Appendix 4: Revegetation Guidelines for Brownfield Sites

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1.0 PURPOSE

The purpose of the revegetation guidelines is to provide advice on acceptable riparian planting practices for brownfield sites (areas with less than 30% natural vegetation). The guidelines provide instruction as to how to develop a site plan describing revegetation treatments as well as a monitoring plan to assess success of the planting project.

Where a streamside protection and enhancement area (SPEA) has been recently or historically disturbed by development activities the objective is to establish natural vegetation to help restore the natural features, functions and conditions that support fish life processes. Trees, shrubs and herbs in functioning riparian areas area source of food, nutrients and large woody debris for streams. They can also moderate stream temperature, stabilize stream banks, filter surface run-off entering the stream and store water to maintain sustained water flows.

A healthy riparian area also provides high value habitat for many wildlife species, including species at risk. Riparian ecosystems are biologically diverse and are used by over 40% of terrestrial species in BC. Listed amphibians such as Tailed Frogs, Painted Turtles and Blotched Salamanders spend most or all of their life stages in riparian areas. Some riparian tree species such as black cottonwood provide very important habitat for birds, including the red-listed Interior Western Screech Owls. Riparian corridors also provide migration routes for many large mammals.

Whether the project is replacing lawn with natural vegetation for a small residential lot or restoring the riparian area at a large industrial site, the following guidance is intended to help plan, implement and monitor the success of the project.

2.0 ROLE OF QUALIFIED ENVIRONMENTAL PROFESSIONAL (QEP)

Although there is no requirement to have a QEP develop, implement and monitor revegetation plans for brownfield sites, it is recommended that expertise appropriate to the scale of the project be involved to ensure goals to protect fish habitat are met. In some situations, a local Streamkeepers group may have the appropriate skills to conduct the project. However, for a larger more complex project a team with a range of expertise may be required.

Specific roles of the QEP (or other expert) include the following:

- Develop and implement revegetation prescription (including layout, species selection, planting techniques, etc.); and
- Develop and implement a monitoring plan that assesses success of meeting prescription goals and objectives.

Prior to starting the project, the local government should be consulted to ensure there are no specific bylaws triggered by riparian planting projects. Also, all planting must occur above the high water mark otherwise a Notification required under Part 7 of the *Water Regulation* or approval under section 9 of the *Water Act* for changes in and about a stream is required.

3.0 DEVELOPING A SITE PLAN

The remaining sections of the guidelines describe the steps required for developing a site plan. The site plan includes a map and treatment prescription that describes treatment objectives and how they are going to be met (see Appendix 1 for template). It describes the area covered by the prescription and identifies the various planting zones or treatment units. A monitoring plan describing how progress toward meeting objectives will be assessed is attached as an appendix to the site plan. The following sections describe information to consider when developing prescription content.

3.1 Setting goals and objectives

Taking the time to develop clear goals and objectives is a very important first step as they provide the framework for the site and monitoring plans. Every prescribed treatment within the site plan must be linked to a specific objective. Implementation monitoring assesses whether or not treatments achieved shorter term objectives; whereas, effectiveness monitoring assesses progress toward achieving longer term goals. Although effectiveness monitoring is very important, these guidelines only describe implementation monitoring.

There are a number of steps to consider when developing goals and objectives:

1. <u>Define goals:</u> Goals describe a desired future condition (Gayton 2001). The overall goal for revegetating any riparian brownfield site is to improve or restore natural features, functions and conditions that support fish life processes. However, other secondary goals will need to be defined to address the current versus desired condition of the site. These may include:
   - To increase large woody debris in the stream for fish cover by planting trees;
   - To establish a multi-storied forest to provide stream shade, as well as organic matter and food for the stream;
   - To increase bank stability and to reduce sediment and pollution from surface run-off by streambank plantings; or
   - To increase surface sediment filtering by re-establishing ground cover.
2. <u>Identify the problem:</u> After the preliminary goals are established, the site is visited to document current condition, identify specific problems that require addressing, identify the SPEA or treatment area boundary, revise goals, and to develop objectives. During the site visit, areas outside the SPEA are looked at to identify any contributing problems (e.g., a paved driveway that directs water onto the brownfield area). Document the current condition and any problem areas on the dataform (Appendix 2) and with photographs.

   At this stage, treatment units (TUs) may be established with different objectives and prescribed treatments. For example, improving bank stability may be the primary objective in the 3m wide streamside TU and prescribed treatments may focus on immediate planting of live stakes. Upland areas may have been disturbed and have lightly compacted soils, therefore increasing organic matter and loosening the soil are important objectives. Requirements may include adding organic soil additives and planting nitrogen-fixing species (e.g. alder).

3. Revise goals if necessary: Information from the site visit may determine that new goals are needed or preliminary goals require revising.

4. Define objectives: Objectives are measures or actions taken to achieve goals. Objectives are measurable and include a description of an end result and are often linked to ecological function. Objectives also set a timeline and will form the foundation of the monitoring plan.

   For example, if the goal is to provide a multi-storied forest to provide stream shade to moderate stream temperatures, then one associated objective may be to plant 2 year old black cottonwood seedlings. These should be placed at 1m spacing along the streambank zone and should reach 5m height by year 5.

It is important to consider the temporal aspect (i.e., the time involved) when developing goals and objectives for restoration projects (Dorner 2002):

- Can the objectives be completed in one year or multiple years? For example, are there areas that may require bank stabilization prior to planting trees and shrubs; and
- Do long-term goals require different short-term objectives? For example, if the long term goals for the site require a dense cover of shrub species that are intolerant of high light levels, then a short term objective may be to create shade.

3.2 Background data collection

The background data collection is completed in 2 stages - office review and field review.

1. During the office review collect information on (see dataform in Appendix 1):
   - Fish inventory data[1].
   - Legal description of property.
   - Site history: What was the site used for? Were any herbicides or other chemicals used that may affect plant establishment and growth? How long since the site was initially disturbed?
   - Uses of neighbouring properties: Are there ways to complement efforts on nearby properties to improve riparian health? Are there neighbouring properties that could participate in a larger riparian revegetation project?
   - Contact local stewardship groups (e.g., Streamkeepers) for background information, for example, on fish enhancement projects carried out along the stream.
   - Contact the local government to determine what other bylaws may apply to the project.
   - Assess if there are any *Water Act* considerations/issues.

2. During the field review collect information to describe current features and condition within the SPEA (see dataform in Appendix 2):

[1] Fisheries Information Summary System: http://www.env.gov.bc.ca/fish/fiss/index.html
Department of Fisheries and Oceans: http://www.pac.dfo-mpo.gc.ca/habitat/links-liens-eng.htm
Community mapping Network: http://cmnbc.ca/

- Biogeoclimatic (BEC) Zone site series (http://www.for.gov.bc.ca/hfd/pubs/Docs/Srs/Srs06.pdf)
- Aspect, elevation, slope, terrain features (e.g., gullies and ravines).
- Streams (number, size, location).
- Existing native plant species, percent cover (see MOFR and MOE 2010 for methods and cover comparison diagrams)and condition. When assessing condition, record observations describing vigour, form, insect/disease incidence, or animal damage (see references in section 10).
- Invasive plant species and percent cover.
- Soil texture, forest floor type and condition.
- Soil disturbance (degree of compaction)/ forest floor displacement[2]
- Erosion/sediment sources.
- Sources of supplemental water.
- Site factors requiring specialized assessment (e.g., hydrologist to design a system to divert sediment laden surface flow into vegetated areas to increase infiltration).
- Features outside the SPEA to consider during planting (e.g., dense tree canopy, steep paved driveway or path directing surface flow into SPEA).

