Forest and Range Evaluation Program Riparian Protocol – Why these indicators?

FREP

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HOW WERE THESE 15 INDICATORS SELECTED?

There are 15 indicator questions used in the *FREP Protocol for Evaluating the Condition of Streams and Riparian Management Areas* (the FREP Riparian Protocol) to assess the functioning condition or 'health' of a stream reach.

Stream reaches that are in **properly functioning condition** are not necessarily pristine streams that lack any kind of human or natural disturbance. Rather, they are streams that can withstand normal peak flood events without experiencing accelerated soil loss, channel movement or bank movement; can filter runoff; can store and safely release water; can maintain aquatic habitat connectivity within the stream network and between the stream and adjacent riparian area; can maintain an adequate root network or large woody debris supply; and can provide shade and reduce bank microclimate change.

Streams will be maintained in a properly functioning condition if the impacts of development on the attributes (i.e., indicators) of the riparian area are one of the following:

- small on average;
- within the range of natural variability of the habitat;
- beyond the range of natural variability in no more than a small portion of the habitat.

The 15 main indicators used in the FREP Riparian Protocol represent biological and physical processes and characteristics of streams and their adjacent riparian areas. They were selected by a multi-agency and multi-disciplinary FREP team of scientists and technical specialists that evaluated a large number of potential indicators (61) assembled from a thorough review of the scientific and resource management literature. Reference was also made to well established methods in use for riparian assessment in other jurisdictions (e.g., the Montana Method). Several strict criteria were used to identify the most appropriate indicators including: foundation in reliable scientific data; relevance and responsiveness to forestry practices, particularly riparian management and road systems; broad geographic coverage; and capability to measure changes in ecological processes and conditions.

Nine of the indicator questions relate to stream channel and bank conditions and six questions relate to riparian area conditions. The indicators are all interrelated because of the natural ecological linkages of stream-riparian systems. A large number of indicators are assessed in this protocol because the more indicators measured – the more flexible and transferrable the method is for use in different locations around the province and for streams with different morphologies.

The stream channel and banks of a non-alluvial stream.
Photo credit: Derek Tripp

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To be a world leader in resource stewardship monitoring and effectiveness evaluations; providing the science-based information needed for decision-making and continuous improvement of British Columbia's forest and range practices, policies and legislation.
http://www.for.gov.bc.ca/hfp/frep/index.htm

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HOW WERE THE THRESHOLDS SELECTED FOR EACH INDICATOR?

When conditions at a harvested site are assessed, the results should ideally be compared to those made in a nearby equivalent un-harvested reference or "control" site so that the findings can be interpreted specifically in relation to forestry practices. Because this is difficult to achieve in large-scale monitoring programs such as FREP, our alternative approach was to develop indicators with threshold values based on the available empirical data with the intent of covering the range of natural variation. Undisturbed conditions can be established in this manner, and the degree of departure from these conditions due to forestry practices or other causes including natural disturbances, unusual natural conditions, or other human activities can be identified. Specialists agree that results that do not fall within these thresholds indicate impaired function or poor health.

The development of the indicators and their threshold values was informed by a large base of empirical data generated from several research programs in B.C. conducted from the 1970s to the present. This research included a long-term (≥ 15-year) series of paired-watershed studies (88 streams, unharvested vs. harvested) conducted in ten major forested Biogeoclimatic Ecosytem Classification (BEC) zones and four physiographic zones of B.C. that focused on the physical attributes of streams. Disturbance thresholds for riffle-pool, cascade-pool, and step-pool stream morphologies were identified separately for indicators such as stream bank erosion, bar frequency, bar stability, stream bed scour, number of deep pools (channel depth variability), logjam frequency, and woody debris load. The thresholds were based on an analysis of data from unlogged watersheds where the influence of physiography, biogeoclimatic zone, and channel gradient were tested for significance.

Indicators that were common with those of the Montana Method or other literature-based indices founded on scientific data (e.g., bare ground, vegetative cover, stream bank erosion, deep-rooted stream banks, substrate moss cover, shade) had thresholds fully or partially incorporated into the FREP Riparian Protocol. The thresholds adopted from the Montana Method were based on thousands of observations of streams in different functional states throughout the western United States.

Indicators that have a foundation in the broad scientific literature, but which were developed specifically for FREP assessments, were assigned threshold values partly on the basis of the outcomes of an experts workshop. These indicators included fish habitat diversity, benthic invertebrate diversity, substrate embeddedness, aquatic connectivity, windthrow, and vegetation form and vigor.

WHAT IS THE RELATIONSHIP BETWEEN STREAM CHANNEL MORPHOLOGY, STREAM SIZE AND THE INDICATORS?

