

Protocol for Evaluating the Condition of Streams and Riparian Management Areas (Riparian Management Routine Effectiveness Evaluation)

For the most current version of this document, please consult the
FREP web site [Indicators-Riparian-Protocol-May2007.pdf](http://www.for.gov.bc.ca/hfp/frep/Indicators-Riparian-Protocol-May2007.pdf)

For other FREP information, please go to
<http://www.for.gov.bc.ca/hfp/frep/>

Version 3.0

April 29, 2007

Citation:

Tripp D.B., P.J. Tschaplinski, S.A. Bird and D.L. Hogan. 2007. Protocol for Evaluating the Condition of Streams and Riparian Management Areas (Riparian Management Routine Effectiveness Evaluation). Forest and Range Evaluation Program, B.C. Min. For. Range and B.C. Min. Env., Victoria, BC.

Prepared by
Derek Tripp
Peter Tschaplinski, PhD
Daniel Hogan
Stephen Bird
B.C. Ministry of Forests and Range

Copies of this report may be obtained, depending on supply, from:
Government Publications
PO Box 9452, Stn Prov Gov't
Victoria BC V8W 9V7

In Victoria (250) 387-6409
Outside Victoria 1-800-663-6105

<http://www.publications.gov.bc.ca>

For more information on Forest Practices Branch publications, visit our web site at:
<http://www.for.gov.bc.ca/hfp/pubs.htm>

© 2007 Province of British Columbia

When using information from this or any FREP publication, please cite fully and correctly.

Acknowledgements

The Forest and Range Evaluation Working Group (FREWG) would like to thank the following people for their significant contribution to the development of the routine-level riparian-fish indicators and protocol: Derek Tripp, Peter Tschaplinski, Stephen Bird, and Daniel Hogan. Erland McIsaac, John Richardson, Steve Chatwin, Richard Thompson, and Andrew Witt also made important contributions to the indicator development process.

We are grateful to the following participants for field-testing the draft riparian evaluation methodologies: Forest Practices Board (Kevin Edquist, Chris Oman, Al Peatt, Kerri Brownie), CanFor (Doug Regeir, Warren Hansen) and resource technicians (Michael Tripp, Bob King). Our special thanks to the district staff who participated in the pilot testing of the riparian-fish monitoring indicators and provided their suggestions for improvements: Campbell River (John Ingram, Darcy Yule, David Kayorie, Jim Simpson, Paula MacKay and Scott Dunn), Chilliwack (Lucy Stad and Len Leroux), Chilcotin (Lee-Ann Poisson and Shane Schofield), Rocky Mountain (Paul Chalifour and Jodie Kalkula), Prince George (Jeff Burrows, Fred Berekoff and Perry Grilz), Kalum (Kevin Kilpatrick and Lisa Hanna), and Vanderhoof (John DeGagne, Kathleen Hebb). Our sincere apologies if we have left anyone out.

Production guidance and editorial assistance was provided by Dean McGeough (Integra Forest Consulting Ltd). Thanks to Doug Fraser for providing a list of increaser-disturbance species. The final layout and design of this handbook was provided by TM NewMedia Inc., Victoria, BC.

FREP Abstract

The Forest and Range Practices Act (FRPA) introduces the transition to a results-based forest practices framework in British Columbia. Under this new approach to forest management, the forest industry is responsible for developing results and strategies, or using specified defaults, for the sustainable management of the 11 resource values (subject areas) identified under FRPA. The role of government is to ensure compliance with approved results and strategies, and other practice requirements, and evaluate the effectiveness of forest and range practices in achieving government's objectives for FRPA's resource values.

Resource stewardship monitoring (RSM) is a key component of the provincial Forest and Range Evaluation Program (FREP).

Resource stewardship monitoring will help identify implementation issues regarding forest policies, practices, legislation, and Forest Stewardship Plan results and strategies. As a result, RSM will be a fundamental component for implementing continuous improvement of forest management in British Columbia.

FREP has been established as a multi-agency program to evaluate whether practices under FRPA are meeting not only the intent of the current FRPA objectives, but to determine whether the practices and the legislation itself are meeting government's broader intent for the sustainable use of resources.

FREP is a long-term commitment designed to:

- assess the effectiveness of FRPA and its regulations in achieving stewardship objectives
- determine if forest and range policies and practices are achieving government's objectives, with a priority on environmental parameters, and consideration for social and economic parameters, where appropriate
- identify issues regarding the implementation of forest policies, practices and legislation as they affect achieving stewardship objectives
- implement continuous improvement of forest management in British Columbia.

In order to accomplish these objectives, FREP will:

- develop specific monitoring and evaluation questions to be addressed
- document the status and/or trends of resource values over time through the use of detailed protocols
- identify causal factors where the status or trend is found to be undesirable
- determine whether resource values are being managed in a sustainable manner through proven or alternative forest practices
- communicate the results of evaluations
- recommend changes to forest and range policies and legislation, where required.

Foreword

This handbook is for anyone with a basic working knowledge of streams and/or riparian habitats, including forest and range planners, developers, and other land users. It is not essential that a person have expert knowledge on any aspect of the subject. In fact, generalists are apt to be more consistent in their assessments because they are less likely to interpret the questions and their indicators, or get overly involved in detailed measurements at the expense of other indicators.

This handbook and the associated checklist are like having a professional or expert on stream-riparian interactions and land-use impacts in your back pocket. The checklist guides the user to a conclusion on the relative health of a stream and its riparian habitat in a timely fashion. Field experience indicates that, with a little practice, riparian assessments can be completed in 1–2 hours.

Even experts can benefit from using the riparian checklist because it covers almost all the basic information required to support "expert opinions," which can be difficult to defend without data. The checklist encourages observation with a repeatable methodology that can be used to support the results of a field review. The methodology has been field tested by people with varied backgrounds and levels of experience, and found to be a consistent method of assessing the health of streams in BC. Perhaps more importantly, the conclusions drawn from the checklist make sense and ring true because they can usually be clearly linked to specific indicators that can be consistently observed or measured.

Table of Contents

Acknowledgements	iii
FREP Abstract.....	iii
Foreword	iv
Document Purpose	1
Goal of Riparian and Stream Channel Monitoring	1
Objectives of the Evaluation Process: Why Assess Effectiveness?.....	1
Principles of Site Selection.....	1
Site Selection Criteria for Riparian-Fish.....	2
Indicators.....	4
Introduction	5
What is Properly Functioning Condition?	5
How is Functioning Condition Assessed?	5
All 15 “Main” Questions	7
Concluding on Functioning Condition	7
How to Assess Properly Functioning Condition	8
Selecting Eligible Reaches	8
Stream and Reach Verification in the Field	9
When to do Riparian Evaluations	11
How Long Should the Reach Be?.....	11
How Wide Should the Riparian Area Be?	12
How Many Questions Need to Be Answered?	12
Are All Questions Applicable in All Cases?	12
What If You Can’t See All of the Reach?	14
What is Stream Channel Morphology (Questions 1 to 4)?.....	15
Getting Started.....	18
Basic Components of Routine Riparian Evaluations	19
Describing the Reach	19
Stream/Opening Identification	19
Riparian Retention Information.....	19
Photo Section.....	20
Collecting the Field Data.....	20
Recording the Field Data	21
Point Indicators.....	21
Continuous Indicators.....	22
Other Indicators.....	25
Minimum Data Requirements	26

FREP

FOREST AND RANGE EVALUATION PROGRAM

Protocol for Evaluating the Condition of Streams and Riparian Management Areas

Answering the Questions	27
The Summary Page	27
Specific Impacts for All No Answers Combined	28
Final Comments.....	28
The Routine Riparian Evaluation Questions	28
Question 1. Is the channel bed undisturbed?	28
Question 2. Are the channel banks intact?	30
Question 3. Are channel LWD processes intact?	33
Question 4. Is the channel morphology intact?	34
Question 5. Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments?.....	36
Question 6. Does the stream support a good diversity of fish cover attributes?.....	37
Question 7. Does the amount of moss present on the substrates indicate a stable and productive system?.....	38
Question 8. Has the introduction of fine inorganic sediments been minimized? ...	41
Question 9. Does the stream support a diversity of aquatic invertebrates?	42
Question 10. Has the vegetation retained in the RMA been sufficiently protected from windthrow?.....	45
Question 11. Has the amount of bare erodible ground or soil disturbance in the riparian area been minimized?.....	46
Question 12. Has sufficient vegetation been retained to maintain an adequate root network or LWD supply?	50
Question 13. Has sufficient vegetation been retained to provide shade and reduce bank microclimate change?.....	51
Question 14. Have the number of disturbance-increaser species or noxious weeds present been limited to a satisfactory level?	53
Question 15. Is the riparian vegetation within the first 10 m from the edge of the stream generally characteristic of other healthy, unmanaged plant communities in the area?	56
Help	59
Glossary	59
References.....	60
Appendix 1. Sample REE field assessment completed forms.....	61
Appendix 2. Field guide to freshwater invertebrates	68

List of Figures

1. The three channel morphologies for small and intermediate-sized alluvial type stream channels, and effects of channel width and channel slope on these morphologies ...	16
2. Types of channel bars	30
3. A cross-sectional view of a small stream showing a stable vegetated overhanging bank on the right	32
4. A cross-sectional view of a small stream with an unstable, overhanging bank on the right side.....	33
5. This is a plan-view sketch of two pool-riffle/cascade sequences in a stream	35
6. To see if you have a “deep” pool, measure pool depth from the deepest part of the pool to the top of the bank	35
7. Comparison charts for visual estimation of foliage cover	40
8. Comparison charts for visual estimates of plant density/distribution.....	40
9. Examples of common benthic invertebrates.....	44
10. A hydrological connection diagram showing where erodible soils are hydrologically connected to a non-gully type stream reach	47
11. Determining the influence of LWD on channel morphology.....	50
12. Comparative browse forms for estimating levels of browse impacts within riparian areas	57

List of Tables

1. Stream channel morphology – general characteristics for small to medium-size streams.....	17
2. Sediment size classes	36
3. Estimating total bare erodible ground.....	49
4. Disturbance-increaser species list	53
5. Common noxious weeds within all regions of BC.....	54
6. Common noxious weeds within the boundaries of the corresponding regional districts.....	55
7. Average stubble heights for riparian species	58
8. Average stubble heights for upland species.....	58

Document Purpose

The following protocol was created to provide background information and instructions for data collection for riparian-fish RSM of the BC Ministry of Forests and Range Resource Evaluation Program.

Goal of Riparian and Stream Channel Monitoring

The goal of monitoring the condition of stream channels and their adjacent riparian management areas is to determine whether FRPA standards and practices governed by regulation are achieving the desired result of protecting fish values by maintaining channel and riparian functions.

“Are riparian forestry and range practices effective in maintaining the structural integrity and functions of stream ecosystems and other aquatic resource features over both short and long terms?”

Objectives of the Evaluation Process: Why Assess Effectiveness?

The routine riparian evaluation arose out of a need to assess the effectiveness of riparian management practices, rather than compliance with a highly prescriptive set of rules. Prior to FRPA, there was an implicit assumption that compliance with legislation and regulations would lead to improved riparian management. Only rarely, however, was this assumption ever tested.

In 2000, the Forest Practices Board of British Columbia conducted a special investigation on the impacts of coastal logging on streams five years after implementation of the Forest Practices Code. The results showed marked improvements over the level of impacts in most streams prior to the Code (Tripp 1992, 1995); however, some streams were still being impacted. That study assessed relatively few attributes of streams, and even fewer attributes of the riparian area. The properly functioning condition of the streams and their riparian habitats as a whole was not assessed.

Principles of Site Selection

A number of statistical design principles were used to develop site selection protocols for RSM. These principles ensure that the data collected and analyzed can be used at multiple scales (district, region, and province) with statistical validity and credibility.

The sampling population is the entire population of potential sites that could be sampled for a given resource value. In this case, sites are the same as cutblocks since the current focus of the assessments is on logging. To ensure the results are objective and defensible, all sites (i.e., cutblocks) sampled under RSM will be selected using random sampling.

The number of sites sampled can vary depending on available resources, variability across the population, or the anticipation of problem sites. Annually, the number of sites sampled per forest district is set at 15, although a district may choose to sample more sites.

For additional information on the site selection process, refer to *Protocol for 2006 Resource Stewardship Monitoring* at http://www.for.gov.bc.ca/hfp/frep/7_rsm.html.

Site Selection Criteria for Riparian-Fish

For riparian-fish, each participating district will be provided with a population list of 200 sites (cutblocks) randomly generated from the Forest Tenure Administration (FTA). The list is located on the Forest Practices Branch FTP server at ftp://hfp/mof_internal/publish/resourcestewardshipmonitoring.

From the list of 200 blocks, each district will begin at the top of the list and select 15 sample blocks, working down in sequential order. Site selection criteria for riparian-fish values include:

- cutblocks limited to those harvested under the Forest Practices Code based on silviculture prescriptions (SPs) approved after June 15, 1997 to ensure that SPs were prepared and forest practices were conducted under full knowledge of Code regulations and the principles and objectives of riparian management guidelines.
- cutblocks limited to those harvested at least two years ago to ensure all streams were exposed to at least two years of post-harvest environmental conditions (e.g., storms).

Sites for the riparian-fish population are actually defined as all individual stream reaches within or adjacent to the sampled cutblocks. It is assumed that all individual streams are statistically 'independent' even if they occur together within one cutblock and/or watershed. Thus, cutblocks will be ignored in the data analysis. Adjacent streams or stream reaches are defined as any stream reach that lies within two riparian management area (RMA) widths of the block boundary for a minimum stream length equal to 30 channel widths. Adjacent streams are included in the population because it is rare for large streams (RMA classes S1–S3, S5) to flow through cutblocks. Most such streams are left out of cutblocks. Assume for planning purposes that streams adjacent to a block have the following channel widths:

- S1 – 20 m
- S2 – 5 m
- S3, S4 – 1.5 m
- S5 – 3 m
- S6 – 1.5 m.

Ideally all stream reaches within or adjacent to the randomly selected blocks will be sampled. However, if all of the stream reaches on a cutblock cannot be sampled due to their great number, they need to be sub-sampled. Try to sample one of each stream class, starting with the highest stream class (e.g., an S1 reach) and proceeding down to the lowest (e.g., S6 stream reaches). For non-fish bearing reaches, further sub-sample the reaches by selecting reaches closest to fish streams. If there are still more reaches that can be sampled, select the number of these reaches using random numbers to select the streams.

Example:

A cutblock lies adjacent to an S2 stream and has, within the boundaries, one S4 stream and four S6 streams that flow directly into a fish stream. Each stream forms a homogeneous reach. There is only time available to sample three streams. Following the above protocol for reach selection in cutblocks, one would sample the S2 stream, the S4 stream, and one S6 stream. The S6 stream would be selected using some simple random method (e.g., dice).

In the above example, if there were only time to sample one stream, the S2 stream would be sampled. If there were time for two stream reaches, the S2 and the S4 would be sampled.

If a district completes sampling the first eligible 15 blocks from the list and wishes to collect additional data, the next blocks should continue to be selected sequentially from the random list.

Blocks should only be removed from the list for very specific reasons, which must be recorded. If a block clearly does not belong to the population, for example because there are no streams within or adjacent to the block, it can be deleted. Questions regarding whether a block is in or out of the defined population should be referred to the Resource Value Team (RVT). One reason a block may be deleted from the population is if active nearby harvesting or other activities in the block make it too dangerous to sample. If there are other reasons for considering deleting a site, discuss these with the RVT.

The goal is to sample 15 streams in each forest district from at least 15 different cutblocks. It may be that more than one stream can be sampled in some cutblocks. If this is the case, then 15 of the streams should come from at least 10 different cutblocks. There is no upper limit on the number of streams that can be sampled, nor the number of cutblocks.

Indicators

The following 15 indicators correspond to the 15 main questions used to assess riparian, stream channel, and fish habitat health in this protocol:

- channel bed disturbance
- channel bank disturbance
- large woody debris (LWD) processes (jams)
- channel morphology
- aquatic connectivity
- fish cover diversity
- moss abundance and condition
- fine sediments
- aquatic invertebrate diversity
- windthrow frequency
- riparian soil disturbance
- LWD supply
- shade and bank microclimate
- disturbance-increaser plants
- vegetation vigour, form, and structure.

Introduction

What is Properly Functioning Condition?

As a measure of overall riparian health, properly functioning condition is a concept that has not been used much in forest harvest planning in BC, but is a widely accepted concept in range planning. The *Riparian Management Area Guidebook* (Province of B.C. 1995) states that riparian habitats will be maintained in properly functioning condition if the impacts of development on the attributes of the riparian area are:

1. on average, small or within the range of natural variability of the habitat; or
2. large and beyond the range of natural variability in no more than a small portion of the habitat.

The key underlying assumption is that if the range of impacts attributable to the management activity affecting the riparian habitat lies “within the range of natural variability over most of the habitat, it is likely that the natural ecological functions of the habitat will be maintained.”

Properly functioning condition as defined in the Forest Practices Code is the ability of a stream, river, wetland, or lake and its riparian area to:

- a. withstand normal peak flood events without experiencing accelerated soil loss, channel movement or bank movement;
- b. filter runoff; and
- c. store and safely release water.

The above definition is expanded here to include the need for fish habitat in streams and riparian areas to be fully connected so that fish habitat is not lost or isolated as a result of some management activity. The ability of the riparian habitat to maintain an adequate root network or LWD supply, and to provide shade and reduce bank microclimate change, is also included in the definition of properly functioning condition. This is in keeping with recommended best management practices for logging by different stream types in the *Riparian Management Area Guidebook* (Province of B.C. 1995).

How is Functioning Condition Assessed?

To assess the functioning condition of each reach, 15 “main” questions are asked about key characteristics of healthy streams and their riparian habitats. These are the types of questions that stream and riparian experts might ask themselves if required to assess the condition or health of a stream. The answers to the questions determine the functioning condition of the stream.

To help experts and non-experts alike answer each main question, a number of “indicator” statements are provided that also require a **Yes** or **No** answer. The indicator statements refer to specific attributes that can be more easily assessed or measured than the more general main questions. The number of **Yes** or **No** answers to the indicator statements determines if the answers to the main questions are **Yes** or **No**. The functioning condition of the stream is based on the total number of **No** answers to the main questions.

Question 1 below on whether or not the streambed is undisturbed is provided as an example to illustrate a main question and its associated indicator statements. For Question 1, two **Yes** answers to the indicator statements are required in order to answer **Yes** to the main question. The need for only two out of three **Yes** answers indicates that some of the indicators are inherently quite variable, and that the question as a whole is judged more leniently.

The "main" question →

Question 1. Is the channel bed undisturbed?		Yes ☐	No ☐
<p>Note: For Questions 1-4, decide what the predominant channel morphology is and then complete the section for that morphology only (i.e., Part A, B or C, not all three).</p> <p>A) Riffle-pool or cascade-pool channels</p> <p>a) Less than 50% of the reach length is occupied by active sediment wedges or mid-channel bars. ☐ ☐</p> <p>b) Less than 50% of the reach has active multiple channels and/or braids. ☐ ☐</p> <p>c) More than 50% of the reach has lateral bars. ☐ ☐</p> <p><i>If answer "Yes" to 2 or more, mark Yes box in Question 1</i></p>			

The "indicator" statements →

TIP: Read all indicator statements carefully. Sometimes the meaning or intent of the statement is not immediately clear. This is because all statements are phrased so that a **Yes** answer is "good" or "healthy." **No** answers are always "not good" or "unhealthy."

Question 8 below is an example of a question on the amount of fine and/or sand-sized inorganic sediment visible on the streambed where less lenience is allowed. If the answer is **Yes** to all of the indicator statements, then the answer to Question 8 is **Yes**. If any of the answers are **No**, then the answer to Question 8 is **No**. Question 8 does not allow for any **No** answers because of the sensitivity of streams to visible increases in sedimentation.

The "main" question →

Question 8. Has the introduction of fine inorganic sediments been minimized?		Yes ☐	No ☐	NA ☐
<p>a) Inorganic ("gritty" feeling) fine and sand-sized sediments on the substrate are best described as little or lacking. Average coverage is less than 10%, with no single areas over 50%. ☐ ☐</p> <p>b) Wetted areas of gravel, sand, or fine sized sediments that a foot can be easily pushed or wiggled into represent less than 1% of the total wetted area. Mark "NA" if the stream is dry. ☐ ☐ ☐</p> <p>c) Gravels and cobbles are not embedded or buried in a matrix of sand or finer sized particles. The sides of individual gravel and cobble particles can generally be seen touching each other. ☐ ☐</p> <p>d) An average of one invertebrate sensitive to the effects of sedimentation is present at most sample sites. Mark "NA" if the stream is dry. ☐ ☐ ☐</p> <p><i>If the answer is "No" to any statement, mark the "No" box for Question 8. Otherwise, mark the "Yes" box.</i></p>				

The "indicator" statements →

All 15 “Main” Questions

- Question 1. Is the channel bed undisturbed?
- Question 2. Are the channel banks intact?
- Question 3. Are channel LWD processes intact?
- Question 4. Is the channel morphology intact?
- Question 5. Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments?
- Question 6. Does the stream support a good diversity of fish cover attributes?
- Question 7. Does the amount of moss present on the substrates indicate a stable and productive system?
- Question 8. Has the introduction of fine inorganic sediments been minimized?
- Question 9. Does the stream support a diversity of aquatic invertebrates?
- Question 10. Has the vegetation retained in the RMA been sufficiently protected from windthrow?
- Question 11. Has the amount of bare erodible ground or soil disturbance in the riparian area been minimized?
- Question 12. Has sufficient vegetation been retained to maintain an adequate root network or LWD supply?
- Question 13. Has sufficient vegetation been retained to provide shade and reduce bank microclimate change?
- Question 14. Have the number of disturbance-increaser species or noxious weeds present been limited to a satisfactory level?
- Question 15. Is the riparian vegetation within the first 10 m from the edge of the stream generally characteristic of other healthy, unmanaged riparian plant communities in the area?