For heavily disturbed sites and large project areas it is advisable test the soils for nutrient levels and bulk density especially if compaction is a concern (see section 5). Soil condition is critical in determining the success of the restoration project and it is important to assess prior to investing in the planting of trees and shrubs. Contact local soil labs to find out sampling requirements.

Current site condition and problem areas should be photographed. At this stage permanent photo plot locations can be established for monitoring (see section 8) to document the baseline condition.

4.0 SPECIES SELECTION

Appendix 3 provides a partial list of plant species appropriate for planting in coastal and southern B.C. riparian ecosystems. Careful species selection ensures better survival rate and also means that objectives are reached as rapidly as possible. Plant species selection depends on careful consideration of many factors including:

1. <u>Project objectives:</u> Having clear project objectives is critical to selecting appropriate plant species. It is likely that different objectives will apply to different treatment units and therefore different plant species combinations will be required. Some areas may have objectives that make it more challenging to select plant species. For example, if one objective is to reduce soil erosion, grasses and legumes may be the best species to use initially on the site. However, they can interfere with tree and shrub establishment which may be an important objective in the same area for large woody debris (LWD) recruitment. If rapid revegetation is required, (for example for severe erosion

[2] Forest floor displacement: This refers to areas where the organic layers have been removed exposing the mineral soil. Loss of the organic layers can reduce long term soil nutrient levels, increase soil drying rates and exposes fine textured soils to precipitation increasing risk of compaction.

concerns) select pioneer species such as alder, as they are adapted to grow fast in harsh conditions (MOF 1997).

2. Site description/characteristics: Environmental conditions at the site affect survival and growth of selected plant species. Light, moisture, elevation, and aspect are all important variables affecting species establishment. Plant species tolerance to heat, drought, shade, water deficit/surplus and nutrient deficits are also important. This information can be addressed by determining the representative biogeoclimatic zone and site series classification (Meidinger and Pojar 1991) for the respective site. This will aid in determining the appropriate soil moisture, nutrient regime, plant associations that will be beneficial to the site.
3. Planting zone: Different treatment units will likely be established reflecting the different vegetation zones that typically occur in riparian areas (Hoag et al. 2001). Vegetation closest to the stream often has flexible stems and rhizomatous roots. Shrubs often occupy the sites above the streambank while trees may only begin to appear in transitional upland sites. Every site has unique characteristics that must be evaluated to determine suitable treatment units.
4. Site condition: Depending on the past use of the site, soil disturbance and forest floor removal may have impacted soil nutrient levels, soil water holding capacity, and soil structure (affecting soil aeration and water infiltration). This may even affect the site series classification (e.g., to more drought-like conditions) and adjustments may be required for species selection to ensure growth and survival.
5. Invasive plant species: For sites with established invasive plants, the planting scheme should consider the competitiveness (hardiness, proliferation and rate of growth) of native plants chosen. For example, selecting shade intolerant native plant species may not be appropriate for sites with extensive Himalayan blackberry until this invasive species is adequately contained or eradicated.
6. Insects and diseases: It is important to factor local insect and disease outbreak patterns into tree and shrub species selection to reduce potential for losses. For example, in areas where spruce leader weevils are common, mixed species stands with a deciduous component will help to deter insect attack.
7. Moisture requirements: Precipitation during the growing season and availability of water for supplemental watering will affect species selection. If supplemental watering is not an option, less moisture dependent species should be planted (Dorner 2002), and/or the species planted during the time of year when they suffer the least amount of water stress (e.g. fall or early spring).
8. Plant associations: In nature, several plant species will often grow together forming a plant community where symbiotic relationships have developed (Dorner 2002) therefore selecting plants that typically grow together is important. This is beneficial for the re-establishmnet and the long-term survival of the plant community. Although many plant relationships may be beneficial, it is also important to evaluate competitive relationships between species when considering plant species combinations. This includes consideration of shade tolerance, growth rates and rate of spread (e.g., seed dispersal, spread by rhizome).

   It is also important to consider the potential for natural regeneration of native plant species. Where natural regeneration is likely, the planted species selected should be from the same community and neither should be a competitor. Creating conditions that support healthy natural regeneration as well as planted trees and shrubs will help to maintain or enhance biological diversity in the riparian ecosystem.

4.1 Reference sites

Nearby reference sites can be assessed for site series (soil moisture and nutrient regime) and plant species which can be used as templates for designing TU prescriptions. Similar sites can be strong indicators of the plant species that are best suited to local environmental conditions, thereby providing guidance for what the restored site could look like. Reference sites also provide a performance standard for the monitoring plan (section 8). As discussed above, for severely disturbed sites, a site series other than the original may be more appropriate, and therefore the reference site may be from a slightly different area. Or, none may exist at all if the site has been too disturbed for too long.

4.2 Genetics

In addition to selecting the appropriate species, it is also important to ensure that provenance[3] is considered in plant selection strategies. Locally sourced native plants have higher survivorship as they are genetically adapted to the local area conditions, such as climate and soil conditions (Withrow-Robinson and Johnson 2006, Dorner 2002). Some plant species are generalists and are adapted to a wide range of conditions whereas other species are specialists occupying a very narrow range of conditions. Therefore it is important to select plants sourced from nearby sites. Plant material should be collected from within the same watershed from areas that have similar aspect, elevation, slope, frost dates, temperature regimes, precipitation, hydrology, soils and vegetation (Dorner 2002).

Also important, is ensuring there is adequate genetic variability so that plants can better adapt to new stresses. Ideally, there are 20 unrelated seed or cutting parents to capture most of genetic variation in a population (Withrow-Robinson and Johnson 2006).

This combination of appropriate species, provenance and genetic variability may be a challenge to source from local nurseries. Ideally plant material (seeds and cuttings) are collected from adjacent sites, then grown in nurseries until they reach an appropriate size for out planting. It may take two or more years to grow the best suited plants for the site, however, long term gains in survival and growth may warrant this delay. There is a need to plan ahead to have these plants grown 1-3 years ahead of the actual restoration; leaving bare soil will only increase the percentage of invasive plant species becoming established.

5.0 SITE PREPARATION

5.1 Assessing soil condition

To ensure native plant survival and growth, site preparation may be appropriate if soils have been disturbed affecting soil structure and nutrient levels. Good soil structure consists of soil aggregates with

[3] Provenance refers to a specific geographic area within the natural range of the plant species.

pore spaces that allow water and air to move freely into and out of soils. Functioning soil structure is required for good plant growth. Soil testing can be used to assess bulk density, nutrient and pH levels. For small sites, do-it-yourself tests can be purchased from garden centers though they are restricted in what they evaluate. For larger projects, soil samples (from throughout the site) can be sent to specialized labs where a more detailed analysis is completed.

