FREP

FOREST AND RANGE EVALUATION PROGRAM

Field Supplement to

Evaluating the Condition of Streams and Riparian Management Areas

(Riparian Management Routine Effectiveness Evaluation)

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Introduction

This field document provides guidance on how to collect the information needed to evaluate the condition of streams and their riparian areas. It is a supplement to the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR) Protocol for Evaluating the Condition of Streams and Riparian Management Areas. The supplement does not replace the full protocol, a complete knowledge of which is still required to select and sample stream reaches and answer each of the 15 questions on the field cards. The most recent version of the field cards can be found on the FREP website at: http://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/integrated-resource-monitoring/forest-range-evaluation-program/frep-monitoring-protocols/fish-riparian.

The field supplement provides guidance on what information is needed and how it should be collected and recorded for each indicator listed on the riparian field cards. While not as complete as the full protocol, the supplement also describes the indicators so they can be readily identified in the field.

The field supplement does not offer guidance on how to answer each of the 15 questions on the riparian field cards. This guidance is provided in the protocol and, to a large extent, by the questions themselves. However, with a complete understanding, evaluation and measurement of each indicator on the field cards, answering the 15 main questions should be straight forward.

Recommended Steps for a Riparian Evaluation

STEP 1 – Conduct an office review of the potential sample reach area before going out into the field to identify any upstream activities that may contribute to the determination of the causal factors. Useful GIS layers include topographic information (to delineate the drainage area upstream of sample reach), tenure boundaries (range, aggregate, recreation, utilities, etc.), cutblocks, and road crossings. Imagery will also be useful to identify any mass wasting that may have occurred.

To provide the information needed on page 1 of the assessment about upstream development, define the drainage basin that is upstream of the lower end of the sample reach and estimate the percent that has been developed. You can use the tools provided in ArcGIS, Google

Earth, or a georeferenced pdf to draw polygons and calculate the areas of both the watershed and the development to help estimate this value. Include road right-of-ways, agriculture pastures, existing cutblocks, transmission lines, and any other man-made features when calculating the area of development.

STEP 2 – Once in the field, before starting any measurements, first confirm the stream is in fact a stream and not a non-classified drainage (NCD), fisheries sensitive zone (FSZ), or wetland. Only streams are eligible for assessment. Continuous definable banks are the most consistent indicators of a stream, even if the banks are subsurface. If unsure, use the Stream Reference Card (Table 1) to help decide if the drainage feature is a stream. Work through the questions in Table 1 by answering "Yes" or "No" beginning with #1, then proceed to the question number indicated in brackets below the appropriate answer until you arrive at a classification.

Table 1. A Key for Identifying Fish Streams, Non-Fish Streams, FSZs and NCDs.

1	Does the drainage feature have any alluvial deposits and/ or scour to a mineral substrate, or have continuous definable banks?	Y (4)	N (2)
2	Does the drainage feature have a gradient < 20%?	Y(3)	N(NCD)
3	Does the drainage feature flow into known non-fish-bearing water, or end before reaching a water body with no possibility of a connection at high flows?	Y (NCD)	N (FSZ)
4	Does the drainage feature have any alluvial deposits or scour to a mineral substrate?	Y (5)	N (13)
5	Are the alluvial deposits or scour to a mineral substrate continuous or in sections less than 10 m apart?	Y (6)	N (13)
6	Is the drainage feature < 100 m long?	Y(7)	N(10)
7	Does the drainage feature flow into known non-fish-bearing water, or end before reaching a water body with no possibility of a connection at high flows?	Y (NCD)	N (8)
8	Is the drainage feature directly connected to potential fish-bearing water (stream, wetland, lake, or FSZ), or potentially connected to these features at high flows?	Y (9)	N (NCD)
9	Is the gradient <20%?	Y (S1-S4)	N (S5-S6)
10	Does the drainage feature flow into a known non-fish-bearing stream?	Y (S5-S6)	N (11)

11	Is the gradient < 20%?	Y(S1-S4)	N(12)
12	Is there any potential fish habitat upstream?	Y (S1-S4)	N (S5-S6)
13	Is the drainage feature < 100 m long?	Y(14)	N(17)
14	Is the drainage feature directly connected to a potential fish-bearing stream, wetland, lake or FSZ, or potentially connected to any of these features?	Y (15)	N (NCD)
15	Is the gradient < 20%?	Y (16)	N (S5-S6)
16	Does the drainage feature receive more than 2/3 of its water from groundwater seepage, overland flow, or floodwater from adjacent water bodies, with less than 1/3 of its water from a lake, wetland or stream?	Y (FSZ)	N (S1-S4)
17	Is the gradient < 20%?	Y(18)	N(NCD)
18	Does the drainage feature flow into known non-fish-bearing water, or end before reaching a water body with no possibility of a connection at high flows?	Y (19)	N (20)
19	Does the drainage feature receive more than 2/3 of its water from groundwater seepage, overland flow, or floodwater from adjacent water bodies, with less than 1/3 of its water from a lake, wetland or stream?	Y (NCD)	N (S5-S6)
20	Does the drainage feature receive more than 2/3 of its water from groundwater seepage, overland flow, or floodwater from adjacent water bodies, with less than 1/3 of its water from a lake, wetland or stream?	Y (FSZ)	N (S1-S4)

Note: If the stream reach, FSZ or NCD in question has hydrophytic plants and subhydric or hydric soils, wetland is probably a more appropriate classification

Confirm that the stream length within or adjacent to the block is also long enough to be a sample. The block is defined as the opening ID boundary as seen on the site map, not only the harvested area. To be eligible, the stream reach length has to be 100 m, or a distance equal to 30 channel widths, whichever is greatest. Channel width is the average distance between undisturbed stream banks. For streams situated adjacent to the block, confirm the stream also meets the adjacency criterion of the entire eligible sample reach being within 2 RMA widths of the opening ID boundary. The 2 RMA width measurement differs by stream class as summarized in Table 2.

Table 2. Threshold distances to determine qualifying stream adjacency.

Stream Class	Distance m (2 RMA widths)
S1	140
S2	100
S3	80
S4	60
S5	60
S6	40

Example: An adjacent S2 stream has a channel width (CW) of 15 m. To be eligible, 450 m of this stream (15 m x 30 CW) should all be within 100 m (2 RMA widths) of the block (opening ID) boundary.

Note that the harvest treatment can differ from one side of the stream to the other. However, the treatment should be more or less the same along the whole reach, not counting roads or other right-of-way crossings. Stream reaches that go from one distinct type of retention to another on the same side, or which are partly in and partly out of a block, should not be assessed as one reach.

STEP 3 – Once you have confirmed the stream is eligible for an assessment, start filling out as much of the Stream/Opening Identification and Riparian Retention sections on page 1 of the field cards as possible. For some attributes, such as channel width, channel depth, channel gradient, buffer widths, etc., this may require making multiple measurements at several points along the stream and averaging the data.

The following guidance is provided to help complete the Stream/Opening Identification section of page 1.

District – The official three-letter code for the Natural Resource District (e.g., DCR for Campbell River Natural Resource District).

Opening ID – The unique 5-7digit code used to select random cutblocks each year from RESULTS.

Licensee - The company that holds the forest licence for the block.

Forest Licence – The forest licence recorded for the cutblock in RESULTS.

Block – The designation used by the licensee on their logging plan or SP map.

Harvest Year – The year timber in the selected block was first harvested along the sample reach.

Stream Name –The name and/or numbers used to identify the stream on the logging plan or SP map.

Harvest Location – The location of harvesting in the block relative to the sample stream, looking downstream. Harvest location for a stream with wide buffers in a wildlife tree patch (WTP) is recorded as both sides if the WTP is in the block with harvesting on both sides.

Stream Class on Plans – Record the stream class (S1 – S6) indicated on the logging plan and/or SP map.

Stream Class in Field –In most cases, this is the same as the stream class on the logging plan. Record a different stream class only if the channel width clearly indicates the stream class should be different, or you have positive evidence of fish in streams designated as non-fish-bearing.

Reach Length (m) – Total length of the reach to be sampled as determined by the initial measurements of channel width.

Stream Order – Record stream order for the sample reach as indicated in the BC Watershed Atlas at 1:20,000 scale. If the stream is unmapped in the BC Watershed Atlas, call it a "zero" (0) order stream.

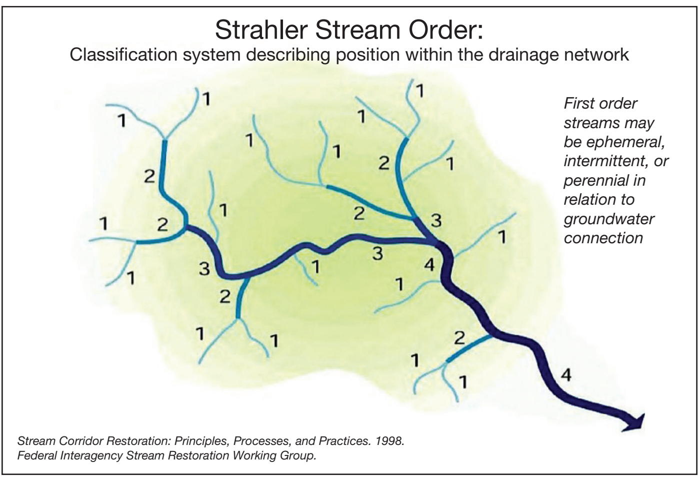

Figure 1. Diagram showing stream order of a watershed.

Stand Age by Stream – Record stand age on each side of the stream. If there is a full or partial buffer present, stand age is the estimated age of the buffer trees. If there is or was no buffer present (e.g., in older second-growth forests), stand age is the age of the regenerating stand.

Number of Road Crossings – Three numbers are asked for – the number of road crossings within the sample reach, the number above the reach but still in the block, and the total number of crossings in and above the reach. The latter should include all the crossings on the mainstem of the sample reach within and above the sample reach, plus all crossings on all tributaries above the sample reach.

% of Watershed Developed Upstream – Delineate the watershed area above the sample reach using topographic map layers and/or imagery, and estimate the total percent area developed to date. See Step 1 for further explanation.

Main Development – Record the one or two main human activities present in the watershed area above the sample reach (e.g., roads, forestry (except roads), agriculture, mining, oil and gas, recreation, transportation, utilities).

Channel Width (m) – Measure channel width from the "rooted" edge of one bank to the "rooted" edge of the opposite bank at undisturbed sites, choosing riffle segments if present. The "rooted" edge of a bank is the lowest point on the bank closest to the water with woody stems coming out of the ground. Exclude any vegetated islands from the channel width measurement, but include mid-channel gravel bars that are not vegetated. Rooted width is synonymous with the terms "channel" width or "bankfull" width.

Channel Depth (m) – At the same point where channel width was measured, extend a line or tape from the most well-defined rooted edge to the opposite bank. This line should be level. Record the maximum depth present from the line down to the deepest part of the channel under the line. This is channel depth.