Concluding on Functioning Condition

The number of **No** answers to the 15 main questions is used to arrive at a conclusion on the functioning condition of the reach, as follows:

- 0–2 **No** answers – the stream is in properly functioning condition.
- 3–4 **No** answers – the stream is in properly functioning condition, but at risk.
- 5–6 **No** answers – the stream is in properly functioning condition, but at high risk.
- 7 or more **No** answers – the stream and riparian habitat is not functioning properly.

How to Assess Properly Functioning Condition

Selecting Eligible Reaches

When you have sequentially selected a cutblock from the random list of 200 cutblocks provided to each forest district, verify with the block silviculture or logging plans that it has a stream within or adjacent to it. If it meets this criterion, the block is an eligible block. If it does not meet the criterion for streams, the next block on the list is selected and examined for streams in the same way. Keep selecting and discarding blocks until you have a minimum of 15 blocks containing streams for the riparian-fish effectiveness evaluations.

Once the blocks are selected, the streams within or adjacent to the blocks will need to be marked off into stream “reaches.” For the purposes of determining stream and riparian functioning condition, a “reach” is a stream section that is more or less homogeneous with respect to fish use, channel width, gradient, confinement, and riparian treatment. This is an office exercise that will require at a minimum information on fish presence/absence, road and trail locations, the RMA treatment proposed, and suitable elevation (i.e., contour) information to determine stream gradient and confinement. Silviculture and logging plan maps should have all of the above information, with the possible exception of elevation data. Assume channel width is constant between junctions of major tributaries. Consult other contour maps or stereoscopic air photographs to determine channel gradients and confinement.

Mark off all the homogeneous reaches eligible for sampling in and adjacent to each cutblock on a map. Mark also the order that each stream should be sampled (1, 2, 3, etc.). Where multiple streams of the same RMA class might be sub-sampled, randomly assign separate numbers to these streams (e.g., 2-1, 2-2, 2-3) so that if only one of the streams is sampled, it is randomly selected.

For areas where the impacts of logging is the main concern, the simplest way of selecting a reach is to consider any stream with the same stream classification and management activity on it within the block to be a reach. In most cases, the stream will probably have similar physical characteristics as well. Gradient and channel confinement are probably the most important characteristics to consider. If the pre-field information or your familiarity with a block or range area is sufficient to clearly distinguish multiple reaches with different physical characteristics within a harvest area, by all means do so. More often than not, this will not be possible until you are actually on site.

TIP: Roads, including ditch lines and cut and fill slopes, and cattle crossings can often cause significant changes to streams. They should always be considered when establishing reach boundaries or assessing the effects of any management activities.

TIP: Road crossings should not be included with a reach if the road is located at the downstream end of the reach. It is much better to include the road crossing with the stream reach below the road. The reach above the road can serve as a control for the road crossing.

TIP: If the stream reach or management activity is significantly less than 30 channel

widths or 100 m in length, (e.g., 15 channel widths or 50 m), the stream is not a good candidate for assessing effectiveness. That said, the definition of the management activity being assessed could be expanded to include multiple impacts. For example, an otherwise uniformly logged reach with a road crossing should probably be subdivided into an upper reach above the road and a lower reach with the road. If this means the reaches end up too short, the upper and lower reaches could be combined into one reach. The reach would be a sample of a harvest treatment with a road crossing and could be compared to harvest treatments without road crossings.

Stream and Reach Verification in the Field

Once in the field, ensure that the management activity or streamside treatment is more or less the same throughout the reach. The reach should also be homogeneous with regard to logging history, gradient, and confinement. If significant differences exist, the reach boundaries should be adjusted to ensure the reach is more or less the same throughout.

TIP: Tributary streams that are close to the same size as the main stream frequently mark reach breaks. This is because the channel usually widens at this point in response to the extra water.

TIP: Road crossings also frequently mark reach breaks. This is because roads are often located at the upper or lower end of confined stream reaches or the upper end of gully headwalls where it is easiest to cross streams and maintain suitable road grades. Where roads mark reach breaks, include the road with the stream reach downstream of the road.

Once in the field, verify the stream(s) selected for sampling are in fact streams and not wetlands or non-classified drainages (NCDs) as defined in the Forest Practice Code *Riparian Management Area* and *Fish Stream Identification guidebooks*. If the stream on the plans turns out not to be a stream, delete it from the sample and select the next stream. In most cases, experience indicates that most stream classification errors will involve NCDs that have been overclassified as S6 streams or fisheries sensitive zones (FSZs) that have been overclassified as S4 streams.

To be a definite stream, there must be a continuous definable channel (which could be subsurface) and a streambed that consists of alluvial materials or scour down to a mineral substrate. A stream could lack one of these characteristics and still be a stream. If the feature in question lacks all of these characteristics, it is not a stream. Note that the continuous definable channel portion of the definition may not always be that continuous or definable in the field, but it could still be a stream if there are alluvial deposits or scour to a mineral substrate. Conversely, the feature in question could still be a stream with neither alluvial deposits or scour to a mineral substrate if it has a continuous definable channel.

The Stream Classification Reference Card that follows is a “key” that can be used to determine if a water course or drainage feature is a stream as defined under FRPA, an NCD, or a FSZ.

Stream Classification Reference Card

Stream, NCD, or FSZ Determination		Circle Yes or No and go to the next statement indicated in the brackets	
1	Does the drainage feature have any alluvial deposits or scour to a mineral substrate?	Y (2)	N (10)
2	Are the alluvial deposits or scour to a mineral substrate continuous or in sections less than 10 m apart?	Y (3)	N (10)
3	Is the watercourse <100 m long?	Y (4)	N (7)
4	Does the watercourse flow into <i>known</i> non-fish bearing water, or end before reaching a waterbody with no possibility of a connection at high flows?	Y (NCD)	N (5)
5	Is the watercourse directly connected to potential fish-bearing water (stream, wetland, lake, or FSZ), or potentially connected to these features at high flows?	Y (6)	N (NCD)
6	Is the stream gradient <20%?	Y (S1-S4)	N (S5-S6)
7	Does the watercourse flow into a known non-fish bearing waterbody?	Y (S5-S6)	N (8)
8	Is the stream gradient <20%?	Y (S1-S4)	N (9)
9	Is there any potential fish habitat upstream?	Y (S1-S4)	N (S5-S6)
10	Is the gradient <20%?	Y (11)	N (NCD)
11	Is the watercourse directly connected to a potential fish-bearing stream, wetland, lake or FSZ, or potentially connected to any of these features?	Y (12)	N (NCD)
12	Does the parent drainage feature the watercourse flows into have a gradient <20%?	Y (13)	N (14)
13	Is the parent drainage feature the watercourse flows into known to be non-fish bearing?	Y (NCD)	N (FSZ)
14	Does the parent drainage feature the watercourse flows into have any potential fish habitat upstream?	Y (FSZ)	N (NCD)

When to do Riparian Evaluations

Properly functioning condition can be assessed anytime of the year as long as the streambed and the ground conditions in the riparian area are clearly visible. However, the optimum time for assessment is a low flow period during the active growing season, when the streambed, stream banks, and ground in the riparian area are clearly visible, there is flowing water in the stream, and vegetation foliage is fully developed. Winter, when the stream is frozen and the stream and riparian area is covered in snow, is the worst time to assess functioning condition.

Low water temperatures alone should not affect the assessment. Other than causing cold hands, benthic invertebrates should be just as simple to collect in cold water as warm water, and just as diverse. Long rubber gloves can keep hands from becoming numb at low water temperatures when collecting benthic invertebrates.

Several indicators, such as the length of reach with gravel bars or the presence of dewatering, are stage dependent, and therefore best observed at the lowest flow period. Conducting the assessment at higher flow periods, when pool areas or gravel bar dimensions may be hard to see, means the evaluation may not be as sensitive to declines in properly functioning condition. Pool and gravel bar lengths may also be hard (though not impossible) to measure when the stream is dry. Stream invertebrates and dewatering are impossible to assess when the stream is dry.

For most areas of BC, the optimum conditions for evaluations coincide with the summer low flow period from July 1 to September 30. However, many streams, particularly streams in areas that lack snow cover or have early spring run-off, can be assessed at other times of the year. Lower-elevation sites in coastal BC, for example, can often be assessed in April, May, or June after plants have leafed out, or in October before leaf fall or fall rains.

Be aware that season has an effect on riparian evaluations, just as the year of the evaluation has an effect. Streams and riparian habitats are dynamic, and therefore constantly changing. Windthrow can differ from month to month or even day to day. Fine sediments that are introduced during high flow periods may only be visible on the streambed during the first low flow period and gone the next. Shade will be hard to estimate after leaf fall unless deciduous vegetation is absent or “twig” or “branch” density can confidently be related to percent shade cover. In some cases, for example, if there is a dense network of leaf-bearing branches present at any given observation point, it may be safe to assume 95–100% shade cover at that point.

How Long Should the Reach Be?

A distance equal to 30 channel widths, or 100 m, whichever is greatest, is considered the minimum distance necessary for a riparian evaluation. This means that a stream with an average width of 20 m should be assessed over 600 m. A stream 5 m wide would be assessed over 150 m. A stream 2 m wide would be assessed over 100 m.

TIP: When you are assessing streams with beaver dams, try to find a section that has no dams or ponds on it to determine average stream width. If the entire stream is ponded, then select a section that looks least affected by the dams. Use the width of this section to determine how much of the stream length should be assessed.

If there is still some doubt about the accuracy or completeness of the assessment after a reach has been evaluated, more of the stream should be examined. For example, it may not be clear if large quantities of fine sediments noted on the streambed are related to conditions within the reach (e.g., windthrow) or to some other sediment source above the stream reach in question. This should be determined by walking to the upstream limit of the treatment being assessed and looking at conditions present upstream. It may be even more worthwhile to look at the stream just above the upper cutblock boundary, especially if the gradient, floodplain width, and channel confinement are similar.

As another example, it may be noted in the field that the reach section selected in the office does not really capture the effects of some windthrow because of the patchiness of the windthrow. In these cases, it may be necessary to assess longer sections of the reach, or to conduct separate assessments, one in the windthrow section and one outside the windthrow.

How Wide Should the Riparian Area Be?

Questions 10–15 focus on the riparian conditions beside the stream. Unless otherwise specified, the minimum width of the riparian area to consider for these questions is 10 m. Wider areas should be considered for Question 10 on windthrow if there are reserves present or management zones with prescriptions for some retention that goes beyond the first 10 m. In these cases, the entire reserve or management zone is assessed for windthrow.

For Question 11, the amount of bare ground or disturbed ground beyond the first 10 m from the stream edge is only considered if the ground is hydrologically linked to the first 10 m. Any ground on a 10% slope, from the edge of the first 10 m of riparian area up to the first topographic break is considered hydrologically linked to the first 10 m of the riparian area. Bare ground further away is hydrologically linked if a distinct channel or slide track connects the bare ground to the first 10 m of the riparian area. It is also hydrologically linked if the channel is connected to steep ground below the topographic break, as long as the steep ground below the break is directly connected to the first 10 m of the riparian area.

How Many Questions Need to Be Answered?

There are 15 questions to answer after the reach is traversed and information on the various indicators has been collected. All 15 questions should be answered **Yes** or **No**, or at least indicated as **Not Applicable (NA)** if that is truly the case. If some applicable questions are not answered, the effects of the treatment being assessed may be underestimated.

Are All Questions Applicable in All Cases?

Twelve of the 15 questions will be applicable to all sites. There are three questions that may not be applicable. When a question is Not Applicable, it should be marked **NA**. For example, Question 4 on stream morphology is not applicable if the stream has no morphology formed by water (i.e., it is considered a “non-alluvial” stream). Small (<2 m), steep (>30%)

streams are typically non-alluvial because the stream lacks the energy to sort the bedload into recognizable patterns. Gravity is more important. Even large streams, however, can sometimes be non-alluvial if the bedload is too large for water to move and gravity is the dominant force responsible for bedload movement.

The two other questions that could be **NA** include:

- Question 6 on fish cover characteristics if the stream is non-fish-bearing. Treat non-fish-bearing streams in community watersheds as non-fish-bearing regardless of their RMA classification.
- Question 9 on the diversity of benthic invertebrates present if the stream is dry, or known to be dry virtually all year.

All other questions besides Questions 4, 6, and 9 should be applicable. There may be some indicator statements within a question that are not applicable, but the question itself will be applicable, and in need of a **Yes** or **No** answer. Some common examples of questions or indicator statements that are sometimes thought to be **NA** but which, in fact, are always applicable, are as follows:

- Question 10. Has the vegetation retained in the RMA been sufficiently protected from windthrow?

Question 10 is always applicable to all streams, even those that are 100% logged to the bank. The recommended retention in S6 RMAs is 5% averaged over an operating area consisting of numerous cutblocks. This means that many S6 RMAs will legally have no tree retention at all. For S6 streams that fall into that category, Questions 10 a) and 10 c) are **NA**, but 10 b) would be **Yes**. This might seem odd, but harvesting everything is one way to reduce windthrow and its impacts. The disadvantages in this strategy are picked up by other checklist questions.

- Question 12. Has sufficient vegetation been retained to maintain an adequate root network or LWD supply?

Indicator statement 12 a) is applicable to all streams regardless of the RMA class. While the rest of the statements may not be applicable, a **Yes** or **No** answer is always required for 12 a). Steep non-LWD dependent S5 or S6 streams that do not flow directly into fish-bearing streams have no recommendations for retention of any dominant or co-dominant trees. However, there is always a recommendation to retain understorey trees, shrubs, and herbaceous vegetation to the fullest extent possible within 5 m of the channel.

No questions are restricted entirely to one activity such as logging or grazing by cattle. Question 12 is focused on logging, but heavy browsing by wildlife or grazing by cattle could lead to a **No** answer for Question 12 if the browse or grazing adversely affects retention levels enough.

- Question 15. Is the riparian vegetation within the first 10 m from the edge of the stream generally characteristic of the other healthy, unmanaged riparian plant communities in the area?

Question 15 and its four indicator statements all require a **Yes** or **No** answer. None of the indicator statements are to be considered **NA**. The main thrust of the question focuses

on cattle impacts, but wildlife impacts and all other significant impacts on the riparian vegetation should be considered. This includes not only logging, but also other unusual events such as forest fires, major wind storms, slides, or beetle epidemics.

Note: Riparian evaluations are not affected by questions that are **NA** for one reason or another. The conclusions about properly functioning condition depend only on the number of **No** answers. Eliminating questions that apply mainly to steep dry, non-fish bearing streams may reduce the sensitivity of the assessment, but this may not be entirely inappropriate for these types of streams.

Note: Each question in the checklist has equal weighting. Some attributes may naturally be more important or sensitive than others, but these differences in importance have been taken into account by varying the thresholds for each indicator or changing the number of indicators that need to be met to obtain a **Yes** answer to a main question. Attributes that are naturally quite variable, such as the amount of eroding bank present, have a relatively high threshold. Others that have low variability or are naturally rare, such as the amount of bare ground present, have a lower threshold.

What If You Can't See All of the Reach?

Other than where safety is the main concern, a significant effort should be made to see all of the stream reach. This is typically easy to do on larger streams, but it can be hard on small streams. On small streams covered over with brush, it will probably be necessary to get down under the brush or pull it away to see the stream. If excessive amounts of debris are suspended across the channel, then it may be necessary to pull the brush aside and peer down between the debris pieces.

Measurement thresholds based on the length of the stream channel (e.g., percent of reach with stable undercut banks, percent of reach with mid-channel bars) should only be based on the length of the channel that is actually observed. Similarly, areas of riparian indicators recorded (e.g., percent bare ground) should only be based on the area of the riparian habitat measured. If sections of the stream or riparian area are not observed, do not include these sections or areas in the calculations of percent coverage or occurrence. Either take into account the reduced length of stream or riparian area observed in your calculations, or increase the stream length or riparian area assessed.

Some streams may be so completely filled with debris that it is no longer possible to see any evidence of a stream. In these cases, detailed measurements of the channel conditions are probably not needed. The answers to Questions 1 to 5 especially can be safely assumed to be **No** because it should be obvious that the streambed, stream banks, LWD processes, channel morphology, and channel connectivity are all drastically altered. The answer to Questions 6, 7, and 9 can similarly be assumed to be **No** since it is very likely moss, fish cover, and stream invertebrate populations are also negatively affected. Only Question 8 (Has the introduction of fine inorganic sediments been minimized?) will be impossible to answer since it is possible that fine sediments are not abundant. In this case, try to remove enough debris from even a portion of the channel to see the streambed. If no streambed is visible, then assume fine sediment introductions have been minimized.

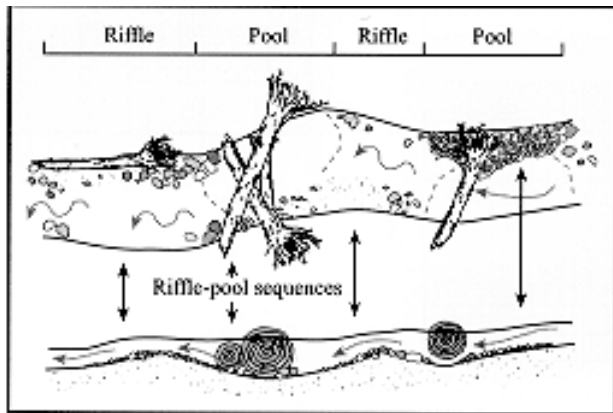
What is Stream Channel Morphology (Questions 1 to 4)?

Questions 1 to 3 have three different sets of indicators, depending on the predominant morphology of the stream (or lack thereof). There is one set of questions for riffle-pool or cascade-pool type streams, one set for step-pool type streams, and one set for non-alluvial streams. You only complete the section that best represents the stream reach.

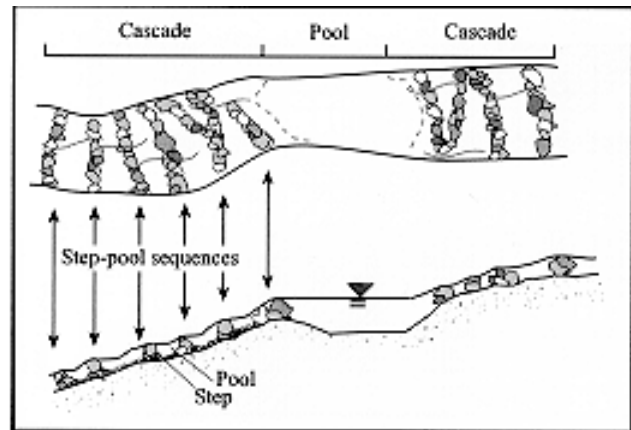
Question 4 has two different sets of indicator questions, one for cascade/riffle-pool type streams and one for step-pool type streams. Since the main question is whether or not channel morphology has been altered, the question is **NA** for non-alluvial streams. By definition, non-alluvial channels have no morphology that is formed by water, and it therefore cannot be changed.

The three types of channel morphologies to know for the first two sets of indicator statements in Questions 1 to 4 are illustrated in Figure 1. General characteristics of each channel type are summarized in Table 1. The channel morphologies include:

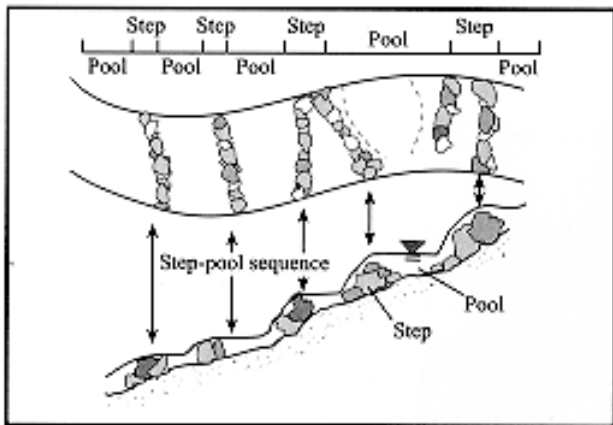
- Riffle-pool and cascade-pool type streams – low to moderate gradient streams (0–7% approximately), usually with abundant alluvial materials arranged by water into repeating sequences of riffles or cascades and pools. For riffle-pool streams, the main type of pool is usually a lateral scour type pool where the deepest part of the channel is off to the side of the channel. The main type of pool in a cascade-pool stream is usually a small plunge pool or scour pool that has formed behind a boulder (“pocket pools”). In cascade-pool channels, most of the habitat often appears to be one long riffle or rapid, with scattered pools that rarely span the whole channel.
- Step-pool type streams – moderate to steep streams (7–15% approximately) with distinct steps where boulders are lined up across the channel (“stone lines”), usually with a distinct plunge pool below the step.



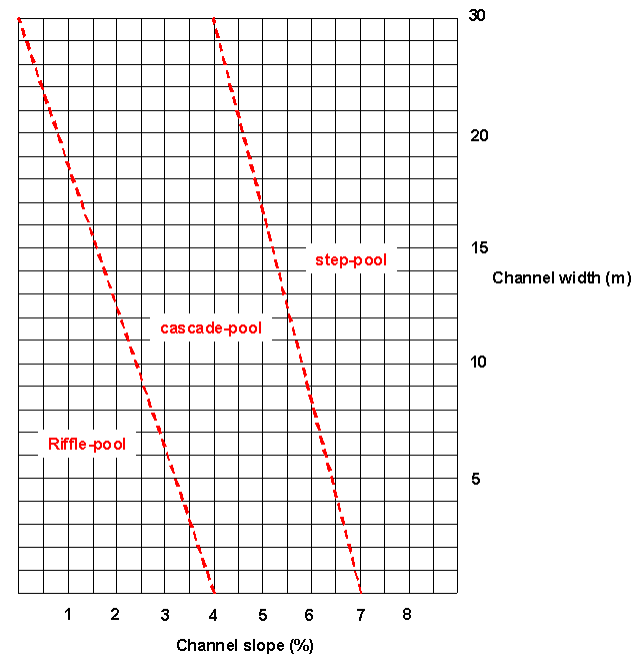
a) Riffle-pool morphology (RP_g and RP_c)



b) Cascade-pool morphology
(CP_c and CP_b ; after Grant et al. 1990)



c) Step-pool morphology
(SP_r , SP_b and SP_{b-w} ; after Church 1992)



d) This figure shows how channel morphology changes with increases in channel width and stream slope. As channel width increases, the slopes that define different morphologies decline.

