Restoration Approach

1.0 INTRODUCTION

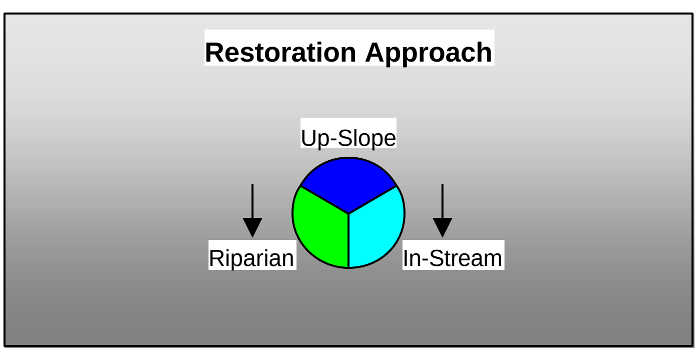
Successful restoration involves looking at all aspects of a watershed, and how each component impacts the other. Watersheds can be broken into four basic components: roads, and gullies (the upslope), and riparian and streams (the down slope).

A comparative analysis called a "Risk Assessment" objectively documents the condition of the four watershed components. Once a watershed is selected for restoration, a watershed Restoration Plan (RP) is developed for agency, and public review. The RP help prioritize restoration activities required to effectively and efficiently enhance the natural restoration processes of the chosen watershed.

2.0 RESTORATION APPROACH

Agriculture, urbanization, and logging practices have all resulted in significant impacts on salmon and trout species habitat. Due to sub-standard forestry road building methods, particularly in the steep coastal settings, there was often an increase in sediment delivery into stream systems. Sources of sediment include road surfaces, poor water management, and land slides. Agriculture results in poor water quality, increased temperature, and peak discharge rates. Important small tributaries were often ditched. Urbanization creates high percentages of impervious surface, poor water quality, and high peak discharge rates.

For restoration of impacted coastal streams the preferred restoration approach utilized is generally top-down, because without addressing sediment sources, in-stream restoration can be very ineffective. The ultimate goal of an up slope restoration program is to address unstable logging roads (through deactivation) before any slides occur, or address chronic sediment sources through enhanced maintenance. Priority of deactivation is dependent on where it would be most beneficial in preventing, or reducing excessive sediment influx.



Deactivate of the highest risk roads are completed first, working consecutively to the lower risk roads.   The approach is to fully restoring the hill slope in the old road location then aggressively seed the exposed soil.

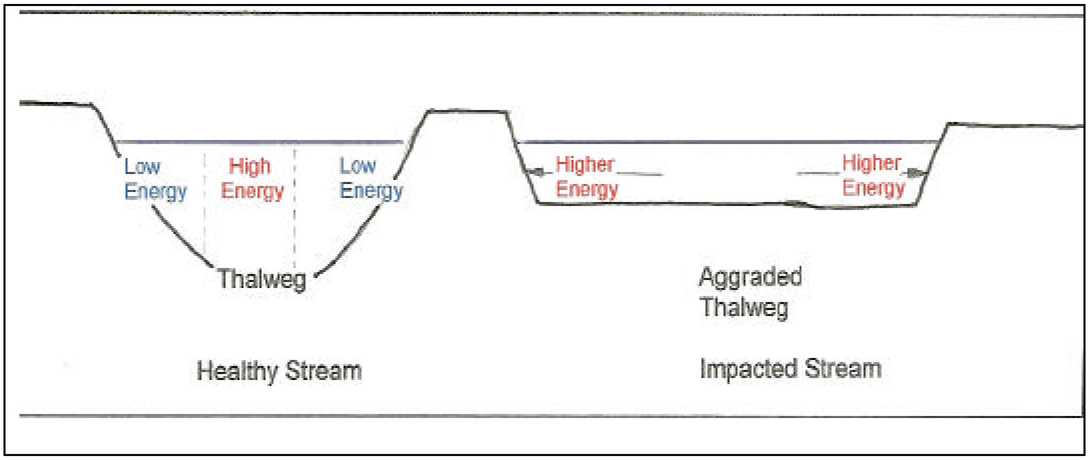
In areas where there has been slide activity open slope failures are hydro-seed with a mixture of grass seed (native seed when available), slow release fertilizer, and mulch. Grass seeding is very effective in reducing fine sediment from leeching from the slide. Grass will establish well on the areas of the slide that are relatively stable. Remaining zones of instability are easily identified the following year by observation of areas of poor grass establishment.

