Stands show structural heterogeneity as gaps develop in the canopy after trees fall. The understorey biomass increases as light becomes available. The presence of dead wildlife trees and rotting logs scattered on the forest floor enhances the value of forests at this seral stage for wildlife.

stream– the watercourse formed when water flows between continuous definable channel boundaries. Flow in the stream channel may be perennial or intermittent.

stream class – method of classifying streams based on size, gradient and presence of fish. The classification system is based on the Code and ranges from S1 to S6. See Table 1 in text for breakdown of classification.

stream reach – relatively homogenous section of a stream having a sequence of repeating structural characteristics (or processes) and fish habitat types.

streamside – the land, and the vegetation it supports, immediately in contact with the stream or sufficiently close to it to have a major influence on, or to be influenced by, its ecological character.

succession – the gradual change that occurs in the vegetation of a given area of the earth’s surface, or when one community succeeds the other.

understorey – shrubs (≤ 2m in height), herbs or mosses growing in a forest.

watershed – the land on which water falls from the atmosphere and moves downslope to other locations. Each watershed is a catchment area divided from the next watershed by topographic features, most noticeably ridgetops. Watersheds are the natural landscape units from which hierarchical drainage networks are formed.

wetland – a swamp, marsh or other similar area that supports natural vegetation that is distinct from the adjacent upland areas. More specifically, a wetland is an area where a water table is at, near, or above the surface or where soils are water-saturated for a sufficient length of time that excess water and resulting low oxygen levels are principal determinants of vegetation and soil development.

wildlife tree – a standing dead or live tree with special characteristics that provide valuable habitat for the conservation or enhancement of wildlife.

windthrow – where trees are blown over due to wind conditions, in situations where harvest of adjoining forest has resulted in loss of wind protection within the remaining forest. Trees in narrow riparian buffer strips can be susceptible to windthrow conditions, especially in areas of high winds and water saturated soils.

xeric – dry moisture conditions.

Tree Species Codes

Species symbol	Common name	Scientific name
Conifers		
Ba	amabilis fir	*Abies amabilis*
Bg	grand fir	*Abies grandis*
Bl	subalpine fir	*Abies lasiocarpa*
Bp	noble fir	*Abies procera*
Cw	western redcedar	*Thuja plicata*
Fd	Douglas-fir	*Pseudotsuga menziesii*
Hm	mountain hemlock	*Tsuga mertensiana*
Hw	western hemlock	*Tsuga heterophylla*
Lt	tamarack	*Larix laricina*
Lw	western larch	*Larix occidentalis*
Pa	whitebark pine	*Pinus albicaulis*
Pl	lodgepole pine	*Pinus contorta*
Pw	western white pine	*Pinus monticola*
Py	ponderosa pine	*Pinus ponderosa*
Sb	black spruce	*Picea mariana*
Se	Engelmann spruce	*Picea engelmannii*
Ss	Sitka spruce	*Picea sitchensis*
Sw	white spruce	*Picea glauca*
Sx	hybrid spruce	*Picea* hybrids
Sxs	hybrid Sitka spruce	*Picea sitchensis* x *glauca*
Sxw	hybrid white spruce	*Picea engelmannii* x *glauca*
Yc	yellow-cedar	*Chamaecyparis nootkatensis*
Broad-leaved trees		
Act	black cottonwood	*Populus balsamifera* ssp. *trichocarpa*
Acb	balsam poplar	*Populus balsamifera* ssp. *balsamifera*
At	trembling aspen	*Populus tremuloides*
Dr	red alder	*Alnus rubra*
Ep	common paper birch	*Betula papyrifera*
Mb	bigleaf maple	*Acer macrophyllum*
Qg	garry oak	*Quercus garryana*

(See Table 1, Appendix 1 for partial list of native shrubs).

Appendix 1. Riparian functions and restoration methods

The functions of riparian vegetation are grouped into two categories:

- ***aquatic functions*** **–** those that provide habitat, energy inputs and other functions for organisms in the stream, lake or wetland they abut
- ***terrestrial functions*** **–** those that provide habitat and energy inputs for organisms within the riparian zone.

The ecological functions performed by riparian vegetation will change as stand structure changes through the course of vegetation succession. Their relative importance will also vary with the biogeoclimatic zone of the watershed. For example, the importance of stream shading may be much higher in fish-bearing streams in the Interior Douglas-fir biogeoclimatic zone (IDF zone), in the hot and dry southern interior of the province, than in cooler, higher rainfall coastal streams.

Aquatic Functions (adapted from McLennan and Johnson 1997)

Large Woody Debris

One of the most important functions of riparian vegetation is the contribution of large woody debris (LWD) to aquatic ecosystems. Generally, input of LWD occurs with bank undercutting, debris avalanching, blowdown of trees in the riparian zone, and transport from upstream sources. Output processes consist of floods and debris torrents which can scour stream beds. In streams, LWD increases the complexity of pool and riffle sequences and alters stream gradient on a local scale. The increase in channel complexity helps retain gravel as well as organic and inorganic particulate matter. Increased channel complexity is particularly important for fish species that use pools and gravel deposits for spawning and rearing. In larger order streams, LWD provides strong current and escape refugia. LWD also provides hiding cover for stream organisms and provides a substrate for biological activity in the stream. In high order streams and lakes, LWD is an important source of cover along the shore providing significant amounts of cover for juveniles. In low order streams, the low velocity currents created by LWD catch leaves and needles and provide the residence time required for fungal and bacterial conditioning to allow invertebrate detritivores to utilize the litter.

The specific role of LWD within a stream depends on the size of the LWD relative to the energy and size of the stream. In low order streams (small streams in watershed headwaters), LWD is highly significant in determining stream morphology and fish habitat. The relatively large piece size in comparison to the small stream size and low energy of lower order stream systems, means that deposited LWD seldom moves far. In middle order streams, LWD has an intermediate influence on channel morphology because the streams are larger in size and have higher energy. In the highest order streams (large streams on the valley floor), the influence of LWD on channel morphology is restricted to debris jams on gravel bars and armouring along banks. Because stream energy is high in higher order streams, LWD residence is short.

In general, trees do not reach a sufficient size to provide adequate LWD until they are in excess of 100 years old. This means that only stands in the mature forest and old forest structural stages can provide useful LWD. Within these stands, only trees sufficiently close to fall into the stream (within the "effective distance") are considered to be future LWD. In general, conifer trees make better LWD because of their larger size and slower rate of decay. Conifers decay over a period of 20–70 years, where as, for example, cottonwood trees decay within 10 years of falling into a stream channel. Given the important aquatic functions performed by LWD, one of the major rehabilitation goals in many watersheds will be to promote the rate at which coniferous LWD grows on a given site.

Small Organic Debris

Stream and lakeside riparian zones make important contributions to the energy balance of aquatic ecosystems through the input of particulate organic matter such as leaf, needle and branch litter, and terrestrial invertebrates. Collectively, this material is referred to as small organic debris (SOD).

In lower and middle order streams a portion of the particulate organic matter input is linked to algae, and algal production is generally higher in the early spring. Both SOD and algal inputs in small order streams are also important because much of the organic matter introduced into small streams in watershed headwaters is ultimately carried to and utilized by aquatic organisms in larger streams below. The influence of stream-side vegetation on direct energy inputs in larger streams is considerably less important than in-stream production because vegetation covers less of the surface area than in small order streams.

Deciduous and coniferous litter inputs have different characteristics. Deciduous litterfall, which is deposited seasonally, is generally higher in nutrients, and more rapidly conditioned by microbes than coniferous needle litter. Because many deciduous species are nitrogen-fixing species, litterfall of such species as red alder may be further enriched in the concentration of foliar nutrients, especially nitrogen. For these reasons, deciduous litter provides the most important source of energy for stream invertebrate populations and is generally a the preferred substrate for aquatic microbes and insects. Conifer needles are lower in nutrient value, and relatively harder to decompose than deciduous foliage, however, conifer needles fall into the stream continuously over the year, as opposed to the seasonal pulse of deciduous leaves.

Stream Shading

Riparian vegetation provides shade that reduces adsorption of solar radiation which decreases stream summer temperatures and light conditions. Loss of stream-side shading has the potential to adversely affect stream ecology and fish populations particularly in the warmer, drier, interior biogeoclimatic zones within the province (e.g., Interior Douglas-fir, and Ponderosa Pine zones).

The importance of shading is a function of the width of the stream, the height of the vegetation, and stream aspect. Thus small streams (S3s) may be effectively shaded by shrub height vegetation (low and tall shrub structural stages), whereas larger streams (S1 and S2s) will require mature trees for effective shading. In the largest streams (>20 m channel width), riparian vegetation will have less impact on the thermal regime.

Surface Sediment Filtering

Input of exposed mineral soil through surface erosion is reduced by a number of factors including the cover of vegetation, especially mosses, herbaceous and small shrub cover, the boles of trees and larger shrubs, and the microtopography of the site. If it is sufficiently wide and stocked with a suitable number of trees, the RRZ can also be important in reducing the impact of large debris flows from upslope sources. The buffering of surface sediments and landslides is especially important in higher gradient streams where hillside processes are most active, and where past forest harvesting operations have the greatest potential to increase sedimentation. Areas of highest risk are found below roadcuts, potentially unstable slopes, and in areas of exposed mineral soil.