Depending on soil texture and coarse fragment content, soil compaction can occur from vehicle or machine traffic, repeated animal use (e.g., cattle) or from precipitation on exposed fine-textured soils. Degree of soil compaction can be assessed by comparing the structure (the combination of soil aggregates and pore spaces) of nearby undisturbed soils to disturbed soils on the planting site. Any noticeable change in density between the two soil samples indicates soil compaction and likely some degree of disruption to natural soil processes.

5.2 Improving soil condition

Various treatments may be prescribed to improve soil condition (MOF 1997). Also, some trees and shrubs are better adapted to highly disturbed sites and compacted soils. For example, alder is nitrogen fixing improving soil nutrient levels, whereas lodgepole pine roots readily penetrate compacted soils helping to improve soil structure and therefore site productivity. Establishing deciduous trees also helps to rebuild soils as the decomposing leaf litter stimulates plant and microbial activity re-establishing soil ecosystem functions (MOF 1997). Fast growing legumes help restore soil structure (MOF 1997) and are nitrogen-fixing. Other nitrogen-fixing plants include lupines, vetches, soopalalie, ceanothus and wolf willow (Gayton 2001). Using chemical fertilizers to improve soil nutrition in riparian areas is not recommended due to potential for negative impacts to water quality. It is also important to remember that some plant species and communities are adapted to poor soils and improving the soil may put these plants at a disadvantage and invasive plant cover may increase (Dorner 2002).

For compacted areas, soil structure can be improved through mechanical tilling dry soils (though this is less suitable for fine-textured soils with low organic matter as re-compaction may occur when soil becomes wet), and/or by planting species with root systems adapted to growing in disturbed soils providing a slow but natural tilling process. Because soil structure varies with soil texture, soil organic matter and soil biological activity (MOF 1997), in order for mechanical tilling to be effective in helping restore soil structure, organic matter must be present. Rapid establishment of plant communities may be sufficient in providing organic matter and soil organisms, however, particularly disturbed soils may require organic soil amendments such as mulch or leaf litter.

One drawback of tilling is that it may increase the number of weed germinants. If this is a concern, one option is to till the soil and leave the site fallow in the first year and destroy the plants prior to seed set.

Alternately, for smaller projects or sites that have been severely degraded it may be possible to bring in topsoil from nearby sites about to be developed (e.g., road construction) (Dorner 2002). This adds organic matter and associated soil organisms (microbes and invertebrates) important for nutrient cycling and creating soil structure. Additionally, it is important to be sure the soil is free from invasive plant seeds and sections of viable roots or rhizomes/stolons (under and above-ground stems).

Coarse woody debris (CWD) can be brought into sites where it is absent to aid in soil restoration. It functions as a sponge to retain soil moisture, provides nutrients through decomposition and provides habitat for organisms that are important for soil building processes.

Careful attention put into site preparation will ensure that soil structure quickly recovers from past damage, and that adequate nutrients and water are available for vigorous plant growth.

5.3 Reducing soil erosion

For sloped sites with minimal vegetation, soil erosion may be a concern requiring immediate attention prior to any planting. Although vegetation may provide the long-term solution to erosion problems, until it becomes established additional measures may be required. Natural biodegradable erosion control mats (made from coconut fiber, wood shavings), physical barriers (e.g., hay bales or silt fences) or mulching (e.g., weed-free hay or straw) can be used to reduce surface runoff (Dorner 2002).

5.4 Dealing with invasive plants

Invasive plant species (e.g. Himalayan blackberry, Japanese knotweed, Scotch broom) if not controlled can out-compete native plant species after revegetation efforts. In addition, these plants can contribute to loss of wildlife habitat, increased soil erosion, and increased fire risk (MoFR 2010). Invasive plants must be contained or eradicated prior to planting to maximize the survival of transplants and to decrease the spread of invasive plants into adjacent areas.

There is extensive information available on how to identify, treat and monitor invasive plants (see section 10 for website links). Strategies to control invasive plants will depend on the species, the size of area to be treated, and the dispersal mechanisms of the invasive plant. There are four main categories of treatment options: mechanical, chemical, ecological and biological. Chemical treatments are not appropriate for riparian areas and biological agents may be less available, therefore ecological and mechanical options will be most often the appropriate methods. Mechanical options to control invasive plants include hand pulling, cutting with loppers or pruners, mowing, cutting with brush saws, burning, tilling, mulching, and in severe cases digging out with back hoe.

With ecological control, ecological functions are changed to discourage invasive plant growth (Dorner 2002). For example, planting dense-crowned trees will eventually shade out knapweed as the canopy closes. Other strategies include flooding, changing disturbance patterns, changing available nutrients or soil pH.

Planning steps for controlling invasive plants:

1. Identify species and estimate percent cover for each species using cover comparison diagrams in MOFR and MOE (2010).
2. Select priority species and areas for containment versus eradication (a tool is available to assist in selection at http://www.goert.ca/documents/Species_Scoring_Algorithm.xls). It is important to first identify ways to prevent further spread prior to implementing any eradication efforts.
3. Define treatment areas based on different treatment strategies (method and timing of treatment). Assess whether repeated treatments are required and at what interval. For example, plants that re-

sprout from roots may require repeated treatments in a single year, whereas, plants with long-term seed storage in soil may only require annual treatments.

4. Do not leave bare soil or the invasive plants will re-establish. Mulch the area, and/or have plants ready for transplanting as soon as the ground has been cleared and prepared, then mulch around the plants after planting.
5. Select appropriate disposal method. Options include removing material from the site, burning on or off site, leave on site to decompose, chip on site and use as mulch. When selecting disposal method, be sure to consider resulting soil disturbance and possibility of accidental seed dispersal.
6. Monitor subsequent regrowth and adjust treatment program.

Taking steps to minimize spread of invasive plants is also important. Before leaving sites with invasive plant species, check clothing and footwear for seeds. If parked in an area with invasive plants, inspect your vehicle to ensure there are no plant parts attached.

6.0 PLANTING

Planting material can be accessed in many ways: seeds, cuttings, nursery stock, rescued plants or live staking. Selecting a method will depend on availability of material, associated survival rates and treatment objectives.

6.1 Planting nursery stock

Appendix 3 describes common tree and shrub species for relevant BEC zones that are most likely to be sourced from local native plant nurseries. Contact local native plant nurseries for species availability. The Native Plant Society of BC has a list of B.C. nurseries specializing in native plants[4]. Plan ahead 1-3 years to contract grow native species for specific sites through local nurseries.

Nursery stock should be a minimum of two years in age as they will have more developed root systems and higher survival rates. Planted nursery stock is available in containers, bare root or wrapped in burlap, each with associated advantages and disadvantages (Dorner 2002). It is important to ensure local native plant nurseries obtain local seed and vegetative inventories. It may be appropriate, especially for larger projects, to arrange for contract growing of trees and shrubs a year or two in advance of the restoration project to ensure the most appropriate source material.

Selecting a planting microsite is an important step. In wet areas consider mounding to create elevated growing sites where roots are out of the water. On dry sites, moist depressions may improve plant survival and growth. When planting, the following steps should be followed (Kipp and Calloway 2002, Dorner 2002):

1. <u>Protect plants:</u> Store plants in a cool, shady location and keep watered. Plant on a cool damp day, no wind and preferably in the evening.