Following the deactivation of the roads there is a focus on restoring the unstable portions of the landslides. To stabilize and revegetate the slides an approach called “bio-engineering” is utilized. Basically this is the use of live willow cuttings to hand build living, self-maintaining, retaining walls. When the upslope areas have been addressed, most of the in-stream restoration work can proceed. Instream work is generally divided into two components: Riparian (a vegetative buffer strip along a stream) and actual in-stream work.

In most cases, one of the largest long-term problems facing impacted fish bearing streams is a lack of incorporation of large woody debris. Large woody debris is very important, in that it is nature’s way of forming its own pool-riffle-glide-cover-spawning areas.

In the past, cut blocks were logged right to the stream banks, which virtually eliminated any chance of larger trees dying and falling into the stream (called “natural recruitment”). In many cases alder has taken over the riparian areas of the streams and rivers. While Alder can supply good cover, when it dies and falls in the stream it does not last very long (conifers are far more resilient). On all of our stream rehabilitation projects there is a strong focus on developing a new coniferous riparian zone.

A common result of some logging practices is that debris torrents have swept away many of the natural LWD structures rendering the stream system relatively featureless (low pool, riffle, and glide frequency). The bedloading fills in the pools and thalweg (the deepest section of a stream) resulting in the energy of the stream to be re-distributed towards the stream banks. As this energy erodes the banks (made even less stable with the lack of large conifer roots), the bedload problem is compounded. LWD is also very important for cover, for protection from predators.



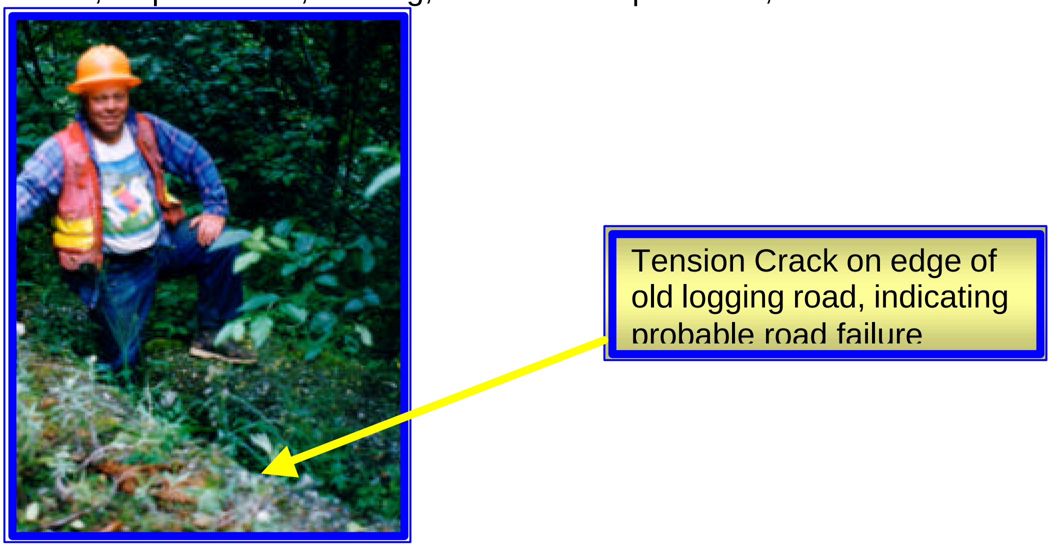
Generally in-stream restoration work involves the creation of pools riffles and glides by installing structures in-stream made of LWD and/or rock. The construction of side channels for temporary creation of stable spawning and/or rearing habitat is also a common practice. By transporting in foreign large woody debris and securing it in place (with cables or boulders) biologists and engineers can temporarily (50 years) mimic nature in its creation of pools riffles and glides. Ultimately we try to mimic nature in these frequencies as much as possible.

2.1 Road Deactivation and Maintenance Planning

A forest road risk assessment procedure is expected to increase the benefits of a road deactivation program. The risk assessment is used to objectively rank and compare potential landslide risk and sediment sources on individual logging roads. This process allows for objective ranking of forest road condition, and helps avoid subjective management. Risk assessments allows planners to have an objectively comparison of all roads within the watershed, or sub-basin.

In order to document road conditions, the field card was broken into sections to give a numerical rating to indicate the relative risk for each road where: *Environmental Risk = Hazard x Consequence*.