Maintenance of Bank Stability

In some situations, the roots of vegetation in the riparian zone play an essential role in the stability of stream banks and alluvial surfaces. After removal of vegetation and root decomposition, there can be an increase in channel instability, lateral erosion and sediment input. This situation is most common in small floodplains and braided channel reaches along small and medium size streams. Lateral erosion of the RMA is a natural process that is, in many cases, unrelated to removal of riparian vegetation. This situation is common along larger streams where fluvial benches are well developed and where roots are found above the zone of lateral erosion. The ability of riparian vegetation to protect stream banks from erosion and maintain stream stability will increase as stands age and root systems become more extensive.

Terrestrial Wildlife Functions and Habitat Restoration

(submitted by V. Poulin, V.A. Poulin and Associates Ltd., Vancouver, BC)

Introduction

Riparian areas contain some of the most biologically diverse wildlife habitats found in forests. Of the 340 vertebrate species that live in BC over 40% can be found to utilize the unique habitats provided by the vegetation and stand structural diversity found adjacent to streams, lakes and wetlands. Methods within the watershed restoration program to improve habitat for wildlife should focus on stand structural and cover characteristics that are needed by wildlife for nesting sites, roosting sites, denning areas, forage, cover from predators, excessive snow depth and low winter temperatures. They are the same attributes that are being managed for at the stand level to meet biodiversity objectives under the Code (*Biodiversity Guidebook* 1995) which include wildlife trees (including standing dead and dying trees), coarse woody debris, tree species diversity, and understorey vegetation diversity. A variety of techniques can be used to obtain relatively quick results where wildlife tree functions are lacking. These approaches can be used individually or in combination to achieve positive long- and short-term changes to the structure of a stand and make for a more fully functioning riparian area.

Stand Structure and Tree Species Diversity

Stand structure refers to the variety of canopy layers (vertical structure) and spatial patchiness (horizontal structure) that occurs in natural stands. When combined with an ecologically appropriate mix of tree species this diversity can meet the habitat requirements for a greater variety of wildlife than can be met in homogenous, single-layer stands. Vertical structure includes the naturally occurring forest understorey of shrubs and forbs. These lower layers contain many of the forage plants used by wildlife for food and contribute to the dense cover needed by wildlife for winter thermal protection and visual screening from predators. To achieve understorey vegetation a partially open or patchy forest canopy is required. It is the high site productivity and the sunlight that passes through gaps in the canopy that gives rise to the pure patches or mixes of vegetation, rapid growth and large plant size found in natural riparian areas.

Techniques for Restoration

Vertical and horizontal structural diversity can be maintained or created by selective use of silvicultural and stand tending techniques. In general, most restoration efforts should promote an uneven-aged stand. This holds true even in ecosystems with fire histories since natural burns usually contain unburned patches of mature forest adjacent to streams, lakes and wetlands that were missed by fire. These areas are often attacked by insects and combined with a presence of tree root diseases result in stands with dead trees, decaying logs, canopy gaps and generally more complex biological characteristics. Techniques aimed at restoring LWD are the same techniques that will provide for a greater diversity in tree species and stand structure for wildlife. They include:

- creating canopy gaps and planting with ecologically suitable tree species in small patches or clusters
- under planting with shade-tolerant tree species
- combining tree plantings with native understorey shrubs to improve vegetation diversity
- selective use of fertilizers to stimulate the growth of individual trees such that for the same age it may be possible to achieve taller trees that gain a competitive height advantage for space and nutrients and thereby grow to provide greater structural diversity. (Use of fertilizers should be considered with caution if eutrophication is a potential problem. Contact a fish or water quality specialist for advice on fertilizing within the RRZ.)

Wildlife Trees

Wildlife trees are those trees that may be dead or alive that have special characteristics that provide valuable habitat for the conservation or enhancement of wildlife. These trees can be infrequent in areas requiring riparian restoration as they were often felled during harvesting. Wildlife trees in second growth areas are generally trees that survived the previous harvesting (veterans) or are pioneer tree species such as alder, aspen or cottonwood that grew rapidly following harvesting and are now dead or dying in the present condition. They commonly have a characteristic condition, age and decay stage; evidence of use; and all too often are scarce in number. All high to medium valued wildlife trees should be retained through the application of safe work areas as required by the Workers' Compensation Board (WCB). These will generally include any larger dead or dying tree present within the RMA. Refer to the "Wildlife/Danger tree field assessment form #FS 715-2 HSP 96/4" for information on how to use tree species, site position, decay value, diameter breast height, and height information to rate a wildlife tree. *(Also see BC wildlife classification system figure elsewhere in the appendices).*

Wildlife trees serve as critical habitat for a wide variety of organisms such as vertebrates, insects, mosses, lichens and fungi. They provide habitat for birds, bats, fur-bearing mammals, amphibians and are used by bears for denning. Their value is sufficiently disproportionate to their number that consideration should be given to recruiting wildlife trees where possible when undertaking a riparian restoration project.

Techniques for Restoration

- Single green trees can be made into wildlife trees by topping or pruning and can be modified to recruit birds within the season of construction by excavating cavities using boring tools or chain saw and fitting entrances with face plates that have holes cut to match the entrance requirements of a target bird species.
- Cavity starts can be made by making small cuts in the bole. These starts introduce decay and create locations that attract birds to naturally excavate the cavity. Bat hibernacula and roosting spots can be similarly constructed.
- Sap wells or places where the bark is stripped and sap is allowed to seep can be provided to attract insects. They serve as feeding stations and get birds or bats in closer vicinity to where cavities have been provided.
- The simple placement of bird boxes on trees in areas otherwise being modified for riparian restoration should not be overlooked. They can greatly increase nesting opportunities for birds and can be added with little cost.
- Top girdling has been used to create snags. Trees girdled at their base tend to rot out at the point of girdling and are generally lost to decay relatively quickly. Top girdling results in the tops of trees decaying naturally and the top snapping off in wind to yield a point where rot can occur from the top down. Girdling lower down, however, can be used to phase in a source of CWD to the site.

Dead and Downed Wood (Coarse Woody Debris)

Large dead and downed wood provide habitat for a wide variety of organisms including fungi, invertebrates, lichens, plants, micro-organisms and larger mammals including rodents and fur-bearing animals. As distinguished from LWD which is fallen wood that is associated with the stream channel, larger pieces of dead and downed wood on the forest floor and horizontal logs are referred to as CWD. Second-growth forests or forests with fire histories generally have reduced amounts of large wood on the ground or suspended close to the ground due to a high rate of decay for wood that is in total or partial contact with soil and the generally small piece size of material left after harvesting. Small mammals and fur-bearers use dead and downed logs and brush piles for security cover, nesting and breeding sites. Wildlife that feed on arthropods such as shrews, salamanders and some birds rely heavily on larger pieces of downed woody debris for foraging. These features can be easily and inexpensively restored in areas where restoration is being undertaken.

Techniques for Restoration

- In areas where felling of riparian trees is required to restore the mix of coniferous or deciduous tree species, felled trees can be stacked and placed in brush piles that can be used by wildlife.
- Cavities in downed logs are important breeding habitats for small mammals and amphibians and can be recreated by hollowing out existing logs or re-introducing logs in the riparian area that have been modified.
- Cavities can also be cut into the base of live trees or old stumps to provide hollows where small mammals can hide and search for food.

These are simple yet effective techniques that have been used in Canada by trappers for well over a hundred years to attract fur-bearing animals and work well in helping to restore habitats in riparian areas.

The needs of all kinds of wildlife, including insects, amphibians and reptiles, birds, rodents and mammals can be met through the various stages of death and decay of terrestrial vegetation. The manipulation of stand structure, wildlife trees and fallen wood can contribute to the improved capacity of the riparian system to support wildlife. Consideration should be given to the techniques mentioned in this chapter when exploring cost-effective solutions for improving wildlife habitat within the riparian zone.

Methods to Re-establish Riparian Functions
(adapted from McLennan and Johnson 1997)

The objective of riparian prescriptions is to provide preferred and alternative prescriptions which, when implemented, will re-establish impaired or lost riparian functions as rapidly as possible. The objective is to develop vegetation communities that maintain a mosaic of healthy, diverse stands throughout the (for most WRP projects) the RRZs of a watershed. Prescriptions should be appropriate to site specific conditions of the RVTs, they should accelerate conditions that provide for the proper functioning condition of the stream channel and provide restoration of fish and terrestrial wildlife habitat.

To develop sound riparian prescriptions assessors will need to shift from management objectives where timber extraction and production are the main emphasis, to those where maintaining long-term ecological functions of the riparian zone predominate. In the RRZ management standards are developed solely to satisfy management objectives for desired levels of aquatic and terrestrial function. For example, where operational standards in the commercial forest call for establishing 1200 free growing sph on a particular site series, a riparian management prescription may require no more than 600 sph. By maintaining lower stocking, larger diameter trees can be produced in a shorter time to provide LWD. Also, at lower stocking levels the productivity of subcanopy shrubs and herbs is increased, with a resulting improvement in forage potential and SOD inputs to streams.