[4]BC Native Plant Society: http://www.npsbc.org/Use/use.htm

2. Preparation: Dig a hole 2 to 3 times larger than the size of the roots. Loosen soil for 20 cm at bottom and sides of hole. For dry sites, fill hole with water. Add compost or bone meal if desired.
3. Planting: Gently untangle roots pruning damaged roots. Mound some soil in bottom of hole to form roots around. Place plant in hole ensuring the top of the root ball is flush with the surface. Fill hole with soil stopping to press out any air pockets every so often taking care not to bury the main stem.

   For container grown plants it may be necessary to slice 2/3 up the root ball from the bottom so roots can be spread during planting (this reduces risk of root girdling).

   Water plants well. In dry areas, create a berm around the plant to hold water. Prune off any dead or damaged branches. Finally, mulch around plant keeping 2.5 cm away from stem.

Bare root stock must be planted while it is dormant while container stock can be planted in spring up to early summer and again in fall. Spring planting allows the plants a full growing season to become established. The site must remain moist enough through natural rainfall or the plants will need supplemental watering.

6.2 Rescued plants

Plants may be rescued from sites about to be developed. The following guidelines will help ensure maximum survival of salvaged plants (GOERT 2011, Gayton 2001):

- Select plants that are known to transplant well (e.g. bulbous perennials; shallow root shrubs), deeply rooted perennials rarely transplant well.
- Salvage plants during their dormant period (e.g. fall through to early spring depending on the location and weather conditions).
- Select small plants for higher survival rates.
- To maximize genetic diversity at the new planting site, select salvage plants over as large an area as possible.
- Protect the roots during excavation by maximizing the size of the root ball.
- Trim any damaged roots to promote rapid healing.
- For shrubs and deciduous trees prune branches back such that the top of the plant is smaller than the root ball to reduce transplant shock.
- Select similar habitat (moisture, temperature, light exposure, aspect) to their natural environmental conditions.
- Plant on site immediately or carefully place in containers.
- Water well for one year after planting, even drought resistant plants.
- Salvage other habitat components such as moss, dead wood and soil which contain mycorrhizal fungi and other beneficial organisms.

6.3 Collecting seeds, stem and root cuttings – Ethical considerations

Collecting seeds and cuttings may be the only choice if the required species or appropriate provenance is otherwise unavailable. Ethical plant collecting guidelines have been developed to decrease the negative impacts of collecting seeds, stem and rhizome cuttings on plant populations and habitats (GOERT 2011, Dorner 2002, Gayton 2001). This will allow the plant community to continue to reproduce and also to provide food for the birds and wildlife. Important guidelines to consider include:

- Do not collect rare or endangered species (refer to the BC Conservation Data Centre's Species and Ecosystem Explorer for species' lists (http://www.env.gov.bc.ca/cdc/).
- Do not collect plant materials from sensitive areas.
- Do not collect cuttings from riparian areas.
- Collect seeds and cuttings over a large area (several microhabitats) to ensure the greatest genetic diversity.
- If you are taking cuttings (or seeds) from a plant, do not remove more than 5%.
- Do not remove cuttings or seeds from a site over successive years.
- Ensure you have allowed adequate time for processing the same day to maintain high viability rates.
- Calculate the amount of material required ahead of time, so that cuttings and seeds are not wasted.

6.4 Live staking

Live staking is a form of soil bioengineering used to decrease erosion along stream banks or unstable slopes. Live cuttings of easily rooting tree or shrub species (e.g., willow species, red-osier dogwood or black cottonwood) are planted at high density into areas with a high water table. Live staking is an inexpensive method to re-vegetate riparian areas, though survival rates can be low.

Various guidelines for using live stakes for riparian plantings have been developed (Polster 2002, Kipp and Calloway 2002, and Walter et al. 2005) and include:

- Select live stakes from appropriate site series and near the planting site.
- Select easily rooting species (e.g., willow species, black cottonwood or red-osier dogwood).
- Collect live stakes during the dormant period.
- Collect stem sections between 1 and 3 years old.
- Select stems 2-3 centimeters in diameter and at least 40 cm long with at least two healthy buds.
- Plant live stakes the same day they are harvested (in late autumn or early spring) while the buds are still dormant or soak the cuttings in water for 5 to 10 days to improve rooting success.
- Two or more buds should be above ground level and ensure buds are pointing up when planted.
- Plant live stakes maximizing contact with the water table and leaving as much of the stem as possible below ground (usually 75 to 80% below ground).

- Cut bottom end on angle for easier installation.
- Remove any side branches.
- In compacted soil, use metal stake to create a pilot hole.
- Plant live stakes 0.25 -0.5 meters apart and perpendicular to slope.
- Prior to staking, keep the cuttings in a cool, moist environment to maintain viability.
- Water regularly for 6 weeks if soils are not permanently moist.

6.4.1 Variations

There are several variations using live staking techniques for bioengineering streambanks (Polster 2002, Bentrup and Hoag 1998, Donat 1995, Walter et al. 2005). Wattle fences can be effective at improving stability of steep wet slopes. In this case, bundles of live stems are secured horizontally creating retaining walls. They are used where steep slopes inhibit establishment of vegetation. Wattle fences create stepped terraces on these steep slopes and moisture seeping through the bank encourages rooting.

In another variation long live stakes are set-up in a tripod formation over small fish habitat channels to provide stream shading (Polster 2002). For live shade tripods the ends should be struck at least 50 cm into the stream bank, and the length adequate to span the stream width. Bundles of branches can also be vertically positioned in the streambank overhanging the stream providing instant cover for fish (Walter et al. 2005).

CAUTION: Live staking projects for the purpose of reducing erosion or stabilizing streambanks may trigger *Water Act* requirements if planting is proposed to occur below the high water mark or natural boundary.

6.5 Native grasses

Establishing ground cover prior to introducing trees or shrubs is sometimes recommended to reduce surface erosion, help rebuild soil structure and decrease the establishment of invasive plants. Native grass (and legume) mixes provide one option, though careful species selection is required as grasses can out-compete shrubs and trees during early establishment phases. For this reason, non-aggressive and non-sod forming species are recommended. Short-lived perennial species or annual grasses can also be used where there are concerns about competition. It is also important to remember that grazing may interfere with establishment when planting native grasses in areas with high ungulate populations.

Native grass seed mixes should be selected based on site specific conditions (e.g. soil type, soil moisture and climate) and on the objectives of the project. Obtain advice from a local seed supplier or professional agrologist on a native seed mixture selection and application rates, remembering to use seeds of local provenance. It may be appropriate to contract out seed collection and cleaning (e.g., through a nursery) well in advance of restoration (1-3 years depending on the species required).

When direct seeding native grasses, for optimal germination seeding should occur in the spring (coast and interior) or fall (interior before first snow). When used as an erosion control measure, seeding is suitable anytime within the growing season. Laying thin mulches after seeding will further reduce erosion as well as enhance germination by protecting seeds and retaining moisture.

Native grass plugs can also be grown in a nursery and may in some instances have better survival rates than direct seed sowing. It takes approximately 8 weeks to grow grass plugs. Grasses should only be used in grassland areas and not in areas that are naturally forested.

6.6 Planting density and pattern

Planting density is species and site specific. Many shrub species can be planted 60 to 100 cm apart spaced in clusters for higher survival rates (Kipp and Calloway 2002). Where dense shrub dominated patches are preferred, planting densities can be higher with spacing ranging from 25 to 50 cm. Also, if high mortality is anticipated due to site conditions, then planting densities may be increased to factor in mortality.