Hazard is a ranking of instability based out of a maximum score of 9. The higher the instability of the road (i.e. the likelihood of a road-related landslide initiating within the next five years) the higher ranking it receives. The card is designed to record hazard indicators of road instability and their location such as tension cracks, displacement, incising, water control problems, etc.



When looking at the stability of an existing road, appreciation of how the roads nearby in the watershed are performing is usually a very good indication. If there are no landslides elsewhere in the watershed, that watershed may be inherently stable. How the road was constructed is also important as roads have different kinds of stability concerns based on what kind of equipment was used to build them. A road built by a bulldozer will have different stability concerns than a road built by an excavator. As well, the geometry and construction material of the road is important. You need to know is how much road-fill you're looking at and what slope the road is sitting on. You need to think about is the material that was used. Is the material a very coarse rocky material that drains well with a fairly high internal strength or is it a fine-grained soil, which is less well drained and doesn't have that same high internal strength?

Consequence is also based on of a maximum score of 9, and is a ranking of what a slide would impact if it were to initiate. The greater the potential damage, the higher the consequence ranking the road receives. A section of the field card was designed to record a list of consequences such as impact on a salmon bearing stream, loss of human life, property damage, visual aesthetics, etc.

Once the roads have been rated for environmental risks, then there is assessment of the feasibility of a proposed deactivation program. This Feasibility Rating also has a maximum score of 9, and includes factors such as access, technical feasibility and level of funding. The Environmental Risk score is then multiplied by the Feasibility Score to give a maximum score of 729, indicating overall risk. i.e. If you've got to put in a $200,000 bridge to access a road to deactivate it, then you'll utilize a whole lot of your budget just putting in that bridge, whereas, if you've got a road with an equal environmental risk but the access is good, then that's the one you should do first. The scores of all of the roads are summarized so they can be objectively compared. Decisions can then be made that ensure that a given level of funding will provide the greatest reduction of risk, thus allowing for a "best investment" planning process. Detailed road deactivation prescriptions are then developed only for those roads identified by the risk assessment that are to be addressed in the next years deactivation program.

Up-slope WRP Risk Assessment Rating
Overall Risk = Hazard x Consequence x Project Feasibility
Maximum risk Rating would be 9 x 9 x 9 = 729

Hazard: (the likelihood a slide will initiate) rating scale is as follows:

Value	Description
7-9 (high)	There is a significant probability that the hazard will worsen within the next 5 years
4-6 (mod)	Addressing the hazard will be required, but it is not expected to worsen significantly Over the next 5 years
1-3 (low)	Low likelihood of a slide initiating now or over the next 5 years

Consequence: (what a slide would impact if it were to initiate) rating scale as follows:

Value	Description
7-9 (high)	Major fish streams, human health, infrastructures
4-6 (mod)	Minor fish streams (resident fish only), productive forest land, significant wildlife Habitat, high visual quality
1-3 (low)	Lower visual quality, informal recreational values

Feasibility:

Access (is access by road possible) rating scale as follows:

Value	Description
3 (high)	Road intact / machine access possible
2 (mod)	Road intact but overgrown / Reactivation required to install drainage structures (road presently cross-ditched/Road previously deactivated (to inadequate standard)
1 (low)	No access possible (road removed by slide)/reactivation not required to reduce hazard

Technical (will work completed using proven road deactivation techniques reduce risk) rating scale as follows:

Value	Description
3 (high)	A reasonable level of intervention is likely to reduce the over-all hazard rating to low
2 (mod)	A reasonable level of intervention is likely to reduce the over-all hazard rating to an acceptable level
1 (low)	A reasonable level of intervention is **not** likely to reduce the over-all hazard rating to an acceptable level/No hazard exists

Fiscal (can road be deactivated given the current funding level) rating scale as follows:

Value	Description
3 (high)	Hazard will be reduced to low given the allotted budget
2 (mod)	Hazard will be significantly reduced with allotted budget
1 (low)	Hazard will **not** be significantly reduced with allotted budget

ENVIRONMENTAL RISK

CRITICAL	**64 or greater**
HIGH	**55 to 63**
MEDIUM	**28 to 54**
LOW	**1 to 27**

OVERALL RISK BREAKDOWN

CRITICAL	**567or greater**
HIGH	**486 to 566**
MEDIUM	**243 to 485**
LOW	**Less than 243**

2.2 In-Stream Restoration Planning

Once the up-slope problems have been addressed in-stream restoration can proceed. To determine the current condition, limiting habitat features, critical reaches, and sites for restoration opportunity, a "Fish Habitat Assessment Procedure" (FHAP) is completed. Based on the FHAP information, site-specific, detailed prescriptions (Level II prescriptions) are developed. This will often require the combined efforts of biologists, engineers, geomorphologists, and hydrologists.