Channel depth is used to determine the minimum diameter required for a piece of wood to be considered eligible to be tallied (min diameter = 10% of channel depth). Channel depth is also used to determine the minimum depth of an eligible "deep pool" (2x the channel depth).

Gradient (%) – Measure channel gradient over a representative section of the reach, preferably a distance that is at least 20% of total reach length. Make sure to sight from eye level to points that are the same height above the water, or channel bed if the stream is dry. Account for possible clinometer error.

Wetted Width (m) – Record wetted width at the upstream end of an undisturbed riffle. Do not include dry gravel bars that might be in the middle of the channel; only measure that part of the channel with water.

Wetted Depth (m) – Record maximum water depth at the same location where wetted width was measured, from the current water surface down to the bottom of the stream.

D95 (cm) – D100 is mid-axis length of the "largest" moveable sediment particles in the stream reach. For D95, record the mid-axis length of the "next largest" moveable sediment particles present at normal (bankfull) flows that do not significantly change the channel. This should represent a piece that is larger than 95% of the remaining movable sediment particles in the channel.

D50 (cm) – Record the mid-axis length of the median sized moveable particles that are present at normal bankfull flows. This is the upper end of the smaller particle size classes that collectively cover 50% of the stream bed.

Largest Mobile Bed Material – Check the largest moveable sediment size class present.

Boulders	>256 mm (larger than basketballs)
Cobbles	64-256 mm (tennis balls to basketballs)
Gravel	2-64 mm (small peppercorns to tennis balls)
Sand	0.0625-2 mm (fern spores to small peppercorns)
Fines (silts, mud)	<0.0625 mm (smaller than fern spores)

Channel Morphology – Determine the dominant channel morphology for the majority of the sample reach and indicate in the appropriate check box.

Apply channel width and gradient measurements to the Figure 2 graph below to help determine channel morphology. Note that Figure 2 is only suitable for alluvial or semi-alluvial channels that are mainly sediment deposition zones. It cannot be used for non-alluvial channels, which are mainly transport zones. Look at the other indicators in Table 3 for additional help on channel morphology.

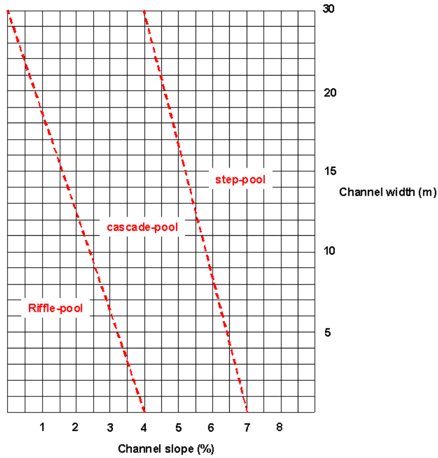

Figure 2. Channel morphology changes with increases in channel width and stream slope. As channel width increases, the slopes that define different morphologies decline.

Non-alluvial streams are streams that do not have floodplains composed of sediments that the stream deposited. Non-alluvial streams only cut through the adjacent land, washing away whatever sediments the stream flows can transport. Large or steep non-alluvial streams typically have fairly coarse substrates, but small, low gradient non-alluvial streams can have fairly fine substrates because of their low transport capability.

Table 3. General Features of Alluvial and Non-alluvial Streams.

Channel Feature	Riffle-Pool	Cascade-Pool	Step-Pool	Large Non-Alluvial	Small Non-Alluvial
Gradient (%)	0 - 3	> 3 - 7	> 5	variable	variable
Deposition characteristics	mainly deposition	mainly deposition	mixed	mainly transport	mainly transport
Flood plains	yes	yes	limited	no	no
Bank material	alluvium	alluvium, colluvium	bedrock, colluvium, alluvium	bedrock, colluvium, glacial deposits	colluvium, glacial deposits, organics
Gravel bars	common	present	limited	limited	limited

Channel Feature	Riffle-Pool	Cascade-Pool	Step-Pool	Large Non-Alluvial	Small Non-Alluvial
Stones	small, smooth	medium, smooth	large, smooth	large, sub-angular	small, sub-angular or all fines
Pools	common, often variable, complex	not as common, also simpler, smaller	mainly plunge, regularly spaced	mainly plunge, but randomly spaced	plunge, or "large-channel" morphology
Moss	present on stable stones in riffles	present on stable boulders in riffles	common on stones, lines and sides	common on sides of channel	common everywhere if substrate is large
Wood characteristics	typically common, with effects on sediment movement and pool-riffle form	less common, with minor effects on pool formation if present	typically absent, little to no effect on pool formation if present	typically uncommon, few effects on channel morphology if present	often present, roots and small logs across stream may form small plunge pools

Riparian Retention – Record the retention characteristics on each side of the stream in the Riparian Retention Information section of page 1. If you feel the information on riparian retention on page 1 does not adequately describe the condition of the riparian area, please provide a sketch of the riparian area on page 18 of the checklist. A photograph or two of the riparian area can also be invaluable in describing the riparian conditions.

The following additional guidance is provided to help complete the Riparian Retention Information section of page 1.

Length of sample reach with full retention (m) – Full retention refers to buffer strips where all dominant and codominant trees have been retained.

Length of sample reach with partial retention (m) – Partial retention includes any retention where dominant or codominant trees have been removed.

Average width of full retention present (max. 100) – Record the average distance from the stream edge to the start of any harvesting, up to a maximum of 100 m, for each side of the stream. This will be the average width of the buffer strips on each side of the stream where all vegetation (including dominant and codominant trees) has been left intact.

Average width of partial retention present (max. 100 m) – Record the average width of the buffer strips on each side of the stream where dominants and codominant trees have been removed, up to 100 m.

Average retention in partial retention area (% of basal area) – Record the estimated % basal area retention of all trees retained (including understory trees) in buffer strips with partial retention, for each side of the stream.

Average distance (m) from stream edge to trees or stumps – Record the average distance from the stream edge to where trees are the dominant vegetation (or stumps if the trees were harvested). This will be "0" in most cases where there is no sedge or shrub meadows between the stream and the forest.

STEP 4 – Place a ribbon at the beginning of your sample reach and mark the ribbon with the stream sample number, date, and "POC = 0+00." For example, for the first riparian sample, write "RSM Stream #1, July 10/06, POC = 0+00." This is your first "Point Indicators" sample station.

STEP 5 – Collect and record the information needed on left and right buffer width, moss, fines, benthic invertebrates, shade, disturbance-increaser species, and noxious weeds at your first "Point Indicators" sample site as per the brief descriptions under this section of the field guide.

STEP 6 – After completing the first point sample station, walk down or up the reach and locate the next five-point sample stations. The inter-station distance between point sample stations should be the reach sample length ÷ 5 (e.g., 100 m ÷ 5 = 20 m between sample stations for a 100-m reach). When you get to each point sample station, repeat the measurements you recorded at the first station (i.e., left and right buffer width, moss, fines, benthic invertebrates, shade and increaser/disturbance plants and noxious weeds).

Note, it is not always necessary to sample every point sample station. For benthic invertebrates especially, fewer stations are acceptable if the stations sampled are representative of the reach as a whole, and the threshold for the indicator has or has not been clearly exceeded.

STEP 7 – As you walk along the reach locating and sampling the Point Indicator stations, try to measure a few Continuous Indicators along the way. Do not, however, try to measure all the indicators at once because it is too easy to miss measurements this way. Also, try not to have one person measure while the other person records. This is not only slow, but it also has a greater risk of missing measurements or recording information incorrectly.

Experience indicates the best approach to measuring Continuous Indicators is for each team member to focus on measuring and recording probably no more than 2-6 indicators at a time by themselves, depending on the complexity of the channel and riparian area. When choosing indicators to measure, try selecting those that relate to each other. For example, one person might tally the wood accumulations and their characteristics in Table 2 of the riparian field cards, while also measuring the main channel bed indicators (gravel bars, side channels, and braided channels for alluvial channels, and moss along the stream bed in non-alluvial channels). Another person might focus on the bank indicators (non-erodible banks, recently disturbed banks, stable undercut banks, and upturned bank root wads). Pool length and deep pools are two more indicators that by themselves are simple to record. The specific indicators selected for measurement will depend on the channel morphology since not all indicators are measured on every type of stream.

STEP 8 – By this step, you and your team member should have walked the entire reach and completed six Point Indicator stations. You should have also completed Table 2 on page 6 (wood characteristics) and collected all the length or area data you need for many of the Continuous Indicators.

Add up and record the totals for each indicator. For the Point Indicators, calculate the means based on the number of stations sampled for each indicator. For the first 10 Continuous Indicators (mid-channel bars to pool length), "%" is the total divided by reach <u>length</u> X 100. Note that if naturally non-erodible banks are present on both sides of the stream at the same time, reach length for the indicators stable undercut banks or well rooted banks is reduced by the length of naturally non-erodible bank present. For new or old windthrow, "%" is % of all the trees that were standing up. For the last 5 Continuous Indicators (Bare erodible ground, compacted ground, etc.), "%" is the total divided by reach <u>area</u> X 100. Reach area is reach length (m) x 20 m., or 2,000 m^2 for a 100-m long reach.

STEP 9 – Review the data collected for the Point and Continuous Indicators and decide which indicators still need to be completed on your walk back to the start point. Pay attention to those values that are close to the thresholds and that might need to be re-checked. Finally, complete the "Yes/No" checklist for "Other Indicators" on pages 4 and 5, and note which ones you still need to assess specifically when you walk back along the reach.

At some point on almost every stream assessment, you will probably find that there are some "Continuous Indicators" or "Other indicators" that you do not have to measure. For example:

- If there is no new debris in the channel, you will not have to count the number of wood accumulations with new wood, or determine the main age of the debris. However, you will still need to note how many accumulations span the channel, and what the main orientation of the debris is – across/diagonal or parallel.
- If there is no windthrow present, or if the windthrow is extensive, you should not have to count or subsample the number of old windthrows, new windthrows, or standing trees present. Simply note what is present or not present (e.g., "Clearcut," "No windthrow," "All windthrown") in the space reserved for recording the counts to justify the number in the "Total" column.
- If there is no road crossing or bare erodible ground or disturbed ground in the riparian area, you will not have to measure any bare ground, bare ground exposed to the sky, bare ground hydrologically linked to the first 10 m, disturbed ground in first 10 m, or disturbed ground hydrologically linked to the first 10 m. Record zeros in the space reserved for recording the data, in the "Total" column, and in the "%" column.

The need to measure other variables may be similarly obvious after you walk along the stream and through the riparian area. Remember, it is very difficult to walk up or down a stream just once to complete an assessment. Usually one has to walk both up and down the stream, sometimes more than once.

STEP 10 – Walk back along the stream to your remaining point sample stations, measuring along the way, the channel, bank, and riparian indicators or observations you skipped on the first walk. After finishing your data collection, review your notes again to identify any missing information or measurements. Walk back along the sample reach to finish off any missing measurements.