Planting in a grid formation is not visually appealing nor does it represent natural structure. Planting in clusters using preferred microsites produces a more natural appearance.

7.0 PLANT CARE/MAINTENANCE

Once established, native plants planted require little care. However, until they are established some maintenance is required to protect the investment. Usually this requires protection from wildlife browsing, invasive plant control, supplemental water and possibly improving soil nutrient levels.

7.1 Protecting new plants

Newly planted trees and shrubs often present an attractive new food source for wildlife such as deer, beaver, voles and mice resulting in growth loss and mortality. Stem girdling caused by rodents often occurs in winter months below snow cover. Ungulate browse can occur at any time, but is common in winter and early spring. While some damage due to wildlife must be planned for, steps can be taken to minimize losses.

Stem collars, seedling covers and tree guards (netting, wire cages, stem guards) can be used to protect new plantings from animal damage. These are commercially available through nurseries and forestry supply outlets. Stem collars can also be created from milk cartons, plastic pop bottles or cans, ensuring they extend 10 centimeters up from the ground. Beaver girdling can be reduced by placing chicken wire around the base of trees to a 1 meter height. Spray repellents can also inhibit ungulate browsing. Scare tactics such as sensor controlled sprinklers or radios can also provide effective protection from animal damage. Any of the barriers must be monitored and removed before they interfere with plant form and growth.

Another option to reduce losses to animal damage is to select plant species that are less or not at all palatable (e.g., Dull or Tall Oregon grape, Western Sword Fern).

7.2 Supplemental watering and improving soil nutrient levels

As noted in preceding sections, adequate water is an essential factor determining survival of newly planted trees and shrubs. Plants may not be fully dormant when planted and supplemental watering reduces transplant stress and assists in firming soil conditions around roots. All planted stock must be watered at the time of planting and regularly during at least the first growing season, and up to three growing seasons (Kipp and Callaway 2002). It is important to water the soil outside the planted area to encourage roots to move away from the original root ball and into the undisturbed soil (Dorner 2002). Once established, native plants appropriate to the site will not require additional watering.

Container grown plants require more water than plants grown in natural soils (i.e., bare root and burlap wrapped) because soil mixes they are grown in typically dry quickly and are difficult to re-moisten once dry (Dorner 2002).

As a complement to supplemental watering, the use of straw mats, mulch (e.g., weed-free straw or shredded leaves) or geo-textile fabrics, placed around new plants will assist with soil moisture retention with the added benefits of weed suppression and frost protection. Mulches also protect the soil from erosion, moderate soil temperature (MOF 1997) and can help improve soil structure (Kipp and Calloway 2002), however, they can contain weed seeds. Manufactured mulch mats have the ability to trap sediment and litter, and are useful in building soil, improving surface soil conditions and restoring soil organic matter (MOF 1997). Bark mulches must be avoided near streambanks and shorelines as they may be toxic (Kipp and Callaway 2002).

Where organic and top soil layers have been reduced or removed, the first step is to improve biomass cycling prior to planting (Gayton 2001). After planting, repeated fertilizer applications are often recommended to aid plant establishment until soil rehabilitation is underway (MOF 1997). By applying fertilizer after planting, growth rates are enhanced improving soil structure through root growth and soil nutrients through litter fall. However, chemical fertilizers must not be used in riparian areas due to possible negative impacts to water quality. Rather, planting nitrogen-fixing species, deciduous species for litter fall and species with strong root systems provide a slower but effective way to improve soil nutrient levels (see also section 5). Adding organic matter such as compost or leaf mulch will also help to improve soil nutrient levels if this is required. However, note that additional nitrogen will increase invasive plant establishment and may even deter native plants from re-establishing.

7.3 Keeping invasive plants out

Although invasive plants may have been removed during site preparation, it is important to ensure they do not re-invade. Root rhizomes and seed may still be stored in the soil and seed from neighboring invasive plants may be transported onto the site. Some steps can be taken to minimize new invasive plants (Dorner 2002):

- Reduce mineral soil exposure.
- Monitor site regularly for new invasive plants and include this in any monitoring plan, particularly early in the season to eradicate any new infestation before it takes hold.
- Remove invasive plants from outside the treatment area.
- Manage for healthy native plants that are able to out-compete invasive plants.

7.4 Other treatments

Other treatments to consider when developing care and maintenance plans include:

- Brushing to reduce light, water and nutrient competition.
- Spacing and thinning once plants achieve a certain size to reduce competition and increase growth rates.
- Space to alter species mix over time (e.g., change species from shade intolerant to shade tolerant; or accelerate transition from early to mid-seral species).
- Pruning to improve health (e.g., remove blister rust infected branches from white pine).

It is important to record all treatments, dates and other notes and incorporate into the monitoring plan.

8.0 MONITORING

A well-designed monitoring plan assesses success in prescription implementation (i.e., how well the treatments were carried out as per prescription objectives), and effectiveness of the treatments in restoring the features, functions and conditions affecting fish life processes (i.e., progress toward meeting goals). Monitoring results are also used to adjust treatments when goals and objectives are not being met. A monitoring plan is developed as an appendix to the site plan to at a minimum monitor prescription implementation. These guidelines do not discuss effectiveness monitoring.

8.1 Implementation monitoring

The scale of implementation monitoring plans will vary depending on the size of the revegetation project. For example, the monitoring plan for a residential lot will likely be as simple as walk through reconnaissance and establishing permanent photo point locations. Large projects (e.g., industrial or commercial properties covering several hectares) may include systematic plots quantifying attributes in addition to photo points and/or plots and walk through assessments. All monitoring plans require performance standards that are measurable and linked to the site plan objectives. Reference sites, if available, can be used to provide guidance when developing performance standards.

Because the range of monitoring plan content will be so diverse due to project scale only an overview of some common monitoring plan elements is provided below. Detailed methodologies and sample plot cards are described by Konag (1999), Winward (2000) and USDA (1999). Additional references are provided in section 10 of these guidelines.

Regardless of the methods, all monitoring plans must identify key response variables to assess objectives. Selected response variables will likely include survival, growth, cover and/or density and condition of vegetation. Other variables may be LWD recruitment, invasive plant occurrence, and changes to surface erosion.

8.1.1 Photo view points

Repeated photographs taken from the same location are a quick and inexpensive way to qualitatively assess project success. Photo points in combination with quantitative data provide a valuable assessment of progress toward meeting objectives.