Figure 1. The three channel morphologies for small and intermediate-sized alluvial type stream channels (a, b, c), and effects of channel width and channel slope on these morphologies (d).

Table 1. *Stream channel morphology – general characteristics for small to medium-size streams*

Channel type	Typical gradient (%)	Dominant type of stones	Main pool types
Riffle-pool	0–3	small; cobbles, gravel or smaller, smoothed by water	lateral, under backwater
Cascade-pool	>3–7	medium; cobbles and boulders, smoothed by water	small plunge, pockets
Step-pool	>7	large; boulders arranged in lines by stream flows	plunge pools below boulder controlled steps
Non-alluvial	>15	varied; gravel, cobbles, and boulders are washed out of the stream banks, and have rough or sharp edges, not smoothed or organized by stream flows. Roots often span the channel	plunge (boulder, root or LWD controlled)

An apparent variant of step-pool types of stream is where roots or pieces of woody debris on small streams form a series of distinct steps, with small plunge pools below the step. However, these should not be considered step-pool type streams because it is not the interaction between mineral sediments and water that is responsible for the steps at these spots, but the roots and woody debris. Streams with root- or debris-controlled steps should be either cascade/riffle-pool streams or non-alluvial streams, depending on gradient.

Non-alluvial streams have no distinct morphology related to fluvial processes (water movement) because the flow of water in the stream does not have the energy to move the substrate material into any kind of recognizable pattern. Most movement of substrate is by gravity, possibly assisted by water. Small non-alluvial streams may have a stepped appearance but the boulders, roots, and woody debris that create this appearance are randomly located.

Most non-alluvial streams are small, steep streams, especially in areas where the colluvial materials are large (e.g., boulders, cobbles) relative to stream width. These small streams are considered to be non-alluvial because the stream does not have enough energy to sort the parent bank material once it is washed out of the stream bank. Most S4 and S6 streams less than 1.5m wide will be non-alluvial when the gradient exceeds 10% or possibly even 5%. Since the boulder, cobble or even gravel-sized particles that wash out of the banks do not move very far in these low energy streams, the particles usually have rough or sharp edges. Small gravel, sand or fine-sized sediments will move downstream as alluvium, but not the large sediments. Because they don't move, the cobbles and boulders in non-alluvial streams frequently have a thick growth of moss.

TIP. If the cobbles and boulders on the streambed have mostly sharp or rough edges and a good growth of moss, the stream is probably non-alluvial.

TIP. If in doubt about the morphology, try answering the indicator questions for each type of morphology. Quite often the answer to the main question is the same regardless of stream morphology.

Getting Started

The following is a list of materials required to conduct a routine riparian evaluation:

- a Riparian Management Routine Effectiveness Evaluation Checklist;
- the Protocol for a Riparian Management Routine Effectiveness Evaluation;
- the Field Supplement to Evaluating the Condition of Streams and Riparian Management Areas;
- a pocket calculator for calculating totals or percent of stream reach length or riparian areas;
- normal field gear (e.g., rain gear, hard hat, vest, pencils, a field notebook, safety/first aid supplies);
- suitable footwear. Riparian evaluations involve walking in, down, and across streams. Unless the streams are small, with little water, waterproof boots are recommended at a minimum. Waders may be needed for larger, deeper streams;
- measuring devices (at a minimum, a hip chain or a logger's tape, a hand-held tape, a clinometer, and a compass);
- flagging tape and marking pens (for marking the reach boundaries and fixed sample points);
- cover class standards;
- benthic invertebrate example pictures;
- a white plastic tray (recommended minimum size approximately 200 mm x 150 mm x 50 mm deep) for examining benthic invertebrates;
- a cruise vest size 0.5–1.0 mm mesh dip net (recommended net opening approximately 200 mm x 150 mm, for sampling benthic invertebrates);
- lists of weed and disturbance-increaser species, with pictures of the most common species (e.g., Field Guide to Noxious Weeds and Other Select Invasive Plants of BC); and
- lists of moisture-loving plants, with pictures of the more common species.

Other equipment that could be used, depending on experience or personal preference includes:

- a camera;
- GPS receivers (for recording UTM co-ordinates at the upstream or downstream end of the stream reach);
- range finders (for measuring riparian area widths);
- a hand lens (for examining benthic invertebrates); and
- a "Teti" angular canopy densiometer (for measuring shade cover).

Basic Components of Routine Riparian Evaluations

Once a stream reach has been selected for evaluation, there are five basic steps to a routine riparian evaluation:

1. describing the reach;
2. collecting the field data;
3. answering the questions;
4. determining functioning condition; and
5. describing the activities or factors that caused or led to **No** answers on the questions.

Describing the Reach

Stream/Opening Identification

The first part (and the first page) of a routine riparian evaluation is the descriptive information needed to identify the reach. It includes space to record basic information such as the forest district, the opening ID, the opening #, the licensee, the license #, the cutting permit, and the year of harvest. If the area is also covered by a Range Use Plan, record the plan #, and if appropriate the pasture ID. Other basic information to record includes the name of the stream and whether the stream is in the block or adjacent to the block. Record also the stream class on the plans and the stream class in the field. Record channel width and channel gradient, which side(s) of the stream is being assessed, and the dominant channel morphology.

The evaluation is sensitive to small differences in the reach section assessed, especially if management-related impacts are present. For this reason, it is important to describe the exact position of the reach. By convention, record the exact distance (in metres) from a convenient landmark, such as a block boundary crossing or road crossing, to the lower (downstream) and upper (upstream) ends of the reach. Mark the ends of the reach with flagging tape. This will allow for repeated measurements over time if a reach is selected for monitoring in later years. It will also ensure quality assurance checks are conducted over the same stretch of stream.

If available, GPS receivers can also be used to record the location of each sample reach. If the exact location of the reach can be identified on a map GIS data can also be used to record the co-ordinates of the upstream and/or downstream ends of the reach. Use UTM coordinates for locating all positions. Do not use latitude or longitude.

Riparian Retention Information

In addition to stream class, information on riparian retention will be used to stratify the samples for analysis. It is recognized that there are many different ways of expressing retention. For purposes of this evaluation, as far as possible express retention as percent of stems retained for both the plans and field assessments. If retention is expressed as a percent of basal area in the plans, assume all trees elected are representative of the dominant and co-dominant trees present. For example, for a plan that specifies 50% basal area retention, assume this equals 50% retention of the dominant and co-dominant trees.

Record the retention specified for the first 10 m of the riparian zone as described in the plans, plus the retention specified for the riparian reserve zone (RRZ) (if there is one) and the riparian management zone (RMZ). Do this separately for the dominants and co-dominants, and then the understorey vegetation. Also estimate and record what was actually retained in the field. This includes trees that have blown over. As before for the plans, record the retention for the first 10 m of the riparian area, the RRZ (if there is one) and the RMZ.

Photo Section

Photographs are not required for the evaluation; however, they can capture the appearance of a leave strip or stream in a way no numbers can. They can also confirm or clarify some of the data entry questions that frequently come up. An upstream view of the stream and adjacent riparian area from the downstream end of the reach and/or a downstream view from the upstream end of the stream reach is recommended. Other useful photographs could include aerial shots if accessing the stream by helicopter, stream crossings in the reach, a close-up of the streambed, and unusual or specific activities or conditions that affected functioning condition of the stream (e.g., windthrow, major erosion, over grazing, beaver dams).

Collecting the Field Data

Collecting information or data on the various indicators used to answer the main questions on properly functioning condition is arguably the most important aspect of the evaluation. When completed, this data is a record of your observations on most of the indicators used in the evaluation. It will help decide which threshold values have been exceeded for most of the indicators used to answer the main question. Other people can use the information to double-check the answers in the case of a discrepancy between the number of **Yes** and **No** answers to the indicator statements and the **Yes** or **No** answer to the main question. This information can also be used to complete the checklist if a question was overlooked.

Many attributes can be measured in different ways. The methods suggested in this handbook are believed to be practical in terms of consistency and/or time, but other methods may be suitable if the results provide a fair assessment. For example, some experienced people may be comfortable making visual estimates of stem density for percent windthrow. Others may not be familiar with windthrow and will want to use a consistent or straightforward method, such as direct counts of standing versus down trees.

Conduct the assessment by walking along the reach in the stream or along the bank, and back down again if necessary, measuring, estimating, or noting indicators as required. One person can complete an assessment, but it is easier if done with a two-person crew. It is frequently well worth the effort to pre-walk the reach before actually recording any information, to get a feel for conditions and to identify where the edge of the 10-m wide riparian area is located.

Experience indicates that a two-person team is initially best for inexperienced people, or even experienced people who might be unfamiliar with the riparian evaluation procedures. One member of the team should have a hip chain to record the overall reach length sampled, and thus the total riparian area surveyed. Both members should also have retractable style metre tapes to measure indicators like pool lengths, bar lengths, recently

disturbed banks, upturned root wad lengths on the banks, and lengths of multiple channels. You could divide the indicators so that one person measures (and records) certain indicators, while the other person measures other indicators and calls out the results to the recorder – whatever works best. Not all indicators will need to be measured since some will be obviously over or under the threshold values in the indicator statements. Experience suggests that most indicators will require at least some measurement until the thresholds are exceeded.

Initially, it may be difficult to remember all the measurements and/or observations that need to be made during a riparian evaluation. However, this becomes much easier with experience using the data form and conducting the measurement processes. The process also becomes easier as users become familiar with the threshold values that determine **Yes** or **No** answers to the indicator statements.

Recording the Field Data

The field data tables on the second and third pages of the riparian checklist are the most common indicators to be measured, with additional space for the actual measurements. The question to which the indicator relates (e.g., Q7, Q8, Q9, Q13) is located in the first column on the far left-hand side of the form. The second to last column on the right has the threshold values for each indicator, while the last column provides space for the mean or total value of each indicator.

The form has three different types of indicators – “Point,” “Continuous,” and “Other.”

Point Indicators

Point indicators are measured at discrete points along a traverse, then averaged to arrive at a mean value. A minimum of six measurements spaced at equal intervals along the traverse is recommended. Fewer measurements may suffice if users are confident the measurements are representative of the whole reach, or it is clearly evident the threshold value for the indicator is exceeded or not.

Specific point indicators and suggested methods of measuring them are as follows:

% Moss – Record percent of the substrate covered by moss, from the bottom of one bank to the bottom of the other bank. Estimate percent coverage of a square plot on the streambed that is as long as the stream channel is wide. As a guide to estimating coverage in the square plot, calculate what the dimensions would be for a square patch of moss equal to 1% of the square plot. For example, 1% of a 2 x 2 m square plot (4 m²) would be a square 20 cm x 20 cm. Alternatively, use standard comparison charts for estimating foliage cover.

% Fines – Record percent coverage by inorganic fines or sands <4 mm in diameter along a line across the channel, from the bottom of one bank to the bottom of the other. To calibrate your eye, stretch a tape across the channel and measure the length of the line occupied by fines. Divide the length of the line with fines by the total length of the line, multiply by 100, and that is the percent coverage by fines.

No. sensitive invertebrate types – sample the benthic invertebrates at each sample station with the dip net, using the white tray to sort through the sample and see the

invertebrates present. Record the number of different invertebrate types present that are usually regarded as “sensitive” (e.g., mayflies, caddisflies or “case-builders,” stoneflies, riffle beetles, “helgrammites”, clams).

No. major invertebrate groups – Record the number of major invertebrate groups present in each sample. Insects, mites, worms, molluscs, and crustaceans are all examples of a major invertebrate group.

No. insect types – Insects dominate the invertebrate fauna of healthy streams. Record the number of different insects only present at each sample station.

Total No. invertebrate types – Record the total number of different invertebrates present. It’s helpful to record the actual types observed in the notes (e.g., 1 stonefly, 3 mayfly types, 2 case-builder types, 1 midge, 1 blackfly, 1 snail, 1 leech, and 1 worm together represent 11 different invertebrates). A table is provided in the field checklist below the point indicators for recording the different types of invertebrates at each sample station.

% Shade – Visually estimate or record percent shade using a “Teti” angular canopy densiometer, by comparison to percent shade example photographs, or by comparison to accepted cover class standards. Percent shade at any one point is the average of the two shadiest of E, S, or W aspects. Measure shade at a 60-degree angle above the horizontal. Looking through a circle made by your thumb and forefinger and held straight out above your head at a 60-degree angle to the E, S, and W is a useful area upon which to base visual estimates.

% Disturbance-increaser species – Record what percent of a 10-m transect is occupied by disturbance-increaser species in the first 10 m of the riparian area. All transects should extend at right angles to the main axis of the stream reach.

% Noxious weeds – Record what percent of a 10-m transect is occupied by noxious weed species in the first 10 m of the riparian area. All transects should extend at right angles to the main axis of the stream reach.

Continuous Indicators

Continuous indicators are better measured or estimated over the entire length of the reach, rather than at discrete points. Ideally, users would document the occurrence of each indicator over the entire reach, but this may not be necessary if it is obvious the threshold value has been exceeded or not exceeded. If it is obvious the threshold value of an indicator has been exceeded (e.g., length of reach with pool habitat is greater than 25%), a note in the data sheet should indicate the approximate value.

Specific continuous indicators and suggested methods of measuring them are as follows:

Mid-channel bars, wedges (m) – Record the reach length occupied by mid-channel bars and sediment wedges. Use a hip chain or hand-held tape to directly measure the length of the reach with the bar types, or visually estimate the length in short manageable sections of known length. Where the same type of gravel bars overlap do not measure the overlap twice.

Lateral bars (m) – Measure as per mid-channel bars and wedges.

Multiple channels (m) – Record the reach length where multiple channels are present. The latter includes wetted channels that are separated by bare gravel bars, and dry side channels separated by vegetated islands. Do not measure the reach length twice where side channels overlap.

Recently disturbed bank (m) – Record the reach length with recently eroded banks, regardless of which side of the channel the eroded bank is located on. Be aware that non-erodible boulder or bedrock banks are not to be included in the calculations of percent of reach with recently disturbed banks. Do not measure the reach length twice where the disturbed banks overlap.

Stable undercut bank (m) – Record the reach length with stable undercut banks present, regardless of which side the undercut bank is located on. Be aware that non-erodible boulder or bedrock banks are not to be included in the calculations of percent of reach with undercut banks. Do not measure the reach length twice where undercut banks overlap each other.

Deep rooted bank (m) – Record the reach length with deeply rooted stream banks on the side(s) adjacent to the treatment(s) that is (are) being assessed. Where two sides are being assessed, measure the bank with the least amount of deep-rooted vegetation.

Upturned bank root wads (m) – Record the reach length with recently upturned root wads at the edge of the bank, regardless of which side of the channel has the upturned bank root wad. Measure the length of each root wad from the upstream edge to the downstream edge. Do not measure the reach length twice where upturned bank root wads overlap each other.

No. debris accumulations – Record the number of separate “clumps” or accumulations of woody debris present. A logjam that spans the channel is one (large) debris accumulation, but so is two to three pieces of debris piled up along the bank.

No. debris accumulations with recent debris – Record the number of debris accumulations above that also have “recent” debris associated with them. Recent debris is any woody debris that has entered the channel after the treatment activity (e.g., road construction, logging) being assessed occurred. The debris could include whole trees, broken or shattered stems, bark, or slash and limbs from falling, bucking, and yarding, fire, windthrow, or slides.

No. debris accumulations with recent debris that span the channel – Record the number of debris accumulations with recent debris that span all or most of the channel, and impede the normal downstream movements of sediment and debris, or impede upstream movements by fish. Do not count debris that is suspended across the channel above the stream banks. Only consider debris that lies within the channel, below the top of the banks.

Pool length (m) – Record the length of each pool present until satisfied the amount of pool habitat present exceeds the threshold for the indicator statement.

Deep pools (No.) – Record the number of pools present where channel depth from the top of the channel to the bottom of the pool is twice the channel depth in the riffle below the pool. Only two deep pools are needed to answer **Yes** to the indicator statement about the number of deep pools present.

Recent windthrow (No.) – Count the number of recent (i.e., post-harvest) windthrown trees present in the designated reserve or management area. With experience in assessing percent windthrow, a simple visual estimate of percent windthrow may be appropriate if the percent of trees windthrown is clearly much greater than 10% of the trees, or less than 1%.

Old windthrow (No.) – Count the number of old (i.e., pre-harvest) windthrown trees present if it looks like the amount of old windthrow needs to be accounted for in assessing the significance of recent windthrow.

Standing trees (No.) – Count the number of standing trees present if the percent of trees windthrown could be between 1 and 10% of all stems, or where you lack confidence in estimating percent windthrow. Rough estimates of the number of trees standing are appropriate if windthrow is clearly less than 1% or greater than 10%.

Bare soil in first 10 m (m^2) – Bare soil and bare erodible ground are the same thing. Locate and visually estimate the area of each patch of bare ground present in the first 10m of the riparian area, including all permanently deactivated or de-built roads. Do not include active roads or seasonally or temporarily deactivated roads. Where bare ground is not present as discrete bare patches that can be measured individually, but is dispersed throughout the vegetation, use the percent cover class card to estimate the amount of bare ground. Net down bare soil that is mixed or armored with woody debris or stones and rocks.

Bare soil exposed to rain in first 10 m (m^2) – For each patch of bare ground recorded as present in the first 10 m of the riparian area, record what area is outside of the drip line and therefore directly exposed to rainfall.

Bare soil hydrologically connected to first 10 m (m^2) – Look at all active roads within the first 10 m of the riparian area plus all other ground beyond the first 10 m to see what bare erodible ground may be hydrologically connected to the first 10 m. Treat seasonally or temporarily deactivated roads as active roads. Bare ground outside the first 10 m of the riparian area could include any other eroded road surfaces, cut/fill slopes, failures, sloughs, slides, or torrents that may be far from the riparian area but nevertheless hydrologically connected in some fashion, either by ditch lines, slide tracks, or stream channels.

Disturbed ground in first 10 m (m^2) – Disturbed ground is affected by pugging, hummocking, or rutting, usually by animals or vehicles. It may have bare soil associated with it, but the main characteristic or concern associated with disturbed ground is soil compaction.

Disturbed ground hydrologically connected to first 10 m (m^2) – Because it is generally drier, disturbed ground outside of the first 10 m of the riparian area tends not to be as common as disturbed ground within the riparian area.

Other Indicators

There are several other less specific indicators that need to be noted during the traverse; however, they don't need to be measured at five or six discrete points or continuously along the traverse. These indicators are best recorded after one has looked at the entire stream and riparian area to be assessed, but before any detailed measurements are made. This way, an assessor will gain a better appreciation of what may or may not have to be measured more carefully. Key words or phrases associated with each indicator can be circled to make data recording easier.

- Q1 Channel Spanning Steps (For Step-Pool Channels Only)* – 50% or more of the stone lines in step-pool type streams do or do not span the channel, and 25% or more do or do not have moss.
- Q1 Sediment and LWD Storage (For Non-Alluvial Channels Only)* - Sediments and/or LWD do or do not completely fill the channel up to the top of the banks at any point or points together representing more than 5% of the reach length.
- Q1 Moss Along the Channel Bed (For Non-Alluvial Channels Only)* - More than 25% of the channel bed length does or does not have some moss on the substrate.
- Q2 Non-Erodible Banks* – Banks that are non-erodible on both sides of the stream at the same time are or are not present. Thresholds for stable undercut banks or deeply rooted banks are based on the length of erodible banks present only. Base the percent of undercut bank or deeply rooted bank present on total reach length minus the length of non-erodible bank present.
- Q3 Main Woody Debris Characteristics* – Note if the channel woody debris is mainly “new” (i.e., post-logging or post-treatment) or old, natural, or logging-related, across or parallel, intact or not.
- Q4 Surface Sediment Texture* – The texture is homogeneous or heterogeneous.
- Q4 Steps and Pools (For Step-Pool Channels Only)* - Cascades lacking steps account for more or less than 25% of the sample reach.
- Q4 Plunge Pool Characteristics (For Step-Pool Channels Only)* - More than 25% of the steps at stone lines do or do not have a plunge pool as deep as the largest rock in the step. More than one step is or is not completely infilled.
- Q5 Connectivity* – Connectivity is or is not good; i.e., open-bottom structures present or not on fish streams, no temporary blockages, no down cutting, no sediment or debris buildups, no dewatering, overland flow areas not isolated, generally free movements of sediments and debris possible.
- Q6 Fish Cover Types Present* – Include deep water, boulders, void spaces, undercut banks, woody debris, aquatic vegetation, and overhanging vegetation. To be considered present, each fish cover type must occupy at least 1% of the channel area assessed. For example, a deep-water area in a channel 5 m wide by 150 m long (750 m²) must occupy at least 7.5 m² (1%) of the total channel area to be considered present.
- Q8 Fine Sediments* – Check if there are any fine or sand-sized sediment deposits that

“blanket” an entire section of stream anywhere. Note also whether the substrate is embedded in sand or fine gravel or not, or whether “quicksand” or “quickgravel” is present or not. As a guideline, an area equal to one channel width in length and width is enough to say sediments blanket the stream in places or that quicksand or quickgravel is present.

Q9 Benthic Invertebrates Observed – List all the different invertebrates sampled.

Q13 Moisture-Loving Plants – (e.g., willows, rushes, reeds, speckled alder, salmonberry, Devil’s club, horsetails, ferns, mosses, liverworts). Moisture-loving plants are or are not present. Those present are healthy, not scorched or dessicated.

Q13 Bank Soils – Bank soils are cool or warm, moist or dry, unchanged or not.

Q15 Vegetation Structure – All vegetation layers and the structure expected of a healthy, unmanaged forest are or are not present (e.g., gaps, snags, trees, tall shrubs, low shrubs, herbaceous plants, mosses, lichens)

Q15 Vegetation - Is form normal or not, vigor normal or not, recruitment normal or not?

Q15 Browse, Grazing - Heavily browsed shrubs are or are not present. Heavy grazing is or is not present on more than 10% of the available forage.