Valley Bottom and Upland Sites

Approaches to rehabilitating RVTs will vary with the wide range of ecological site–riparian stand combinations that may be encountered in the RRZ. However, in terms of regeneration systems to be employed for rehabilitation, a general distinction can be made between to major sites groups that will dominate RRZ areas, namely, moist-and-rich valley bottom sites and fresh-to-dry upland sites.

Valley Bottom Stands – Floodplains, Forested Wetlands and Moist to Very Moist Upland Sites

These sites are grouped together because they are moist to wet, nutrient rich to very rich sites, and most frequently found in valley bottom positions adjacent to streams. Direct regeneration of coniferous species is very difficult due to vigourous growth of subcanopy shrub and herb species following harvesting. Natural forest succession following disturbance is characterized by the establishment and dominance of rapidly growing deciduous species such as black cottonwood and red alder on the coast, and black cottonwood, paper birch and trembling aspen in the interior. Establishment of full conifer stocking on these sites is difficult and expensive and often conflicts with management objectives for terrestrial and aquatic resources. For this reason, the establishment of fully stocked conifer plantations is not considered a viable regeneration alternative. The preferred regeneration systems on these sites include establishment of nurse tree shelterwoods, clustered conifers, and pure broad-leaved stands.

Upland Sites – Fresh to Dry Sites

The establishment of conifers in upland site units is much easier than in the valley bottom sites mentioned above due to the reduced levels of vegetative competition. The RRZ of many lower order streams will typically be dominated by upland sites. In most cases planting prescriptions will seek to establish well stocked conifer stands which would likely be a lower stocking standard than identified in the Code *Establishment to Free Growing* guidebooks for each forest region. Where the site assessment of an RVT determines that units are not sufficiently stocked with conifers, or are stocked with hardwood species like red alder, trembling aspen or paper birch, it may be desirable to increase conifer stocking in order to increase future sources of durable LWD and CWD.

Nurse Tree Shelterwoods and Conifer Clusters

A variety of vegetation regeneration systems are available. Regeneration systems are designed to create stands with a variety of densities, and to account for brush competition on the site. In the case of nurse tree shelterwoods and conifer clustering, establishment techniques are experimental and have not been used operationally on an extensive basis.

Nurse Tree Shelterwoods

This approach attempts to mimic the natural succession of shade tolerant conifers regenerating under fast-growing deciduous species in high brush hazard areas (McLennan and Klinka, 1990). The hardwoods act as a nurse crop that decreases the growth and vigour of shade intolerant deciduous brush while permitting acceptable growth of shade tolerant conifers. Nurse tree shelterwoods combine a fast growing deciduous and shade tolerant conifer species. The choice of species combined in these systems will be determined by the regional climate.

Nurse tree shelterwoods can be established in two ways depending on the state of development of vegetation in the RVT:

i. *Where competing vegetation is not well developed and the RVT is in the initial or shrub-herb regeneration stage:* conifers and hardwoods can be planted directly into the site or, conifers are planted and deciduous species are allowed to develop naturally. Where hardwoods are not planted, the results of the Level 1 or 2 survey of which tallied deciduous tree density will ensure there are a sufficient number to form a continuous canopy.

ii. *Where competing vegetation is already well developed, at the shrub-herb stage:* mechanically scarify 1m × 1m plantable spots for the conifers and plant vigourous, large, conifer stock. Use black cottonwood whips that are long enough that the stem will remain 30 cm above competing vegetation after planting.

The major advantage of the nurse tree shelterwood approach is that conifers on high brush hazard sites can be established without herbicides at relatively low economic and environmental costs. Using this system, sites are rapidly occupied and sediment erosion control (sediment filtering), shade and SOD functions are rapidly re-established. Over time the hardwood canopy will die out or can be selectively removed to allow conifers to grow through the canopy. As the hardwoods die they provide excellent habitat for cavity nesters and for raptor roosting and perch sites. The advantage of this method is that it mimics the natural succession that occurs on alluvial and forested wetland sites, and provides a constant supply of LWD and CWD in the long term. The low leaf area index of the deciduous species also ensures that a healthy forage community, when compared with a fully stocked stand of conifers, is retained. The forage community will provide SOD, stream shade, foraging habitat and a higher degree of species biodiversity than pure stands of either conifer or broad-leaved species.

The largest problem with this approach is that the method is largely untried operationally, and complete rotations have not been observed in British Columbia. However, the method is commonly employed in European forestry (McLennan and Klinka, 1990). Observations of young nurse tree stands established by McLennan and Klinka (1990) exhibit high survival and good growth of subcanopy conifers.

This option is appropriate without constraint on the high bench of alluvial floodplains and moist to very moist upland sites. In middle bench alluvial sites and forested wetlands, conifers are generally restricted to raised microsites, so planting of conifers should use the clustered approach described below. On the lowest benches of alluvial floodplains conifer growth is severely limited and pure hardwood stands could be established.

Establishing Clustered Conifer Stands

The second option for re-establishing conifers in high brush hazard sites is to establish planted conifers in clusters so that management efforts are centred on known points. Depending on the number of conifers per cluster and the distance between clusters, the gaps in the canopy can be maintained in the developing stand for the entire rotation (McLennan and Johnson, 1993). Under this regime, it is expected that survival will be higher and establishment costs considerably lower than traditional operational approaches aimed at fully stocking these sites with conifers. The cluster concept can be used in RVTs at any stage of structural development. In the initial and shrub-herb stages establishment will be easiest as competition will not yet be fully developed. In deciduous pole-sapling and young forest stages it may be possible to establish conifer clusters by cutting gaps in the canopy to free up site resources and create light environments suitable for conifer growth.

Clustered planting arrangements of conifers on high brush hazard sites can be established during the regeneration, or juvenile spacing operations of the stand (McLennan and Johnson, 1993). Where the clustered approach is used as a method to regenerate conifers in RVTs, the primary objective is the production of LWD and CWD. Clustered plantations also maintain vigourous brush communities which rapidly fulfill SOD, stream shade, filtering and forage functions of the RVT. This method may be most appropriate where it is important to integrate the foraging habitat for ungulates and bears, while fulfilling necessary aquatic functions. In fact, the cluster method is being employed in clearcuts by MELP to provide forage in important grizzly bear habitats in coastal BC.

Like nurse tree shelterwoods, there are few observations on the long-term success of the clustered approach. For example, the optimum arrangement of trees per cluster, inter-tree distance within clusters, and number of clusters per hectare has not been determined. Trials established by McLennan and Johnson (1993) comparing these variables are currently being monitored.

Like the nurse tree shelterwood, cluster planting is appropriate without constraint on the high bench of alluvial floodplains and moist to very moist upland sites. In middle bench alluvial sites and forested wetlands conifers should be clustered on raised microsites. On the lowest benches of alluvial floodplains conifer growth is severely limited and the method should not be applied. On moist to fresh upland sites this approach may be appropriate to create gaps in the canopy particularly during juvenile spacing.

Establishing Seedlings

The following prescription to increase the stocking of conifers, hardwoods or shrubs for the variety of management objectives discussed above assumes the planted seedlings will experience the highest levels of competition for site resources – light, soil moisture and soil nutrients. As discussed below, the intensity of stand tending can be reduced or avoided based on expected levels of competition within a given site unit. Refer to the MOF *Silviculture Manual* for more discussion on planting considerations.

Site Preparation

To reduce competition in the rooting zone, plantable spots should be prepared so that existing roots are completely removed from a minimum area of 1 m × 1 m. Where it is operationally feasible, efforts should be made to ensure that root removal minimizes removal of the humus layer of the forest floor. Options for spot scarification include:

- manual spot scarification with a grub hoe or shovel
- machine spot scarification with a hand-held power scarifier

- machine spot scarification using the teeth on the bucket of an excavator, a brush rake mounted on an excavator, or special heads, such as the Hy-test Tiller or VH Mulcher, mounted on an excavator.

Stock Type

Plant robust stock, such as 415 or 615 styroblock plugs or 2.0 m deciduous whips, into the centre of the screef the spring or summer after site preparation. Shrubs planted as either container grown plugs, cuttings or whips should also be large to provide a competitive advantage over established less desirable vegetation. On fresh to dry sites where competition is reduced, smaller container seedlings in the case of conifers, or cuttings in the case of deciduous species and shrubs may be planted. Where summer drought is not a problem, summer planting may give the seedlings an added advantage in that resources are put into root development prior to the initiation of bud-burst the following year. Bare root stock or plug transplants are not recommended for manually prepared sites because the root mass of the seedlings is unwieldy and difficult to plant through the roots of herbaceous competition. Bareroot stock is also not recommended for sandy or gravely soils where seedlings may experience significant drought the first summer after planting. For more detailed information on seedling stock type selection, consult the *Provincial seedling stock type selection and ordering guidelines* (MOF 1998) on the internet at <http://www.for.gov.bc.ca/hfp/pubs/stocktype/index.htm>.