Once the Level II prescriptions are approved by MWLAP, a permit (Section 9) to work in and about a stream is applied for and in-stream restoration work proceeds within the established "fish window".

2.3 Riparian Restoration Planning

Riparian areas are an essential component of healthy forest and stream ecosystems. Functioning riparian ecosystems provide many of the essential attributes required by fish and other aquatic organisms including shade, bank stability, protection from flood events, and a recruitment source of large woody debris and course woody debris.

Non-functioning (or impaired) riparian ecosystems supply poor bank protection and are a poor recruitment supply of large woody debris. This impaired ecosystem will eventually recover, but over an extended period of time (D. Prichard, 1993).

The Riparian Zone is the area of forest that borders the edges of streams. Riparian Vegetation Types (RVT's) are broken into 5 basic classifications (Poulin, Harris, Simmons, 2000) where:

? RVT 1: Brush dominated, with poorly stocked conifer component
? RVT 2: Over stocked conifer
? RVT 3: Deciduous forest over top of a good conifer understory
? RVT 4: Deciduous forest with a poor conifer understory
? RVT 5: Old growth or old second growth forest

Each sub-basin requires stratification of the different RVT types. There can then be a focus of treatments of the highest priority RVT's. RVT 1 and RVT 4 are the highest priority for treatment, followed by RVT 2.

While Alder and brush may be a good nitrogen fixers, they lacks adequate root strength for stream bank stability. Alder and brush are shade intolerant colonizing species of disturbed sites.

Alder is an extremely fast growing tree that puts most of its' energy into canopy and stem growth in an effort to maximize its' exposure to the sun. As an Alder approaches the end of its' life span, the supporting root structure becomes insufficient to bear the weight of the tree, and if it doesn't blow over, it will basically just fall over.

Alder growing close to a river bank will often grow towards the centre of the river to capitalize on the sun light, as the trees grow older and fall over into the river, the upturned root ball creates a divot along the river bank resulting in an erosion "nick point".

Once Alder has fallen into a stream system, it will degrade quickly. While it is beneficial for invertebrate populations (and hence food sources for rearing fry and smolts), its rapid degradation makes it a poor species for in-stream LWD structures. It is these characteristics of Alder that make it a poor dominant riparian species.

Conifers are generally more shade tolerant than deciduous species. Conifers are slower growing but longer lived, so will eventually out compete a deciduous forest. They have a more developed rooting system, and therefore far more likely to provide stream bank stability. They are also far slower to degrade once in the water, therefore are superior for LWD structures. As a result of these differing characteristics RVT 1 and RVT 4 represents the highest opportunity and priority for recommended treatment (Poulin, Simmons 1998).

2.4 Nutrient Replacement Planning

Due to a combination of pre-code logging practices, over harvesting of fish, and climactic conditions, returning runs of Salmon and Steelhead have been reduced significantly. Fish returning to river or stream systems to spawn play an important role in enhancing the nutrients of that stream or river. The nutrients, in turn, have significant impact on the health of aquatic invertebrate populations, which become a primary food source for emerging fry.

When runs of returning fish become depleted, the nutrients they bring to that stream or river system is also reduced, potentially affecting the health of the invertebrate population. Nutrient replacement can help augment the required levels for a healthy food source for emerging fry.

Healthy levels in a stream of Nitrogen and Phosphorus are as low as two parts per billion (or 2 seconds every 33 years). Water sampling can identify any shortfalls in nutrient levels, and a customized blend of slow release fertilizer briquettes can be designed to bring the level of nutrients up to a healthy level.

As the returning numbers of fish improve, the level of nutrient replacement is reduced.

3.0 PROJECT OBJECTIVES

3.1 Roads

- Reduce the residual risk of a road related slope failure to low, where low is defined as the residual risk associated with a similar area without roads.
- Improve water quality by restoring surface and subsurface hydrology
- Improve site productivity

3.2 Riparian

The objective of a riparian treatment is to speed up the natural recovery process by re-establishing a more natural frequency of conifer species and promoting the conifer species growth.