Minimum Data Requirements

Some discretion on the number of plots, samples, measurements, or counts required is allowed when it is clear that they are unnecessary, or that the answer to a question is unequivocal. One measurement, however, that definitely should be followed is the length of stream that is walked on the ground, so that one can say that the stream and associated riparian area was diligently examined. The protocol suggests that a minimum distance equal to 30 channel widths be inspected, **or more** if that is what it takes for the assessor to be confident of the conclusion on functioning condition.

Complete measurements or a full complement of transects may not be required for many variables in an intact reserve zone with a vigorous growth of climax vegetation and no evidence of any man-made or natural disturbances (e.g., no floods, no fire, no roads, no windthrow, no bare ground, and no weeds). It should also be obvious that many variables (e.g., shade, windthrow, standing trees and vegetation structure) will not require detailed measurement in riparian areas that are logged to the edges of the stream. Simply noting the extent of the logging in these cases is sufficient if it clearly explains why there was no need to estimate the variables in question. In other cases, for example where fine sediments on the streambed initially appear to be completely absent, it may be sufficient to record the observation as a note and skip making any additional measurements. The danger in making these types of assumptions is that if fine sediments are observed later on, it may be necessary to re-do parts of the assessment.

A defensible document that will support your conclusion on stream functioning condition or the effectiveness of a specific management activity will include:

- complete information on the location of the stream reach and a description of the retention planned or achieved;

- complete field data cards with adequate notes explaining, if necessary, why such and such a variable did not require detailed measurement;
- a completed checklist;
- a summary of the **No** answers and your conclusion on functioning condition;
- a description of the activities, conditions, or events that led to each **No** answer; and
- perhaps a sketch or some photographs of the stream.

A conclusion based on a quick visual survey with no notes, no data, or any actual measurements is not defensible.

Answering the Questions

After completing the reach inspection and indicator data collection aspects of the evaluation, answer each of the 15 questions about the channel, bank, and riparian characteristics of the reach. Guidance, definitions, tables, graphs, and tips to help answer each question are provided in “The Routine Riparian Evaluation Questions” section later in this protocol.

The Summary Page

Page 16 of the checklist (after the questions) is a summary page to record the **Yes**, **No** or **NA** answers to each main question. Add up and record the number of **No** answers, and conclude on properly functioning condition as described in the “Concluding on Properly Functioning Condition” section.

List the questions that had a **No** answer in the table at the bottom of the summary page, and check off what you believe was the main reason for the problem. This is a very important part of the assessment. We want to know if natural events, upstream events and/or treatment events caused the **No** answer. We want to know this for each **No** answer so that background impacts can be separated out from treatment impacts. In this way we can judge the effectiveness of the treatment more accurately, while also providing information on what aspects of the treatment were not effective.

A **No** answer due to natural causes would include any natural events such as insects, fires, floods, slides, or diseases that were clearly unrelated to man’s activities in the stream or adjacent riparian area. Check logging, cattle, roads or other man-made as a cause if any of these factors directly affected the specific stream or riparian area assessed in this evaluation. Check upstream factors if the **No** answer was the result of some event or condition that occurred upstream, regardless if it was man-made or natural.

In some cases, there might be a **No** answer for more than one reason. If so, indicate as many as possible. For example, there may be naturally high background levels of fines and sediments in the stream that caused the answer to Question 8 to be **No**. An eroding road crossing (active or deactivated) and bare ground due to windthrow and machine activity in the first 10 m, however, may have resulted in even higher levels of fine sediments within the treatment reach being assessed. In this case you would note that the high sediment levels were the result of naturally high background levels, plus the eroding road and bare ground exposure.

Specific Impacts for All No Answers Combined

Page 17 of the checklist (see Appendix 1) is a list of more specific impacts. Check off those impacts that resulted in **No** answers to the 15 questions on functioning condition. Mark as many as apply, plus any others not listed. Check off the impacts that occurred within the stream reach and associated riparian area separately from those that occurred upstream.

Final Comments

Use the “Final Comments” page at the end of the checklist (page 18) to complete the assessment. Indicate if you agree with the conclusion on functioning condition, and if not, why not. If needed, also try to describe more specifically what management activity (e.g., post-harvest windthrow, eroded roads, road deactivation, culvert blockages, falling and yarding), or natural impacts (e.g., floods, slides, fires, and pre-harvest windthrow) were responsible for the **No** answers. Distinguishing the attributes of the stream/riparian area that were negatively affected by the management activity from those that were affected by other factors will provide a clearer picture of the effectiveness of the overall management activity.

Be as specific as possible about the nature of the problems. Natural events could include soil erosion due to a forest fire in or adjacent to the riparian area, or a landslide on the unlogged side. Upstream impacts could include both natural and man-made impacts above the stream reach. Treatment impacts relate to impacts within the stream and riparian area that can be linked to the treatment (usually harvesting, but possibly also cattle grazing, lot development, other agriculture activities, or right-of-way clearing for pipelines or transmission corridors).

A sample Riparian Effectiveness Evaluation (REE) field assessment is appended for reference (see Appendix 1).

The Routine Riparian Evaluation Questions

Question 1. Is the channel bed undisturbed?

A significant increase in the supply of sediment to a stream system can lead to severely aggraded channels. This condition is often noted in watersheds with many recent or active slides, eroding roads, or collapsing/eroding banks. As a channel aggrades, or fills in, channel morphology becomes simpler because the riffles extend longitudinally into pools. In severely aggraded streams, the pools get filled in, eventually disappearing altogether. Resting and feeding areas with good cover for fish are lost.

The opposite of channel aggradation is channel degradation. In this case, the damage to fish habitat is the result of too little sediment. This condition is often noted downstream of obstructions such as weirs or dams (man-made, beaver), logjams, or culverts that block or impede the natural downstream movement of sediment (boulders, cobbles, gravel, sand, and silt). As the local channel sediment below obstructions is moved downstream by normal fluvial processes, with no replacement of sediment from either upstream or the banks, channel morphology becomes less complex. It may ultimately result in severe fish habitat loss. Spawning habitat is especially affected.

For both excessive aggradation and degradation, the result is usually a reduction in deep or shallow sections of the channel (i.e., channel depth becomes more uniform, the number of pools is reduced, and the amount of productive fish habitat is reduced).

Indicator Statements

To determine the answer to Question 1, first decide what the predominant channel morphology is, as described previously, then complete the section for that morphology.

Question 1 needs information on three indicators (mid-channel bars, lateral bars, multiple channels) to answer the question. Only two out of three indicator statements need a **Yes** answer in order to answer **Yes** to the main question. Some of the answers will be quite easy. The thresholds should also be relatively easy to remember (e.g., 25 or 50% thresholds in the case of how much of the reach has different types of bars and multiple channels).

The answer to indicator statements may be obvious in some streams. When the answer isn't obvious, measurements may be required. For example, for Question 1, a measurement of the length of reach occupied by the different bar types may be required.

Record the reach length occupied by multiple channels, lateral bars, and mid-channel bars or sediment wedges. Use a hip chain or hand-held tape to directly measure the length of the reach with the bar types, or visually estimate the length in short manageable sections of known length. Where the same type of gravel bars overlap do not measure the overlap twice.

TIP: Mid-channel bars, diagonal bars, spanning bars, and braided bars should all be treated as mid-channel bars. They all indicate aggrading channels. Sediment wedges are gravel bars that are piled up behind an obstruction, usually LWD. They are called wedges because a longitudinal section through them resembles a wedge. Like mid-channel bars, they are usually an indication of an aggrading channel, and should be recorded with mid-channel bars. Both indicate aggrading channels (see Figure 2).

TIP: Multiple channels include any active channel that is separated by an "island," whether the "island" is vegetated or not. Bare, unvegetated mid-channel bars have multiple channels that equal the bar in length.

TIP: Lateral bars, point bars, and sidebars are different names for essentially the same type of gravel bar (see Figure 2). These bars are typical of stable, meandering medium-to-large gravel-bedded streams, where a gravel bar forms on the inside of the meander bend. The bars are formed mainly from sediments that are being continually eroded out of a bank on the opposite side of the stream, usually opposite or just upstream of the gravel bar. To form the bars, the stream must therefore have enough energy to erode the stream banks. Since not all streams have the energy to continually erode the stream banks, not all streams have lateral bars. Once a channel is eroded, the remaining bank material may be too large for the stream to continue to erode.

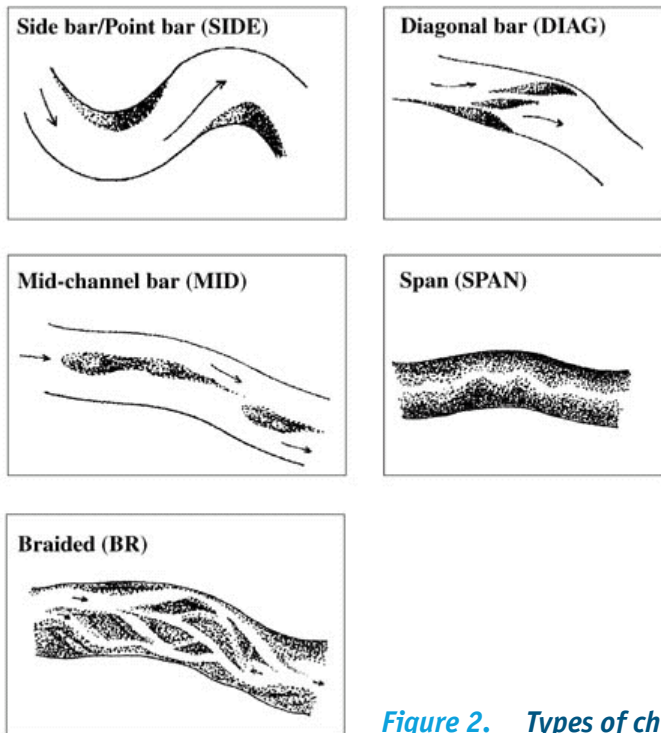


Figure 2. Types of channel bars.

Question 2. Are the channel banks intact?

Streams and stream channel banks by definition are erosion features. When we ask if the channel banks are disturbed, we are really asking if they are recently disturbed. Over time, banks do stabilize and become vegetated if there is adequate soil. The tops of the banks especially become vegetated because they are high enough above the mean annual flood level to escape the constant negative effects of flow on germinating seeds and seedlings that lack developed root systems. As vegetation grows and encroaches on the stream, overhanging banks develop because the root mat is strong enough to be “cantilevered” out over the stream when stream flows erode the soil out from underneath.

The banks of most streams, lakes, and wetlands in their natural undisturbed state are protected from excessive fluvial erosion or wave action by vegetation with well-developed root systems. Most trees, shrubs, and native grasses will serve this function. These plants also trap sediments to build and restore banks.

Forest harvesting or excessive grazing can reduce or eliminate the amount of deep-rooted vegetation present on the banks of aquatic habitats, thereby reducing the ability of the banks to withstand erosion through fluvial erosion or wave action. When the sediment load in a channel is increased, banks can be further eroded as the channel widens in order to deliver the sediment-laden flow downstream. Falling, yarding, windthrow, and trampling by large animals can also directly crush, collapse, shear, or otherwise damage stream banks.

Recently disturbed stream banks, if widespread enough, can be directly responsible for filling in or blanketing the substrates with fine and sand-sized sediments. They can also contribute substantial quantities of coarser sediments (gravel, cobbles, and boulders),

leading to further channel aggradation and dewatering.

Recently disturbed banks can be identified by some of the following characteristics:

- there is no overhang;
- banks are sloped backwards or vertical with no vegetative cover;
- live exposed roots have a ragged appearance, with numerous fine rootlets exposed;
- live roots have de-barked areas with no signs of recent healing;
- exposed soil is largely unoxidized;
- exposed soil lacks any evidence of natural armoring; or
- clumps of bank material that have collapsed or been sheared off rest on the stream bottom.

Question 2A and 2B have four indicator statements:

- a) length of stream bank with deeply rooted vegetation;
- b) length of stream reach with recently disturbed banks;
- c) length of stream reach with recently upturned root wads; and
- d) length of stream reach with stable undercut banks.

Question 2C (for non-alluvial channels) has only three indicator statements (a, b, and c). Indicator statement d) about stable undercut banks does not apply to non-alluvial channels.

Indicator statement a) about the length of stream bank present with deeply rooted vegetation is only measured for the bank adjacent to the activity being assessed. If only one side has an activity (e.g., logging), then only that side closest to the activity is measured for the length of deep-rooted vegetation present. The other side is ignored if both sides of the stream have an activity or treatment that is being assessed (i.e., both sides are logged), then both banks are surveyed, and both must have deep-rooted vegetation to be counted.

For the other three indicators (disturbed bank, upturned root wads, and stable undercut bank), measure the total length of each indicator on both banks even if the management activity being assessed occurs on only one side of the stream. However, do not record stream length twice where the indicator on one bank overlaps the same indicator on the other bank. Percent of the reach with disturbed banks, upturned root wads or stable undercut banks is the length of each indicator divided by the total erodible reach length. Total erodible reach length is total reach length minus non-erodible (i.e., bedrock controlled) bank length.

TIP: Banks that have lost or lack deeply rooted vegetation are not considered disturbed until there is also evidence of recent disturbance on the face of the bank.

TIP: Only banks that are potentially erodible are considered. Non-erodible banks (i.e., banks composed of large rock or bedrock) are not considered part of the reach when assessing bank condition. If the banks are composed entirely of non-erodible material, there is little likelihood they will be disturbed. The answer to Question 2

then would be **Yes**, the banks are undisturbed.

TIP: When assessing the amount of bank with deeply rooted vegetation, consider only the vegetation within 1 m of the rooted edge (i.e., the natural mean annual high-water mark).

TIP: Deeply rooted banks are not the same as stable undercut banks. All of the banks could be deeply rooted due to the trees and shrubs present, but this is no guarantee that the banks will also be undercut.

Stable undercut banks are banks that are usually vegetated and overhanging the stream. The root mass of the vegetation holds the soil together as the stream erodes away the deeper, non-rooted portions of the bank underneath the vegetation. The bank ends up looking “cantilevered” out over the stream. The extent of the overhang will depend on the strength of the root mat, the size of the stream and the type of bank material. Fine-grained soils with a vigorous cover of vegetation will be more undercut and stable than coarse grained, weakly rooted soils.

The depth of undercutting present refers to the horizontal distance from the edge of the bank to the back of the undercut (Figure 3). There are no firm guidelines on how much undercutting is required before undercut banks can be said to be present. For the purpose of this protocol, this depth should probably be at least 2% of the total channel width. The height of the undercut above the streambed should also be within two times this distance. Thus stable undercut banks on a 2-m wide stream should be at least 4 cm deep (2% of 2 m) and no more than 8 cm above the streambed. A 10-m wide stream should have undercut banks 20 cm deep and no more than 40 cm above the streambed.

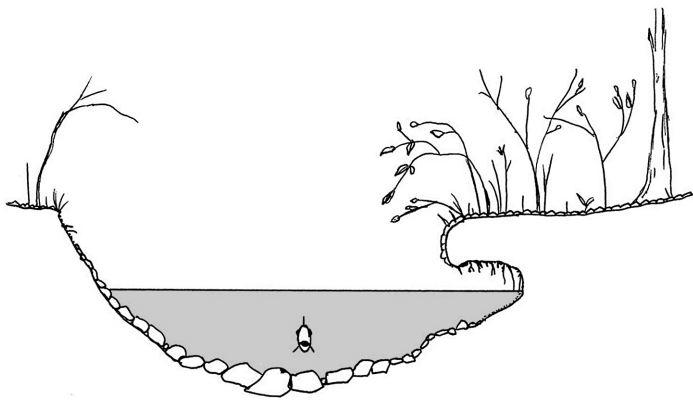


Figure 3. A cross-sectional view of a small stream showing a stable vegetated overhanging bank on the right. The bank is “cantilevered” out over the channel, with no obvious signs of recent erosion.

A stream bank can overhang the stream, but if the overhang is less than 2% of the channel width, or more than twice this length above the streambed, it probably should not be counted as an undercut bank (Figure 4). A stable undercut bank should be distinctly cantilevered out over the stream, not just overhanging because it is in the process of collapsing.

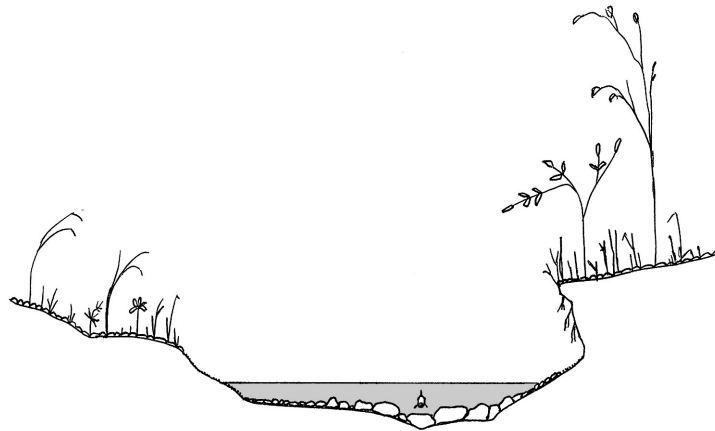


Figure 4. A cross-sectional view of a small stream with an unstable, overhanging bank on the right side. The distance from the streambed to the top of the bank is distinctly more than twice the extent of the overhang. The bank is not clearly “cantilevered” out over the stream.

Question 3. Are channel LWD processes intact?

Channel LWD processes are the how, when, and where of what happens to LWD after it enters a stream channel (i.e., how, when, and where it is stored, broken down, and transported down the channel). Changes in channel LWD processes can have a major impact on the fish habitat characteristics of streams, regardless of whether the streams are dependent on LWD or not. For the purposes of this protocol, LWD is defined as branches or stems with a diameter equal to 10% of the channel depth at the crest of the riffles. For small streams where the channel depth may be only 15 cm, LWD would be any piece of wood with a diameter of at least 1.5 cm. For a stream with a channel depth of 50 cm, LWD is any wood with a diameter of at least 5 cm. Length is not a factor.

In Question 3, there are up to five indicator statements for each of the three categories of channel types – riffle-pool/cascade-pool, step-pool, and non-alluvial. The focus is mainly on the impacts of timber harvesting as opposed to range use. To answer the question, first decide what the predominant channel morphology is, then complete the answers to the indicator statements. Answer **Yes** to Question 3 if there is no more than one **No** answer to the indicator statements.

All three channel types share four of the same indicator statements, as follows:

1. Most woody debris is old and does not appear to have been recently deposited.

TIP: “Most” is more than half the apparent volume. “Old” refers to debris that was present before the treatment (i.e., the most recent harvesting or road building). “Recently deposited” means debris that was deposited after road building and harvesting was completed.

TIP: To be considered “in the channel,” the debris must actually extend into the channel. Logs that are suspended on the banks above the channel are not included, but any branches associated with the log could be in the channel.

TIP: Post-harvest windthrow-related debris is considered “recently deposited debris” if it extends into the channel.

2. Half or more of all woody debris accumulations lack recent debris (e.g., branches, treetops, bark, small logs and LWD with cut ends, recently crushed or shattered logs).

TIP: Debris accumulations may be made up entirely of “old” debris that was present before the management activity being assessed took place. They may also be made up of “new” or “recent” debris that was introduced into the channel. In many cases, debris accumulations will be “old” debris with a new layer of “recent” debris. Debris accumulations with just new debris are treated the same as old debris with additional new debris. Both are counted as debris accumulations with recent debris.

3. Woody debris oriented parallel to the channel banks (particularly small logs and limbs with lengths much less than the bankfull channel width) is not abundant.

TIP: Parallel means not angled away or toward a bank more than 30 degrees off parallel. A long log that is more or less pointing downstream but which goes from one bank to the other bank is not parallel to the stream banks. An abundance of parallel debris means more than one-third of the small logs and limbs present are parallel to the banks.

4. There is no indication that natural debris was recently removed from the channel by hand, slides, torrents, or catastrophic floods.

TIP: Look for saw cuts on debris that was embedded in the stream banks, or on old pre-harvest logs perched on the banks. Also look at debris piles placed on the banks and decide if any of the debris was old, pre-harvest stream debris.

Riffle/cascade-pool and step-pool type streams have an additional indicator – the number of debris accumulations with recent debris present. For riffle/cascade-pool type streams, it is the number of debris accumulations with recent debris that span the channel that need to be counted. For step-pool channels, the indicator is the number of debris accumulations with new debris present, whether they span the channel or not. For both stream types, answer **Yes** if there are fewer than 12 such accumulations present. Answer **No** if there are 12 or more.

TIP: A “logjam” is a debris accumulation that spans the channel. However, not all debris accumulations are logjams. Some are just clumps of debris that only partly span the channel.

TIP: Strictly speaking, a debris accumulation is any collection with more than one piece of debris. Practically speaking, consider a meaningful accumulation of debris to be at least 5–10 pieces that are as long as the channel is wide.

Beaver Ponds and Dams

Treat a beaver dam as debris that spans the channel. When you are assessing streams that are ponded up by beaver dams, try to find a section that represents the normal width of the stream had it not been ponded. Use the width of this section to determine how much of the stream length should be assessed.

Question 4. Is the channel morphology intact?

Question 4 only has indicators for riffle/cascade-pool type streams and step-pool type streams. Only complete the indicators for the type of stream being assessed. If the stream is non-alluvial, then it has no flow-related morphology, and the question is therefore Not Applicable.

The frequent repetition of distinct pool-riffle sequences in streams is one of the hallmarks of productive fish streams. Factors that blur the differences between pools and riffles or cause an actual reduction in

the number of pools or riffles often reduce the amount of productive fish habitat. In this question, the two key indicators are:

1. the number of deep pools – there should be at least two to be considered healthy; and
2. the amount of pool area – more than 25% of total reach length should be pool habitat in riffle/cascade-pool type streams. In step-pool streams, steps and pools should alternate over at least 75% of the stream length. Long cascades should be less than 25% of the channel length.

TIP: Only measure the main pools in a stream – the pools that go from one side of the stream to the other. Do not measure small side or backwater pools, or pockets of quiet water behind boulders in a riffle (Figure 5).

TIP: A deep pool is any pool where the maximum channel depth is twice the average channel depth at riffle crests.