Methods:

- Permanently establish a plot center. This can be done with a metal post or a large spike and washer spray painted a bright color. This plot location is mapped, GPSed or tied into a permanent feature using distance and bearing. The number of plots will vary depending on size of area and extent of other sampling methods. Because they are easily established and are effective at evaluating growth, it is recommended that a maximum number of plots be established.
- Baseline pre-treatment and immediately post-treatment photographs are required as well as annual follow-up photos.
- Photographs are usually taken in at least 2 directions. Record bearings.
- Take photographs annually at the same time of year and preferably at the same time of day and weather conditions. Record date, time and weather conditions.
- Take previous year's photographs with you to line up picture frame to capture same structural elements.
- Place some sort of scale within the photograph (e.g., a person or metal pole with painted height intervals). This scale should be located at the same position and should be the same item each year for easier comparison.
- Record any observations at the time of photographing as quantitatively as possible (e.g., down to 10% cover of Scotch broom likely due to increased shading; ungulate browse affecting 5% of new growth on Saskatoon; average height growth of Douglas-fir was 30cm).
- Relate any observations to the objectives and determine if any actions are required.
- Record the plot label in photo

8.1.2 Photo plots

Where a photo view point captures the surrounding area, a photo plot is a bird's eye view of a permanently established location on the ground. This can be used to monitor changes in vegetation and/or soils. Pre- and post-treatment photos are required in addition to annual photos. Typically a 1m x 1m frame is placed on the ground at the same location each year. A frame of this size can usually be captured within the photograph without the use of a step ladder.

8.1.3 Reconnaissance assessments

This involves a walkthrough of the treatment area noting changes in vegetation as they relate to objectives. Whereas a photo plot is stationary, a walk through can capture changes throughout the treatment site and information can be used to adapt subsequent treatments. It is a fast and effective way to assess plant survival and other project objectives. For revegetation projects that require several years to complete, a walkthrough can provide useful information that can be used to adjust next steps. The level of detail will vary with scale of project; however, observations need to be recorded and can include:

- Date of walkthrough.
- Produce a sketch map of the route walked noting approximate location of observations.
- Record observations with special attention to plant survival, invasive plant occurrence, forest health issues, browse incidence, and soil erosion issues (also note any wildlife observations).
- Photograph important observations (e.g., unknown foliar disease, areas with surface erosion).
- Relate any observations to the objectives and determine if any actions are required.

8.1.4 Systematic sampling

More intensive sampling may be appropriate for revegetation projects covering large areas, especially when past use has created extensive site disturbance, and detailed information is required to quantify progress toward achieving objectives. After identifying key response variables, the following general methods are applied:

1. Confirm boundaries and determine plot spacing. Systematic monitoring plots should cover 5% of the treated area (Dorner 2002).
2. Stratify plots by treatment unit if appropriate. For smaller projects, line transects may be established perpendicular to the stream and cross several TUs to qualitatively capture changes in vegetation over time.
3. Locate plots in the field, permanently mark and GPS locations.
4. Establish photo plots as described above.
5. Collect and record data pre-treatment and immediately post-treatment to capture baseline conditions.
6. Measurements must be repeated at a frequency described within the monitoring plan. Usually, annual sampling will be required for the first 3 to 5 years. After this time, sampling may be repeated at extended intervals, such as every 5 years. Sampling frequency will be greatest at large and heavily disturbed sites. This will allow for adapting maintenance plans to current conditions to ensure investments are protected as well as riparian function restored as quickly as possible.
7. Determine analysis methods while designing the monitoring plan (well before any data collection begins) to ensure data will provide accurate results.

8.1.4.1 Measuring tree, shrub and herb layers

Several subplots may be located at one plot center, each measuring response variables for the different plant layers. Several options exist for vegetation sampling (USDA 1999) and are briefly described below. Plot cards are also provided for each method in USDA (1999) and MOFR and MOE (2010).

Line transects: Line transects consist of a measuring tape set out from the plot center at a random bearing over a predetermined distance (e.g. 20 or 30m). A permanent stake marks the end of the transect so that the exact same location can be repeatedly assessed. This method is used to assess species composition and cover of herbs, shrubs, trees and invasive species, though is best suited for assessing the shrub layer. Average height and condition can also be recorded for each species. View photo points along the transect can be used to capture change in shrub development.

The percent cover is calculated for each species by totaling the intercept measurements along the transect and converting this to a percentage of the total transect distance. The percentages for each species can be totaled to assess total cover (which may add up to > 100% if crowns are overlapping). Species composition is calculated by comparing each species percent cover to the total percent cover.

Daubenmire frames: A Daubenmire frame is a 20cm x 50cm quadrant frame that is placed at defined intervals along a transect to assess cover, frequency and composition of herbs, small shrubs (e.g., kinnickinick), and invasive species. There are 6 cover classes measured onto the frame: 0-5%; 5-25%; 25-50%; 50-75%; 75-95%; and 95-100%. The midpoint of each cover class is recorded. Photo plots can be established at each quadrant location to visually document change.

The percent cover is calculated by species by adding up the midpoint cover value for each species, adding them up for all samples along the transect and then dividing it by the number of samples. Species composition is calculated by dividing the cover of each species by the total cover. Frequency can be calculated by adding the number of quadrants a species occurred within, dividing it by the number of quadrants and multiplying by 100%.

The same transect can be used for the Daubenmire frame as laid out for the line transect measurements. For example, the species composition at a particular site may make it suitable to use the line intersect method to assess shrubs and the Daubenmire frame to assess herb species.

Fixed radius plots: Fixed radius plots are most often used to record tree growth, however they can also be used to assess the shrub and herb layers (Konag 1999). Plot radius is selected that captures an average of 6 trees per plot. Within the plot species, number of stems and condition (live, dead, damage or wildlife tree class) can be recorded. Height and diameter can be measured for all trees or for one or more of the dominant species. Canopy closure can be visually estimated. Percent cover of herb and shrub species can also be visually estimated for each species (MOFR and MOE 2010). Comparison charts for estimating herb and shrub cover are provided in MOFR and MOE (2010). Photo plots or photo points may also be established around the plot center to further document change.

When time and budget are limiting factors, it may be possible to select indicator species to assess plant performance against objectives (Gayton 2001). The plant species selected must be related to goals and objectives. For example, if LWD recruitment is an important goal, them measuring survival, growth and vigour of fast growing tree species may be a priority. If improving streambank stability is important, measuring success of willow live-stakes may be most important.

Plot type selection may also depend on size and orientation of sample area. For example, long transects may not be appropriate in narrow riparian areas. Or bias may be introduced to make sure transect orientation remains within the riparian area. Transects may also be shortened to remain inside the riparian area.

8.1.4.2 Assessing damage to vegetation

Regardless of sampling method and plant layer, it is important to document damage. This includes animal damage, insect and disease incidence and abiotic damage (e.g., frost, snow press, wind damage, etc.). There are several guidebooks available help identify sources of damage (see section 10).

Suggested categories for quantifying browse (Winward 2000) are: No use (0-5%); slight use (6-20%); light use (21-40%); moderate use (41-60%); and heavy use (61-80%); and severe use (81-100%).

8.1.4.3 Other monitoring assessments

The monitoring plan needs to include methods to assess other performance standards. For example, for severely damaged sites the monitoring plan may need to document changes to soil bulk density and nutrient levels. Therefore soil sampling may be scheduled at appropriate intervals.