3.21 RVT 1 Restoration Objectives

- To re-establish conifers, through planting or release of existing conifers, within the riparian zone to stabilize the channel, reduce bank erosion, and provide a long term recruitment source of LWD
- To reduce brush competition through brushing

3.22 RVT 2 Restoration Objectives

- To reduce conifer densities
- To establish as future recruitment source of LWD

3.23 RVT 3 Restoration Objectives

- To lower Alder density to reduce conifer competition (low priority)

3.24 RVT 4 Restoration Objectives

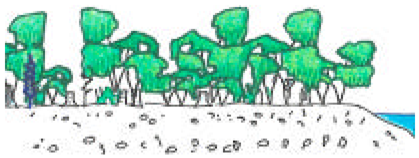
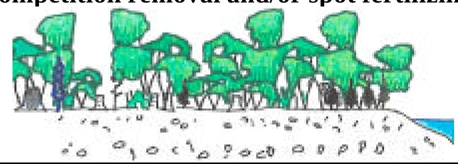
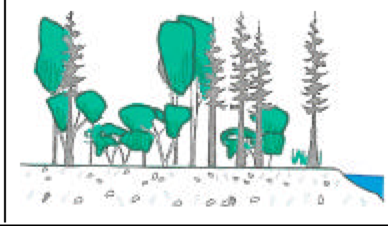
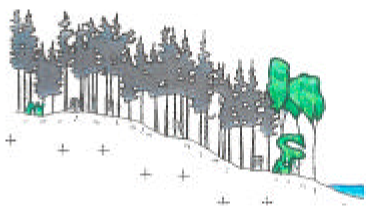
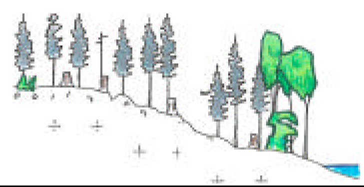
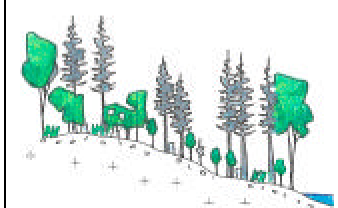
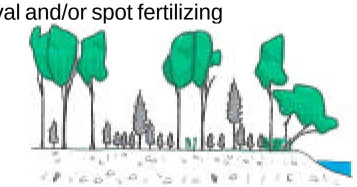
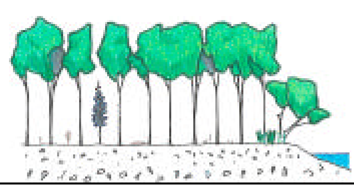
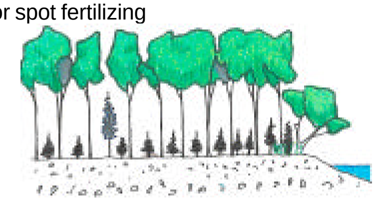
- To re-establish conifers, through planting or release of existing conifers, within the riparian zone to stabilize the channel, reduce bank erosion, and provide a long term recruitment source of LWD.
- To lower Alder density to reduce conifer competition

3.25 RVT 5 Restoration Objectives

- No treatment required

3.3 In-Stream

- To address limiting habitat
- To establish, if required, a more natural frequency of pools, riffles, and glides
- To provide, if required, stable spawning and/or rearing habitat
- To speed up the natural recovery process

RVT	Stand Condition	Function Impaired	Area (ha)	Recommended Treatment	Desired Future Condition
1	**Brush dominated, poorly stocked conifer component** 	Large wood, shade, bank and floodplain stability		**Improve conifer stocking by planting. Release suppressed trees through competition removal and/or spot fertilizing** 	
2	Over stocked conifer, >800 stems per ha 	Large wood, forage for wildlife, structural diversity		Thin to 400-600 sph, favouring largest diameter trees; vary densities creating gaps and clusters. Opportunities for bird and bat nests, and wildlife trees. 	
3	Deciduous forest over top a good conifer understory 	Large wood, bank and flood plain stability		Release over topped conifers through competition removal and/or spot fertilizing 	
4	**Deciduous forest over top a poor conifer understory** 	Large wood, structural diversity, bank and flood plain stability		Improve conifer stocking by planting. Release suppressed trees through competition removal and/or spot fertilizing 	
5	Old growth, or old second growth (>70 years)			No treatment required	N/A

Riparian Vegetation Types, and Their Recommended Restoration Treatment