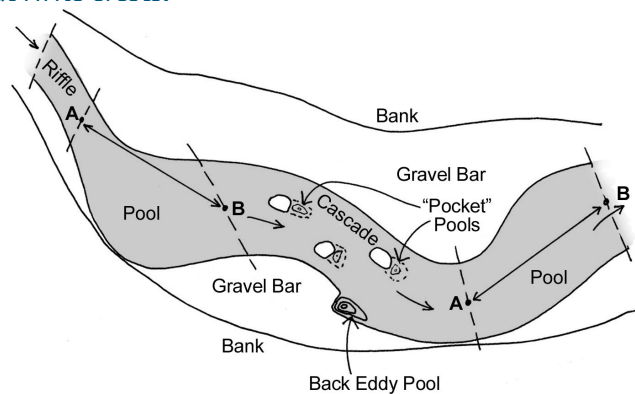


Figure 5. This is a plan-view sketch of two pool-riffle/cascade sequences in a stream. To determine the length of the reach with pool habitat, only measure the length of the main pools that occupy the width of the wetted channel, not back eddies or small scour holes or “pocket” pools behind boulders. Measure the length of the main pools from A to B, the mid-points of the pool-riffle boundaries.

Maximum pool channel depth is the distance from the top of the bank to the deepest part of the pool. Channel depth at the riffle crest is the distance from the top of the bank to the deepest part of the riffle at the pool/riffle break (Figure 6).

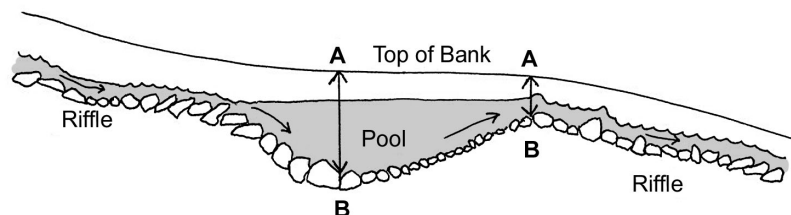


Figure 6. To see if you have a “deep” pool, measure pool depth from the deepest part of the pool to the top of the bank (A to B). Then measure riffle depth at the pool/riffle break below the pool from the deepest part of the riffle to the top of the bank (A’ to B’). A deep pool needs to be at least twice as deep as the riffle.

The last indicator in Question 4 is a heterogeneous substrate. A heterogeneous substrate indicates a healthy channel morphology. A heterogeneous substrate is well sorted, with distinct clusters or lines of boulders, and conspicuous concentrations of gravels and cobbles. In streams with strongly heterogeneous substrates, there are clear differences in substrate composition between pools, pool-riffle breaks, and riffles. There is invariably a large number of different sediment size classes present.

The opposite of heterogeneous is homogeneous. Homogeneous substrates may be composed of different sediment size classes (e.g., small gravels, large gravels, and cobbles), but the different size classes are randomly mixed together. Picture a truckload of sand, gravel, and cobbles all thoroughly mixed together and you have a uniformly random mixture of sediments that is not heterogeneous. Picture a streambed with clumps of boulders in the riffles separated by smaller gravels and cobbles with sands along the margins and you have a heterogeneous substrate. A list of commonly accepted size classes for different sediment types is summarized in Table 2.

Table 2. Sediment size classes

Class	Size (mm)	Description
Fines and sands	<4	Smaller than ladybug size
Gravels	4–64	Ladybug to tennis ball size
Cobbles	65–256	Tennis ball to basketball size
Boulders	257–2000	Basketball size to table size
Rock	>2000	Larger than table size, including bedrock

Question 5. Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments?

Many aspects of forest harvesting can compromise or block fish access to upstream, tributary, or off-channel habitats.

- Newly formed logjams, especially those formed with logging debris, are usually effective sediment traps that can adversely affect fish habitat in the short term (<10 years) by blocking sediment movement downstream.
- Bridges or culverts can also block sediment movement downstream, but they may also constrict flow and create velocity barriers or impassable jumps for fish.
- Roads that lack drainage structures can directly block off-channel areas.
- Access to tributaries or off-channel areas from the main channel can also be blocked if the streambed degrades or cuts down into the streambed (“down cutting”) as a result of a constriction or blockage that impedes sediment movement downstream.
- Excessive aggradations (accumulations of sediment) may similarly block fish access upstream due to dewatering. At dewatered areas in a stream, the water that normally flows over the streambed now percolates through the gravel.

Question 5 uses eight indicator statements to cover the scope of land use impacts on aquatic connectivity. Because of the importance of maintaining connectivity at all times, the answer to Question 5 is **No** if the answer to even one indicator statement is **No**.

There may be more than one reason for a lack of connectivity. Knowing all the reasons why connectivity is affected is important for assessing the effectiveness of the riparian treatment because it may indicate that landscape- or watershed-scale events upstream are contributing factors.

TIP: Dewatering refers to a lack of surface flow. The channel appears dry; however, there may in fact be water flowing beneath the surface. To see whether the channel is truly dry or not, look for bedrock outcrops or very large in-stream boulders where any water present will be visible at the base of these features. Streams typically dewater first in the most downstream, low gradient reaches of a channel because this is where sediments tend to accumulate. Widespread dewatering can result in large-scale fish kills when fish become trapped in isolated pools that subsequently dry up.

TIP: If a stream is dry, be sure it is not because water has been withdrawn or diverted elsewhere.

TIP: A stream should be considered incised and cut off from its adjacent floodplain if the average two-year flood cannot escape the channel.

TIP: Treat beaver dams as logjams, and therefore natural breaks in connectivity to fish, sediment, and debris movements. Answer **No** to Question 5 a) if the beaver dam is new. Answer **Yes** to Question 5 a) if the beaver dam pre-dates the riparian treatment being assessed. If a road crossing is part of the assessment, and there is a beaver dam at the entrance to the culvert or bridge, answer **No** to Question 5 a) and 5 c).

Question 6. Does the stream support a good diversity of fish cover attributes?

TIP: Question 6 is **NA** if the stream is a non-fish bearing stream (RMA class S5, S6).

Question 6 determines the presence of seven possible different types of fish cover. The answer to Question 6 is **Yes** if there are at least five different fish cover types present. The answer is **No** if there are less than five different cover types present. The seven types of cover include:

1. Deep pools – slow moving water that is twice as deep as the average channel depth in riffles. Pools usually have some deep quiet water, but also often contain some shallow parts as well.
2. Stable, unembedded boulders – provide both overhead cover from predators and resting areas from the current. Boulders with moss and/or organic stains are considered stable. Unembedded means that the edges of two boulders (if present) are touching each other. To estimate the total area of stable boulder cover, multiply the average boulder footprint area by the number of boulders.
3. Stable woody debris or root wads – provides protection from the current and predators. More complex arrangements provide better protection from flows and better cover from

predators. A single smooth log in a riffle provides minimal cover, whereas a large permeable logjam on top of a pool provides very good cover. If needed, multiply the estimated length of individual pieces or clumps of woody debris by the estimated width to estimate total area coverage.

4. Stable (usually vegetated) undercut banks – provide excellent protection from predators and the current. The lower the bank and the deeper the undercut extends horizontally under the bank, the better the cover. Measure the length and depth of the undercut to estimate total area.
5. Submerged or emergent aquatic vegetation – aquatic vegetation refers to flowering plant species and long filamentous species of aquatic moss. Measure the approximate length and width of the coverage to estimate total area.
6. Overhanging vegetation – terrestrial vegetation that arches over the channel is considered cover if it is within 1 m of the water surface when the channel is full. Measure the length and extent of the arching vegetation over the channel surface to estimate total coverage.
7. Stable substrate with void spaces for fish to hide in – stable, unembedded gravel, cobbles, boulders, or debris with obvious nooks and crannies underneath them represents good cover for small young and juvenile fish. Unembedded means the sides of the gravels, cobbles, or boulders can be seen touching each other.

To qualify as cover, each cover type should represent at least 1% of the total channel area. For a 2-m wide by 100-m long stream, with a total channel area of 200 m², each cover type should have a total area of 2 m² to be considered present.

A diversity of fish cover types is typical of undisturbed aquatic systems with well-developed riparian habitats. Actual amounts of fish cover can vary substantially, but it is rare for stable streams and riparian habitats in properly functioning condition to not have at least five different types of cover present. The number of different cover types available can be reduced when riparian vegetation is removed, banks begin eroding, and sediment supplies are suddenly increased or reduced.

Be aware of the different types of cover present as you walk up or down the stream, or along the banks. Make a mental note of whether or not there is enough of each cover type to qualify as being present. Some types of cover tend to be very common. Overhanging vegetation, for example, is often present along the entire stream. Other types of fish cover, such as aquatic vegetation, tend to be uncommon and confined to low-gradient, slow-flowing streams.

Question 7. Does the amount of moss present on the substrates indicate a stable and productive system?

A healthy growth of moss on the cobbles and boulders of a stream indicates clean water, stable flows, a stable streambed, and adequate shading and nutrient levels. The relative abundance of moss on streambeds is correlated to fish numbers and/or invertebrate productivity. Poor moss growth usually indicates an unstable substrate, low nutrient levels, or both.

TIP: Moss is almost always restricted to shallow riffles and the margins of pools that are dry during low flow periods. Moss will not grow where it is completely covered with water for too long. It is therefore naturally absent in deep pools of all streams and the deep central sections of riffles/cascades in large streams.

TIP: Shallow, low flowing streams directly exposed to sun all the time will frequently have patches of

bright green, filamentous material waving in the water. It is limp and threadlike when pulled out of the water, with a slightly slippery feel. This is green algae, not stream moss, which closely resembles the common terrestrial species of sphagnum moss.

Question 7 has three indicator statements. The first indicator statement is a measure of abundance:

- a) Moss patches are easily observed from almost any point along the margins, riffles, or shallow pools of the stream. Average coverage on mineral substrates only is 1% or more of the channel bed, from the toe of one bank to the toe of the other bank.

Answer **Yes** if you feel the abundance of the moss in the reach is described by the statement. Also answer **Yes** if you feel that the number of moss patches can best be described as present, common, frequent, or abundant, not lacking, little, or occasional. For more guidance on moss abundance, consider 1% coverage the cut-off for a **Yes** answer if you wish to use cover standards (see Figure 7). Consider Class 1 the cutoff for a **Yes** answer if you wish to use density/distribution standards (see Figure 8).

The second and third indicator statements for Question 7 are related to the condition of the moss. If no moss is present, the statements are marked **NA**. Unless the moss is intact and vigorous, the answers to indicator statements b) and c) will be **No**. The moss will be dead, desiccated, scoured, or buried.

TIP: Healthy moss has a thick spongy appearance, with bright green tips on top of dark green or black stems when new growth is present.

TIP: Thin brown patches on the largest rocks mark patches of moss that have had their green stems washed away, leaving only a smooth, brown root mass. In severely scoured areas, dark blackish stains on the largest rocks may all be that is left of the moss.

TIP: If you can readily see moss on the streambed upstream of a recent slide deposit or road failure, but none in the area of the deposit, it is probably safe to assume the moss has been buried.

TIP: Rolling stones gather no moss.

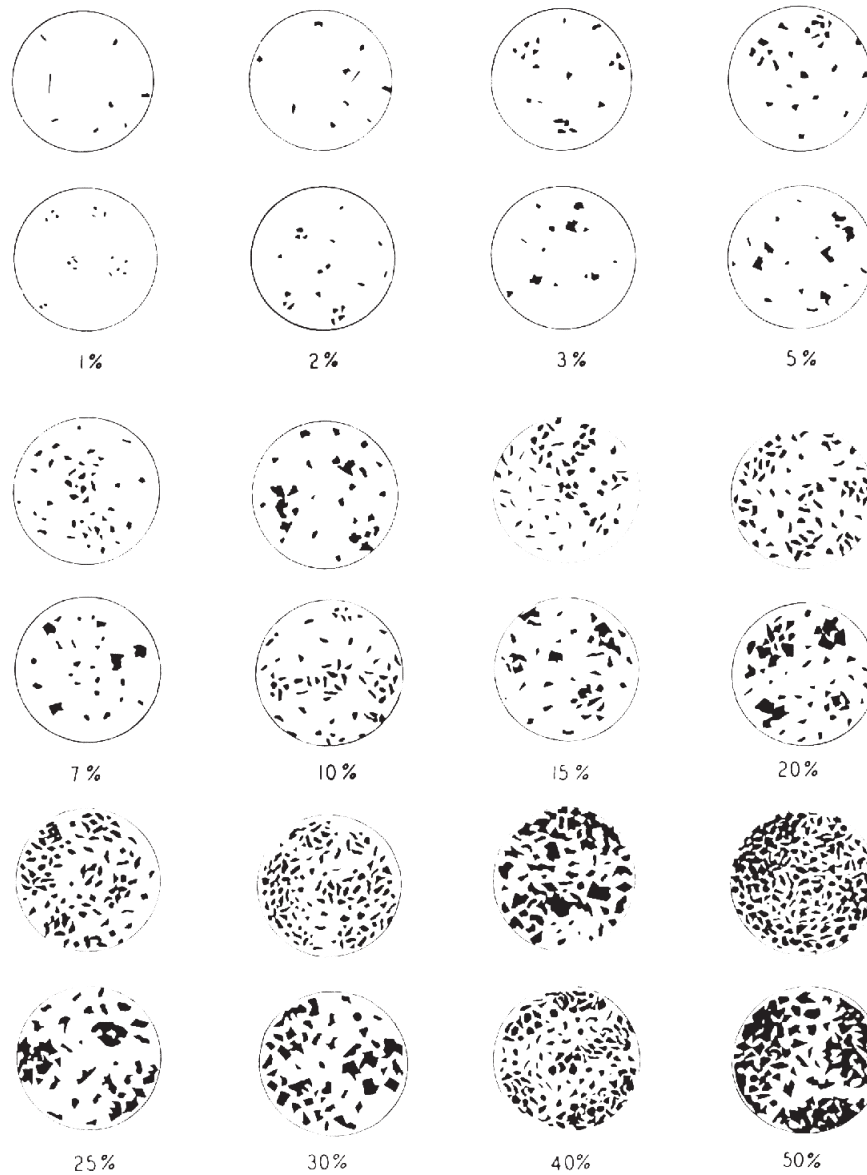


Figure 7. Comparison charts for visual estimation of foliage cover (from Luttmerding et al. 1990).

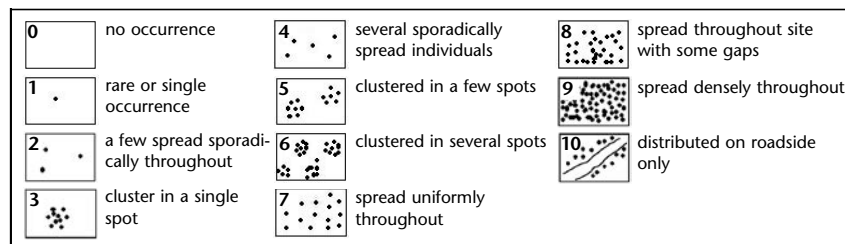


Figure 8. Comparison charts for visual estimates of plant density/distribution.

Question 8. Has the introduction of fine inorganic sediments been minimized?

An increase in sediment supply can lead to harmful channel aggradations. If the sediment supply is fine textured, it can also lead to harmful impacts on inter-substrate fish and invertebrate habitats by filling in the nooks and crannies in the substrate, or blanketing the surface.

Fine sediments may be easily observed on the surface of the streambed, particularly when recently deposited. Over time, fine sediments may be incorporated into the streambed where they are not as visible. In some cases, the streambed may be so completely filled in with fine or sand-sized sediments as to be completely impermeable, yet the streambed may still look fine on the surface.

Because of the complex nature of fine sediment impacts on streambeds, four very different indicator statements are used to assess the impacts of fine and sand-sized sediments on streambeds. Many other potential assessment methods exist (e.g., measurements of subsurface dissolved oxygen concentrations, flow rates, percent composition), but these are typically time consuming and expensive to conduct.

The four indicator statements for Question 8, with explanatory notes, are as follows. If the answer to any indicator statement is **No**, the answer to Question 8 is also **No**.

- a) Inorganic fine and sand-sized sediments on the substrate are best described as little or lacking. Average coverage is less than 10%, with no single area over 50%.

TIP: Organic materials are not considered to be sediments. Unlike organic sediments, inorganic sediments have a “gritty” feel to them that can be used to distinguish the two types of sediment. Sand-sized particles are particles up to 4 mm in diameter. “Little” can be interpreted to be no more than 10% coverage on average, with no sites with more than 50% coverage. If the amount of fine and sand-sized sediments present is not obvious, estimate the coverage along a line across the stream at five or six points along the reach traverse to confirm the approximate amount of sediment in the stream.

- b) Wetted areas of gravel, sand or fine-sized sediments that a foot can be easily pushed or wiggled into represent less than 1% of the total wetted area. Mark **NA** if the stream is dry.

TIP: Wetted areas that a foot can be pushed or wiggled into feel like “quicksand” or “quickgravel.”

- c) Gravels and cobbles are not embedded in a matrix of sand or finer sized particles. The sides of individual gravel and cobble particles can generally be seen touching each other.

TIP: Gravels and cobbles that are embedded in fines and sand look as if they are cemented into place. Fines and sands occupy the space between the gravel or cobble particles.

- d) Invertebrates sensitive to the effects of sedimentation are present at most sample sites. Mark **NA** if the stream is dry.

TIP: Because they have external gills, caddisflies (i.e., “case-makers”), mayflies, and stoneflies are the insects most commonly considered to be sensitive to the effects of fine and sand-sized sediments. “Easily found” should be interpreted as being present at any suitable site inspected along the traverse. A suitable site is a riffle with stable subangular cobbles and boulders that can be easily picked up and examined by hand.

Question 9. Does the stream support a diversity of aquatic invertebrates?

Healthy gravel-, cobble-, or boulder-bedded streams that flow most or all of the year will almost always have many different kinds of invertebrates at all times of the year. Easily affected by a wide range of substances, such as sand, silt, toxic compounds, inorganic or organic pollutants, the diversity of the benthic invertebrate community is a good direct assessment of properly functioning condition.

TIP: Question 9 is considered **NA** if the stream is dry, or strongly suspected of being dry most of the year. If a stream only flows during winter, the number of invertebrates may be very low because the stream has to be colonized by invertebrates every year. Even streams that flow year-round can seem barren if the area being sampled has only recently been covered with water. Winter colonization rates on previously dry portions of a stream can be very slow.

Most of the aquatic invertebrates in streams are called “benthic invertebrates.” The word “benthic” means bottom. Benthic invertebrates therefore live on the stream bottom, mostly under the rocks, but also on the top and sides of rocks if the rocks are stable or protected from flows. They also occur on aquatic plants or woody debris, if present. Generally, the more angular and stable the rocks, the higher the number of benthic invertebrates living on them. Substrates composed mostly of fines or organic detritus also have benthic invertebrates, but they are usually not as abundant or diverse as on stable gravel and cobble substrates.

Sample Methods

There are many different ways invertebrates can be sampled in streams. For the riparian checklist, simple hand collections with a small portable net and small white tray are recommended. As close as possible to each sample station, select a riffle with a substrate that can be stirred up by hand, not too large (e.g., large boulders), but not too small either (e.g., all mud). While holding the net on the streambed, stir up the substrate upstream of the net so those invertebrates clinging to the substrate are washed down by the current into the net. Sample an area as wide as the dip net and two to three times the area of the dip net opening. Try to minimize the amount of mud, sand, or organic debris collected. Empty the net and its contents into the white tray with a little water.

With clear water and not too much debris in the tray, any invertebrates present in the sample should be quite visible. If there is too much debris, put some of the debris back in the net and examine smaller amounts until all of the sample is gone. If the water is cloudy, gently tip the excess water out and replace it with clean water. Because invertebrates are heavier than water, they will sink to the bottom of the tray as you tip excess water out of the tray.

A hand lens can help identify or confirm the presence of invertebrates. Most invertebrates, however, are identifiable as to its main type with the naked eye. As a person gains experience, rocks can be picked up and examined directly to identify the type of invertebrates present. Remember, it is only the number of different types of invertebrates present that is important, not the number of each type of invertebrate.

Ponded or Organic-Bedded Streams

Some streams may be almost all pool habitat with deep quiet water and substrates composed of fine organic detritus. For these streams, we recommend gently dragging the dip net along the bottom or sides of the stream for 20–30 cm to collect a 1- to 2-cm thick sample of the substrate.

Number of Sites to Sample

We recommend six sites be sampled to determine overall average invertebrate diversity for the stream reach. In some very uniform reaches, however, it may be possible to determine that the reach as a whole has many different kinds of invertebrates by just looking at one site. If this is not the case, investigate the site more thoroughly. If it still looks like there are only one or two types of invertebrates present, at least two other locations should be sampled before drawing conclusions on invertebrate diversity.

Identifying Invertebrates

Look at the illustrations in Figure 9 for some of the most common benthic invertebrates found in streams. Most invertebrates will be insects, but other major groups include worms (nematodes, flat worms, true worms) or snails and clams (molluscs). Crustaceans (freshwater shrimp water fleas) may also be found if lakes or wetlands are flowing into the stream. The most common stream benthic invertebrates found in streams typically include mayflies, caddisflies, chironomids (midges), other Diptera (true flies) larvae, oligochaetes (small worms), and stoneflies.

Sensitive Invertebrate Types

Insects with external gills and freshwater clams are considered to be sensitive invertebrate types. Insects with external gills include mainly mayflies, stoneflies, and caddisflies. The two to three tails present can readily identify mayflies and stoneflies. Caddisflies can also be easily identified because almost all build distinctive cases to live in made of sand, small pebbles, wood, twigs, or needles. Free-living caddis flies or caddisflies that have lost their cases can be identified by the presence of two prolegs at the end of their abdomens. Each proleg will have a single hook. Other sensitive invertebrates include “water pennies” (Coleoptera), riffle beetles, Dobson flies (“helgrammites”), clams, and snails that have their opening on the right when held toward you with the open end on the bottom.

Scoring

Answer **Yes** to Question 9 if two or more of the indicator statements are answered **Yes**.