Animal Control

Riparian areas are heavily used by wildlife and, as a result, browse protection may be required in order to establish seedlings which are palatable to wildlife. Redcedar, true fir, cottonwood and many of the native shrubs are prone to browsing by rodents and ungulates. Vexar tubing of different sizes is available to protect conifers from browsing. Where cottonwood trees are prescribed, plastic vole collars may be required to prevent girdling. In areas of severe browse pressure, small fences or cages may be placed around each seedlings.

Controlling Competing Vegetation

Seedlings introduced into areas already occupied by other trees, shrubs, herbs and grasses will experience severe competition for light and other resources, and will suffer from mechanical effects such as snow press and whipping. For this reason considerable effort must be expended to ensure survival of planted seedlings. Because of proximity to aquatic areas non-chemical approaches are preferred.

Brush Mats

In order to reduce the immediate competition and lengthen the brushing window, a brush mat with minimum dimensions of 90 × 90 cm should be placed over the planted tree. The brush mat will reduce the amount of encroachment from competing vegetation and the amount of sprouting of competing plants with the rooting zone of the seedling. Larger mats have proven to be more effective in high brush hazard areas because they provide a larger area of reduced competition. To prevent light from penetrating the mat, it should be secured using steel pins and stretched tightly over the screefed area. The slit around the seedling should also be pinned to reduce the area of exposed soil and the chance of vegetation developing. Although brush mats will not remove the need for brushing, they will remove the need for brushing until at least the first fall after planting. In subsequent years, brush mats will lengthen the window in which brushing can be conducted by reducing the amount of competition in the rhizosphere and reducing the density of herbaceous cover directly over the seedling.

Manual Brushing

You should plan to assess seedling performance every two months for the first year to monitor the development of competing vegetation. Ensure that vegetation is not encroaching on the seedling, either through the slit in the brush mat, or by overtopping or pressing the seedling. If brush mats are used, the first brushing treatment will be required in the fall to reduce vegetation press over the winter. If brush mats are not used, at least two manual brushing treatments should be planned in the first year – one, in July, to increase the light intensity of planted seedlings and a second, in the fall, to reduce vegetation press. Plan brushing and weeding activities as required for up to three years.

Monitoring the Competition

Conduct a stocking survey at the end of the first growing season to determine fill planting requirements for the following spring. Replant seedlings as required in the first year following planting. In some areas, fall planting in the first growing season may be a viable option if stock is available.

The rigour of the above establishment regime can be reduced, depending on the different combinations of site unit, age and development of competing vegetation. For example, on some mesic sites where stands are less than 20 years old, much less effort will be required to establish conifers.

Increasing Conifer Stocking and Future LWD Provision

In many areas, an important objective of rehabilitating riparian function is to increase conifer stocking to ensure that there are adequate numbers of large conifers to fill present and future LWD requirements. The approach and difficulty of establishing conifers in a given RVT will vary with:

- the biogeoclimatic subzone and site specific characteristics
- the age and composition of the existing stand in the RVT
- the nature of competing vegetation in the RVT.

The selection of conifer species for planting should be based on knowledge of the biogeoclimatic subzone and the site series (see glossary for definition) where planting will occur. Regional FPC ecosystem guides and free growing standards can be used to make these choices (for example, the *Establishment to Free Growing Guidebook*). In general, shade-tolerant conifer species should be selected, especially where seedlings will be planted into competing vegetation, or under existing deciduous or coniferous canopies.

Forest stands in the RRZ will be of various ages and at various levels of crown closure. Because the growing space occupied by trees increases with tree age, competition between established trees in stands at or near crown closure, can be expected to increase with increasing stand age and density. In stands up to five years of age, planted conifers will experience the lowest amounts of above and below ground competition for light, moisture, and nutrients from other trees. In stands between five and 20 years, competition for resources increases accordingly because more of the rooting zone is occupied and canopies close. In stands greater than 20 years of age, trees will occupy substantial areas and it will be difficult to establish seedlings. Consequently, when prescriptions are prepared, the density and age of existing trees will determine the number of seedlings prescribed for fill planting. At a given density, the number of available plantable spots will decrease as stands age because the existing trees occupy a larger proportion of the growing space. If fill planting is prescribed in older stands, high mortality should be anticipated and repeated fill planting should be scheduled in order to achieve stocking targets. If additional growing space is required for seedlings, gaps in overstorey canopies may have to be manually created to provide sufficient site resources for the conifer seedlings.

In addition to competition from established trees, planted conifers will be under competition from shrubs and larger herbs. The degree of impact from competing vegetation generally increases with availability of moisture and nutrients (competition from salal on dry to mesic, nutrient-poor sites in the CWH zone is an important exception to this general rule). Moister and richer sites invariably support rapidly growing brush and weed complexes that will compete aggressively with planted conifers. Such sites are common in RMAs, especially in floodplain areas. However, most of the species in the brush and weed complexes of moist and rich sites are shade-intolerant, so their vigour is usually significantly diminished as stands age, canopies close, and light levels decrease. Mesic and drier sites can be expected to support less vigourous communities that will not compete as strongly with planted conifers.

Increasing Shrub Cover

It may be desirable to increase the cover of shrubs in an RVT because of factors such as poor shrub recovery following timber harvesting; high conifer stocking (especially where dense stands of western hemlock or lodgepole pine have regenerated); livestock damage in range areas; or other vegetation management activities. Shrubs are important for bank stability, surface sediment filtering, provide SOD for streams, wildlife forage, and have been successfully employed for rehabilitation of landslide areas.

In general, shrubs to be planted in an RVT should be compatible with prevailing regional climates of the subzone in which the rehabilitation is being completed (Table A1-1). Many other native shrub species besides those listed in Table A1-1 have potential for planting as well. For example, only *Alnus sinuata* is listed in Table A1-1, but other shrub alder species, such as *A. crispa* or *A. incana*, have equally high potential for regeneration an RVT. *Salix*, *Rosa* and *Rubus* are examples of genera with different species in the different subzones of BC, and many have potential for rehabilitation use. Within subzones, shrubs may have site-specific requirements, and the various regional ecosystem guides can be used to help assess shrub suitability based on the site units comprising the RVT scheduled for treatment.

Table A1-1. Partial list of native shrubs for rehabilitating RMAs. Species listed are those that have been successfully employed for rehabilitation of landslide areas. Source: Beese *et al*. (1994).

Scientific name	Common name
Alnus sinuata	Sitka alder
Cornus stolonifera	red-osier dogwood
Holodiscus discolor	ocean-spray
Philadelphicus lewisii	mock-orange
Physocarpus capitatus	Pacific ninebark
Rosa spp.	roses
Rubus spectabilis	salmonberry
Rubus parviflorus	thimbleberry

Sambucus racemosa	red elderberry
Salix spp.	willows
Spiraea douglasii	hardhack
Symphoricarpos albus	common snowberry

Restoring Lost Surface Sediment Filtering Capacity

As discussed previously, vegetation and forest litter within the RMA protect the soil surface and diffuse the impact of rainwater on the underlying mineral soil. In some cases, tree harvesting or harvesting related activities such as road building or log sorting sites, have exposed mineral soils, and surface erosion is carrying sediment directly into adjacent streams. The objective for rehabilitating areas of exposed mineral soils is to quickly establish cover of surface vegetation to protect the mineral soil. Direct seeding of grass and legume mixtures is the most widely used procedure to rapidly revegetate exposed mineral surfaces. Where possible native species should be used. Techniques developed primarily for revegetation of roadsides are well established in BC, and are described in detail in Beese *et al*. (1994), Berglund (1978), Carr (1980, 1985), and Chatwin *et al*. (1994). Grass and legume mixes are either dry-seeded or hydro-seeded depending on factors such as slope, surface texture and site productivity (Beese *et al*., 1994). Dry seeding can be carried out relatively easily on small areas using a rotary-type ground-based spreader, or on larger areas using a helicopter. Because areas will generally be small, ground-based seeding will be the most appropriate technique for stabilization of mineral soils in an RVT. Usually, after seeding, a rotary spreader is used to fertilize the treatment area. However, fertilization within the RMA may not be desirable if eutrophication is a potential problem.

References

Beese, W.J., T.P. Rollerson and R.N. Green. 1994. Forest site rehabilitation for coastal British Columbia (Interim Methods). B.C. Min. Environ., Lands and Parks, and B.C. Min., Watershed Restor. Progr., Victoria, BC. Watershed Restor. Circ. No. 4.

Berglund, E.R. 1978. Seeding to control erosion along forest roads. Oreg. State Univ. Ext. Serv., Corvallis,OR. Ext. Circ. 885.

Carr, W.W. 1980. Handbook for forest road surface erosion control in British Columbia. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 4.

_____. 1985. Watershed rehabilitation options for disturbed slopes on the Queen Charlotte Islands. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 36.

Chatwin, S.C., D.E. Howes, J.W. Schwab and D.N. Swanston. 1994. A guide for management of landslide-prone terrain in the Pacific Northwest. B.C. Min. For., Victoria, BC. Land Management Handb. No. 18. 2nd ed.

Marchant, C. and J. Sherlock. 1994. A guide to the selection and propagation of some native woody species for land rehabilitation in British Columbia. B.C. Min. For., Victoria, BC. Research Rep. RR84007-HQ.