STEP 11 – Go through the rest of the field cards and answer Questions 1 to 15 using the data recorded for the indicators and other observations. Summarize the Yes/No/NA answers on page 16 of the field cards, identify the general causes of each No answer in the small table at the bottom of the page, and fill in the specific causes to the “No” responses in the table on page 17. Complete the last two pages of the field cards at this time, perhaps walking or driving further upstream above the sample reach or into an unlogged area to clarify the cause of the impacts.

Be as diligent as possible in determining the most direct cause of any “No” answer. If, for example, the cause is clearly attributable to some known or unknown event upstream, then record the general cause as “upstream.” If you are positive about the specific cause, then identify it on page 17 as an upstream factor. If you do not know the specific cause, then the best course is to record it as “unknown.”

Record, at most, only the two main general factors that cause a “No” answer. Also record only the most proximate or defensible cause. For example, it may be tempting to record “other manmade” as a cause for fluvial disturbance if we assume global warming led to beetle infestations, and beetle infestations caused flooding, but flooding as a natural event will likely be the only appropriate causal factor to record in this case. There should be a clear and defensible linkage between all “No” answers and the factor(s) that caused the “No” answer.

Recording Data and Subsampling

Every space in the “Total”, “Mean”, or “%” columns for the Point and Continuous Indicators should have a number if the indicator was measured, or “NA” if not. There should be no blanks, nor any other text (e.g., “estimate,” “approx.”) or symbols (e.g., “>,” “<”) in these columns. Confine text or symbols to the space provided for recording individual measurements or notes.

For the Point Indicators, the number in the “Total” column should be the sum of the numbers recorded at each point station, while the number recorded in the “Mean” column will be the number in the “Total” column divided by the number of stations sampled.

For the Continuous Indicators, the number recorded in the "Total" column should be a value that represents the entire reach. Done properly, the number in the "Total" column divided by total reach length, total naturally erodible reach length (for undercut banks and deeply rooted banks), or total riparian area will yield the correct number for the "%" column. The exception is windthrow where the number in the "%" column is based on the number of trees originally standing in the riparian reserve zone (RRZ) or riparian management zone (RMZ).

Subsampling is acceptable for the Continuous Indicators, but the value determined for the subsample must be extrapolated to the entire reach before it is recorded in the "Total" column. For example, if it is clear that the pool length present in a 120-m-long reach exceeds the threshold because 30 m of the pool was present in the first 40 m of the stream, indicate that the 30 m was measured over 40 m of the reach (e.g., "30 m over 40 m of reach"). The number recorded in the "Total" column would then be 90 (30/40 X 120), the estimate of total pool length in the reach. The number in the "%" column would be 75 (90 ÷ 120 x 100).

Visual estimates are acceptable where the measured value for the indicator over the entire reach would be clearly and significantly lower or higher than the threshold value (e.g., pool length is 90% of the reach, new windthrow is 50%). Record the visual estimate for the whole reach in the "Total" column, but indicate that the value is a visual estimate in the space provided for recording numbers, text or symbols. Do not use visual estimates if the estimate is close to the threshold value.

Point Indicators

There are eleven Point Indicators to record at each of six sample sites. Field guidance on measuring these indicators is as follows.

Width of Buffer Strips

Measure the width of the buffer strip on both the left and right sides of the stream to a maximum of 100 m. <u>Start your measurements from the stream edge</u>. Measure to the nearest meter with a range finder, hip chain or tape. Each side may require separate measurements if the buffer has both a full retention and partial retention component. Make a note or provide a sketch of the buffer and dimensions on page 18 when the buffer involves more than one type of retention.

Moss

Visually estimate moss cover to the nearest 0.1% at the closest riffle to each sample point. If there is no riffle before reaching the next sample point, leave the space for recording coverage blank, or write "NA." Do not include moss on the sides of the banks, on woody debris, or on the "tops" of very large rocks that stick out of the channel. If coverage is less than 0.1%, record 0% coverage.

To estimate moss cover at a sample site, use a square plot equal in width and length to the width of the stream channel. In a 1-m-wide stream, a patch of moss 10 cm x 10 cm would be 1% coverage, while an area approximately 5 cm x 5 cm would be 0.25%. In a 5-m-wide stream, a patch 50 cm x 50 cm is 1% coverage.

Question 7 for "Moss" is not applicable if all of the stream has an organic substrate or is naturally composed of sand or smaller sized particles. "All" means at least 90% of the reach length and at least 5 of the 6 point sample stations should be 100% organic or composed of natural fine sediments. Ensure that the moss is not simply buried under excessive deposits of fine sediment before answering N/A, and that the channel bed is naturally composed of fine materials. If you are uncertain, compare with an upstream reach or reach in an unlogged basin in the same area.

Organic substrates in forest streams are composed mainly of particulate leaves and wood. Sphagnum mosses become more important as conditions become more bog-like. In the uppermost headwater areas of a stream where definable channels are starting to form, organic substrates tend to be mainly saturated soils, which may include some inorganic fines mixed in with the organic components.

Fines

At the pool-riffle break closest to each sample point, estimate the amount of sand and smaller-sized particles that occupy a line across the channel bed, from the toe of one bank to the toe of the other. To calibrate your eye, stretch a tape across the channel and measure the length of the fines present along the line. Divide the length of line with fines by the total length of the line, then multiply by 100, to get the percent coverage by fines. Only measure inorganic, mineral-type fines, not organic fines.

Like Question 7 for "Moss," Question 8 on whether or not the introduction of fine inorganic sediments has been minimized is not applicable if the substrate is naturally all organic, or clearly all the fines and sands present are from natural sources only. For more information on determining whether fines are applicable, see the explanation in Fine Inorganic Sediments on pg 38.

Benthic Invertebrates

The collection method described here will work for most streams with a mineral substrate. See the protocol for hints on sampling other stream types (e.g., streams with organic or mud substrates, beaver ponds).

At each sample point, select the nearest riffle with a substrate that can be stirred up by hand (avoid large boulders or mud deposits). While holding the net securely on the streambed (so nothing can escape under the net), pick up the larger rocks and clean them off in the net and then stir up the substrate upstream of the net so that invertebrates clinging to the substrate are washed into the net. Empty the net and its contents into the white tray with a little water, and identify the different types of invertebrates present.

For samples with abundant debris or sediment in the net, try placing only small portions of the sample in the tray at any one time. The more white space that is visible, the easier it is to identify the invertebrates. Try limiting the amount of sediment or debris in the tray to 50% or less of the tray area.

There are four separate indicators for benthic invertebrates:

1. The number of different sensitive invertebrate types (or "species") present;
2. The number of different major invertebrate groups present (e.g., insects, worms, crustaceans, other arthropods like spiders and mites);
3. The number of different insect types (species) present; and
4. The number of different benthic invertebrate types (species) present.

Figure 3 illustrates a diverse collection of invertebrates. Altogether there are four major groups, including worms, crustaceans, insects, and a snail. Among the insects there are 11 different types (or species), seven of which are considered sensitive. The latter includes two stoneflies, one mayfly, one riffle beetle larva and three caddisflies. Other sensitive invertebrates not shown include Dobson fly larvae (helgrammites), water pennies (Coleoptera), riffle beetles (larvae and adults), snails with the opening on the right side (this diagram has the opening on the left = not sensitive) and clams.

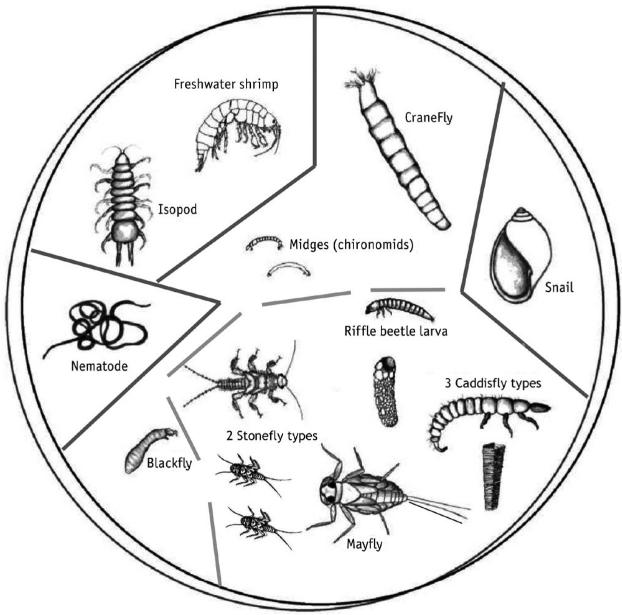

Figure 3. There are four major groups in this collection of invertebrates. (Note that there are three stonefly individuals shown, but only two types. There are also two different midges)

Record the number of sensitive invertebrates, major groups, insects, and total invertebrate types present in the appropriate space for each sample site. For the example shown in Figure 2, you would record:

- No. of sensitive invertebrate types – 7
- No. of major invertebrate groups – 4
- No. Insect types – 11
- Total no. invertebrate types – 15

A second table is provided below the Point Indicators to assist in identifying and summarizing the number of different invertebrates found at each sample point by major group, subgroup and type. Small example figures of the different kinds of invertebrates likely to be found are also provided, along with the general "sensitivity" of each subgroup to sedimentation.

For additional information on the sensitivity of invertebrates not shown, consult:

1. The field guide to freshwater invertebrates in Appendix 2 of the riparian protocol (good);
2. Appendix 1 (Field Identification and Pollution Tolerance Charts) and Appendix 2 (Key to Invertebrate Groups) from the DFO/BC Streamkeepers' Training Module 4 (better); or
3. The field guide and companion CD on Macroinvertebrates of the Pacific Northwest by Jeff Adams and Mace Vaughan of the Xerces Society (best).

When the last site is completed, tally up the totals for all sites sampled in the "Total" column. Calculate the average for each invertebrate indicator, round the average to the nearest whole number, and record it in the last column under "Mean."

Shade

At each of the six point samples, estimate the amount of shade present on each side of the stream, then average the two estimates to determine average shade at each sample point.

To determine shade on each side of the stream, stand along the edge of the bank, make a circle with your thumb and forefinger, and hold it straight up at a 60-degree angle above the horizontal. While looking through the circle, estimate the proportion of the circle that has vegetation, not sky. Use the foliage cover standards in Figure 4 to calibrate your eye. Do this for the two shadiest of the E, S or W aspects, and average the two estimates for an average estimate of shade on each side of the stream. The average of the estimates for each side of the stream is the value you record for each sample station.