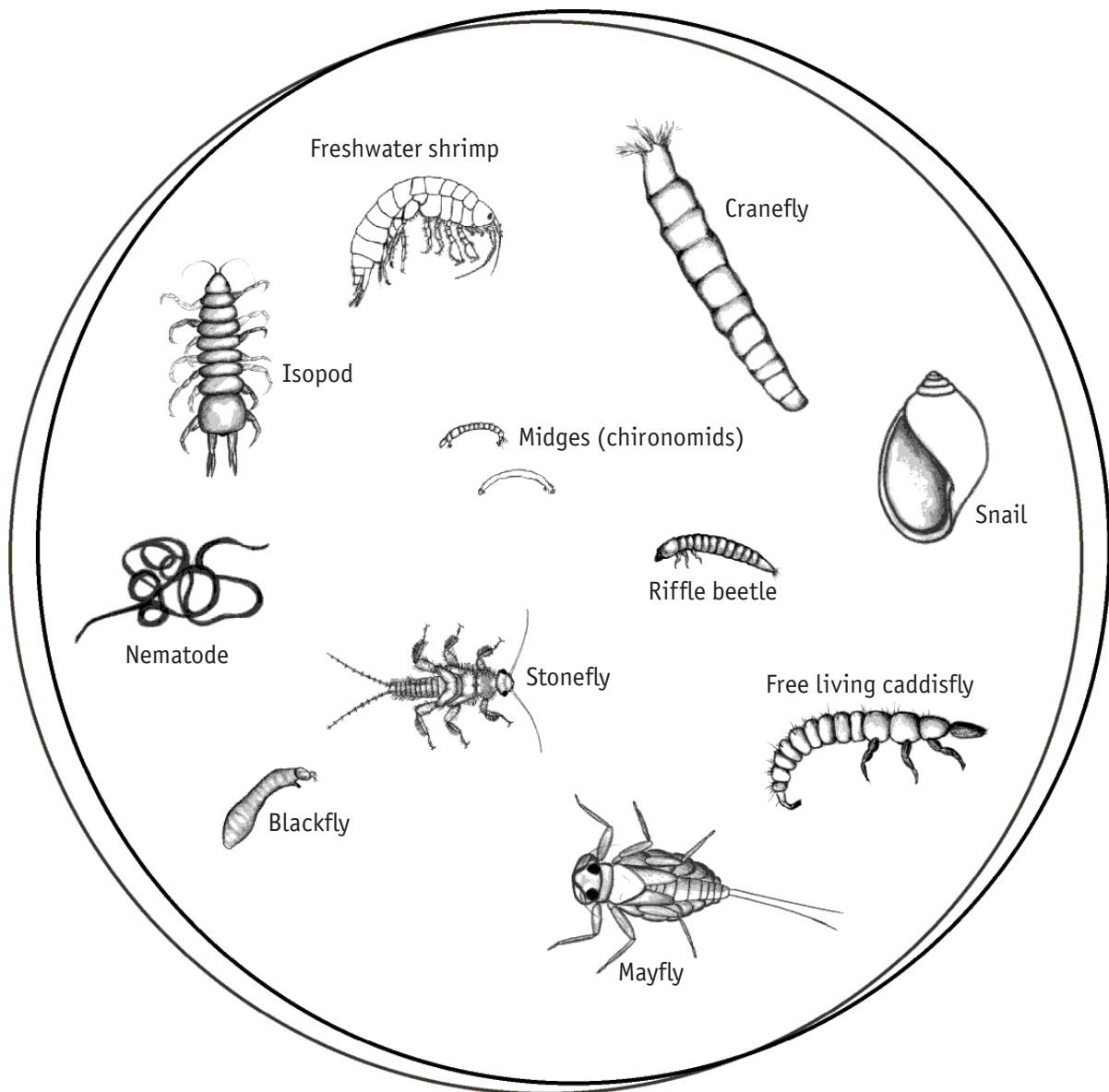


Figure 9. Examples of common benthic invertebrates.

To help with identifying invertebrates, refer to the Field Guide to Freshwater Invertebrates in Appendix 2.

Question 10. Has the vegetation retained in the RMA been sufficiently protected from windthrow?

One of the main objectives of a RMZ is to protect riparian reserves from excessive windthrow. The amount of windthrow present in riparian reserves is, therefore, a direct indicator of how successful or effective the management zone is in protecting the reserve.

On streams that lack riparian reserves, management zones are used mainly for retaining key wildlife habitat attributes characteristic of natural riparian systems, providing some shade to reduce bank microclimate changes, and maintaining bank and stream stability. In this regard, windthrow is a direct indicator of management success or failure. If retained trees blow down, then it is likely that key wildlife attributes will also be disrupted. If windthrow is extensive, there is a good chance that the integrity of the stream and stream bank environment is also compromised.

Question 10 has three indicator statements, only one or two of which will be applicable to any given stream. The number of applicable statements depends on if a reserve is present, if only a management zone is present, or if designated wildlife trees or wildlife tree patches are present beside the stream.

Sample Methods

Percent windthrow over and above what was naturally present in the riparian area prior to the treatment must be estimated in order to answer the indicator statements. A simple visual estimate of percent windthrow is appropriate if the percent of trees windthrown is clearly less than 1%. A visual estimate is also appropriate if the amount of windthrow is greater than 10% of the trees in reserve zones, or 20% of the trees in management zones. Whatever estimate is used to answer the questions should be noted on the field data card.

More quantitative measures of windthrow are needed if the threshold values in the indicator statements have not obviously been met or exceeded. Any method is suitable, provided it is reasonably accurate and readily reproducible. A direct count of all standing and windthrown trees is the simplest and most straightforward method. All trees in the reach can be enumerated this way, or the reach could be subsampled.

Types of Trees to Count

Windthrow is any dominant or co-dominant tree that has been snapped off or tipped over by a strong wind. Sub-dominant trees are not included in the counts unless they were the only trees retained. To be called windthrow, a wind-snapped tree has to be linked to the stem it snapped off. Tipped over trees have to have a definite root wad or root plate attached to it. Trees that have no obvious root plate or a root plate that only has the “stubs” of the main roots present should not be counted as windthrow. Snags that snap off should also not be counted as windthrow.

The terms “new,” “recent,” “post-harvest,” and “post-treatment” windthrow all mean the same thing. Harvest refers to logging, while treatment is a more inclusive word meant to cover any and all management activity, including harvesting. Other treatments being assessed could include cattle grazing, urban development, or hydro development.

“New,” “recent,” “post-harvest,” and “post-treatment” windthrow is windthrow that occurred after the treatment being assessed (usually the last harvest date). Old windthrow is any windthrow recognizable as such that occurred before the treatment. Sometimes the “new” windthrow can look quite old if a cutblock was last harvested many years ago. In these cases one often has to be a bit of a detective to separate out trees that had blown over before the harvesting started. Aging conks growing on the different trees can be used sometimes to decide if a windthrow was old or new. Age the conks by counting the “growth rings.”

Width of Riparian Area to be Assessed

In a RMA, if a reserve is present, the entire reserve or wildlife tree patch should be assessed for windthrow. Also check for windthrow in the adjacent management zone if trees were retained. If there is no reserve or wildlife tree patch, the entire management zone should be assessed, provided some retention was prescribed.

Calculating % Windthrow:

1. % Old Windthrow = $\frac{(\# \text{ Old Windthrown Trees})}{(\# \text{ Standing Trees} + \# \text{ Old Windthrown Trees} + \# \text{ New Windthrown Trees})} \times 100$
2. % New Windthrow = $\frac{(\# \text{ New Windthrown Trees})}{(\# \text{ Standing Trees} + \# \text{ New Windthrown Trees})} \times 100$

To calculate percent new windthrow over and above the natural pre-treatment windthrow, subtract calculation 1 from calculation 2.

Question 11. Has the amount of bare erodible ground or soil disturbance in the riparian area been minimized?

Bare erodible ground is any soil or fill with particles smaller than “pea gravel” that is not covered by plants, litter, lichens, moss, downed wood, or coarse gravel. Bare erodible ground is exposed soil or erodible mineral deposits that water can wash into the adjacent stream. Examples include road cut-and-fill slopes, bladed trails, gouges and scalps due to yarding, tipped over root wads and windthrow scars, slides, and slumps. It also includes animal trails or recreation trails if mineral soil is exposed. Exposed soil subject to erosion contributes to stream channel infilling and bank erosion, reduces sediment entrapment, alters rainfall run-off rates, and provides an opportunity for invasion by weeds.

Bare ground includes discrete patches of ground such as root wad scars left when a tree blows over. For this type of bare ground, estimate and record the area of the ground exposed at each site, and tally up the total at the end of the survey. For root wads, there may be two surfaces to consider, the root wad itself if it has soil attached to it and is susceptible to erosion, and the root wad scar, which may still contain soil that can erode.

Bare ground also includes the ground exposed in thinly vegetated areas, possibly due to over grazing. For this type of bare ground, use the percentage cover cards to estimate total bare ground area (see Figure 7). If the surface of the bare erodible ground is partially covered with non-erodible material such as plants, litter, lichens, moss, downed wood, or coarse gravel, the area has to be “netted down” to arrive at a more accurate estimate of the area of bare erodible ground. In complex areas, stratify the area and estimate bare ground in each stratum.

Sediment deposited on the ground in the first 10m of the riparian area from upslope sources is considered bare ground for Question 11, but not if the sediment is deposited due to flooding (i.e., overbank deposits).

Bare Ground in the Riparian Area vs Bare Ground Hydrologically Connected

With the exception of active roads and seasonally or temporarily deactivated roads, all bare ground is considered within the first 10-m of the riparian area past the edge of the stream, even if it is not obviously hydrologically connected to the stream. Active roads within the first 10 m of the riparian area must be hydrologically connected to the stream, while all other bare ground outside of the first 10 m must be hydrologically connected to the first 10 m of the riparian area before it is considered. Seasonally or temporarily deactivated roads are treated the same way as active roads. Examples of bare erodible ground outside of the riparian area could include road surfaces, slides, or debris torrents in tributary streams. There is no limit on how far away the bare ground is from the first 10 m of the riparian area, as long as it is hydrologically connected to the stream. To be considered hydrologically connected, the bare ground must either be on a steep side slope within 30 m of the stream edge, or contain a channel that leads to such a slope or into the first 10 m of the riparian area (see Figure 10).

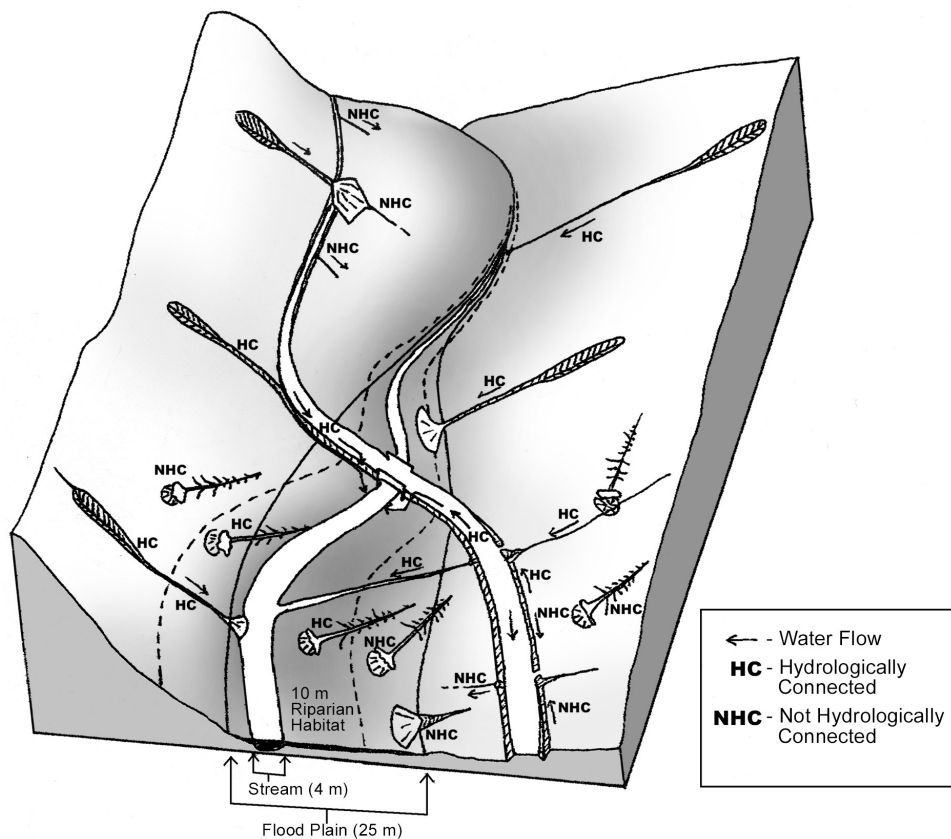


Figure 10. A hydrological connection diagram showing where erodible soils (from windthrow, road surface, ditch or slope failures) are hydrologically connected to a non-gully type stream reach.

The hydrological connection of some exposed soils will be obvious. For example, a slide or slump that starts 50 m above the riparian area and extends to the stream is obviously connected. Other sources will not be so obvious. Cross-ditches or culverts on roads will frequently form short channels on the slopes below the road, but dissipate further down the slope. To be considered connected to the stream, the channels should reach the first 10 m of the riparian area, or the first 30 m of a steep slope leading to the stream. Bare ground on level slopes with no distinct drainage channels leading to the first 10 m of the riparian area or a steep slope within 30 m of the stream is not hydrologically connected.

Active Roads

Active roads are treated differently from other roads that impinge on the first 10 m of the riparian area. Because of the large area they represent, including active roads as bare ground would automatically give a **No** answer to Question 11, even where good design and erosion control measures mean no erosion products can enter the stream. To eliminate this potential bias against road crossings, or roads that closely parallel streams, the surface area of a road and its fill/cut slopes within the first 10m of the riparian area is only considered bare ground if it is hydrologically linked to the stream and riparian area outside the road lens. If poor design means that the road surfaces are hydrologically linked to the stream, the area(s) considered linked is to be included with all other bare ground considered hydrologically linked.

Evidence of hydrological linkage should be conspicuous, such as ruts or eroding tracks down the road, possibly with small rills down the sides of the fill slopes to the ditches, or a direct connection between the ditch and the stream.

Estimating the area of bare erodible ground hydrologically connected to a stream or its riparian area can be challenging. Not all surfaces have the same amount of material susceptible to erosion. Some surfaces may be all erodible soil, others may be a mixture of rock, vegetation, other debris, and erodible material. Not all surfaces will be equally connected to the stream either. Some may show direct movement from the source to the stream via a conspicuously eroded channel. However, others may have only a small chance of making it to the stream due to vegetative cover or ground infiltration.

Table 3 is an example of how the total area of bare erodible ground hydrologically connected to a stream at a hypothetical road crossing can be estimated. The crossing assumes that only the right approach is of any concern because the left approach slopes away from the stream.

Table 3. *Estimating total bare erodible ground*

Road Section of Concern	Length (m)	Width (m)	Bare erodible ground exposed (%)	Chance of erodible material reaching the stream (%)	Bare ground hydrologically connected (m ²)
Running surface	150	5	20	10	15
Left fill slope	150	2	10	50	15
Right fill slope	150	0	5	50	4
Right cut slope- Section 1	100	2	90	10	18
Right cut slope- Section 2	50	3	30	100	45
Total bare ground hydrologically connected (m ²)					97

Total bare erodible ground that is hydrologically connected for each road area of concern is the product of length, width, % bare erodible ground present, and the chance that erodible material will reach the stream or riparian area.

For example, total bare erodible ground on the running surface hydrologically connected is: 150m X 5m X 0.2 X 0.1 = 15m².

Total bare ground on the entire road right-of-way that is hydrologically connected is the sum of all the products for each road section, or:

$$15\text{m}^2 + 15\text{m}^2 + 4\text{m}^2 + 18\text{m}^2 + 45\text{m}^2 = 97\text{m}^2.$$

Disturbed Ground

Disturbed ground is ground that is compacted and sheds water quickly. It is not otherwise susceptible to erosion because it is still largely covered with vegetation, wood, mulch, duff, gravel, or rock. Disturbed ground also includes the pugging and hummocking found where cattle are walking through heavy, saturated soils. When cows or other hooved animals step into the soft vegetated ground in riparian areas, their track shears off the vegetation around the edge of the track, leaving what looks like bare ground that has been compacted in the track. In between the tracks, the ground bulges up in response to the ground being compacted by the tracks. The hummocks tend to dry out, changing the characteristics of the riparian soils substantially.

Hummocking is disturbed ground because it certainly isn't bare. The pugging could be considered bare or disturbed, but if it is called bare ground, then it should only include the exposed soil that is susceptible to erosion. In practice, it is easier to just measure the whole area that is disturbed by all the tracks and call it disturbed ground. If the riparian area of interest is so badly trampled that there is no vegetation or duff left, and there is only soil left that will erode or is eroding into the stream, it would be properly called bare ground. To estimate area affected by pugging and hummocking, use the widest dimensions of the area affected. If pugging is considered bare ground, the total area must be netted down so that only bare ground is measured.

Other disturbed ground includes animal trails that are still covered with vegetative

material, backspars trails, ruts, and paved surfaces. Because they are compacted by nature, the running surfaces of unpaved roads and landings could be called disturbed ground. Even if they are not erodible, they shed water quickly because of the absence of vegetative cover. They are also difficult to revegetate because of their compacted nature. If a road is “de-built” or “de-compacted,” it should no longer be called disturbed ground, but rather bare ground until it is revegetated or otherwise protected (e.g., mulched) from erosion.

Question 12. Has sufficient vegetation been retained to maintain an adequate root network or LWD supply?

An adequate root network is needed to maintain bank strength in all streams. Together with LWD, roots also help to maintain the channel form of many small streams <2 m wide. Roots become less important in maintaining channel form in streams larger than 2 m wide; however, many streams 25–40 m wide continue to be dependent on LWD for much of their form, depending on slope gradient. To determine whether a stream is dependent on LWD, refer to Figure 11.

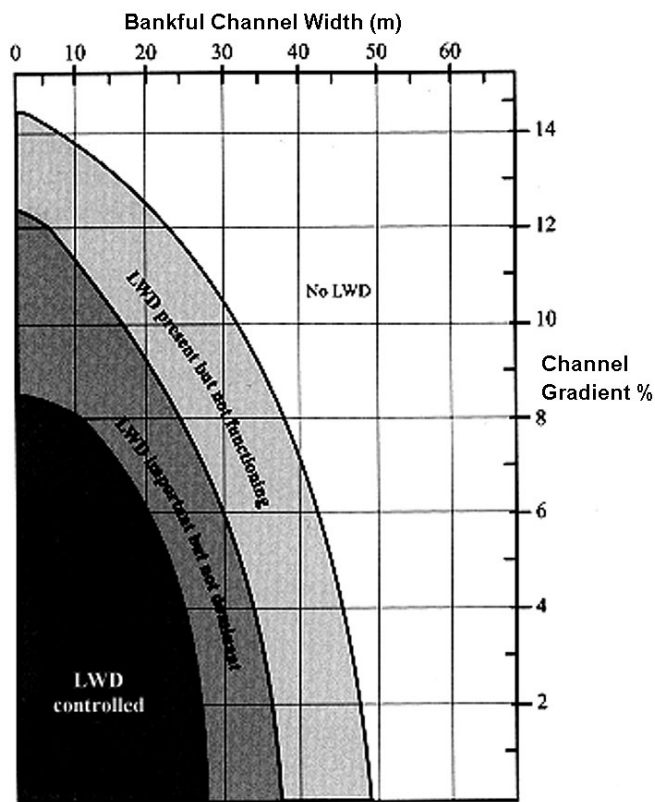


Figure 11. Determining the influence of LWD on channel morphology.

Large woody debris can fall directly into a stream from the adjacent bank, it can float downstream from upstream areas, or it can enter a stream from upslope areas via slides. In streams where there is no upstream or upslope supply of debris, 99% of the LWD supply comes from the first 10 m of the riparian area.

The seven indicator statements needed to answer Question 12 are based on the stream classification and retention levels recommended as best management practices in the Riparian Area Management Guidebook (Province of B.C. 1995). Determining retention levels is fairly straightforward, and can be estimated visually very quickly. It is not the intention of a riparian evaluation to confirm that an intact 20 or 30-m reserve has been retained, only that the supply of LWD is adequate within the first 10 m.

Only one of the seven indicator statements is applicable to all streams (statement a). To answer Question 12, first answer **Yes** or **No** to indicator statement a), and then proceed to the one additional statement that matches the classification of the stream reach being assessed.

TIP: The stream's riparian classification should be indicated in the silviculture prescription or logging plan maps. Record the riparian class as indicated in these documents. If no stream classification is indicated, try to assign the class on the basis of gradient (<20%) and channel width (see the Riparian Management Area Guidebook or the FRPA Forest Planning and Practices Regulation). Fish-bearing status will not be possible to confirm unless a fish is sighted. Riparian classification for difficult sites may need to be addressed after the survey is completed.

TIP: Windthrown trees are included in the retention levels. If all of the trees in an otherwise intact 10 m reserve zone have blown over, the retention level is still 100%.

Question 13. Has sufficient vegetation been retained to provide shade and reduce bank microclimate change?

Vegetative cover includes trees, shrubs, and grasses in riparian areas that moderate the direct impacts of rainfall on exposed soils as well as serving many other functions. For example, trees and shrubs also supply food and habitat for terrestrial and aquatic invertebrates, both of which are critical food sources for many vertebrates including fish. Harvesting or intensive browsing and grazing can significantly reduce the vegetative cover of trees, shrubs, and grasses along streams.

Shade in riparian habitats is particularly critical on sunny days for moderating air temperatures and maintaining soil moisture levels. Shade cover varies with plant species, height, and density. It is also sensitive to the time of year, aspect, and latitude because it involves a lateral measurement of light penetration by direct rays of the sun.

Question 13 has four indicator statements, three of which must be answered **Yes** in order to check the **Yes** box for the overall question.