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10.0 ADDITIONAL INFORMATION

Autecology:

Tree species compendium: http://www.for.gov.bc.ca/hfp/silviculture/Compendium/index.htm

USDA Natural Resources Conservation Services: http://plants.usda.gov/java/

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Tree Book: http://www.for.gov.bc.ca/hfd/library/documents/treebook/index.htm

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MFLNRO Invasive Alien Plant Program: http://www.for.gov.bc.ca/hra/plants/index.htm

MFLNRO reference guide: http://www.for.gov.bc.ca/hra/plants/RefGuide.htm

Invasive Species Council of BC: http://www.bcinvasives.ca/resources/outreach-materials/invasive-plants-tips

Garry Oak Ecosystem Recovery Team: http://www.goert.ca/publications_resources/invasive_species.php

Native plant nursery lists:

Garry Oak Ecosystem Recovery Team: http://www.goert.ca/at_home_buying_native_plants.php

Native Plant Society of BC: http://www.npsbc.org/Use/use.htm

Ecological restoration:

Ecological Restoration Guidelines for BC. FRBC.: http://www.env.gov.bc.ca/fia/documents/TERP_eco_rest_guidelines/intro/index.html

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Revegetation establishment: Monitoring principles and practice. A case study at Bowker Creek Restoration Demonstration project:
http://members.shaw.ca/a.jensen/Bowker_UVic_RNS_Reveg_Principles_Practice.pdf

Alberta Riparian Health Management Society: http://www.cowsandfish.org/riparian/health.html

VRI standards:
http://www.ilmb.gov.bc.ca/risc/pubs/teveg/vri_gs_2010/vri_gs_manual_ver%204.9_final.pdf

Assessing damage:

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11.0 APPENDICES

APPENDIX 1. DATA FORMS

OFFICE DATA FORM:

LOCATION		
PROPERTY OWNER	LEGAL DESCRIPTION (PID)	ADDRESS
COLLECTED BY	DATE	AREA (HA)

FISH INVENTORY DATA			
INVENTORY DATE	INFORMATION SOURCE	FISH SPECIES	COMMENTS

SITE HISTORY			
DATE	DISTURBANCE	IMPACTS TO SITE	COMMENTS

ADJACENT PROPERTIES – Describe any			
LOCATION	CONDITION OF RIPARIAN HABITAT	OPPORTUNITIES	COMMENTS

LOCAL STEWARDSHIP GROUP CONTACTS (information on stewardship projects)				
DATE	NAME	ORGANIZATION	PHONE/EMAIL	COMMENTS

LOCAL GOVERNMENT BYLAWS		
NAME (LG)	RELEVANT BYLAWS	COMMENTS

OTHER INFORMATION

FIELD DATA FORM:

LOCATION		
PROPERTY OWNER	LEGAL DESCRIPTION (PID)	ADDRESS
COLLECTED BY	DATE	AREA (HA)

SITE HISTORY – FIELD OBSERVATIONS
Disturbance type, severity, timing

RIPARIAN CONDITION – ADJACENT AREAS
Development density, extent of riparian vegetation, wildlife use, etc.

CURRENT SITE CONDITION - OVERVIEW
Soil compaction, CWD/LWD, wildlife trees, invasive plants, forest floor, etc.

STREAM DESCRIPTION					
STREAM NAME	MAP ID	STREAM TYPE	STREAM WIDTH (est.) (M)	STREAM GRADIENT (%)	COMMENTS/DESCRIPTION
		Wetland, lake, creek, river, etc.			*Bank stability*

SITE DESCRIPTION				
PLOT	SLOPE	ASPECT	ELEVATION/TERRAIN	COMMENTS
1			*gullied, rolling*	*seepage area, drainage, etc.*
2				
3				

4				
5				

ECOLOGICAL INFORMATION				
PLOT	BEC	VARIANT	SITE SERIES	CRITICAL SITE CONDITIONS AFFECTING TIMING OF TREATMENT
1				
2				
3				
4				
5				

SOILS						
PLOT	SOIL TEXTURE	DUFF DEPTH (CM)	SOIL DEPTH (CM)	DRAINAGE (good, fair, poor)	CURRENT COMPACTION (N/A, low, moderate, high)	SOURCES OF EROSION (description)
1						
2						
3						
4						
5						

OTHER VALUES	
VALUE	**OBSERVATIONS**
Water intakes, wildlife features, species at risk	

UN-NATURAL FEATURES (culverts, septic, docks, decks, trails, driveway, lawn, house, etc.)		
FEATURE	LOCATION	IMPACTS ON RIPARIAN AREA
Water source		

CURRENT CONDITION – Treatment Site					**PLOT:**
Native plants					
TU	LAYER	SPECIES	% COVER	VIGOUR	COMMENTS
Invasive plants					
TU	LAYER	SPECIES	% COVER	VIGOUR	COMMENTS

ATTACH SKETCH MAP

CURRENT CONDITION – Reference Site				
Location:				
Native plants				
SPECIES	LAYER	% COVER	VIGOUR	COMMENTS
Invasive plants				

RIPARIAN REVEGETATION SITE PLAN

1. TREATMENT GOALS

- *To restore the features, functions and conditions that support fish life processes in the riparian area.*
-
-

2. PROJECT LOCATION

PROPERTY OWNER	LEGAL DESCRIPTION (PID)	ADDRESS
PREPARED BY	DESIGNATION	DATE

3. STREAM DESCRIPTION

STREAM NAME	MAP ID	STREAM TYPE	STREAM CLASS	FISH SPECIES
		Wetland, lake, creek, river, etc.		

4. AREA UNDER THE PLAN

TU	DESCRIPTION		AREA (HA)
1	*Brief summary of existing vegetation, terrain (gullies, rolling, etc.), aspect, exposure (cold air drainage, salt spray, etc.), site condition, etc.*		
TU	DESCRIPTION		AREA (HA)
2			
TU	DESCRIPTION		AREA (HA)
3			
	TOTAL RIPARIAN LENGTH (M)	SPEA WIDTH (M)	TOTAL AREA (HA)

5. SITE DESCRIPTION

TU	SLOPE	ASPECT	ELEVATION	TERRAIN FEATURES
1				
2				
3				

6. SITE DESTURBANCE

TU	SOIL TEXTURE	DUFF DEPTH (CM)	SOIL DEPTH (CM)	CURRENT COMPACTION (nil, L, M, H, VH)	FOREST FLOOR REMOVED (est. % of site)	CURRENT SEDIMENT DELIVERY TO STREAMS
1						
2						
3						

7. C. ECOLOGICAL INFORMATION

TU	BEC	VARIANT	SITE SERIES	CRITICAL SITE CONDITIONS AFFECTING TIMING OF TREATMENT
1				*Fine soils susceptible to compaction, poor drainage, etc.*
2				
3				

8. TREATMENT PLAN

TU 1:	*TU number/name*			
A. OBJECTIVES:	• • • •			
B. TREATMENT DESCRIPTION:				
C. SITE PREPARATION:				
Treatment description		Timing	Conditions at time of treatment	
E.g., Invasive plant removal, adding CWD, tilling, adding organics		*Season, year*	*E.g., Dry soils for tilling, moist soils for hand-pulling invasive plants*	
D. PLANTING:				
Layer:	Species	Density or spacing	Age or size (stock type)	Planting requirements
Tree				*Season, water*
Shrub				
Herb				
E. PLANT CARE AND MAINTENANCE				
Layer:	Treatment	Timing/Frequency	Other	
Tree	*E.g., Irrigation, browse protectors*			
Shrub				
Herb				
F. STRATEGIES TO PROTECT SOILS				
• • •				

TU 2:	
G. OBJECTIVES:	•

	• • •
H. TREATMENT DESCRIPTION:	

I. SITE PREPARATION:				
Treatment description		Timing	Conditions	
J. PLANTING:				
Layer:	Species	Density or spacing	Age or size (stock type)	Planting requirements
Tree				
Shrub				
Herb				
K. PLANT CARE AND MAINTENANCE				
Layer:	Treatment	Timing/Frequency	Other	
Shrub				
Herb				
L. STRATEGIES TO PROTECT SOILS				
• • •				

TU 3:	
M. OBJECTIVES:	• • • •
N. TREATMENT DESCRIPTION:	*overview*

O. SITE PREPARATION:				
Treatment description		Timing	Conditions	
P. PLANTING:				
Layer:	Species	Density or spacing	Age or size (stock type)	Planting requirements
Tree				
Shrub				
Herb				
Q. PLANT CARE AND MAINTENANCE				
Layer:	Treatment	Timing/Frequency	Other	
Tree				
Shrub				
Herb				

R. STRATEGIES TO PROTECT SOILS
• • •

9. PROTECTING OTHER VALUES

VALUE	STRATEGIES TO PROTECT
E.g., water intake, eagle nest, fish enhancement project, etc.	