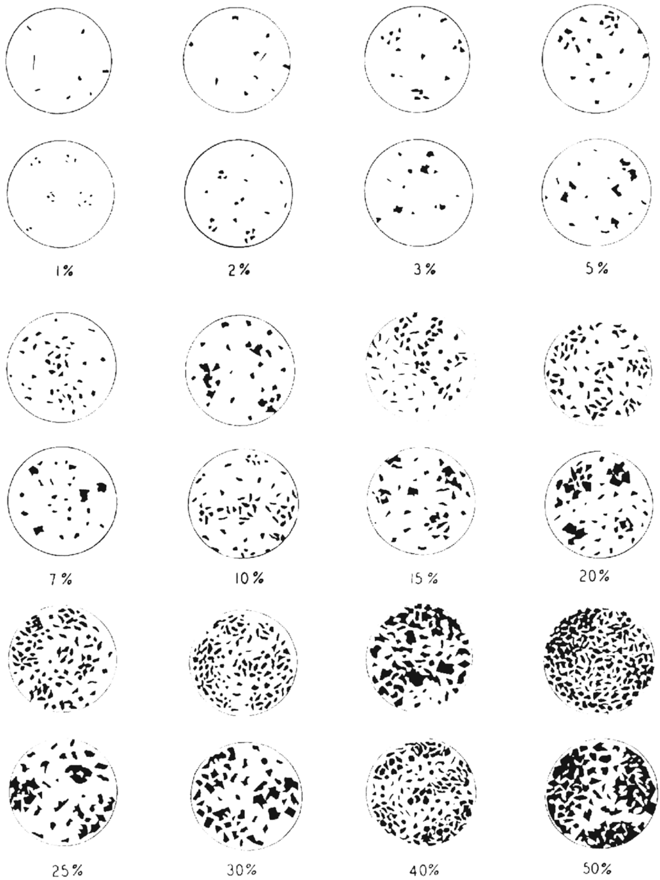

Figure 4. Comparison charts for visual estimation of foliage cover (from Luttmerding et al. 1990).

Disturbance-Increaser Species and Noxious Weeds

Disturbance-increaser and noxious weed species are listed in Appendix 1. Familiarize yourself with the list and their appearance in the field. A number of field guides are available, including the Field Guide to Noxious and Other Selected Weeds of British Columbia

(Cranston et. al. 2005). There is also Weeds of Canada (Royer and Dickerson 1999).

Record what percent of a transect line 10 m long on both sides of the stream at each point sample station is touched or occupied by disturbance-increaser species and/or noxious weeds. All transect lines should extend from the top of the stream bank at right angles to the main axis of the stream. Record percent coverage to the nearest 5% for disturbance-increasers, and the nearest 1% for noxious weeds.

Continuous Indicators

Continuous Indicators are indicators you measure along the entire length of the sample reach. The first 10 Continuous Indicators from “Mid-channel Bars and Sediment Wedges” to “Pool Length” are indicators you measure in the stream and along the banks. The last 8 indicators cover windthrow, bare erodible ground, and compacted (disturbed) ground in the riparian area on both sides of the stream. For windthrow, the riparian area is the entire RRZ or the RMZ if there is no RRZ. For bare erodible ground and compacted ground, the riparian area is defined as the first 10 m on either side of the stream.

Mid-channel Bars and Sediment Wedges

A “bar” is an accumulation of sediment in a stream channel. If it is composed mainly of gravel size stones, it is called a “gravel bar,” but bars can also be composed mainly of sand, cobbles or even boulders.

Unless it is obvious that much more or much less than half the sample reach has mid-channel bars or sediment wedges, measure the length of the stream reach that is occupied by these types of bars. Note that bars do not have to be out of the water to be called bars. They are still present even if they are covered by water.

Mid-channel bars and sediment wedges are the types of bars that are signs of sediment accumulation in a stream. Mid-channel bars are bars that will have some evidence of flow on both sides of a high point on the bar. Sediment wedges are bars that are essentially accumulations of sediment that have formed above (i.e., upstream) a partial or complete obstruction in the channel, such as a log or debris jam that extends partway or all the way across the channel.

Lateral Bars

Unless it is obvious, measure the length of the stream reach that has lateral bars to determine if half or more of the reach has lateral bars. If it is obvious that the channel has few if any bars, then just note this in the space provided for the measurements.

Lateral bars are usually easy to see at low flow on large, low gradient streams, especially on the inside curves if the stream is meandering. They are harder to identify if water levels are high or the stream is straight or small. If the stream has a distinct thalweg, i.e., a narrow but distinctly deeper channel that runs down the main channel, and the substrate gets progressively smaller from the thalweg to the inside bank, then that is likely a lateral bar. In very small streams, a lateral bar might only be a narrow strip of fines, sands or pea gravel depending on overall substrate size in the channel.

Lateral bars have a smooth continuous slope from the stream bank to the water's edge or thalweg. If there is any evidence of another channel or dip between the bank and the outside edge of the bar, then the bar is probably not a lateral bar, but more a mid-channel bar.

Multiple Channels

Unless it is obvious that much more or much less than half the sample reach has multiple channels, measure the length of the sample reach with multiple channels present. These include multiple or "braided" channels separated by non-vegetated gravel bars (i.e., mid-channel bars), plus side channels separated from the main channel by vegetated "islands." Don't measure the reach length twice where one extra channel overlaps with another extra channel.

Moss Along the Channel Bed

On non-alluvial streams only, record the length of stream reach that has moss on the streambed between the "toes" of each bank. This is not an area measurement of abundance like the measurements made for moss at each point sample station. It is a linear measurement of moss presence along the length of the sample reach. As an example, a continuous thin line of moss along the entire length of the stream may only cover a very small area of the streambed, but it is recorded as present over 100% of the stream reach because there is no point along the reach that does not have some moss on the streambed.

Non-Erodible Banks

Record the reach length where naturally non-erodible banks are present on both banks at the same time. Note that this does not include man-made changes to the bank that are non-erodible such as rip-rap or culverts. These are considered disturbed banks.

Naturally non-erodible banks are banks consisting of bedrock, or large boulders on small streams if the stream is incapable of transporting the boulders downstream.

Reach length with naturally non-erodible banks on both sides of the same section of stream is subtracted from total reach length to give total "erodible" reach length. Percent of reach length with undercut banks or deep-rooted vegetation is based on "erodible" reach length, and not total reach length.

Recently Disturbed Banks

Measure the length of stream reach occupied by recently disturbed banks, regardless of which side of the channel the disturbed banks are located. Where a section of disturbed bank on one side of the stream overlaps a section of disturbed bank on the other bank, do not measure the overlap twice. Total percent of reach length with recently disturbed banks cannot exceed 100.

Recently disturbed banks are banks that have been negatively affected (exposed or buried) by stream flows, windthrow, infilling, animals (hoof shear, trampling), roads (culverts, rip-rap), or harvest and silviculture activities. On recently disturbed banks that are not buried or modified with rip-rap or culverts, look for fresh looking, unoxidized mineral soils below a ragged line of bank vegetation with exposed fine roots, or larger roots that are freshly broken or scraped.

Stable Undercut Banks (see Figures 5 and 6)

Record the erodible reach length with stable undercut banks, regardless of which side the undercut bank is located on. Do not measure the reach length twice where undercut banks overlap each other. To determine the percent of reach with stable undercut banks, divide the total length of reach with stable undercut banks by the length of erodible stream reach present, all multiplied by 100.

To be called undercut, the depth of the undercut should be at least 2% of the total channel width. The height of the undercut above the mean annual highwater mark should also be within two times this distance (4%). Thus, stable undercut banks on a 2-m-wide stream should be at least 4 cm deep (2% of 2 m), with the stream edge of the overhang no more than 8 cm above the mean high-water mark.

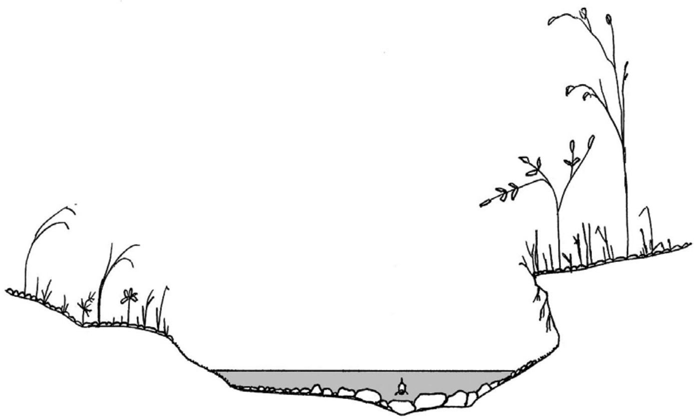

Figure 5. A cross-sectional view of a small stream with an unstable, overhanging bank on the right.

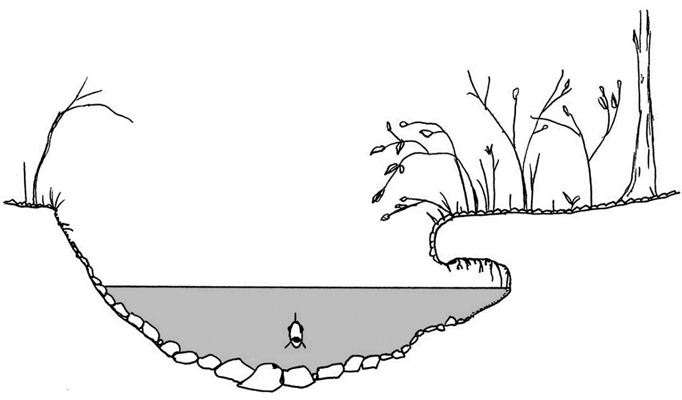

Figure 6. A cross-sectional view of a small stream with a stable vegetated overhanging bank on the right.

Deep Rooted Banks

Deep rooted banks are banks with deep rooting grass species, shrubs or trees – not moss, shallow rooting grass species, small herbs or forbs. Only consider vegetation within 1 m from the edge of the bank. Consider any part of the bank that lies within the crown width or drip line of deeply rooted grasses, shrubs or trees to be deeply rooted.

Record the erodible reach length with deeply rooted stream banks on both sides. Because most banks are well rooted, it might be easiest to record the reach length in the space provided, minus what bank length is shallow rooted on either side of the stream.

Upturned Bank Root wads

Measure the length of the reach occupied by recently upturned bank root wads or bank root wad scars. Upturned bank root wads are root wads that were once part of the bank, but which are now tipped over. Include bank root wads that were tipped over, but which may now be upright because the stem was salvaged.

Pool Length (see Figure 7)

Measure the length of the pools present to determine if 25% or more of the reach length has pools. Measure only pools that are main features, not small back eddies, or pockets of quiet water behind boulders in a cascade.

Pools are easiest to identify when flows are lowest. They start to get "drowned out" at higher flows, which means their length may be underestimated at these times.

To more accurately measure pool length at higher flows, step into the pool and walk slowly downstream. As you walk downstream, you will feel yourself walking uphill until you reach the end of the pool and the start of the next riffle. The ground will feel level at this point, or start to feel like it is going downhill. This point marks the end of the pool and the start of the next riffle.

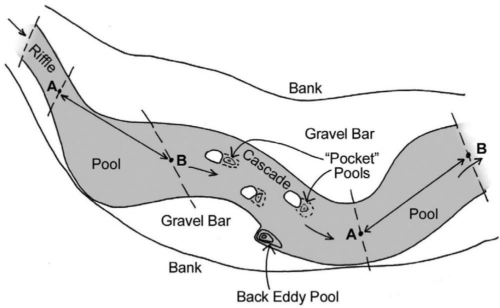

Figure 7. A plan-view sketch of two pool-riffle/cascade sequences in a stream.