- a) With the exception of active roads at stream crossings, bare ground directly exposed to rain is less than 1% of the riparian habitat in plan view. Bare ground exposed to rain is any bare ground not encompassed by the outside edge of the overhead canopy and understorey shrubs. This edge is sometimes called the "drip line." It differs from foliar cover, which is a measure of foliage density. If bare ground outside the drip line has some other cover component such as grass, woody debris, or stones and rocks, net down the bare ground exposed to rain by the estimated amount of cover.

TIP: Canopy and ground cover together shield bare ground from direct rainfall. If there is no bare ground other than on active road surfaces at stream crossings, bare ground exposed to rain is automatically 0%.

- b)** Shade (the average amount of sky not visible due to vegetation) averages more than 60%, as estimated visually for any two of the east, south, and west aspects at 60 degrees above the horizontal, or as estimated with a “Teti” angular canopy densiometer (operator’s manual provided by the supplier).

The quickest and probably most repeatable method of estimating shade is to hold your hand up at a 60-degree angle and visually estimate the coverage by vegetation visible in a circle made by your thumb and forefinger. Having a cover class card handy (see Figure 7) helps to gauge the coverage. Remember that you can use the percentage cover plots to estimate coverage over 50% by reversing the dark and light areas in your mind.

If they are available, another acceptable method for estimating shade is comparisons of visual observations to reference photographs containing examples of percent shade. Taking photographs for later analysis of shade is not recommended. The software for determining shade requires considerable experience. The process is also time-consuming, after which the results must be entered in the checklists. Making visual estimates in the field by eye or with an angular canopy densiometer is much quicker.

- c)** Moisture-loving macrophytes, mosses, ferns, or other bryophytes are present and in vigorous condition, with no indication of stress due to sunburn, drought, or desiccation.

Answer **No** to this indicator if there are no moisture-loving plants present in the riparian area.

Also mark **No** to this indicator if moisture-loving plants are present but they are scorched, mottled, desiccated, brittle, or otherwise stressed.

- d)** Soil in the riparian habitat is moist or cool to the touch.

Where to Measure Shade

Total shade (cover provided by all vegetation types) may be measured at five or six evenly spaced points along the stream reach. Shade is measured at the edge of the stream closest to the area being assessed, while standing in the stream. Where both sides of the riparian area are assessed, and there appears to be a difference in shade cover on the two sides, measure shade on both sides of the stream and average the two measurements. Large streams (>5 m) will almost always require separate estimates of shade for each side of the stream. Small streams (<2 m) will likely only need one measurement.

Question 14. Have the number of disturbance-increaser species or noxious weeds present been limited to a satisfactory level?

Question 14 has two indicator statements.

- a) Disturbance-increaser plants (domestic grasses, dandelions, pineapple weed, buttercups, etc.) occupy less than 25% of total area in the first 10 m of the riparian zone.

Disturbance-increaser species are native or introduced plants that are typically absent, or present in low numbers, in undisturbed habitats. Populations of these species can become more prevalent with certain kinds of disturbances such as grazing or active roads and trails. Disturbance-increaser plants are not just invasive plants or pioneer plants, but plants that tend to thrive under conditions of constant disturbance. Species like red alder or fireweed are invasive or pioneer species, but they rarely establish themselves where there is constant ongoing disturbance.

Disturbance-increaser species are regarded as undesirable because they tend to not provide a deep-binding root mass for bank protection. An increase in the number of disturbance-increaser species indicates a trend away from the natural plant community in riparian areas, and a decline in the proper functioning condition of the riparian habitat. Most of these species provide less soil-holding and sediment-trapping capabilities, as well as less desirable forage and wildlife values. Although the presence of disturbance-increaser species may be natural, they often suppress the growth of other species that may be better at maintaining or re-establishing root networks and bank strength.

A list of disturbance-increaser species is provided in Table 4.

Table 4. Disturbance-increaser species list

Strawberry (<i>Fragaria spp.</i>)	Pineapple weed (<i>Matricaria matricariodes</i>)
Cinquefoil (<i>Potentilla spp.</i>)	Dock (<i>Rumex spp.</i>)
Yarrow (<i>Achillea millefolium</i>)	Pasture sage (<i>Artemisia frigida</i>)
Baltic rush (<i>Juncus balticus</i>)	Gumweed (<i>Grindelia squarrosa</i>)
Dandelions (<i>Taraxacum spp.</i>)	Pussytoes (<i>Antennaria spp.</i>)
Sow thistles (<i>Sonchus spp.</i>)	Buttercups (<i>Ranunculus spp.</i>)
Foxtail barley (<i>Hordeum jubatum</i>)	Bluegrasses (<i>Poa spp.</i>)
Goatsbeard (<i>Tragopogon dubius</i>)	Plantains (<i>Plantago spp.</i>)
Clovers (<i>Trifolium spp.</i>)	

- b) Noxious weeds occupy less than 5% of total area in the first 10 m of the riparian area.

Noxious weeds are considered separately from disturbance-increaser species. While they can also be disturbance-increaser species, most noxious weeds are invasive, non-native species that are highly competitive. Noxious weeds can spread rapidly to cover large areas and prevent the development of healthy, native riparian communities.

A list of noxious weeds is summarized in Tables 5 and 6.

Table 5. Common noxious weeds within all regions of BC

Annual sowthistle (<i>Sonchus oleraceus</i>)	Purple nutsedge (<i>Cyperus rotundus</i>)
Canada thistle (<i>Cirsium arvense</i>)	Rush skeletonweed (<i>Chondrilla juncea</i>)
Crupina (<i>Crupina vulgaris</i>)	Scentless chamomile (<i>Matricaria maritima</i>)
Dalmatian toadflax (<i>Linaria dalmatica</i>)	Spotted knapweed (<i>Centaurea maculosa</i>)
Diffuse knapweed (<i>Centaurea diffusa</i>)	Tansy ragwort (<i>Senecio jacobaea</i>)
Dodder (<i>Cuscuta spp.</i>)	Velvet leaf (<i>Abutilon theophrasti</i>)
Gorse (<i>Ulex europaeus</i>)	Wild oats (<i>Avena fatua</i>)
Hound's-tongue (<i>Cynoglossum officinale</i>)	Yellow nutsedge (<i>Cyperus esculentus</i>)
Jointed goatgrass (<i>Aegilops cylindrica</i>)	Yellow starthistle (<i>Centaurea solstitialis</i>)
Leafy spurge (<i>Euphorbia esula</i>)	Yellow toadflax (<i>Linaria vulgaris</i>)
Perennial sowthistle (<i>Sonchus arvensis</i>)	

Unless their abundance is obvious (i.e., the plants are absent or obviously greater than the threshold values in the indicator statements), record the coverage for disturbance-increaser species and noxious weeds at six points or plots along the reach to estimate overall coverage along the traverse. Plots can be standard circular plots centred 5 m from the stream bank or 10-m-long line transects that extend 10 m from the stream bank at right angles to the main axis of the stream reach. Use the same bearing for all transects after determining what the bearing is for the main axis of the reach.

Table 6. Common noxious weeds within the boundaries of the corresponding regional districts

Blueweed	<i>Echium vulgare</i>	Cariboo, Central Kootenay, Columbia-Shuswap East Kootenay, Okanagan-Similkameen, Thompson-Nicola
Burdock	<i>Arctium spp.</i>	Bulkley-Nechako, Cariboo, Columbia-Shuswap Fraser-Fort George, Kitimat-Stikine, North Okanagan, Okanagan-Similkameen, Peace River, Thompson-Nicola
Cleavers	<i>Galium aparine</i>	Peace River
Common bugloss	<i>Anchusa officinalis</i>	Kootenay-Boundary
Common tansy	<i>Tanacetum vulgare</i>	Bulkley-Nechako, Central Kootenay, Columbia- Shuswap East Kootenay, North Okanagan
Field scabious	<i>Knautia arvensis</i>	Bulkley-Nechako, Kootenay-Boundary, Thompson-Nicola
Green foxtail	<i>Setaria viridis</i>	Peace River
Hoary alyssum	<i>Berteroa incana</i>	Kootenay-Boundary
Hoary cress	<i>Cardaria spp.</i>	Columbia-Shuswap North Okanagan, Thompson- Nicola
Kochia	<i>Kochia scoparia</i>	Peace River
Marsh plume thistle	<i>Cirsium palustre</i>	Bulkley-Nechako, Fraser-Fort George
Meadow knapweed	<i>Centaurea pratensis</i>	Columbia-Shuswap
Night-flowering catchfly	<i>Silene noctiflora</i>	Peace River
Orange hawkweed	<i>Hieracium aurantiacum</i>	Bulkley-Nechako, Cariboo, Central Kootenay, Columbia-Shuswap East Kootenay, Thompson- Nicola
Oxeye daisy	<i>Chrysanthemum leucanthemum</i>	Cariboo, North Okanagan, Thompson-Nicola, Peace River
Perennial pepperweed	<i>Lepidium latifolium</i>	East Kootenay, Thompson-Nicola
Plumeless thistle	<i>Carduus acanthoides</i>	Central Kootenay
Puncturevine	<i>Tribulus terrestris</i>	Okanagan-Similkameen
Purple loosestrife	<i>Lythrum salicaria</i>	Comox-Strathcona (by regional district bylaw)
Quackgrass	<i>Agropyron repens</i>	Peace River
Russian knapweed	<i>Acroptilon repens</i>	North Okanagan
Russian thistle	<i>Salsola kali</i>	Peace River
Scotch thistle	<i>Onopordum acanthium</i>	North Okanagan
Sulphur cinquefoil	<i>Potentilla recta</i>	Columbia-Shuswap North-Okanagan, Okanagan- Similkameen, Thompson-Nicola
Tartary buckwheat	<i>Fagopyrum tataricum</i>	Peace River
White cockle	<i>Lychnis alba</i>	Peace River
Wild chervil	<i>Anthriscus sylvestris</i>	Fraser Valley
Wild mustard	<i>Sinapsis arvensis</i>	Peace River

Question 15. Is the riparian vegetation within the first 10 m from the edge of the stream generally characteristic of other healthy, unmanaged riparian plant communities in the area?

Most riparian areas support a diversity of trees and/or shrubs, with an understorey of herbaceous plants and ground cover (mosses, lichens). The presence of woody plants in all age classes (especially young plants), in vigorous condition and in their natural form, is a good indication of a healthy riparian area.

Question 15 uses four indicator statements. In order to mark Yes to the question, three of the four indicator statements need to be answered Yes.

- a) All of the major vegetation layers expected of healthy, unmanaged riparian areas (gaps, snags, live trees, tall shrubs, low shrubs, herbaceous plants, mosses, and lichens) are present over more than 75% of the stream reach normally capable of supporting vegetation.

A healthy riparian area is usually a tangle of herbaceous vegetation, shrubs and trees. Unhealthy or intensively managed riparian areas may still support trees, but there is typically a lack of structural diversity. Answer Yes if all of the expected main vegetation layers (trees, shrubs, and ground cover) occur over more than 75% of the stream reach normally capable of supporting vegetation. In most cases, all of the reach would be considered. Sometimes, however, there may be large expanses of bedrock incapable of supporting any vegetation. In this case, only consider the ground that is not bedrock.

It should be relatively simple to decide if all expected layers are present in intact old seral stage riparian areas, or conversely, riparian habitats that have recently been altered by grazing, logging, fires, slides, wind storms, or beetle epidemics. It will be considerably more difficult to decide when all expected layers have been satisfactorily re-established in riparian areas that are recovering from these impacts. Factors to consider include the age, seral stage of the normal climax forest, the frequency and type of disturbance characteristics of the forest, and the characteristic structure and species diversity of the forest. In keeping with the general guidelines used for coverage in the riparian area, any factor that meets or exceeds 75% of the final characteristics desired could be considered a reasonable measure of recovery.

- b) The dominant species present in the tree and shrub layers exhibit high vigour, normal growth form, and good recruitment of seedlings or saplings.

Mark **No** if more than 25% of the specimens in these layers are stressed, dying, dead, burned, mushroomed, windthrown, or harvested. Mark **No** if there is also no recruitment.

Answer **Yes** if fewer than 25% of the branches on the shrubs and trees are dead, if less than 25% of the plants show a mushroom or hedged appearance, and if healthy seedlings or saplings are present. If more than 25% of the trees or shrubs are logged, burned, windthrown, or beetle killed, these layers as a whole are definitely not vigorous. This may seem facetious, but if many riparian trees are represented only by their stumps, then their form isn't very good. As for burned, windthrown, or beetle-killed trees, these may be natural events, but their effect on form and vigour is still catastrophic. These events and their impacts on streams are a reminder that not all natural streams and their riparian areas are in proper functioning condition.

A **No** answer to 15 a) and 15 b) means that most heavily harvested S6 streams (and many S4 and S5 streams too) will get a **No** answer to Question 15. If both 15 a) and 15 b) are **No** answers, the riparian vegetation is probably no longer characteristic of other healthy, unmanaged riparian plant communities in the area.

- c) Heavy browse is absent on a preferred browse species in the shrub layer. Heavy browse on a plant is browse down to second-year wood over most (>50% of the branches) of the plant (see Figure 12).

To determine if there is heavy browse in the reach, look for specimens of a preferred browse species that are accessible to animals along the reach. Examine the plants and decide approximately what percent of the branches are nipped back to second-year wood. Do this for the streamside closest to the treatment being assessed. If both sides of the stream are treated, assess the browse level on both sides. If any one plant can be categorized as heavy browse, the answer to 15 c) is **No**.

TIP: If beaver-cut stems are noted at a site, record this as heavy browse.

TIP: If a preferred browse species is present but only in inaccessible areas such as on rock bluffs, or high stumps, or fenced enclosures, this can be taken as indirect evidence of heavy browse. Prolonged heavy browsing can eliminate the preferred browse species in accessible areas.

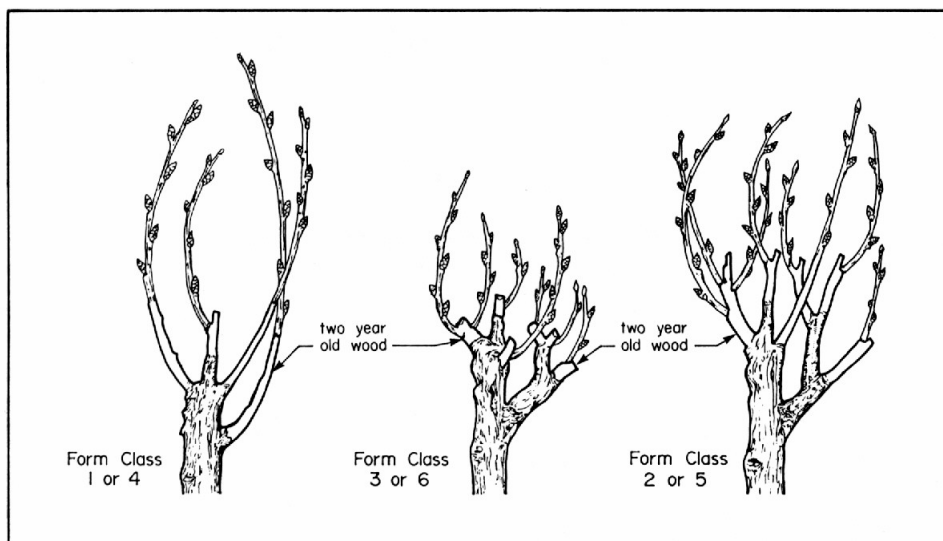


Figure 12. Comparative browse forms for estimating levels of browse impacts within riparian areas.

- d) Heavy grazing occupies <10% of the available grazing area. Heavy grazing is defined as less than the recommended target stubble height for the dominant forage species present.

To determine if there is heavy grazing in the reach, measure the stubble height of the dominant forage species (the species most consumed) at six evenly spaced sites along the stream reach. If possible and time permits, measure the stubble height of 10 plants at each site to determine the average stubble height. The overall average stubble height is the average of the stubble heights at each of the sample sites.

Answer **Yes** to the indicator statement if the overall average stubble height exceeds the target stubble height for the dominant forage species. Target stubble heights for riparian and upland forage species are summarized in Tables 7 and 8 (Fraser 2003).

TIP: Forage in overgrazed areas has a “slick” or “smooth” appearance. Undergrazed areas have a “ragged” appearance if there is any grazing at all.

TIP: Look for forage plants that are protected from grazing at the base of dense shrubs, in areas of heavy windfall, or in enclosures to get an appreciation of what the normal height and form of the local forage might be.

Table 7. *Average stubble heights for riparian species*

Species	Average stubble height (cm)
Baltic rush	10
Bluegrasses	10
Bullrushes	incidental use
Canada reedgrass (Bluejoint)	12
Cattails	incidental use
Desert saltgrass	7
Foxtail barley	10
Hairgrass, tufted	12
Kobresia	8
Sedges (large)	20
Spikerush	15

Table 8. *Average stubble heights for upland species*

Species	Average stubble height (cm)
Bluegrasses	8
Bromes (introduced)	10
Fescue, Altai	17
Fescue, creeping red	7
Fescue, Idaho	12
Fescue, rough	17
Needlegrass	12
Orchardgrass	10
Pinegrass	15
Ricegrass, rough-leaved	8
Timothy (alpine)	10
Timothy (domestic)	8
Wheatgrass, bluebunch	15
Wheatgrass, crested	8
Wheatgrass, northern	15
Wheatgrass, slender	15
Wheatgrass, western	12
Wildrye, blue	15

Help

If you require assistance on the use of the riparian management RSM forms and/or protocol, please contact one of the following:

Derek Tripp	(250) 751-5052 or db-tripp@telus.net
Peter Tschaplinski	(250) 387-3025 or Peter.Tschaplinski@gov.bc.ca
Dan Hogan	(604) 222-6752 or Dan.Hogan@gov.bc.ca
Stephen Bird	(604) 536-5702 or sbird@fluvial-systems.com

Glossary

Alluvial – water-borne material.

Channel aggradation – accumulation of too much sediment in a stream channel, commonly attributed to slides, road erosion, and collapsing/eroding stream banks.

Channel degradation – a reduction in biological productivity or diversity due to reductions in sediment input.

Dewatering – conditions in a stream channel where all the flow occurs within permeable streambed sediments so that no surface water is left; common in small streams with considerable accumulations of gravel.

Indicator – a measurable attribute or component (often environmental or social) of a resource value that provides reliable information on the status or state of that resource.

Properly functioning condition – streams, wetlands, and lakes and their adjacent riparian areas are functioning properly when adequate vegetation, landform, or large woody debris is present to maintain the physical and biological integrity of the riparian-aquatic system. Functions include dissipating stream energy associated with high waterflows, reducing riparian soil and channel erosion, filtering sediments from runoff, storing and safely releasing floodwater, moderating stream bank and channel movement, maintaining full connectivity of aquatic and fish habitats, providing LWD, nutrients, and organic matter for aquatic ecosystems, and providing shade to maintain water temperatures and stream bank microclimate conditions.

Stream reach – a length of channel exhibiting homogeneous characteristics and patterns.

Substrate – the mineral and organic components comprising the streambed.

References

- Church, M. 1992. Channel morphology and typology. In *The rivers handbook: Hydrological and ecological principles*. C. Callow and G. Petts (eds.). Oxford: Basil Blackwell, pp. 126–143.
- Cranston, R., D. Ralph and B. Wikeem. 2002. *Field Guide to Noxious and Other Selected Weeds of British Columbia*. Fourth edition. B.C. Min. Agric., Food and Fisheries, Food Safety and Quality Br., and B.C. Min. For., Silv. Br. Victoria, BC.
- Fitch, L., B.W. Adams and G. Hale. 2001. *Riparian Health Assessment for Streams and Small Rivers – Field Workbook*. Lethbridge, Alberta: Cows and Fish Program. 90 p.
- Fore, L.S. 1998. *Guide to Freshwater Invertebrates*. Online Internet guide available at <http://www.seanet.com/~leska/Online/Guide.html> and made possible by a King County Regional Water Quality Block Grant and the Bellevue Utilities Department (Seattle, WA).
- Fraser, D.A. 2003. Applying best stubble heights on rangeland. B.C. Min. For., For. Prac.Br., Victoria, BC. Range and Health Brochure 6.
- Grant, G.E., F.J. Swanson, and M.G. Wolmon. 1990. Pattern and origin of stepped-bed morphology in high-gradient streams, Western Cascades, Oregon. *Geol. Soc. Amer. Bull.*, 102: 340–352.
- Luttmerding, H.A., D.A. Demarchi, E.C. Lea, D.V. Meidinger, and T. Vold (editors). 1990. *Describing ecosystems in the field*. 2nd ed. B.C. Min. Environ. Victoria, BC. Manual No. 11.
- Province of British Columbia. 1995. *Riparian Management Area Guidebook*. B.C. Min. For., Victoria, BC.
- Province of British Columbia. 1996. *Channel Assessment Procedure Guidebook*. B.C. Min. For. and B.C. Min. Water, Land, and Air Protect., Victoria, BC.
- Resources Inventory Committee of British Columbia. 1999. *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory – Site Card Field Guide*. Forest Renewal BC and Resources Inventory Committee, Victoria, BC.
- Tripp D.B., A. Nixon and R. Dunlop. 1992. The application and effectiveness of the Coastal Fisheries Forestry Guidelines in selected cutblocks on Vancouver Island. B.C. Min. Environ., Lands and Parks, Fish and Wildl. Div., Nanaimo, BC. 25 p.
- Tripp D.B. 1995. The use and effectiveness of the Coastal Fisheries Forestry Guidelines in the Chilliwack and Mid-Coast Forest Districts of coastal British Columbia. B.C. Min. For., Integr. Resour. Br., Victoria, BC. 82 p.
- For an updated version of references and support information of this document, please consult the FREP web site at http://www.for.gov.bc.ca/hfp/frep/3_indicators.html.