Stream channel morphology is determined by stream size, gradient, and sediment supply. There are four types of stream channel morphology addressed in the FREP Riparian protocol, they are riffle-pool, cascade-pool, step-pool, and non-alluvial.

Some indicators are more sensitive to stream channel morphology than others. Channel bed disturbance, channel bank disturbance, and large woody debris, and channel morphology are all sensitive to stream channel morphology and for this reason the questions for each of these indicators vary by stream channel morphology.

The questions in the FREP Riparian protocol address all stream classes (S1-S6). As all stream classes are not fish streams the questions in the protocol and the thresholds for the indicators vary by stream class. Assessors collect information during their assessments on stream width, gradient, and connectivity in order to confirm stream class in the field and this information is recorded in their assessments. There is one question that assessors do not evaluate if a stream is non-fish bearing (e.g. S5, S6) – question 6 relating to whether the stream supports a good diversity of fish habitat. For question 12 related to sufficient vegetation being retained to maintain an adequate root network or large woody debris supply, the sub-questions that assessors answer vary depending on whether they are assessing a fish stream, a non-fish stream that is directly connected to a fish stream, or a stream that is not directly connected to fish habitat.

WHAT IS THE SIGNIFICANCE OF EACH INDICATOR?

Channel bed disturbance

(Protocol question 1 – Is the channel bed undisturbed?)

Channel bed disturbance decreases the stability of stream channels. This indicator is assessed by measuring the frequency, abundance, and location of gravel bars in a stream. Gravel bars located in the middle of a stream channel indicate instability, excessive bed load, and excessive sediment input and movement in the stream channel.

A significant increase in the supply of sediment to a stream system can lead to severely aggraded (i.e., filled-in) channels. This condition is often noted in watersheds with many recent or active slides, eroding roads, or collapsing/eroding banks. As a channel aggrades, the pools fill with bedload. For fish, this results in the loss of resting, shelter, and feeding areas with good cover.

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

Channel bank disturbance

(Protocol question 2 – Are the channel banks intact?)

The stream banks of most small to medium size streams (less than 30 m wide) in their natural undisturbed state are usually protected from excessive fluvial erosion by vegetation with well-developed root systems. Most trees, shrubs, and native grasses will serve this function. These plants also trap sediments to build and restore banks.

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

The stream channel, banks and riparian area of a previously logged S3 pool riffle stream on Vancouver Island. Photo credit: Derek Tripp

Recently disturbed stream banks, usually equate to a loss of stable undercut bank or overhanging vegetation. If widespread or serious enough, recently disturbed banks can be directly responsible for filling in or blanketing the streambed with fine and sand-size sediments. Recently disturbed stream banks can also contribute substantial quantities of coarser sediments (gravel, cobbles, and boulders), leading to a cycle of aggradation and more bank erosion until a new equilibrium is reached between the erosive powers of the stream, the strength of the banks, channel volume, and mean annual flood levels.

Large woody debris

(Protocol question 3 – are channel large woody debris processes undisturbed?)

Large woody debris can have a major effect on the channel morphology of medium size low gradient streams. Photo credit: Derek Tripp

The key considerations for woody debris in streams are the age, abundance, width, orientation, and distribution of the pieces. For the purposes of the FREP Riparian protocol, woody debris is defined as branches or stems with a diameter equal to 10% of the channel depth at the crest of the riffles. For small streams where the channel depth may be only 15 cm, woody debris is any piece of wood with a diameter of at least 1.5 cm. Length is not a factor.

An important future source of woody debris to streams is understory vegetation in the riparian area; therefore, it is important to retain this vegetation. Large woody debris in streams is essential for channel form and the diversity and stability of habitat features in many streams. It provides for fish habitat by reducing stream velocity, and providing both habitat cover, and a source of organic material for stream invertebrates. The function of large woody debris in a stream depends partly on its orientation in the channel; where wood is located parallel to the flow in the stream, it is not contributing to channel form or stream habitat and indicates disturbance in the stream. The abundance and distribution of logjams also impacts several stream functions and fish habitat. The presence of numerous logjams indicates significant disturbance in the stream channel and reduction in habitat area.

Channel morphology

(Protocol question 4 – is the channel morphology intact?)

Determination of whether channel morphology is intact is done by measuring the presence and extent of pools and deep pools. The frequent repetition of distinct pool-riffle or pool-cascade sequences in streams is one of the key indicators of a productive fish-bearing stream. An excess of sediments (especially gravels, cobbles or boulders) can blur the difference between pools and riffles or cause a reduction in the number of pools or riffles thus reducing the amount of productive fish habitat. A variety of well sorted sediments is characteristic of productive streams.