McLennan, D.S., and K. Klinka. 1990. Black cottonwood – a nurse species for regenerating western redcedar on brushy sites. For. Can. and B.C. Min. For. , Victoria, BC. FRDA Rep. No. 114.

McLennan, D.S. and T. Johnson. 1993. Adaptive management to develop silvicultural alternatives that optimize silvicultural objectives and promote grizzly bear forage values in coastal British Columbia. First year report. B.C. Min. For. and B.C. Min. Environ., Lands and Parks, Victoria, BC. Contract rep.

Appendix 2. Questions for riparian evaluation

The following list of questions can be used to help identify functionality of riparian areas. The questions are adapted from the proper functioning condition (PFC) checklist-style assessment of the U.S. Bureau of Land Management (Prichard et al. 1998a). The PFC method requires a stream hydrologist, soils specialist, fish habitat biologist and riparian vegetation specialist to walk the stream together and make on-site evaluations based on their professional judgment. The results of their checklist exercise are then used to determine the functional rating of the riparian area, whether the area is in:

1. proper functioning condition
2. functional – at risk
3. nonfunctional
4. unknown.

Where the riparian area is determined to be functional – at risk, the trend for function is then indicated, whether function – at risk and

1. trending upwards
2. trending downwards
3. trend not apparent.

To effectively use this method, consult the complete documentation of the PFC method (Prichard et al. 1998) and the supporting scientific references.

Hydrology

1. Is the floodplain above bankfull inundated in relatively frequent events?
2. Are beaver dams present that are active and stable?
3. Are sinuosity, width/depth ratio and gradient in balance with the landscape setting (i.e., landform, geology and bioclimatic region)?
4. Is the riparian wetland area widening or has it achieved potential extent?
5. Is the upland watershed not contributing to riparian-wetland degradation?

Vegetation

6. Is there a diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)?
7. Is there a diverse composition of riparian-wetland vegetation (for maintenance/recovery)?
8. Do the species present indicate maintenance of riparian-wetland soil moisture characteristics?
9. Is the streambank vegetation comprised of those plants or plant communities that have root masses capable of withstanding high steamflow events?
10. Do the riparian-wetland plants exhibit high vigour?
11. Is there adequate riparian-wetland vegetation cover present to protect banks and dissipate energy during high flows?
12. Are the plant communities capable of supplying an adequate source of large woody material-debris (for maintenance/recovery)?

Erosion/Deposition

13. Are the floodplain and channel characteristics (i.e., rocks, overflow channels, large woody debris) adequate to dissipate energy?
14. Are the point bars revegetated with riparian-wetland vegetation?
15. Is lateral stream movement associated with natural sinuosity?
16. Is the system vertically stable?
17. Is the stream in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)?

Appendix 3. Biogeoclimatic ecosystem classification of British Columbia

(Descriptions taken from Biogeoclimatic Zones of British Columbia [colour map], MOF, 1992.)

AT	Alpine Tundra
BG	Bunchgrass
BWBS	Boreal White and Black Spruce
CDF	Coastal Douglas-fir
CWH	Coastal Western Hemlock
ESSF	Engelmann Spruce–Subalpine Fir
ICH	Interior Cedar–Hemlock
IDF	Interior Douglas-fir
MH	Mountain Hemlock
MS	Montane Spruce
PP	Ponderosa Pine
SBPS	Sub-Boreal Pine Spruce
SBS	Sub-Boreal Spruce
SWS	Spruce–Willow–Birch

Alpine Tundra – The alpine tundra, essentially a treeless region characterized by a harsh climate, is found on high mountains throughout the province. The long, cold winters and short, cool growing seasons create conditions too severe for the growth of most woody plants – except in dwarf form. Hence this zone is dominated by dwarf shrubs, herbs, mosses and lichens. This zone has high recreational appeal. It also provides important range for caribou, mountain goats and mountain sheep. Due to the severe climate it is extremely sensitive to use. Disturbed landscapes require decades, or even centuries to recover to their natural states.

Spruce–Willow–Birch – This is a subalpine zone occurring in the severe climate of the north of the province, at elevations above the boreal forest and below the alpine tundra. At lower elevations, the zone is characterized by open forests of primarily white spruce and subalpine fir; upper elevations are dominated by deciduous shrubs including scrub birch and willow. In some high wide valleys, cold air collects resulting in a mosaic of scrub, grassland and wetlands on valley floors below a band of forest on the valley sides. Above, the forest again gives way to shrubs. This zone provides extensive moose, caribou, and in the east, elk habitat.

Boreal White and Black Spruce – This zone is part of the extensive belt of boreal coniferous forest occurring across Canada. It occupies the northern valleys west of the Rocky Mountains and the gently rolling topography of the Great Plains. Winters are long and cold and the growing season short; the ground remains frozen for much of the year. The severe climate results in forests of low productivity. Numerous past fires have created extensive successional forests of aspen and lodgepole pine. Where flat, the landscape is typically a mosaic of black spruce bogs and white spruce and trembling aspen stands. Valuable agricultural land is prevalent in the Peace River area.

Sub-Boreal Pine–Spruce – This zone occurs on the high plateau of the west central interior in the rainshadow of the Coast Mountains. Due to the cold, dry climate the forests are generally of low productivity. The landscape is rolling and dotted with numerous wetlands important for wildlife and hay production. The zone is also characterized by many even-aged lodgepole pine stands, the result of an extensive fire history. A minor amount of white spruce regeneration occurs. Lichens and/or feathermosses usually dominate the understory. Pinegrass and kinnikinnick are also common. The profuse ground lichens in the drier parts of the zone provide valuable winter range for caribou.

Sub-Boreal Spruce – This zone occurs in the central interior of the province primarily on gently rolling plateaus. The zone is intermediate between the interior Douglas-fir forests to the south and the boreal forests to the north. Forest productivity is moderately good, and although the climate is severe, the winters are shorter and the growing season longer than in boreal areas. Hybrid Engelmann-white spruce and subalpine fir are the dominant trees; extensive stands of lodgepole pine occur in the drier portions of the zone due to numerous past fires. Wetlands are abundant, dotting the landscape in poorly drained areas. Moose are common throughout this zone.

Mountain Hemlock – This is a subalpine zone occurring at high elevations along the Pacific coast. The growing season is short and the annual snowfall is high. Trees are absent where the snowpack remains late in the spring, or where the ground freezes under snow. In the upper elevations forests thin out into open parkland, where trees are clumped and interspersed with sedge or mountain-heather communities. At lower elevations the forest is continuous and more productive Mountain hemlock and amabilis fir, important commercial species, are the dominant trees; varying amounts of yellow-cedar also occur. Due to the adverse climate, forest regeneration is often slow.

Engelmann Spruce–Subalpine Fir – This is a subalpine zone occurring at high elevations throughout much of the interior. The climate is severe, with short cool growing seasons and long cold winters. Only those trees capable of tolerating extended periods of frozen ground occur. The landscape at the upper elevations is open parkland, with trees clumped and interspersed with meadow, heath and grassland. Engelmann spruce, subalpine fir and lodgepole pine are the dominant trees. Rhododendron and false azalea are common understory shrubs. Under drier conditions, extensive lodgepole pine and whitebark pine forests are common. In wetter areas where snowfall is more abundant, mountain hemlock occurs.

Montane Spruce – This zone occurs in the south-central interior at middle elevations and is most extensive on plateau areas. The winters are cold and summers moderately short and warm. Engelmann and hybrid spruce and varying amounts of subalpine fir are the characteristic tree species. Due to past wildfires successional forests of lodgepole pine, Douglas-fir and trembling aspen are common. This zone is intermediate between the Engelmann Spruce-Subalpine Fir Zone above and the Interior Douglas-fir Zone at lower elevations. Forestry activities are extensive through most of this zone. In addition the zone provides important summer and fall range for mule deer and cattle.

Bunchgrass – This is a grassland zone confined to the lower elevations of the driest and hottest valleys of the southern interior. It supports critical winter and spring forage for bighorn sheep and white-tailed deer and is the home of the burrowing owl. This zone also provides important spring livestock range and with irrigation has provided some of the province's most valuable agricultural land. Bluebunch wheatgrass is the dominant bunchgrass on undisturbed sites. At the lower elevations big sagebrush is common, particularly on overgrazed areas: Ponderosa pine and Douglas-fir occasionally occur in draws and on coarser textured soils, although the dry climate restricts their growth.

Ponderosa Pine – This is the warmest and driest forest zone. It is confined to a narrow band in the driest and warmest valleys of the southern interior where it often borders the Bunchgrass Zone along its lower or drier limits. As the zone name indicates ponderosa pine is the dominant tree. Its wide-spacing, round crowns, and yellow-orange bark distinguish this zone. Frequent ground fires are important for creating and maintaining these stands. Douglas-fir is common on the colder and moister sites. Where not overgrazed, the understory includes abundant grasses such as bluebunch wheatgrass and rough fescue providing excellent forage.