Appendix 1. Sample REE field assessment completed forms

Riparian Management Routine Effectiveness Evaluation - Page 1



BRITISH
COLUMBIA

Forest and Range
Evaluation Program

Riparian Management
Routine Effectiveness Evaluation

Sample No. 1 Date June 9, 2006 Evaluator(s) DT, DM

Stream/Opening Identification

District Blackfly Opening ID 21024 Licensee Woodfor
 Licence A16085 Block 200-3 Harvest Year 2002
 Range Use Plan None Pasture ID None
 Stream Name Speedy Creek Stream Location In Block ☒ Beside Block ☐
 Stream Class on Plans S4 Stream Class in Field S3
 Reach Location 0 to 120 m US ☐ DS ☒ from culvert entrance, main road
 UTM at US ☒ DS ☐ end of reach East 581956 North 5439596 Zone 11
 Channel Width(m) 4 Channel Gradient(%) 3 RMA Assessed (looking downstream) L ☐ R ☐ Both ☒
 Channel Morphology Rifle-pool or Cascade-pool ☒ Step-pool ☐ Non-alluvial ☐

Riparian Retention Information in RMA (Distance to harvest edge(m) 5)

	Dominants & codominants in plans	Dominants & codominants in field	Understory retention in plans	Understory retention in field
% Retention in first 10m of the RMA (all classes)	30	30	100	30
% Retention in rest the of the RRZ (for S1,S2, S3)	0	0	100	0
% Retention in the rest of the RMZ (all classes)	0	0	0	0

Photo Section

Photo #	Photo Description
1	DS view from culvert on main road
2	New upturned bank root wads
3	Mid-channel bars, fines, in filling at mid point
4	US view from bottom of reach, note windthrow

Riparian Management Routine Effectiveness Evaluation - Page 2

Sample No 1

Field Data									
Question No.	Point Indicators (Measure at 6 equidistant points along the reach)						Threshold	Mean	
	Transect No.	1	2	3	4	5			6
Q7	% Moss	0	0	0	1	0	1	1%	2/6
Q8	% Fines/sands	0	5	10	5	40	60	10%	20
Q9	# of sensitive invertebrate types	3	1	0	1	1	0	1	1
Q9	# of major invertebrate groups	2	1	2	2	2	1	2	1.7
Q9	# of insect types	5	2	2	3	1	0	3	2.2
Q9	Total # of invertebrate types	6	2	3	5	2	1	4	3.2
Q13	% Shade	30	25	40	80	90	10	60%	46
Q14	% Disturbance - increaser species	40	0	0	0	0	0	25%	<25
Q14	% Noxious weeds	10	0	0	0	0	0	5%	<2

Number of Different Invertebrate Groups & Types Sampled								
"Group"	"Type"	Sensitivity	Transect Number					
			1	2	3	4	5	6
Insect	# of mayfly types 	Yes	2	1		1	1	
Insect	# of stonefly types 	Yes						
Insect	# of caddisfly types 	Yes	1					
Insect	# of midge types 	No	1	1	1	1		
Insect	# of other diptera types 	No	1		1	1		
Insect	# of riffle beetle, water penny types 	Yes						
Insect	# of other beetle types 	No						
Clams	# of clam types 	Yes						
Snails	# of right snail types 	Yes						
Snails	# of left snail types 	No						
Flatworms	Flatworms ("Planaria") 	No						
Nematodes	# of nematode types 	No						
Worms	# of other "worm" types 	No	1		1	2	1	1
Crustaceans	# of crustacean types 	No						
Arachnids	# of spider or mite types 	No						
	# of "other" types	Unknown						

Riparian Management Routine Effectiveness Evaluation - Page 3

Sample No. 1

OTHER INDICATORS TO NOTE

Q1 Channel Spanning Steps (For Step-Pool Channels Only). 50% or more of the boulder steps do or do not span the channel. 25% or more do or do not have moss.

NA. Channel has pool-cascade morphology

Q1 Sediment and LWD Storage (For Non-Alluvial Channels Only). Sediments and/or LWD do or do not completely fill the channel up to the top of the banks at any point or points together representing more than 5% of the reach length.

NA. Channel has pool-cascade morphology

Q1 Moss Along the Channel Bed (For Non-Alluvial Channels Only). More than 25% of the channel bed length does or does not have some moss on the substrate.

NA

Q2 Non-erodible Banks. Banks that are non-erodible on both sides of the stream at the same time are or are not present. Thresholds for stable undercut banks or deeply rooted banks are based on the length of erodible banks present only. Base the percent of undercut bank or deeply rooted bank present on total reach length minus the length of non-erodible bank present, if any.

All banks are erodible.

Q3 Main Woody Debris Characteristics. Is the channel woody debris mainly new or old, natural or logging related, across or parallel, intact or not, recently removed or not by hand, catastrophic floods, or debris torrents?

Q4 Surface Sediment Texture. The texture is homogeneous or heterogeneous.

Channel filled in with gravel and sand.

Q4 Steps and Pools (For Step-Pool Channels Only). Cascades lacking steps account for more or less than 25% of the sample reach.

NA

Q4 Plunge Pool Characteristics (For Step-Pool Channels Only). More than 25% of the steps at stone lines do or do not have a plunge pool as deep as the largest rock in the step. More than one step is or is not completely infilled.

NA

Q5 Connectivity is or is not good; i.e., open-bottom structures present or not on fish streams, no temporary blockages, no down cutting, no sediment or debris buildups, no dewatering, overland flow areas not isolated, generally free movements of sediments and debris possible.

Q6 Fish Cover Types Present include deep water, boulders, void spaces, undercut banks, woody debris, aquatic vegetation, overhanging vegetation

Q8 Fine Sediments. Check if there are any fine or sand-sized sediment deposits that "blanket" the stream anywhere or not, whether the substrate is embedded in sand/fines or not, or whether "quicksand" or "quickgravel" is present or not.

Q13 Bank Soils are cool or warm, moist or dry, unchanged or not. Moisture-loving plants are present or absent, are or are not in good condition.

Q15 Vegetation. All vegetation layers and the structure expected of a healthy, unmanaged forest are or are not present (e.g., gaps, snags, trees, tall shrubs, low shrubs, herbaceous plants, mosses, lichens)

Most trees and understory cut.

Q15 Vegetation. Is form normal or not, vigor normal or not, recruitment normal or not?

Stumps, windthrow, no seedlings.

Q15 Browse, Grazing. Heavily browsed shrubs are or are not present. Heavy grazing is or is not present on more than 10% of the available forage.

Riparian Management Routine Effectiveness Evaluation - Page 4

Sample No 1

Field Data				
Question No.	Continuous indicators (Measure along the total length of the reach)		Threshold	Total
Q1	Mid-channel bars, wedges (m, measure all but no overlap)	3, 2, 2, 8, 2, 5, 10, 15, 20	50% of reach	67m
Q1	Lateral bars (m, measure all but no overlap)	2, 1, 1, 1	50% of reach	5m
Q1	Multiple or braided channels (m, measure all but no overlap)	33 (1 new side channel)	50% of reach	33m
Q2	Recently disturbed bank (m, always measure both sides, but no overlap)	4, 2, 3, 1, 1, 3, 2, 4, 2, 4, 33	10,15% of reach*	59m
Q2	Stable undercut bank (m, always measure both sides, but no overlap)	3, 4, 1, 1, 3	50% of reach	12m
Q2	Deep rooted bank (m, only measure the side(s) affected by the treatment)	All except upturned rootwads (120 - 19 = 101)	65,75% of reach*	101m
Q2	Upturned bank root wads (m, always measure both sides, but no overlap)	4, 3, 3, 3, 4, 2	10,25% of reach*	19m
Q3	Number debris accumulations	////	NA	4
Q3	Number debris accumulations with recent debris	//// //// ////	50% of all accumulations	14
Q3	Number debris accumulations with recent debris that span the channel	//// //// //	12 per reach	12
Q4	Pool length (m)	8, 14, 10	25% of reach	32m
Q4	Deep pools (number)	None - All filled in	2 per reach	0
Q10	Recent windthrow (number)	3, 8, 5, 6, 12	5% in RRZs otherwise 10%	34
Q10	Old windthrow (number)	1, 1	NA	2
Q10	Standing trees (number)	4, 2, 3, 2	NA	11
Q11	Bare soil in first 10m (m ²)	2, 1, 1, 3, 2, 3, 6, 8, 4, 16, 1	1% of area	48m ²
Q13	Bare soil exposed to rain in first 10m (m ²)	All bare soil is exposed to rain	1% of area	48m ²
Q11	Bare soil hydrologically connected to first 10m (m ² ; include with bare soil in first 10m to decide if threshold is exceeded)	15, 60, 12, 10, 20 (all from road & ditch)	5% of area	117m ²
Q11	Disturbed ground in first 10m (m ²)	0	10% of area	0
Q11	Disturbed ground hydrologically connected to first 10m (m ² ; include with disturbed ground in first 10m to decide if threshold is exceeded)	0	15% of area	0

*Threshold varies depending on channel morphology

Riparian Management Routine Effectiveness Evaluation - Page 16

Sample No. 1

Summary				
	Question	Yes	No	NA
Question 1	Is the channel bed undisturbed?	☐	☒	
Question 2	Are the channel banks intact?	☐	☒	
Question 3	Are channel woody debris processes intact?	☐	☒	
Question 4	Is the channel morphology intact?	☐	☒	☐
Question 5	Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments?	☐	☒	
Question 6	Does the stream support a good diversity of fish cover attributes?	☐	☒	☐
Question 7	Does the amount of moss present on the substrates indicate a stable and productive system?	☐	☒	
Question 8	Has the introduction of fine sediments been minimized?	☐	☒	
Question 9	Does the stream support a diversity of aquatic invertebrates?	☐	☒	☐
Question 10	Has the vegetation retained in the RMA been sufficiently protected from windthrow?	☐	☒	
Question 11	Has the amount of bare ground or soil disturbance in the riparian area been minimized?	☐	☒	
Question 12	Has sufficient vegetation been retained to maintain an adequate root network or LWD supply?	☐	☒	
Question 13	Has sufficient vegetation been retained to provide shade and reduce bank microclimate change?	☐	☒	
Question 14	Have the number of disturbance-increaser plants or noxious weeds present been limited to a satisfactory level?	☒	☐	
Question 15	Is the riparian vegetation within the first 10m from the edge of the stream generally characteristic of other healthy unmanaged riparian plant communities in the area?	☐	☒	

No. of "Yes" answers: 1 + No. of "No" answers: 14 + No. of "NA" answers: 0 = Total No. of answers: 15

Conclusion on
Functioning Condition
(check one):

☐ Properly Functioning
(0-2 "No's")

☐ Properly Functioning but
at High Risk (5-6 "No's")

☐ Properly Functioning but
at Risk (3-4 "No's")

☒ Not Properly Functioning
(>6 "No's")

List the questions that had a "No" answer below, and check what you believe was the main reason for the problem. A "No" answer due to natural causes would include any natural event such as insects, fires, floods, slides, diseases etc. that were clearly unrelated to man's activities in the stream or adjacent riparian area. Check Logging, Cattle, Roads or Other Manmade as a cause if these factors directly affected the stream or riparian area assessed in this evaluation. Check Upstream Factors if the No answer was the result of some event or condition that occurred upstream, regardless if it was manmade or natural.

"No" answer questions	Cause of "No" Answers					
	Logging	Cattle	Roads	Other Manmade	Natural Factors	Upstream Factors
3,5,11	☒	☐	☒	☐	☐	☐
2,10,12,13	☒	☐	☐	☐	☐	☐
1,4,6,7,8	☐	☐	☒	☐	☐	☐
9	☐	☐	☒	☐	☐	☐
15	☒	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐

Riparian Management Routine Effectiveness Evaluation - Page 17

Sample No 1

Checklist of Specific Impacts for All "NO" Answers Combined		
	Stream Impacts that Apply	
	Within Stream Reach	Above Stream Reach
Logging Related Impacts		
Falling and yarding	☐	☐
Machine disturbance during harvesting	☐	☐
Machine disturbance during site preparation	☐	☐
Windthrow	☒	☐
Low retention	☒	☐
Old logging	☐	☐
Slides/sloughs	☐	☐
Torrenting	☐	☐
Water courses diverted	☐	☐
Roads, Crossings		
Running surface eroding into stream	☒	☐
Ditches eroding into stream	☒	☐
Fill or cut slopes eroding into stream	☒	☐
Road lens failing/collapsing	☒	☐
Cross ditching inadequate	☐	☐
Ditch blocks inadequate	☐	☐
Cross drains inadequate	☒	☐
Sediment traps inadequate	☒	☐
Berms/ruts trap water on road	☐	☐
Crossing leaks fines into stream	☐	☐
Water courses diverted	☒	☐
Crossing opening too small	☒	☐
Crossing misaligned	☒	☐
Crossing not open-bottomed	☒	☐
Culvert evert too high	☐	☐
Culvert damaged	☐	☐
Culvert plugged	☐	☐
Animal Disturbance		
Excessive grazing/browsing (cattle)	☐	☐
Excessive grazing/browsing (other ungulates)	☐	☐
Excessive grazing/browsing (beavers)	☐	☐
Trampling (cattle)	☐	☐
Trampling (other animals)	☐	☐
Stream dammed (beavers)	☐	☐
Excessive manure	☐	☐
Natural Impacts		
High natural background sediment levels	☐	☐
Organic stream bed	☐	☐
Fire	☐	☐
Beetle kills	☐	☐
Other diseases, epidemics	☐	☐
Wind	☐	☐
Slides	☐	☐
Torrents	☐	☐
Floods	☐	☐
Unknown	☐	☐
Other Impacts (List)	☐	☐
	☐	☐
	☐	☐
	☐	☐
	☐	☐

Riparian Management Routine Effectiveness Evaluation - Page 18

Sample No. 1

Final Comments
<p>Does the conclusion on functioning condition generally agree with your personal opinion on the functioning condition of this stream reach? If not, why not?</p> <p><i>Yes, the stream has experienced a tremendous amount of damage below the road crossing.</i></p>
<p>Describe more specifically what the reasons were for the "No" answers.</p> <p><i>Impacts to the stream were caused by windthrow and a culvert "wash-out" on the main road. Stream conditions above the road were much more normal looking.</i></p>
<p>All No answers are weighted equally. Were any specific problems identified that affected the assessment more than others?</p> <p><i>The culvert wash-out and erosion off the road seemed much more damaging than the windthrow.</i></p>
<p>Have you marked the stream reach assessed on a map in a way that will be legible when photocopied?</p> <p><i>Yes.</i></p>
<p>Does the leave strip appear as indicated in plans or on plan maps?</p> <p><i>Yes.</i></p>
<p>Do you have any recommendations for improving the Riparian Effectiveness Routine Evaluation Checklist or Protocol?</p> <p><i>Add an extra column to the continuous indicators tables to indicate the total and treshhold values for each indicator.</i></p>

(from Leska S. Fore; Annabel Wildrick [illustrations])

[illegible]

<http://www.seanet.com/~leska>

Excellent stream site

Here we find a variety of organisms with very different body shapes and ways of making a living. High biodiversity (or taxa richness) indicates a site with low human influence: most of the animals on this guide sheet should be present in a riffle sample. Several different types (or taxa) of stoneflies, mayflies, and caddisflies indicate a healthy site. More than one type of riffle beetle may also be identifiable, some are longer and skinnier than others. Some caddisflies are tolerant of degradation, so a large number of caddisflies does not necessarily indicate a good site, especially if they are the same species.

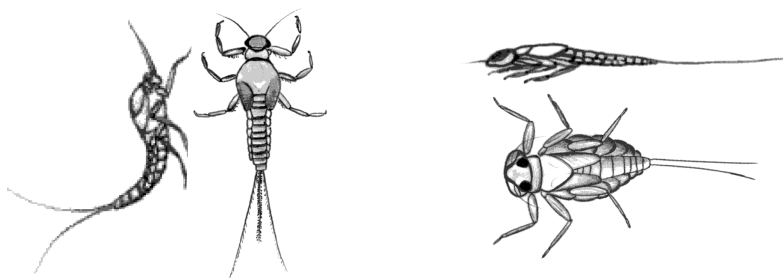
Moderate stream site

The total number of different types of organisms (taxa richness) declines as degradation increases. About half to two-thirds the number of taxa found at an excellent site are found in a moderate site. The primary change from an excellent site is that there will be many fewer taxa of stoneflies. Mayflies will be present, but probably fewer taxa as well. Several types of caddisflies may be present depending on the type of degradation. The relative proportions of soft-bodied worms, baetid mayflies, simuliid flies, or amphipods may increase. Beetles are probably still present; molluscs are not.

Poor stream site

The total number of taxa will be low. Most of the taxa found are soft-bodied animals, e.g., fly larvae, oligochaetes, nematodes, and in very poor sites, leeches and planaria. Worms are often difficult to distinguish from each other because their shapes are similarly adapted to living in soft sediments. Stoneflies are absent entirely. The only mayflies present are probably baetids (a family of mayflies). Caddisflies may be present, but only a few tolerant types. Amphipods are often present. There may be a large proportion of a single type of animal. In general, animals present may be smaller than those found at an excellent site.

Mayfly nymphs (*Order Ephemeroptera*)



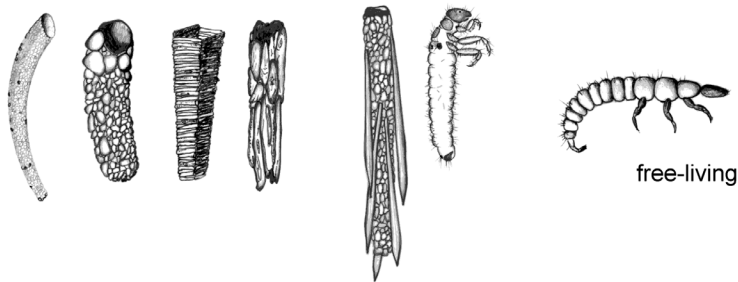
Mayflies are insects that spend most of their lives in streams, emerging briefly as adults (“ephemerally”) to mate and lay eggs. Gills are often visible along the abdomen. If an animal has three tails, it’s a mayfly; but some mayflies have two tails. Mayfly nymphs are strong swimmers and move like dolphins. As immature nymphs many mayflies feed on algae; as adults they do not eat. Mayfly diversity declines as streams are degraded; mayflies are particularly sensitive to mine waste

Stonefly nymphs (*Order Plecoptera*)



Stonefly nymphs are typically found on or near stones in the stream. They are rather primitive and may have been among the first insects to develop flight. Adult males and females emerge from the water to mate and locate each other by drumming with their abdomens. Stoneflies move like turtles and many are predators that hide and stalk their prey between stones and cobbles. Stoneflies look similar to mayflies but are stockier. The diversity of these animals declines rapidly at the first signs of human disturbance.

Caddisfly larvae (*Order Trichoptera*)



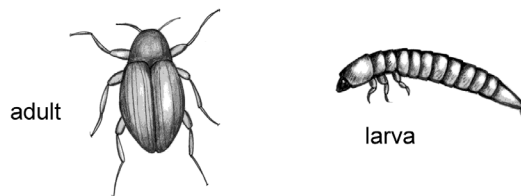
Caddisflies use silk (like butterflies) to build cases from gravel, twigs, needles, or sand. Different species build distinct cases, but they often lose them when removed from a stream. Caddisflies are insects that emerge to mate as winged adults. Caddisfly larvae make a living in a variety of ways: some capture food in nets, others scrape algae or shred leaf litter. Free-living caddisfly larvae do not build cases; many are predators and need to move quickly to capture other animals for food. Some caddisflies are very sensitive to human disturbance; others are tolerant.

Adult mayflies, stoneflies, caddisflies



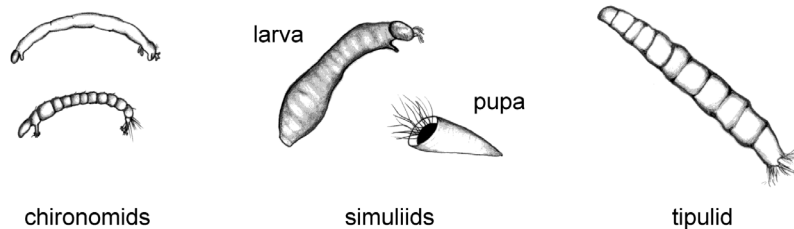
All three of these groups leave the water to mate as winged adults. Large swarms of mating mayflies and caddisflies often occur when all the individuals of a single species emerge at the same time. Stoneflies crawl out of the water and mate on the ground. The females of all three groups fly upstream and drop their eggs onto the water, or dive into the stream to attach them to rocks or leaves.

Riffle beetles (*Order Coleoptera*)



Riffle beetle larvae are specially adapted to cling to smooth rocks in fast-flowing water (riffles). After emergence, adults fly for a short time but return to the water to feed in the same habitat as the larvae. Both the larvae and adults are rather small, dark-colored, and tend to drift to the bottom of a sample so they may be hard to see. Riffle beetles collect and gather a variety of different foods.

Fly larvae (*Order Diptera*)



There are many species of true flies, but you are likely to recognize three main groups or families. Midge larvae (or chironomids) are very small, often C-shaped, and have a spastic squirming movement. They are often attached to debris by their tiny legs. Blackfly larvae (or simuliids) are dumb-bell shaped and soft. They attach themselves to the substrate and prefer soft sediment. Crane fly larvae (or tipulids) are large and fleshy with very short “tentacles” at one end.

Aquatic worms



planaria



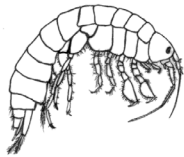
nematode



oligochaete

Flatworms (planaria), roundworms (nematodes), and freshwater earthworms (oligochaetes) are properly called worms; but don't confuse them with the soft-bodied larvae of flies, for example, which are not. Nematodes and oligochaetes are long and thin and writhe like snakes. Note that these animals do not have legs.

Crustaceans



amphipod



isopod

Amphipods (or "scuds") are very fast swimmers that look like shrimp. They have many appendages and look fuzzy. High proportions of these animals are present in very degraded sites. Isopods (or sowbugs) are usually found creeping through leaf litter.

Molluscs (Classes Gastropoda & Pelecypoda)



snails



limpet



clam

Most snails and limpets eat algae they scrape from rocks. Check to see if the animal is still in the shell. As larvae, freshwater mussels (or clams) may hitch a ride by attaching themselves to migrating fish. Mussels are very sensitive to sediment because they feed by filtering stream water through their shells. Mature mussels indicate an undisturbed site and may be up to 40 years old.