Aquatic connectivity

(Protocol question 5 – are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments?)

Aquatic connectivity includes longitudinal connectivity in the channel, between the channel and its tributaries, and between the channel and its flood plain. Connectivity in a channel is important for downstream distribution of water, nutrients, aquatic invertebrates, and inorganic alluvium (sediments). Gravel and other alluvium needs to be replenished as it is continually being washed downstream. Connectivity between a stream channel and its tributaries is needed to maintain connectivity of fish habitat. Fish require access to seasonal habitat and fish at different life stages require access to different habitats. Connectivity between channels and floodplains is also important because floodplains allow streams and riparian areas to absorb and buffer the effects of major storms.

Many aspects of forest harvesting have the potential to impact fish access to upstream, tributary, or off-channel habitats.

- Newly formed logjams can adversely affect fish habitat in the short term (< 10 years) by blocking sediment movement downstream. If logjams are large or solid, they may also hinder fish movement.
- Bridges or culverts can block sediment movement downstream, and may also constrict flow creating velocity barriers or impassable jumps for fish.
- Roads that lack drainage structures can directly block off-channel areas.

Fish cover diversity

(Protocol question 6 – does the stream support a good diversity of fish cover attributes?)

Fish cover consists of: deep pools; stable, unembedded boulders; stable rootwads; woody debris or other organic material; stable, deep-rooted, undercut banks; submerged and or emergent aquatic vegetation; overhanging vegetation; and stable unembedded gravels and cobbles with void spaces for fish to hide in.

Different fish species require different types of cover; for example, trout can handle higher velocity streams by occupying locations sheltered by boulders whereas Coho prefer pools.

A diversity of fish cover types is typical of undisturbed aquatic systems with well-developed riparian habitats. Actual amounts of fish cover can vary substantially, but stable streams and riparian habitats in properly functioning condition usually have at least five different types of cover present. The number of different cover types available can be reduced when riparian vegetation is removed, banks begin eroding, and sediment supplies are suddenly increased or reduced.

Moss

(Protocol question 7 – does the amount of moss present in shallow areas of the channel indicate a stable and productive system?)

Moss is one of the best indicators of stream health and function. A healthy growth of moss on the cobbles and boulders of stream riffles indicates clean water, stable flows, a stable stream bed, and adequate shade and nutrient levels. The relative abundance of moss on cobble or boulder-bedded stream beds is correlated to fish numbers and/or invertebrate productivity. Poor moss growth in riffle sections usually indicates an unstable substrate, low nutrient levels, or both.

A healthy growth of moss on the cobbles and boulders in a stream indicates a stable substrate and good water quality. Photo Credit: Dean McGeough

High levels of sediment movement in a stream causes scouring of the stream bed which results in damage and movement of moss. Where moss is desiccated or dried out, this may indicate that riparian microclimate has been altered by a reduction in shade due to canopy removal. Moss indicators are also a reflection of stream productivity (i.e. nutrient levels to support fish and invertebrates).

Fine Sediments

(Protocol question 8 – has the introduction of fine inorganic sediments been minimized?)

Fine sediments enter streams from a variety of sources including upstream areas, hillslopes, roads, road crossings, banks, and the riparian area. The presence of excessive fine sediments is an indicator of channel instability.

Large amounts of fine sediments in a stream can fill in hiding spaces for fish – spaces that fish use for resting in high velocity areas of a stream. Fine sediments can also fill pools, embed substrates, blanket the surface of the streambed, and impact egg survival.

Properly functioning streams are most frequently free of fine sediments that cover the surface of the streambed, are unembedded, and have clear water.

Aquatic invertebrate diversity

(Protocol question 9 – does the stream support a diversity of aquatic invertebrates?)

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

Most of the aquatic invertebrates in streams are called "benthic invertebrates." Generally, the more angular and stable the rocks, the higher the number of benthic invertebrates living on them. Substrates composed mostly of fines or organic material also have benthic invertebrates, but they are usually not as abundant or diverse as on stable gravel and cobble substrates.

A diverse assemblage of benthic invertebrates at a sample site is a sign of a healthy stream. Photo Credit: Jeff Adams

Windthrow

(Protocol question 10 – has the vegetation retained in the riparian management area been sufficiently protected from windthrown trees (windthrow)?)

Windthrow can result in a significant input of wood to stream channels resulting in logjams and channel disturbance. Windthrow can expose erodible mineral soil that, if directly connected to a stream channel, is a source of fine sediment to the channel. Windthrow at the stream edge also removes cover for fish on fish bearing streams.