Interior Douglas-fir – This is the second warmest forest zone of the dry southern interior, occurring in the rain-shadow of the Coast, Selkirk and Purcell mountains. Douglas-fir is the dominant tree. Fires have frequently resulted in even-aged lodgepole pine stands at higher elevations while ponderosa pine is the common seral tree of the lower elevations. Pinegrass and feathermoss dominate the understory. Soopolallie and kinnikinnick are common shrubs. Along its drier limits the zone often becomes savannah-like, supporting bunchgrasses including rough fescue and bluebunch wheatgrass. This zone is important for summer livestock range as well as mule deer and elk habitat.

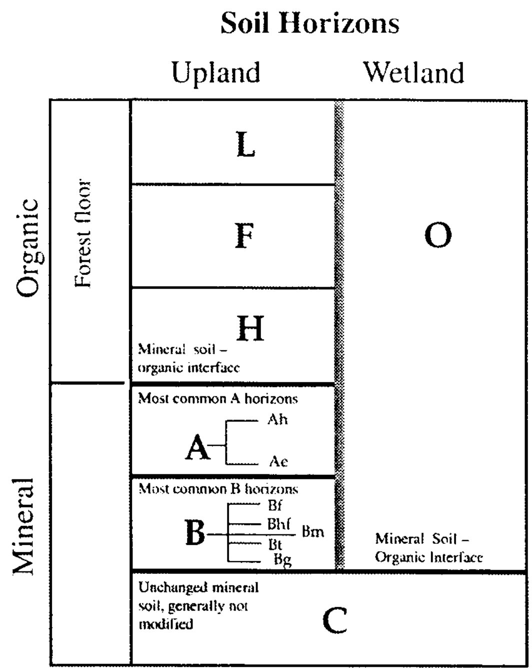
Coastal Douglas-fir – In the lee of the Olympic and Vancouver Island mountains a mild 'Mediterranean' type of climate prevails. These rainshadow coastal forests are dominated by Douglas-fir, with an understory commonly consisting of salal and/or Oregon grape. Western redcedar is typical of wetter sites and Garry oak and arbutus are abundant on drier sites. The latter two trees are characteristic for this zone and occur nowhere else in Canada. The favourable climate also results in some of the province's most productive agriculture land. In addition, blue grouse and black-tailed deer habitats are abundant.

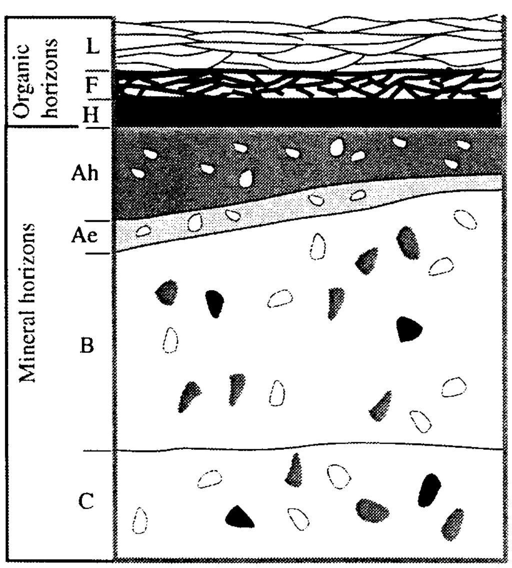
Interior Cedar–Hemlock – This zone occurs at lower to middle elevations in the interior wet belt of the province. Winters are cool and wet, and summers are generally warm and dry. This zone is the most productive in the interior and has the widest variety of coniferous tree species of any zone in the province. Western hemlock and western redcedar are characteristic species but spruce (white-Engelmann hybrids), and subalpine fir are common. Douglas-fir and lodgepole pine are generally found on drier sites. Wet sites are often easily recognized by a dense understory of devil's club and/or skunk cabbage.

Coastal Western Hemlock – The northern latitude rainforests comprising this zone occur at low elevations along the coast. Western hemlock and amabilis fir are the dominant climax trees, although several other species are also common. Abundant rainfall and mild temperatures make these forests the most productive in Canada. In the drier parts of this zone, old-growth Douglas-fir can approach 100 metres in height; on floodplain soils, western redcedar and Sitka spruce can reach up to four metres in diameter. Mature stands of timber within this zone provide important areas for grizzly bears and black-tailed deer, but such stands are dwindling.

Appendix 4. Soil horizon characteristics

(Submitted by V.A. Poulin and Associates Ltd., Vancouver, BC.)





Soil horizons and definitions important in the classification of soils. Not all sub-horizons are shown or defined, see soil classification in regional site guides for keys to identification of soil groups.

Common mineral horizons

Mineral horizons contain 17% or less organic carbon (about 30% organic matter) by weight.

Ae	Light-coloured horizon at or near the surface from which iron, aluminum, organic matter and clay have been removed.
Ah	Dark-coloured horizon at or near the surface that is enriched with organic matter.
Bf	Dark-reddish brown to red horizon enriched with iron and aluminum but little organic matter.
Bg	Horizon with blue-grey colours and/or mottling (rust-coloured patches), indicative of permanent or periodic anaerobic saturation (gleyed).
Bhf	Reddish brown to red horizon enriched with iron, aluminum and organic matter.
Bm	Brownish horizon with only slight additions of iron, aluminum or clay.
Bt	Brownish horizon enriched with clay that has been removed from a horizon above.

Organic horizons

O – This is an organic horizon developed mainly from mosses, rushes, sedges and woody materials under poor drainage conditions. They commonly occur at the surface of mineral soils, but can be buried by other deposits. They may be divided into sub-horizons, (Of, Om, Oh) depending on state of decomposition:

- f – fibric, poorly decomposed
- m – mesic, moderately decomposed
- h – humic, well decomposed

L, F and H – These are organic horizons that developed primarily from the accumulation of leaves, twigs and woody materials with or without a minor component of mosses. Usually they are not saturated with water for prolonged periods.

L	Litter layer consisting of relatively fresh, undecomposed residues of leaves, twigs, wood and dead moss.
F	Layer of partially decomposed organic material; these are discoloured and fragmented, but still largely recognizable.
H	Layer consisting of well-decomposed organic material. The original structure is no longer recognizable.

Humus forms

Mor	Humus form in which the L, F and H horizons are prominent. F horizon matted; fungal mycelia abundant. Smells of mushrooms. Usually an abrupt transition to mineral soil.
Moder	Humus form in which the L, F and H horizons are prominent. F horizon is loose and friable; fungal mycelia less abundant. Common insects and droppings. Rich, potting soil smell. May have thin Ah horizons.
Mull	Humus form in which the Ah is prominent. F, H horizons <2 cm, F horizon very friable. Ah horizon usually granular, with earthworms present.