Recent Windthrow

Windthrow only applies to trees that were alive when they snapped off or tipped over. Do not count dead trees or snags that get blown over or snapped off as windthrow. Windthrow is measured over the entire riparian reserve zone of S1-S3 streams, or the riparian management zone of S4-S6 streams. Do not measure windthrow in management zones if there is a reserve zone. Also, only count windthrow or standing trees that grew in the assessment area. Do not count trees or windthrow that fell into the assessment area. Live trees that snapped off at the stem are included as windthrow, as long as the snag or stump the tree came from can be identified.

The word "recent" is the same as "new" or "post-treatment." Recent windthrow is any windthrow that happened during or after the treatment you are assessing. If the treatment is harvesting that occurred 10 years ago, then recent windthrow is any windthrow that occurred in the past 10 years.

It is not always necessary to count recent or new windthrown trees. If all the trees were harvested or it is obvious that the number of windthrown trees is clearly very low (i.e., essentially absent), a note in the space provided is sufficient (e.g., "clearcut" or "no windthrow present"). Similarly, if the number of windthrown trees is clearly very high, record what the <u>estimated</u> windthrow is (e.g., "25% est.") in the space provided.

If it is not clear what the percentage of recent windthrown trees is above the percentage of old windthrows, you will have to count the number of old and new windthrows present, plus the number of standing trees. The threshold for new or recent windthrow in a reserve (riparian or wildlife tree) is 5% of the trees originally left standing, over and above what the background level of windthrow is. The threshold for new or recent windthrow in a management zone where there is no reserve is 10% of the trees originally left standing. Do not bother to estimate old or new windthrow in a management zone if there is also a reserve zone present. The only time you do so is when windthrow in both the reserve and management zones is similar, and it is easiest to combine the two zones to estimate windthrow in the reserve.

Only count dominant and codominant trees. When comparing percent old windthrow to new windthrow, remember to only compare like sized trees. The areas being compared must also be the same.

Old Windthrow

Old windthrow is windthrow that occurred before the treatment you are assessing, but is still recognizable as windthrow. To be considered old windthrow as opposed to "ancient" windthrow, the windthrow should still have a root wad (major lateral roots present).

Count and record the number of old (i.e., pre-treatment) windthrown trees present.

Standing Trees

Record "NA" in the space provided if a standing tree count is not needed, with a brief note why (e.g., "riparian area clearcut," or "windthrow >50% – visual estimate").

If the number of standing trees is needed to determine percent windthrow, count the standing live trees present in the area of concern, or subsample the riparian area to get a total stem count. Three 10 m x 10 m square plots on each side of the stream are recommended for subsampling. Record the average and the number of plots used in the space provided (e.g., average plot count 6.0, n=6).

Bare Soil in the First 10 m of the Riparian Area

Bare soil and bare erodible ground are the same thing. Bare erodible ground includes any soil or fill with particles smaller than 2 mm ("small peppercorn-sized sand") 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,[1] and windthrow scars, slides, and slumps. It also includes animal trails or recreation trails if mineral soil is exposed.

Sediment deposited on the ground from upslope sources is considered bare ground for Question 11, but not the sediment that is deposited due to flooding (i.e., overbank deposits – these are considered natural).

With the exception of active roads, measure and record the amount of bare erodible ground present in the first 10 m of the riparian area. In estimating the amount of bare ground, remember to net out the vegetation, gravel, rocks, roots, debris, etc. that are not erodible.

Example: The lower surface of a tipped over root wad measures 3 m X 2 m, with about half of this area comprised of erodible soils. The rest of the area is comprised of roots and coarse sediments. The net bare erodible soil area recorded is 2 x 3 x 0.5 (proportion of total root wad area estimated to be sand and fines) = 3 m^2. Do this type of calculation for each identifiable patch of ground with bare erodible soil in the first 10 m of the riparian area.

Example: A 0.5 m wide trail parallels the entire length of a 100-m long reach. It is mostly litter, but approximately 20% (i.e., "a little") of its net area is sand and fines. The net bare erodible soil recorded in the first 10 m of the riparian area is 0.5 m X 100 m X 0.2 = 10 m^2.

Inactive roads are to be considered potential bare erodible ground where they encroach on the first 10 m of the riparian area, either parallel to or across the stream. Inactive road crossings are road crossings where the stream crossing is removed, the stream bed restored to its natural gradient, and the approaches pulled back. Roads that have only been temporarily or seasonally deactivated are still "active" if the crossing is still in place.

Active roads in the first 10 m of the riparian area are not recorded as bare ground within the first 10 m of the riparian area. If they were, then every stream with an active road crossing would probably result in a "No" answer to Question 11. This would bias the evaluation

1 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 away.

against management steps that could be taken to reduce erosion from roads. Bare erodible ground on active roads within the first 10 m of the riparian area is recorded separately with the rest of the road as "bare erodible soil hydrologically linked to the first 10 m of the riparian area."

Bare Soil Exposed to Rain in the First 10 m of the Riparian Area

For each patch of bare erodible ground recorded as "bare soil in the first 10 m of the riparian area," consider if it is also directly exposed to rainfall. This is bare soil exposed to rain. In many cases, the two numbers will be the same. However, bare soil exposed to rain could be much lower than the bare soil in the first 10 m if all of the bare soil is protected by a canopy of tall shrubs and (or) trees.

Bare Soil Hydrologically Connected to the First 10 m of the Riparian Area

Bare soil hydrologically connected to the first 10 m of the riparian area is any soil that can be reasonably expected to reach the stream if exposed to rainfall or flowing water. This has to be determined most often when you have an active road crossing in your sample reach. It also applies to any other exposed ground that erodes into the riparian area. Examples include:

- Bare soil on any non-vegetated slopes (e.g., sloughs, slides) immediately adjacent to the 10-m riparian area;
- Bare soil on vegetated slopes of 10% gradient or steeper that are immediately adjacent to the riparian area, up to the first topographic break;
- Bare soil past the topographic break if there is a channel showing a clear connection to the stream;
- Bare soil on active road surfaces within the first 10 m of the riparian area, including the crossing, if there is evidence that fines eroding off the road surfaces can reach the stream. This includes the road surfaces plus all cut-and-fill slope surfaces associated with the road, within the first 10 m of the riparian area; and
- Bare soil on active or deactivated road surfaces beyond the first 10 m of the riparian area if there is evidence that fines eroding off these road surfaces will reach the stream.

To estimate the area of bare soil hydrologically connected to the first 10 m of the riparian area, first identify each "polygon" or area of concern. It might be a slide, or more commonly the running surface of a road and the cut or fill slopes associated with the road. Measure or estimate the area of each surface, the net amount of bare erodible sand or fines associated with the surface, and the degree of hydrologic connectivity to the riparian area. Multiply the four values together to estimate the net bare erodible ground hydrologically connected to the riparian area. Do this for each polygon and sum the results for an estimate of total bare ground hydrologically connected to the first 10 m of the riparian area.

Example: A 50-m long by 5-m wide road surface has "a lot" of fines on the surface, but only looks "a little" connected hydrologically to the riparian area. The net area of bare erodible ground hydrologically connected to the riparian area is 50 m X 5 m x 0.8 (for "a lot" of fines) X 0.2 (for "a little" connected) = 40 m^2.

Example: An old 100-m long by 20-m wide slide that ended up on the ground beside the stream reach had only a trace of fine- or sand-sized sediments still exposed. The net area of bare erodible ground on the slide surface hydrologically connected to the riparian area is 100 m X 20 m X 0.01 (for "a trace" of fines) X 1.0 (for "all connected") = 20 m^2.

Any value from 0-1 can be used to estimate the net amount of bare erodible ground present in individual areas or the degree of hydrologic connectivity to the riparian area. Suggested equivalent values for various amounts of bare erodible soil or degrees of hydrologic connectivity are as follows, from the FREP Water Quality Protocol.

"all fines and sands" or "all hydrologically connected"	= 1.0
"a lot of fines and sands" or "a lot connected"	= 0.8
"half fines and sands" or "half connected"	= 0.5
"a little fines and sands" or "a little connected"	= 0.2
"no fines and sands" or "not connected"	= 0.0

Compacted (formerly "Disturbed") Ground in the First 10 m of the Riparian Area

Compacted ground is any ground that does not absorb water readily. It includes by definition both gravel or paved roads, but it also includes skid trails, backspar trails, ATV trails, bike trails, or animal trails. Compacted ground also includes the pugging and hummocking found where cattle or other ungulates walk through heavy, saturated soils.

Compacted (formerly "Disturbed") Ground Hydrologically Connected to the First 10 m of the Riparian Area

To assess the hydrologic connectivity of compacted ground to the riparian area, use the same categories for degrees of hydrologic connectivity you used to assess the hydrologic connectivity of bare erodible outside the first 10 m of the riparian area.

Compacted ground hydrologically connected to the first 10 m of the riparian area is any compacted ground in the first 30 m of a 10% or steeper gradient slope that is immediately adjacent to the riparian area. To be hydrologically connected to the first 10 m of the riparian area, any compacted ground on slopes less than 10% or further than 30 m away on slopes steeper than 10% should show some signs of surface water transport that connects the compacted ground to the stream. Net area of any compacted ground hydrologically connected to a stream is the area of the compacted ground multiplied by the degree of hydrologic connectivity.

Other Indicators

These are the indicators to note as you mark (ribbon) your point sample stations and collect your data on the Point and Continuous Indicators. Other Indicators are mainly observations, though some of these need to be tallied to keep track of the overall conclusions. Table 1 on the riparian field cards is there to help keep track of the boulder line characteristics of step-pool channels. Tables 2-4 are there to help track in-channel wood and riparian area characteristics. As with all indicators, a second walk along the stream or through the riparian area may be needed to confirm some of your observations. Don't hesitate to walk back along the stream if you are not sure.

Boulder Line/Step Pool Characteristics (For Step-Pool Channels Only)

Another term for “boulder lines” is “stone lines.” Both terms refer to boulders that are arranged by stream flows into a line across the channel.

Water flowing over “stone lines” will scour out a plunge pool below the stone line, creating a “step” that looks like a small waterfall over the stones into the pool. Sometimes excess gravel, cobbles and boulders will fill in the plunge pools, leaving only the tops of the stone lines visible. Typically, a stone line spans the channel in a straight line from one bank to the other. Extreme floods or sediment pulses, however, will bury or scatter part or all of the boulders that make up the stone lines.

Only cascade-pool or step-pool streams have these “stone lines,” and they are only used as an indicator in step-pool channels. Mark “NA” for all these indicators if the stream has some other morphology.

If the stream has a step-pool morphology, determine if 50% or more of the steps or stone lines actually span the channel. Some may only go part way across. Do this by counting subsamples or all of the stone lines. Also, determine if 25% or more of the stone lines have moss growing on at least one of the stones, or if 25% of the stone lines have “deep plunge pools” associated with them.