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

Wind throw in a previously logged second-growth riparian reserve zone on Vancouver Island. The stream is located on the left-site of the photo. Photo Credit: Dean McGeough

Riparian soil disturbance

(Protocol question 11 – has the amount of bare erodible ground or soil disturbance in the riparian area been minimized?)

This indicator assesses the amount of bare erodible ground in the riparian area. Bare erodible ground is exposed soil or erodible mineral deposits that water can wash into the adjacent stream. Examples include road cut-and-fill slopes, bladed trails, gouges and scalps due to yarding, tipped over root wads and windthrow scars, slides, and slumps. It also includes animal trails or recreation trails if mineral soil is exposed. Exposed soil subject to erosion contributes to stream channel infilling and bank erosion, reduces sediment entrapment, alters rainfall run-off rates, and provides an opportunity for invasion by weeds.

Retention in Riparian Areas for Root Networks & Large Woody Debris Supply

(Protocol question 12 – has sufficient vegetation been retained to maintain an adequate root network or large woody debris supply?)

In addition to the merchantable overstory, non-merchantable vegetation (e.g., non-merchantable conifer trees, understory deciduous trees, shrubs, and herbaceous vegetation) play a critical role for all streams. Retention of non-merchantable vegetation in the first five meters of the riparian area is important for maintaining root networks that provide bank stability, stable banks are resistant to erosion and disturbance due to storms. Stable banks that overhang streams provide important habitat for fish (see Channel Bank Disturbance).

Together with large woody debris, roots help to maintain the channel form of many small streams < 2 meters wide. Roots become less important in maintaining channel form in streams more than 2 meters wide. Vegetation in the first 10 meters of the riparian area is critical to supplying large woody debris to the stream.

Shade and bank microclimate

(Protocol question 13 – has sufficient vegetation been retained to provide shade and reduce bank microclimate change?)

Shade in riparian habitats moderates air temperature and maintains soil moisture levels. A moist microclimate is important for sustaining streamside vegetation that is beneficial for riparian and aquatic ecosystems.

In addition to providing shade, vegetative cover (trees, shrubs, grasses) in riparian areas also moderate the direct impacts of rainfall on exposed soils (see Riparian Soil Disturbance). Harvesting or intensive browsing and grazing can significantly reduce the vegetative cover of trees, shrubs, and grasses along streams.

A good growth of vegetation along the edge of a stream will shade a stream from the direct warming effects of sunlight on the stream banks and stream bed. Photo credit: Dean McGeough

Disturbance increasers

(Protocol question 14 – have the number of disturbance-increaser species, noxious weeds, and/or invasive plant species present been limited to a satisfactory level?)

Disturbance-increaser species are native or introduced plants that are typically absent, or present in low numbers, in undisturbed habitats. Populations of these species are associated with certain kinds of disturbances such as grazing or active roads and trails. Disturbance-increaser plants are not just invasive plants or pioneer plants, but plants that tend to thrive under conditions of constant disturbance.

Disturbance-increaser species are regarded as undesirable because they generally do not provide a deep-binding root mass for bank protection. Most of these species provide low soil-holding and sediment-trapping capabilities, and have little value as forage. Although the presence of disturbance-increaser species may be natural, they often suppress the growth of other species that may be better at maintaining or re-establishing root networks and bank strength.

Riparian area vegetation form and structure

(Protocol question 15 – is the riparian vegetation and forest structure within the first 10m from the edge of the stream generally characteristic of what the healthy unmanaged riparian plant community would normally be along the reach?)

Most riparian areas support a diversity of trees and/or shrubs, with an understory of herbaceous plants and ground cover (mosses, lichens). The presence of woody plants in all age classes (especially young plants), in vigorous condition and in their natural form, is a good indication of a healthy riparian area. Vigorous vegetation provides shade, organic material, temperature moderation, and a source of terrestrial insects (e.g., beetles, spiders) that fall into streams and provide food for fish.

HOW DO ASSESSORS DETERMINE WHETHER IMPACTS TO STREAMS ARE DUE TO NATURAL OR HUMAN FACTORS?

Assessors are required to determine whether any 'no' answers to questions in the FREP Riparian protocol are a result of natural or human causes. Assessors do this by examining areas upstream and upslope of the stream reach being sampled to determine if there are any sources of disturbance or alterations to the site. Examples of these include road crossings or natural landslides that may contribute sediment. Assessors also compare post-logging windthrow to that that has occurred naturally in the stand, and compare the structure of vegetation retained in the riparian area to that which occurs in an un-logged area.

For more information about FREP visit:

http://www.for.gov.bc.ca/hfp/frep/

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