Appendix 5. Synopsis of silvical characteristics

Species	Distribution along the climatic gradient (in the forested biogeoclimatic zones)										Distribution along the soil moisture gradient						Distribution along the soil nutrient gradient						Shade tolerance						Potential for natural regeneration		Spatial requirements	Special adaptations and indicative values
	MH	ESSF & MS	BWBS	SBS	SBPS	IDF	ICH	PP	CDF	CWH	very dry	dry	fresh	moist	wet	ranking*	very poor	poor	medium	rich	very rich	ranking*	very shade-tolerant	shade-tolerant	moderately shade-tolerant	shade-intolerant	very shade-intolerant	ranking*	in the shade	in the open		
Pacific silver fir	●	○					○			•		○	●	●	○	16	○	•	●	●	○	8	●	•	○			1	H	L	L	heavy snow cover- & flood-tolerant; indicator of maritime, wet (snowy) climates
Grand fir						•	•		•	○		○	●	●	○	16		○	•	●	●	18	○	•	●	●	○	8	L	L	M	fluctuating water table & flood-tolerant; indicator of nutrient-rich sites
Subalpine fir	○	●	•	●	○	○	•			○	○	•	●	●	•	18	○	•	●	●	•	9	○	●	●	•	○	3	H	L	L	frost-, heavy snow cover- & flood-tolerant; at high elevations, vegetative reproduction by layering
Tamarack			•	○									○	•	●	26			○	●	•	16					●	26	L	M	H	frost- & flood-tolerant; indicator of continental boreal, moist to wet & nutrient-rich sites
Subalpine larch		•									○	●	•			4		○	●	•	○	6				○	●	22	L	M	H	frost-tolerant; indicator of continental subalpine boreal climates
Western larch		•				●	•	○			○	●	•	○		5		○	•	●	•	14				○	●	18	L	M	H	frost-tolerant; deep & wide-spreading root system; indicator of continental temperate climates
Engelmann spruce	○	●		•	○	○	•			○	○	•	●	●	○	18		•	●	●	•	12		○	•	●	•	12	L-M	M	M	frost-, heavy snow cover- & flood-tolerant
White spruce		○	●	●	•	○	○			○		•	●	●	○	15		○	•	●	●	18		○	•	●	•	11	L-M	M	H	frost- & flood-tolerant; indicator of continental boreal climates
Black spruce			●	•	○		○					○	•	●	●	23	●	●	•	○		2	○	•	●	○		6	M	L	L	persistent & semi-serotinous cones; vegetative reproduction by layering; frost-tolerant; indicator of continental boreal climates & nutrient-poor sites
Sitka spruce	○								○	•		○	•	●	•	21			○	•	●	25			○	●	•	14	L	H	H	frost & snow-intolerant; ocean spray-, brackish water- & flood-tolerant; indicator of wet mesothermal climates
Whitebark pine	○	•									•	●	•	○		5		•	●	•		7				○	●	18	L	L	H	regeneration largely from seed caches of Clark's nutcracker; frost-tolerant indicator of subalpine boreal climates
Jack pine			○								•	●	○			3	●	●	•			1				○	●	22	L	L	H	serotinous cones; frost-tolerant; indicator of continental boreal climates and dry & nutrient-poor sites
Lodgepole pine	○	●	●	●	●	●	•		○	•	•	●	•	○	○	7	●	●	●	○		3			○	•	●	17	L	L-H	L-M	serotinous cones; frost-tolerant
Limber pine		○				○					●	•	○			2			•	●		15				○	●	18	L	L	H	regeneration largely from seed caches of Clark's nutcracker; frost-tolerant; calciphytic; indicator of continental subalpine boreal climates
Western white pine	○	○				○	•		○	•		○	●	•	○	12		○	•	●	●	18	○	•	●	●	•	9	L-M	L-M	M-H	flood-tolerant
Ponderosa pine		○				•	○	●			●	●	•	○		1		○	•	●	●	18			○	●	•	15	L	L	H	moderately frost- & flood-tolerant; calciphytic; indicator of dry sites
Douglas-fir	○	•		•	○	●	•	○	●	•	○	●	●	•		8	○	•	●	●	•	9	○	•	●	●	•	10	L-M	M-H	M	flood- & heavy snow cover-intolerant
Western hemlock	○	○				○	●		○	●		○	●	•	○	10	●	●	●	○		3	•	●	•			2	H	H	L	indicator of acid substrates
Mountain hemlock	●	○		○			○			○		○	●	•	○	10	●	●	●	○		3	○	•	●	○		4	M	M	M	heavy snow cover-tolerant; indicator of acid substrates
Alaska yellow-cedar	●	○								•		○	•	●	●	23	○	•	●	●	•	9	○	•	●	○		6	L-M	M	L	frost-intolerant, heavy snow cover-tolerant; indicator of maritime wet (snowy) climates
Western redcedar	○	○		○		•	●		•	●	○	•	●	●	•	18	○	•	•	●	●	17	○	•	●	○		4	M	M-H	L	flood-tolerant
Balsam poplar & black cottonwood	○	○	•	•	•	○	•	○	•	○		○	•	●	○	25			○	•	●	18				○	●	22	L	H	H	vegetative reproduction from root & stump sprouts; frost- & flood-tolerant; indicator of fresh to moist & nutrient-rich (alluvial) sites
Trembling aspen		•	●	●	•	•	•	○	○	○	○	•	●	●	○	13		○	•	●	●	18			○	•	●	16	L	H	H	vegetative reproduction from root suckers & sprouts & stump sprouts
Red alder									•	●	○	•	●	●	●	22		○	•	●	●	18				○	●	18	L	H	H	in symbiosis with N-fixing *Actinomyces alni*; vegetative reproduction from stump sprouts; frost- & snow-intolerant, flood-tolerant; indicator of mesothermal climates
Bigleaf maple						○			●	•		○	•	●	○	14			○	•	●	25			○	●	•	13	L	H	H	vegetative reproduction from stump sprouts; frost-intolerant, flood-tolerant; indicator of maritime climates & nutrient-rich sites
Paper birch		○	•	•	○	•	•	○	○	○	○	•	●	•	○	9		○	●	●	•	13				○	●	22	L	H	H	vegetative reproduction from stump sprouts; frost- & flood-tolerant

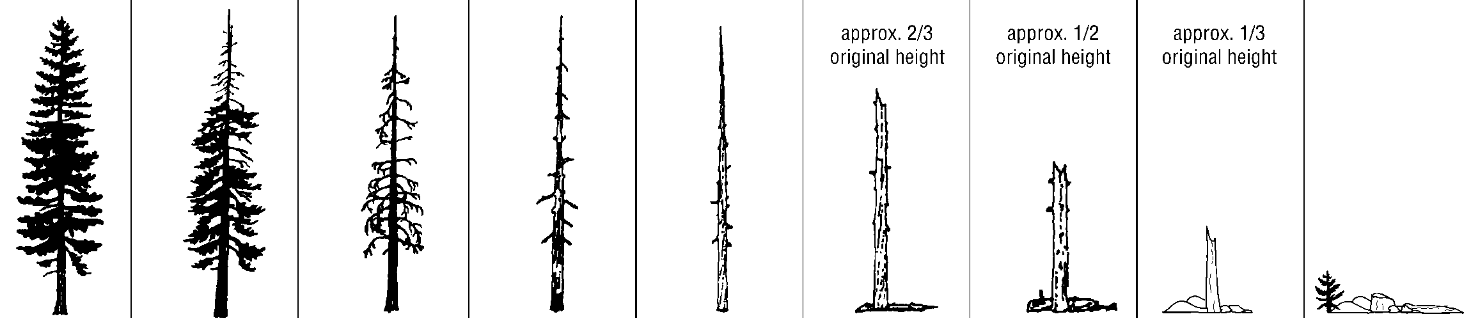
● very frequent • frequent ○ less frequent ☐ absent

L low
M medium
H high

* Approximate comparative ranking of the species along the gradients (+2 or 3 of the 26 species listed); i.e., 1 – driest soils, nutrient-poorest soils, or most shade-tolerant to 26 – wettest soils, nutrient-richest soils, or most shade-intolerant.

Klinka, K. et al. 1990. Ecological principles: applications. *In* Regenerating British Columbia's forests. D.P. Lavender, et al. (eds.) Univ. BC Press, Vancouver, BC. p. 66.

Appendix 6. Wildlife tree characteristics

	LIVE		DEAD					DEAD FALLEN	
			Hard			Spongy	Soft		
Decay class	1	2	3	4	5	6	7	8	9
						approx. 2/3 original height	approx. 1/2 original height	approx. 1/3 original height	
Description	**Live/healthy;** no decay; tree has valuable habitat characteristics such as large, clustered or gnarled branches or horizontal, thickly moss-covered branches.*	**Live/unhealthy**; internal decay or growth deformities (including insect damage, broken tops); dying tree.*	**Dead**; needles and twigs present; roots healthy.	**Dead**; no needles/twigs; 50% of branches lost; loose bark; top usually broken; roots stable.	**Dead**; most branches/bark absent; some internal decay; roots of larger trees stable.	**Dead**; no branches or bark; sapwood/heartwood sloughing from upper bole; decay more advanced; lateral roots of larger ones softening; smaller ones unstable.	**Dead**; extensive internal decay; outer shell may be hard; lateral roots completely decomposed; hollow or nearly hollow shells.		**Debris**; downed trees or stumps.
Uses and users	Nesting (e.g., bald eagle, great blue heron colonies, marbled murrelet); feeding; roosting; perching.	Nesting/roosting[1] —strong PCEs[2] (woodpeckers); SCUs[3]; large-limb and platform nests (ospreys); insect feeders.	Nesting/roosting—strong PCEs; SCUs; bats.	Nesting/roosting—PCEs; SCUs; insect feeders.	Nesting/roosting—weak PCEs (nuthatches, chickadees); SCUs; bats; insect feeders.	Weaker PCEs; SCUs; insect feeders; salamanders; small mammals; hunting perches.	Insect feeders; salamanders; small mammals; hunting perches; occasionally used by weak cavity excavators such as chickadees.		Insect feeders; salamanders; small mammals; drumming logs for grouse; flicker foraging, nutrient source.
Decay value	2	1	1	1	1	2	3		

[1] Large witches' brooms provide nesting/denning habitat for some species (e.g., fisher, squirrels). [2] PCE = primary cavity excavator [3] SCU = secondary cavity user

* This classification system does not recognize root disease trees specifically. Such trees become unstable at or before death.

Source: Guy, S. 1997. Wildlife/Danger Tree Assessor's Course Workbook. B.C. Min. Environ., Lands and Parks, B.C. Min. For., and Worker's Compensation Board, Victoria, B.C.

Appendix 7. WRP riparian assessment forms (blanks and examples)

Form 1. Riparian Overview Assessment

Form 1. Riparian Overview Assessment

Watershed name: ____________________ NTS map: ____________________

Watershed code: ____________________ Air photo series/scale: ____________________

Reach no.[1]	Polygon no.	Stand structure	Tentative RVT no.	Stream class	Harvesting/Restocking history	Other disturbances	Priority for Level 1

[1]Recommended if conducting riparian assessment concurrently with channel or fish habitat assessment.

Form 1. Riparian Overview Assessment – example

Form 1. Riparian Overview Assessment

Watershed name: Squamish River
NTS map: 92G14
Watershed code: 900-0976-000-000
Air photo series/scale: 30BCC94116 No. 65-66

Reach no.[1]	Polygon no.	Stand structure	Tentative RVT no.	Stream class	Harvesting/Restocking history	Other disturbances	Priority for Level 1
1	1	PSd	1	S1	logged 1968	possible flooding	Yes
1	2	MFm	4	S1	logged 1898		Yes
1	3	PSd/Dr	3	S1	logged 1975	possible flooding	Yes
1	4	YFd	2	S1	logged 1958	possible flooding	Yes
1	5	PSd/Dr	3	S1	logged 1975	possible flooding	
1	6	MFm	4	S1	logged 1898		
1	7	YFm	5	S1	logged 1938	possible flooding	Yes
1	8	PSd/Dr	3	S1	logged 1975	possible flooding	
1	9	YFd	2	S1	logged 1958	possible flooding	

[1] Recommended if conducting riparian assessment concurrently with channel or fish habitat assessment.