The measurement for “deep plunge pools” differs from the measurement for “deep pools” which was the depth from the deepest part of the pool up to the mean annual high-water mark (assumed to be where the rooted vegetation edge is located). For deep plunge pools, the depth measurement needed is “residual pool depth.” This is the depth of the pool when the water just stops flowing out of the pool. To estimate “residual pool depth,” subtract the deepest water depth of the riffle below the plunge pool from the deepest water depth in the plunge pool. Compare this depth to the “middle” dimension of the largest stone in the stone line above the plunge pool. All stones have three dimensions, the longest, the shortest, and a middle. Use the middle dimension to see if the plunge pool is as deep as the largest stone.

Use Table 1 on the riparian field cards to help track how many stone lines are present, how many span the channel, how many have moss, and how many have deep plunge pools. Use this table to also track the length of the reach where there are no stone lines with plunge pools, just cascading riffles or rapids.

The example table below shows what a completed table might look like for a "disturbed" step-pool reach 7 m wide by 210 m long. Altogether, there were 27 stone lines identified. Because only 9 of these spanned the channel, check the "No" answer to the first indicator question "Do 50% or more of the boulder lines/steps span the channel?" Because 6 of the stone lines had moss, check the "No" answer to the second indicator question "Do 25% or more of the boulder lines/steps have moss?" Because only 5 of the stone lines had a deep plunge pool, check "No" to the third indicator question "Do 25% or more of the boulder lines/steps have plunge pools as deep as the largest rock in the line?" Finally, because more than 25% of the reach (68 m out of 210 m) lacks boulder steps and plunge pools, check "No" to the fourth indicator question "Do cascades lacking boulder lines/steps represent less than 25% of the reach?"

Boulder line/step characteristics of a step-pool type reach 7 m wide by 210 m long

Number of boulder lines/ steps	Number of channel spanning boulder lines/ steps	Number of boulder lines/ steps with moss	Number of boulder lines/ steps with a deep plunge pool	Length of reach with no boulder steps and plunge pools
~~////~~ ~~////~~ ~~////~~ ~~////~~ ~~////~~ //	~~////~~ ////	~~////~~ /	~~////~~	25, 33, 10 (Total = 68 m)

Sediment and LWD Storage (For Non-Alluvial Channels Only)

Check that sediments and woody debris do not completely fill the channel for any more than 5% of the total channel length. Channel segments that are completely filled with sediment will look like they have no banks. Recent sediment wedges that pile up behind (upstream of) a log or a debris jam frequently fill the entire channel, sometimes causing the channel to flow elsewhere.

Moveable sediments refers to sediments that are being transported downstream during normal high-water events. Widely distributed moveable sediments means they should be easily observed at almost any point along the stream. Mark "No" to this indicator if 75% or more of the channel lacks moveable sediments.

Wood Characteristics

For the purposes of this assessment, only consider wood with a diameter equal to or greater than 10% of the channel depth. Thus, any wood in a channel 30 cm deep has to be at least 3 cm in diameter to be considered, while wood in a channel 1 m deep has to be at least 10 cm in diameter. Small branches and twigs in most cases will not be considered wood.

Only count wood that is in the channel. Wood suspended above the channel or lying across the channel on the banks is not in the channel. To be considered in the channel, wood must be between the banks and below the high-water mark. Wood that is suspended over the channel does not count, but branches from the suspended wood that reach into the channel do count.

"Old" wood is wood that is stable, and well incorporated into the streambed, streambanks or pre-existing log jams. The wood is usually mossy though this is not critical. "New" wood is any wood that is not stable or well incorporated into the streambed, streambanks or stable log jams. New wood is usually wood that was recently deposited after road building and the latest harvesting began. However, new wood could also be old wood that was once stable, but that has recently moved and is no longer stable.

Most new wood will probably be wood that was introduced as a result of the treatment you are examining. In most cases, this will be wood that has been introduced where there has been falling and/or yarding across a stream. Windthrow is also new wood if it happened after the treatment (logging) and makes it into the channel. "Fall down" from trees killed by insects, fire and/or self-thinning can also be new wood.

In your mind, organize the wood along the reach into recognizable accumulations or "clumps." An accumulation of wood is any accumulation with two or more pieces of wood. Then use Table 2 on Page 6 of the riparian field cards to help track the characteristics of the wood in the channel. In Table 2, for each accumulation of wood identified, determine if the accumulation has any "new" wood associated with it and record it under the column "Number of accumulations with new wood." A wood accumulation with even one piece of "new" wood qualifies as an accumulation with new wood. Next look at the accumulation and decide if the accumulation spans the channel. If it does, record this in the column "Number of channel spanning accumulations." Then decide if the wood in the accumulation is mainly new or old wood in terms of the overall volume present. Record this as "O" for old or "N" for new in the column "Main age of wood in each accumulation." Finally, decide if the wood in each accumulation is mostly parallel ("P") to the main axis of the channel as opposed to across or diagonal ("X"). To be mostly parallel, more than half the volume of the accumulation should be pointing within 30 degrees of directly downstream.

Repeat the above assessment for each accumulation of wood tallied.

The example table below shows what a completed Table 2 might look like for a reach where 13 separate accumulations of wood were identified.

Wood Characteristics of Riffle-Pool Type Sample Reach

Number of wood accumulations	Number of wood accumulations with new wood	Number of channel spanning wood accumulations	Main age of wood in each accumulation (Record "O" for old, "N" for new)	Main orientation of wood in each accumulation (Record "P" for parallel, "X" for diagonal or across)
~~////~~ ~~////~~ ///	~~////~~ ////	///	OOONOOONOOOOO	XXXPXXPPXXXXP

Of the 13 accumulations of wood, most (9) had new wood associated with them, 3 spanned the channel, most of the wood (11 of 13 accumulations) was mainly old, and most of the wood was oriented across or diagonal to the stream (9 of 13 accumulations).

To determine if wood in the channel is intact (i.e., not recently lost or removed by hand, catastrophic floods, debris flows, or debris torrents), look for wood that is piled up along the banks, deposited there by flood flows or during excessive hand cleaning operations. Also, look up and down the channel. If the channel looks open, with little or no wood across the channel, then floods have probably washed most of the wood away. Old logged streams or streams beside roads or developed areas frequently have this appearance because there has been little new recruitment of wood to the channel to replace what is normally lost every year.

A stream reach that is completely full of wood has an "infinite" number of small clumps or accumulations, not one long clump. In these cases where half or more of the stream is completely full of wood, record a number greater than 12 for the number of accumulations present so that the result is a “No” answer for this indicator. Otherwise, very large and apparently single accumulations of wood would be recorded as being within the normal range of 1-12 accumulations and result in a “Yes” answer or false positive.

Surface Sediment Characteristics

Record if more than half the reach has a mainly heterogenous or homogenous substrate. Most streams have heterogenous substrates. These are substrates that have several sediment size classes sorted by stream flows so that boulders tend to be more apparent in the faster flowing or deeper middle sections of the stream, while the smaller gravels and sands end up closer to the shallow sides of the stream. Different size classes of sediment tend to be “clumped,” with recognizable groups of boulders or cobbles separated by smaller cobbles or gravels.

In most cases, a stream with a homogeneous substrate will have streambed materials primarily made up of only one sediment class (e.g., only mud, or sand, or cobbles, etc.). Homogenous streams tend to have little ability to move sediment, excessive new sediment introductions, or conversely, lack sediment input.

In some cases, such as a stream where sediment aggradation is exceeding the ability of the stream to transport sediment, a streambed made up of several sediment classes is also homogeneous if the sediments are unsorted by stream flows, and thus still randomly mixed. (A truck load of boulders, cobbles, gravel, and sand all mixed together would be called homogenous.)

Deep Pools

Count the number of deep pools present to determine if there are at least two in the sample reach. To be considered a “deep pool,” the pool depth from the deepest part of the pool to the mean annual high-water mark (assume this to be the same as the “rooted edge”) has to be twice the average channel depth at stable, undisturbed pool/riffle breaks (a “break” is the boundary where the water surface of a pool “breaks” at the upper end of a riffle). Ignore the water level when assessing pool depth or channel depth (Figure 8). Water level is not relevant for measuring the presence of “deep” pools.

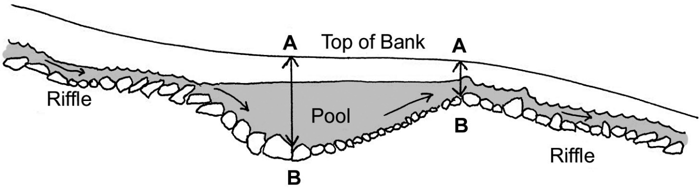

Figure 8. To see if you have a "deep" pool, measure pool depth from the deepest part of the pool to the top of the bank (A to B), not the water. This is the channel depth for the pool. Channel depth at deep pools needs to be at least twice as deep as the channel depth at stable, undisturbed pool/riffle breaks or boundaries (A1 to B1).

In streams where pools are separated by water flowing over logs, the logs represent riffles. In these cases, measure channel depth from the deepest spot along the top of the log to the rooted edge of the banks. Log steps can often be the only "riffles" in low gradient streams, especially streams with organic substrates.

For step-pool type channels, do not confuse "deep pools" with the "deep plunge pools" you are also asked to measure in step-pool channels. A "deep plunge pool" in a step-pool channel only has to be as deep at zero flow as the largest rock in the boulder step or line that forms the plunge pool. This may or may not be as deep as twice the channel depth for the step.

When measuring channel depth in step-pool type streams, do not measure channel depth at a riffle right at the step. Instead, measure riffle depth from the channel bed just upstream of the step to the rooted edge of the bank.

Connectivity

Make a note here of any structure or channel characteristic that breaks the normal movement of fish upstream or flow of sediments and debris downstream. On fish-bearing streams, round metal culverts are automatically considered impediments to fish movement unless it is clear that fish passage objectives were achieved. Any culvert or bridge can also block or impede sediment and debris movement if the opening is too small to accommodate peak flows. Look for evidence of significant debris or sediment buildup at the entrance to any crossing structure.

Log jams or beaver dams that completely fill the channel are frequent blockages to fish, sediment and/or debris. On fish streams, call these barriers to fish moving upstream blockages if the height of the obstruction is more than twice the channel depth immediately below the obstruction.

On all streams, also consider log jam blockages to sediment or debris movement downstream if recent sediment or debris deposits are accumulating above the blockage and more than two-thirds of the bankfull flow is being forced above or around the original channel. The diverted water may be forced laterally, forming a new or wider channel, or vertically, with new higher stream banks. In both cases, the presence of recent or ongoing erosion of the adjacent banks or floodplain is key to deciding if the blockage is currently an unstable blockage. If there is no evidence of any recent erosion, i.e., the banks and adjacent floodplain are free of recent erosion, then the blockage should be considered stable and no longer a break in connectivity to downstream movements of sediment and debris.

Other examples of a lack of connectivity include “dewatering,” where short or long sections of the channel are completely dry because the water is flowing entirely beneath excess deposits of gravel instead of on top of the gravel. The stream may also be down cutting into the streambed at such a rate that tributary streams or floodplain areas are no longer accessible to fish. Roads or recreational trails that lack suitable drainage structures, particularly in floodplains, can also effectively isolate off-channel areas from the main stream channel.

Fish Cover

There are 7 basic types of fish cover – deep water, woody debris, undercut banks, overhanging vegetation, unembedded boulders, interstitial spaces, and instream vegetation. Interstitial spaces are the nooks and crannies in unembedded gravels and cobbles that small fish can hide in. Woody debris typically includes the woody material derived from the branches, stems and root wads of trees. In this case, it also includes other organic debris such as shredded wood or leaves that fish can hide in.

To be considered present, each type of cover should represent at least 1% of the channel area sampled. For example, in a 5-m wide by 150-m long stream reach sample, there would have to be 7.5 m^2 of each cover type present (1% of $5 \times 150 = 7.5\ m^2$).

Fine Inorganic Sediments

In gravel, cobble or boulder bedded streams, note if there are any local deposits of sand or finer-sized sediments that entirely cover the streambed. This is what is meant by fine sediments "blanketing" the substrate. To be considered present, at least one such deposit by itself should cover at least 1% of the total channel bed area present.

Note if there are any parts of the channel bed present with sand or gravel that you sink into easily when you walk on it, or areas that you can easily wiggle your foot into. This is what we are calling "quick-sand" or "quick-gravel." A "No" is recorded when the affected area is greater than 1% of total channel area at ONE location. Do not record a "No" for organic or muck-bottomed streams.

Note whether the dominant substrate particles present are buried or embedded in a matrix of smaller-sized particles. Gravels, cobbles and boulders that are covered, buried or embedded in sand and finer size particles are the main concern. However, boulders can also be embedded in small gravels. You can't see the sides of embedded particles, only the tops of the particles.

In naturally occurring sand, silt or clay bedded streams, consider whether there is an excess of fine sediments in the channel. These types of streams are more common where the natural composition of the top layer of soil consists of glacial deposition materials, and can be identified by observing sand, silt and/or clay layers in the channel bank profile during low flows. Under unaffected conditions, the fine inorganic sediment indicator at these sites should be marked "NA." Before doing so, look for excessive deposits that are impairing the natural flow of the stream. Signs include the presence of soft dunes that have resulted in dewatering, multiple channels, and/or misdirected flow that is contributing to fresh bank erosion. If any of these signs are present, do not record "NA" and instead answer "No" to either of the first two questions related to fine sediments. To assign a logging-specific cause to this response, look for sediment trails from nearby roads, landings or recently exposed soil within the cutblock. If uncertain, compare with an upstream reach or an unharvested stream in the same watershed.

Bank Microclimate Soils

Moisture-loving plants are invariably present on stream banks. In most cases, these will be bryophytes, such as mosses and ferns, but it may also include macrophytes that have their "feet" in water, such as cat tails and rushes or sedges, or plants dependent on a high-water table or seasonal inundations such as skunk cabbage, Devil's club, salmon berry, and willows. Mark "Yes" to Question 13 c if these plants are present and in good condition, not scorched, mottled, desiccated, brittle or otherwise stressed due to the habitat drying out. Do not confuse dead vegetation at the end of the growing season or last year's growth with vegetation dried or killed by drought conditions.

Determine if the bank surfaces are mostly cool or warm, moist or dry, or intact or not (not collapsing or sloughing into the stream). "Mostly" would mean half or more of the reach length. For most streams, all bank surfaces should be vegetated and thus cool, moist and intact. Any conspicuous deviation from this should be noted.

Note if the banks support moisture loving mosses, bryophytes, herbs or shrubs. Note also if they are in vigorous condition, not dry, brittle or scorched. Bare, exposed, trampled, culverted, rip-rapped or collapsing banks will lack moisture loving plants typical of riparian areas. Naturally desiccated or recently exposed sites may also lack these species.

Riparian Structure

Note if there are any vegetation layers or components of healthy, unmanaged riparian areas that are over- or under-represented in terms of species composition, abundance or quantity, or the range of decay classes present (for snags and coarse woody debris). Consider the site characteristics and biogeoclimatic zone. To be considered over- or under-represented, the component or the number of plant species and/or their density in any particular layer should be clearly much less or much more than expected. If you do not know what the expected structure of the normal plant community is or what the relative abundance of the main components should be, look at an undisturbed site upstream and use this as a benchmark, but allow for considerable variation.

Be conservative in your assessments. Try not to compare your site to an "ideal" site. Forest structure is naturally variable, so consider this variability when deciding if any one component is under- or over- represented. Under-representation is easy to see in a recent clearcut, but over-representation is often overlooked. A riparian area with pine trees killed by mountain pine beetle clearly has more snags now than a healthy forest, while the number of live trees may be under-represented. Shrubs and herbs can also be over-represented in regenerating forests.

Use the riparian structure field data summary table provided in the riparian field cards to help answer this question. That table is a guide that works best where the riparian community has been significantly altered. It is not needed if the mature forest is intact and undisturbed. For each box under a vegetation layer or structural component in the table, record approximately how closely, as a percentage, that component compares to an otherwise healthy, unmanaged area. In most cases, this will be a comparison with a mature climax forest. Do this for each layer and component, taking into account the number of main species that should present and their density (e.g., stems per hectare). In the second-to-last box, record the total of all the percentages. Divide the total of the percentages by the number of vegetation layers or structural components assessed and record this number in the last box. This is your answer for Q15(a) for "Other Indicators."

The example below shows what a completed table might look like for a second-growth forest in the CWH that was first harvested 60 years ago. It has a tall, closed canopy formed exclusively of Douglas-fir, no snags, little coarse woody debris (CWD) except what was left when the forest was first harvested, few understory trees, heavy browse on the few small shrubs present, and an under developed lichen community. A score of "100" was recorded for the main tree layer, but a score of "50" was recorded for understory trees because they were almost absent. Similarly, scores of "0" were recorded for the snags and gaps because these components were missing altogether.

The moss layer was well represented, but not the low shrub or herbaceous layers, possibly due to shading, competition for water and nutrients, and heavy browse by deer. Note that the score for the tree layer could be downgraded if the forest normally has more than one common tree species present. The number of species in the lichen community was also very limited, as was the number of CWD decay classes. Total score for the 10 layers was 500%, for an average score of 50% (500 ÷ 10). Because this is less than the 75% established as a cutoff, the answer to Q 15(a) would be “No.”

A 60-Year-Old Managed Stand in the CWH

Snags (%)	Gaps (%)	Over-story trees (%)	Under-story trees (%)	Tall shrubs (%)	Low shrubs (%)	Herbs (%)	Mosses (%)	Lichens (%)	CWD (%)	Total (Sum of %s)	Average % (Answer to Q15a)
0	0	100	50	100	50	50	100	25	25	500	50

Each score assigned to a vegetation layer or structural component should be based on what you believe the minimum or maximum value would be. If you know that the shrub layer is highly variable, but typically covers 20 - 80% of the area in a certain biogeoclimatic ecosystem classification (BEC) zone or BEC zone variant, then any coverage of 20 - 80% should get a score of 100%. If shrubs only covered 10 or 90% of the area, then your score might be 50%.

For some areas, you may know that a certain layer or component should be present, but more specific information on what the coverage should be is lacking. In this case, any representation at all should probably get a score of 100%. As an example, you may know that the normal healthy, unmanaged riparian area has standing snags, but not how many. In this case, it is probably wisest to give a score of 100% for one snag, and 0% if there are no snags.

Note that not all riparian areas are expected to have each of the layers or components listed in Table 3. Natural grasslands, sedge meadows, and shrub-carr complexes, to name a few vegetation communities, naturally lack snags and trees. CWD levels and the lichen community can similarly be expected to be quite different. Other riparian areas may naturally have a well-developed tree layer with few openings, but lack herbaceous vegetation or moss cover. For these simpler types of communities, record “NA” for the layers or components not expected. Base the overall average percentage in the last box on the number of layers or components expected.

Riparian Form, Vigor and Recruitment

In most cases, a “No” answer to Question 15a automatically means that Question 15b is also “No.” The exceptions would be where Question 15a had a “Yes” answer, but many of the components had poor form, vigor or recruitment. In this case, assess if the form, vigor and recruitment of the vegetation layers and other forest components collectively approach 75% of what a healthy, unmanaged riparian area would normally be along the reach.

Use the Riparian Vegetation Form, Vigor and Recruitment table in the riparian field cards to help answer this question. In the table, each vegetation layer and structural component of the riparian community is given a “Yes” or “No” answer in terms of its form, vigor and recruitment. Where one or more layers or components are naturally lacking in the mature, healthy, unmanaged state, record “NA” for those layers. Also record “NA” where the vigor of a gap, snag or CWD component makes no sense, or a vegetation component is missing altogether and cannot be assessed.

Record the total number of “Yes” answers in the third column from the right, and the total possible number of “Yes” answers in the second column from the right. Calculate the percent of eligible cells with “Yes” answers and record this in the last column. If the last number is 75% or more, mark “Yes” for the question indicating that collectively the form, vigor and recruitment of the riparian approaches what is expected at similar but otherwise healthy, unmanaged riparian areas.

The table below is an example of an assessment for a 60-year-old stand that started as a clearcut. As before, it has a tall, closed canopy formed exclusively of Douglas-fir, no snags, little CWD except what was left when the forest was first harvested, few understory trees, heavy deer browse on the few small shrubs present, and an underdeveloped lichen community.

Riparian Vegetation Form, Vigor and Recruitment for a Riparian Area Clearcut to Both Edges of the Stream 60 Years Ago

	Snags	Gaps	Overstory trees	Understory trees	Tall shrubs	Low shrubs	Herbs	Mosses	Lichens	CWD	Total possible number of Yes answers	Actual number of Yes answers	% of cells with Yes answers (Answer to Q15b)
Form	N	N	Y	N	Y	Y	Y	Y	N	N	25	16	(16/25 x 100) = 64%
Vigor	NA	NA	Y	NA	Y	N	Y	Y	NA	NA			
Recruitment	Y	Y	N	N	Y	Y	Y	Y	N	Y			

With no snags or understory layer, no gaps in the overstory, and all of the CWD in an advanced state of decay, a “No” answer is given to these layers and components for form. The understory and lichen communities were similarly underdeveloped and given a “No” answer for form. The overstory trees were given a “Yes” answer, though it could have been answered “No” if other tree species were felt to be underrepresented.

Vigor is conceptually impossible to score for snags, gaps and CWD and so “NA” is recorded for these components. “NA” is also recorded for the understory and lichen layers that are missing and cannot be assessed. With the exception of the low shrubs, all other layers showed normal vigor. Vigor for the low shrubs was given a “No” answer due to the heavy deer browse evident and the shrubs’ spindly appearance.

Recruitment is marked “Yes” for snags, gaps and CWD because there is a well-developed tree layer present that should soon start contributing to the snag and CWD components and forming gaps in the canopy. Recruitment to the tree and understory layers themselves is poor due to the absence of any seedlings. All other layers showed some recruitment in the form of smaller or younger specimens. The total score was 16 “Yes” answers out of a possible 25, for an overall average of 64%. Although close to the target of 75%, a “No” answer is given for this indicator question as a whole.