Form 2. Riparian Assessment Field Form (p1)

POLYGON #:	1. PRELIMINARY INFORMATION				
PLOT #:	SSt:	CREEK NAME:		REACH #:	
LOCATION:		CREEK ASPECT:		BEC ZONE:	
AIR PHOTO:		RVT SLOPE: %		STREAM GRADIENT: %	
MAP #:	UTM:	PLOT RADIUS/MULT: 3.99 m/200x 11.28 m/25x			
Wb: m	CODE STREAM CLASS:	RRZ: m	RMZ: m	RMA: m	
DATE:	TIME:	CREW:	YR OF HARVEST/REPLANT:		

2. OVERSTOREY										
LAYER	**TREE SPECIES STEM TALLY**						**TOTAL SPH**		**DOM. SPECIES**	
(DBH)							**Conif.**	**Decid.**	**HGT (m)**	**DBH (cm)**
1a >22 cm										
1b 12.6 21.9 cm										
2 7.5 12.5 cm										
3 0.1 7.4 cm										
4 <1.3 m Height										

COMMENTS:

Form 2. Riparian Assessment Field Form (p2)

3. UNDERSTOREY				**MEAN HEIGHT OF DOMINANT LAYER:** m					
LAYER	**% C**	**SPECIES**	**HGT**	**% C**	**SPECIES**	**HGT**	**% C**	**SPECIES**	**HGT**
TALL SHRUB (>2 m)									
SHORT SHRUB									
HERB									
MOSS									

4. PLOT SUMMARY	TOTAL % C	TOTAL SPH
OVERSTOREY (1a, 1b)		
UNDERSTOREY		X

5. SNAGS (>5 m height)		
TOTAL/PLOT	DBH RANGE	
SPECIES	% LWD	TTL/ha

6. DISTURBANCE INDICATORS							
	Y	N	C		Y	N	C
Beaver activity				Flooding			
Blow down				Fire			
Surface erosion				Slide			
Slope failure				Road			
Bridge/Culvert				Grazing			
Insects/Disease				Other			

7. SOIL HORIZONS			
HORIZON	DEPTH	TEXTURE	%CF
HORIZON	DEPTH	TEXTURE	%CF
HORIZON	DEPTH	TEXTURE	%CF

8. LEVEL OF FUNCTIONING		
LWD:	(L,M,H)	
SHADE:	(L,M,H)	
SOD:	(L,M,H)	
SURF. SED. FILTER	(L,M,H)	
CHANNEL STAB:	(L,M,H)	
BANK STAB:	(L,M,H)	

9. PHOTOS:	Roll:	Frame #s:

COMMENTS:

Form 2. Riparian Assessment Field Form (p1) – example

POLYGON #: 1	**1. PRELIMINARY INFORMATION**				
PLOT #: 1	SSt: PS	CREEK NAME: Squamish River		REACH #: 1	
LOCATION: Squamish R. 18 M. marker		CREEK ASPECT: South		BEC ZONE: CWHdm	
AIR PHOTO: 30BCC94116 NO 066		RVT SLOPE: 0-2 %		STREAM GRADIENT: 1 %	
MAP #: 92G14	UTM:	PLOT RADIUS/MULT: 3.99m/200x 11.28m/25x			
Wb: 100 m	CODE STREAM CLASS: S1		RRZ: 50 m	RMZ: 20 m	RMA: 70 m
DATE: 2/11/98	TIME: 10:00:00	CREW: VP,BS	YR OF HARVEST/REPLANT: 1968 (harvest)		

2. OVERSTOREY

LAYER	TREE SPECIES STEM TALLY						TOTAL SPH		DOM. SPECIES	
(DBH)	Act	Dr	Cw				Conif.	Decid.	HGT (m)	DBH (cm)
1a >22 cm	7	6					0	325	Ac-30	38
1b 12.6 - 21.9 cm	2	8	2				50	250	Dr-25	20
2 7.5 - 12.5 cm			0				0	0		
3 0.1 - 7.4 cm			13				325	0	Cw-7.4	4.8
4 < 1.3m Height			5				125	0	Cw-1.0	<.1

COMMENTS:

Conifers clumpy, plot overestimates number of Cw for overall site.

Form 2. Riparian Assessment Field Form (p2) – example

3. UNDERSTOREY — MEAN HEIGHT OF DOMINANT LAYER: 2.3 m

LAYER	% C	SPECIES	HGT	% C	SPECIES	HGT	% C	SPECIES	HGT
TALL SHRUB (>2m)	40	Salmonberry	2.3m	30	Dogwood	4.5m	20	Elderberry	3.8m
SHORT SHRUB	0								
HERB	1	Equisetum	1.0m						
MOSS									

4. PLOT SUMMARY	TOTAL % C	TOTAL SPH
OVERSTOREY (1a, 1b)	50	625
UNDERSTOREY	90	

5. SNAGS (> 5 m height)

TOTAL/PLOT	2	DBH RANGE	19-25cm
SPECIES	Alder	%LWD 0	TTL/ha 50

6. DISTURBANCE INDICATORS

	Y	N	C		Y	N	C
Beaver Activity				Flooding	X		1
Blow Down				Fire			
Surface Erosion				Slide			
Slope Failure				Road			
Bridge/Culvert				Grazing			
Insects/Disease				Other			

7. SOIL HORIZONS

HORIZON	DEPTH	TEXTURE	%CF
H	1 cm		<30
Ae	2 cm	silt	<30
Ah	2 cm	silt	<30

8. LEVEL OF FUNCTIONING

LWD:	(L,M,H)	L
SHADE:	(L,M,H)	H
SOD:	(L,M,H)	M
SURF. SED. FILTER	(L,M,H)	M
CHANNEL STAB:	(L,M,H)	L
BANK STAB:	(L,M,H)	L

9. PHOTOS: Roll: 1 Frame #'s: 3,4

COMMENTS: C1. site situated on large bar within the Squamish River floodplain.

Age of trees suggest frequent flooding. 1.5 m sand deposit on top of river gravel. Low to nil soil development

Recommend Level 2 assessment.

Form 3. Riparian Level 1 Assessment Summary

Form 3. Riparian Level 1 Assessment Summary

Watershed name: ______________________

Watershed code: ______________________

NOTES:

Rch No.[1]	Polygon No.	Polygon (ha)	RVT No.	RVT label	Level of functioning[2]: LWD/CWD	Sream shading	SOD	Surf. sed. filter	Chan. stability	Bank stability	Summation	Disturbance indicators	Recommendations	Priority[3] (H,M,L)

Total ______ (ha)

Area (ha) by restoration priority for Level 2 High Priority: ______

Medium Priority: ______

Low Priority: ______

[1] Recommended if conducting riparian assessment concurrently with channel or fish habitat assessment.

[2] For level of functioning, assign a number for each category (e.g., low - 1, medium - 3, high - 5, or use L,M,H).

[3] Priority for Level 2 Assessment and Prescription phase.

Form 3. Riparian Level 1 Assessment Summary – example

Form 3. Riparian Level 1 Assessment Summary

Watershed name: Squamish River

Watershed code: 900-0976-000-000

NOTES:

Rch No.[1]	Polygon No.	Polygon (ha)	RVT No.	RVT label	Level of functioning[2]: LWD/CWD	Sream shading	SOD	Surf. sed. filter	Chan. stability	Bank stability	Summation	Disturbance Indicators	Recommendations	Priority[3] (H,M,L)
N/A	1	14.4	1	PSd/AcDr/Cw(Ss)	1	5	3	3	1	1	14	occasional flooding, logged 1968	consider for Level 2	H
"	2	7.2	4	MFm/CwMb(Ss)	3	5	5	5	5	5	28	occasional flooding,logged 1898	functioning well, not priority	L
"	3	2.9	3	PSd/Dr	1	5	3	1	1	1	12	frequent flooding, logged 1975	flooding frequent, leave as is	L
"	4	1.4	2	YFd/DrMb(Ac)	1	5	3	3	1	1	14	logged 1958	consider for Level 2	H
"	5	1.4	3	not assessed in field										
"	6	72.3	4	not assessed in field										
"	7	4.3	5	YF/MbAc(Cw)/Mb	1	5	5	3	3	3	20	occasional flooding, logged 1938	consider for Level 2	H
"	8	2.9	3	not assessed in field										
Total		107	(ha)											

Area (ha) by restoration priority for Level 2	
High Priority	20.1
Medium Priority:	
Low Priority:	10.1

[1] Recommended if conducting riparian assessment concurrently with channel or fish habitat assessment.

[2] For level of functioning, assign a number for each category (e.g., low - 1, medium - 3, high - 5, or use L,M,H).

[3] Priority for Level 2 Assessment and Prescription phase.