Browsing/Grazing

A heavily browsed shrub is one with half of its stems browsed down to second-year wood. The presence of just one heavily browsed shrub in the riparian area is all you need to conclude there is heavy browse present in the riparian area. A stem that has been chewed off by a beaver also constitutes heavy browse.

Heavy grazing is where the stubble height of a forage species is less than the recommended minimum for that species. Consider the riparian area free of heavy grazing if 90% or more of the available forage has a stubble height greater than the recommended minimum.

Appendix 1

Disturbance-increaser species list

Strawberry (*Fragaria* spp.)

Cinquefoil (*Potentilla* spp.)

Yarrow (*Achillea millefolium*)

Baltic rush (*Juncus balticus*)

Dandelions (*Taraxacum* spp.)

Sow thistles (*Sonchus* spp.)

Foxtail barley (*Hordeum jubatum*)

Goatsbeard (*Tragopogon dubius*)

Clovers (*Trifolium* spp.)

Pineapple weed (*Matricaria matricariodes*)

Dock (*Rumex* spp.)

Pasture sage (*Artemisia frigida*)

Gumweed (*Grindelia squarrosa*)

Pussytoes (*Antennaria* spp.)

Buttercups (*Ranunculus* spp.)

Bluegrasses (*Poa* spp.)

Plantains (*Plantago* spp.)

Common noxious weeds within all regions of British Columbia

Common name	Latin name	Page number[a]	Description
Annual sowthistle	*Sonchus oleraceus*	p57, P13	milky juice in stem (garden and roadside weed)
Purple nutsedge	*Cyperus rotundus*	p14b	
Yellow nutsedge	*Cyperus esculentus*	p362, P21	weed of cultivated fields (leaves triangular)
Canada thistle	*Cirsium arvense*	p32, P4&55	leaves & stems prickly, flowers less than 2.5 cm (aggressive crop weed, can reduce yield by 100%)
Rush skeletonweed	*Chondrilla juncea*	P15b	yellow flowers, deep rooted, tiny leaves on stems
Crupina	*Crupina vulgaris*	P5b, c	
Scentless chamomile	*Matricaria maritima*	p48, P16	daisy like flowers (forage area weed)
Dalmatian toadflax	*Linaria dalmatica*	p136, P6,23	yellow flowers up to 1.2 m – pasture, rangeland and roadside weed
Yellow toadflax	*Linaria vulgaris*	p138, P23	aggressive rangeland weed
Spotted knapweed	*Centaurea maculosa*	p28	purple flowers (pasture and roadside weed) – not in Field Guide to Noxious Weeds...of BC
Diffuse knapweed	*Centaurea diffusa*	p29, P7	white flowers (pasture and roadside weed)
Yellow starthistle	*Centaurea solstitialis*	p29, 22c	yellow flowers
Tansy ragwort	*Senecio jacobaea*	p59, P18,28	yellow ray flowers – distinguishes it from common tansy, toxic to livestock
Dodder	*Cuscuta spp.*	p260, P8	climbing parasite on agricultural crops – no green parts

Common name	Latin name	Page number[a]	Description
Velvetleaf	*Abutilon theophrasti*	p228, P19	can grow to 2 m plus, weed in corn or soy crops
Gorse	*Ulex europaeus*	P10b	spiny shrub, south coastal and islands
Wild oats	*Avena fatua*	p172, P20	serious crop weed, annual
Hound's-tongue	*Cynoglossum officinale*	P9b	seeds like velcro
Jointed goatgrass	*Aegilops cylindrica*	P11b, c	
Leafy spurge	*Euphorbia esula*	p368, P12	weed of pastures, range and roadsides, poisonous to livestock – greenish yellow flowers with 2 yellow bracts
Perennial sowthistle	*Sonchus arvensis*	p54, P13	crop weed, clasping stem with milky latex in stems

[a] Page numbers following a lowercase "p" are given for the descriptions found in Weeds of Canada. 1999. Royer and Dickerson. Lone Pine Publishing and The University of Alberta Press. Page numbers following an uppercase "P" are from the Field Guide to Noxious Weeds and Other Selected Invasive Plants of British Columbia. 2005. Cranston et al. British Columbia.

Common noxious weeds within the boundaries of the corresponding regional districts

Common name	Latin name	Regional district	Page number[a, b]
Blueweed	*Echium vulgare*	Cariboo, Central Kootenay, Columbia-Shuswap, East Kootenay, Okanagan-Similkameen, Thompson-Nicola	p76, P24
Burdock	*Arctium spp*.	Bulkley-Nechako, Cariboo, Columbia-Shuswap, Fraser-Fort George, Kitimat-Stikine, North Okanagan, Okanagan-Similkameen, Peace River, Thompson-Nicola	p21, P25
Cleavers	*Galium aparine*	Peace River	p72, P26
Common bugloss	*Anchusa officinialis*	Kootenay-Boundary	pNA, P27
Common tansy	*Tanacetum vulgare*	Bulkley-Nechako, Central Kootenay, Columbia-Shuswap, East Kootenay, North Okanagan	p58, P28
Field scabious	*Knautia arvensis*	Bulkley-Nechako, Kootenay-Boundary, Thompson-Nicola	p382, P29
Green foxtail	*Setaria viridis*	Peace River	p198, P30
Hoary alyssum	*Berteroa incana*	Kootenay-Boundary	pNA, P27
Hoary cress	*Cardaria spp.*	Columbia-Shuswap, North Okanagan, Thompson-Nicola	p272, P32
Kochia	*Kochia scoparia*	Peace River	p158, P33
Marsh plume thistle	*Cirsium palustre*	Bulkley-Nechako, Fraser-Fort George	pNA, P34

Common name	Latin name	Regional district	Page number[a, b]
Meadow knapweed	*Centaurea pratensis*	Columbia-Shuswap	pNA, P35
Night-flowering catchfly	*Silene noctiflora*	Peace River	p326, P36
Orange hawkweed	*Hieracium aurantiacum*	Bulkley-Nechako, Cariboo, Central Kootenay, Columbia-Shuswap, East Kootenay, Thompson- Nicola	p40, P37
Oxeye daisy	*Chrysanthemum leucanthemum*	Cariboo, North Okanagan, Thompson-Nicola, Peace River	p30, P38
Perennial pepperweed	*Lepidium latifolium*	Central Kootenay	pNA, P39
Plumeless thistle	*Carduus acanthoides*	Okanagan-Similkameen	p27, P40
Puncture-vine	*Tribulus terrestris*	Comox-Strathcona (by regional district bylaw)	p96, P41
Purple loosestrife	*Lythrum salicaria*	Peace River	p224, P80
Quackgrass	*Agropyron repens*	North Okanagan	p170, P42
Russian knapweed	*Acroptilon repens*	Peace River	pNA, P44
Russian thistle	*Salsola kali*	North Okanagan	p162, P43
Scotch thistle	*Onopordum acanthium*	Columbia-Shuswap, North Okanagan,	pNA, P45
Sulphur cinquefoil	*Potentilla recta*	Okanagan-Similkameen, Thompson-Nicola	p357, P46
Tartary buckwheat	*Fagopyrum tartaricum*	Peace River	p82, P89
White cockle	*Lychnis alba*	Peace River	p328, P36
Wild chervil	*Anthriscus sylvestris*	Fraser Valley	pNA, P47
Wild mustard	*Sinapsis arvensis*	Peace River	p266, P48

[a] Page numbers following a lowercase "p" are given for the descriptions found in Weeds of Canada. 1999. Royer and Dickerson. Lone Pine Publishing and The University of Alberta Press. Page numbers following an uppercase "P"are from the Field Guide to Noxious Weeds and Other Selected Invasive Plants of British Columbia. 2005. Cranston et al. British Columbia.

[b] NA = not available in the Weeds of Canada publication

Invasive plant species of British Columbia

Common name	Latin name	Page number[a]
Anchusa	*Anchusa officinalis*	pNA, P27
Baby's breath	*Gypsophila paniculata*	p320, P50
Black knapweed	*Centaurea nigra*	pNA, PNA

Common name	Latin name	Page number[a]
Blueweed	*Echium vulgare*	p76, P24
Brown knapweed	*Centaurea jacea*	pNA, PNA
Bull thistle	*Cirsium vulgare*	pNA, P55
Canada thistle	*Cirsium arvense*	p32, P4
Common burdock	*Arcticum minus*	pNA, P25
Common tansy	*Tanacetum vulgare*	p58, P28
Dalmation toadflax	*Linaria dalmatica*	p136, P6
Diffuse knapweed	*Centaurea diffusa*	P29, P7
Field scabious	*Knautia arvensis*	P382, P29
Giant knotweed	*Fallopia sachalenensis*	PNA, PNA
Gorse	*Ulex europaeus*	pNA, P10
Hoary alyssum	*Berteroa incana*	pNA, P31
Hoary cress	*Cardaria draba*	P272, P32
Hound's- tongue	*Cynoglossum officinale*	pNA, P9
Japanese knotweed	*Fallopia japonica*	p91, P71
Leafy spurge	*Euphorbia esula*	p368, P12
Marsh plume thistle	*Cirsium palustre*	pNA, P34
Meadow hawkweed	*Hieracium caespitosum*	pNA, P37
Meadow knapweed	*Centaurea debeauxii*	pNA, P35
Nodding thistle	*Carduus nutans*	p26, P40
Orange hawkweed	*Hieracium aurantiacum*	p40, P37
Oxeye Daisy	*Leucanthemum vulgare*	p30, P16
Perennial pepperweed	*Lepidium latifolium*	pNA, P39
Plumeless thistle	*Carduus acanthoides*	p27, P40
Puncture-vine	*Tribulus terrestris*	p96, P41
Purple loosestrife	*Lythrum salicaria*	p224, P80
Rush skeletonweed	*Chondrilla juncea*	pNA, P15
Russian knapweed	*Acroptilon repens*	pNA, P44
Scentless chamomile	*Matricaria perforata*	p48, P16
Scotch broom	*Cystisus scoparius*	pNA, P82
Scotch thistle	*Onopordum acanthium*	pNA, P45
Spotted knapweed	*Centaurea biebersteinii*	p28, P17
St. John's wort	*Hypericum perforatum*	pNA, P85
Sulphur cinquefoil	*Potentilla recta*	p357, P46
Tansy ragwort	*Senecio jacobaea*	p59, P18
Teasel	*Dipsacus fullonum*	pNA, PNA
Yellow iris	*Iris pseudacorus*	pNA, PNA
Yellow starthistle	*Centaurea solstitialis*	p29, P22
Yellow toadflax	*Linaria vulgaris*	p138, P23

[a] Page numbers following a lower case “p” are given for descriptions in Weeds of Canada. 1999. Royer and Dickerson. Lone Pine Publishing and the University of Alberta Press. Page numbers following an uppercase “P” are from the Field Guide to Noxious Weeds and Other Selected Invasive Plants of British Columbia. 2005. Cranston et al. British Columbia.