10. SCHEDULE

DATE	ACTIVITY	COMMENTS

Attached maps must include:

- Legal description of property
- North arrow
- Scale
- SPEA boundary
- Natural features (e.g., gullies, ravines, streams)
- TU boundaries
- Permanent and temporary structures inside the SPEA (e.g., dock footings, sheds, retaining walls, decks, driveways)
- Permanent and temporary structures outside the SPEA that may influence FFCs within the SPEA
- Sources of water for supplemental watering
- Features associated with disturbance history (e.g., areas treated with herbicides, compacted areas, erosion sources)
- Location of fish enhancement projects

APPENDIX 3. PLANT LIST (Note: This plant list describes common riparian species but is not considered complete. Further research is recommended during plant species selection.)

Species	Latin	Soil moisture regime	Soil nutrient regime	Shade tolerance	Planting zone	Ecosystem Type: Coastal - Dry (CDF, CWH - dry)	Coastal - Moist/Wet (CWH - moist, wet)	Southern Interior - Dry (PP IDF MS)	Southern Interior - Moist (ICH)	Comments
Deciduous trees:										
Bigleaf maple	*Acer macrophyllum*	dry to moist	rich to very rich	H	floodplains	Y				Does well on disturbed sites
Red alder	*Alnus rubra*	wet	rich to very rich	M	streambanks, active floodplains, disturbed sites	Y	Y			Nitrogen-fixing; ferns, grasses and sedges grow well beneath whereas acid loving salal and vaccinium species do not; fast-growing; reproduces vegetatively from stump sprouts
Paper birch	*Betula papyrifera*	moist, well-drained soils	medium to rich	M	moist forest, seepage sites, floodplains,	Y	(Y)	Y	Y	Reproduces vegetatively from stump sprouts; unable to tolerate long periods of drought or saturated soils
Pacific dogwood	*Cornus nuttallii*	moderately dry to moist, well-drained soils	poor to rich	M	along streams or gullies, open to dense forests	Y				
Pacific Crabapple	*Malus fusca*	moist to wet	medium to rich	M	edges of standing and flowing water, upper beaches	Y	Y			
Black Cottonwood	*Populus balsamifera* ssp. *Trichocarpa*	moist to very moist	rich to very rich	L	floodplains, streambanks, lakeshores, seepage sites	Y	Y	Y	Y	Reproduces by root suckers and stem sprouts; low seed viability
Trembling Aspen	*Populus tremuloides*	slightly dry	medium to rich	L	open forest, edges of grasslands			Y	Y	Unable to tolerate long periods of saturated soils; reproduces by root suckers and stem sprouts; low seed viability
Bitter cherry	*Prunus emarginata*	slightly dry to moist	poor to very rich	M	along streams, logged areas	Y	Y		Y	Occurs on logged sites
Choke Cherry	*Prunus virginiana*	dry to moist	rich moist to disturbed sites	L	adapted to a wide range of sites			Y		Leaves, bark, stem and cherry pit are toxic. Good for erosion control due to spread by rhizomes and tendency to create thickets.

						Ecosystem Type				
Species	Latin	Soil moisture regime	Soil nutrient regime	Shade tolerance	Planting zone	Coastal - Dry (CDF, CWH - dry)	Coastal - Moist/Wet (CWH - moist, wet)	Southern Interior - Dry (PP IDF MS)	Southern Interior - Moist (ICH)	Comments
Conifers:										
Amabalis fir	*Abies amabilis*	moist to very moist, deep, well-drained	poor to rich	H			Y			Grows with western hemlock, sitka spruce and western redcedar; produces abundant understorey due to high shade tolerance
Grand fir	*Abies grandis*	slightly dry to very moist	very rich	H		Y		Y	Y	Grows with Douglas-fir
Western larch	*Larix occidentalis*	moderately dry to slightly dry	medium to rich	L	open forest			Y	Y	
Englemann Spruce	*Picea engelmannii*	slightly dry to very moist	poor to rich	M	seepage sites, floodplains, lakeshores		Y	Y	Y	
White Spruce	*Picea glauca*	slightly dry to very moist	medium to very rich	M	wet draws, floodplains, seepage sites			Y	Y	
Sitka Spruce	*Picea sitchensis*	moist to very moist, well-drained soils	rich to very rich	M	alluvial floodplains	(Y)	Y			Shallow rooted
Lodgepole Pine	*Pinus contorta*	very dry to moist	very poor to medium	L	dry rocky slopes to deep rich soils	Y	Y	Y	Y	Tolerant of poor soils and compacted soils
Western White Pine	*Pinus monticola*	dry to moist	poor to rich to very rich	M	moist creek bottoms, benches	Y			Y	Drought tolerant
Ponderosa Pine	*Pinus ponderosa*	very dry to moderately dry	medium to very rich	L	open forests			Y	(Y)	Very drought tolerant
Douglas-fir	*Pseudotsuga menziesii*	dry to moist	medium	L-H	dense to open forest	Y	Y	Y	Y	Does not tolerate saturated soils
Western Redcedar	*Thuja plicata*	slightly dry to wet seepage sites	poor to very rich	H	alluvial sites	Y	Y	Y	Y	Tolerates saturated soils; Low drought resistance

Species	Latin	Soil moisture regime	Soil nutrient regime	Shade tolerance	Planting zone	Ecosystem Type: Coastal - Dry (CDF, CWH - dry)	Ecosystem Type: Coastal - Moist/Wet (CWH - moist, wet)	Ecosystem Type: Southern Interior - Dry (PP IDF MS)	Ecosystem Type: Southern Interior - Moist (ICH)	Comments
Western Hemlock	*Tsuga heterophylla*	moist to very moist; prefers soils with high organic content (acidic)	Very poor to medium	H	moist creek bottoms, seepage sites	Y	Y		Y	Creates dense canopy limiting understorey growth; not drought tolerant
Shrubs:										
Vine Maple	*Acer circinatum*	moist to wet	medium	H	under forest cover, open areas, stream banks	Y	Y			
Douglas Maple	*Acer glabrum*	dry to moist but well-drained	medium	H	open sites, moist open forests, seepage sites, moist gullies	Y		Y	Y	
Mountain alder	*Alnus tenuifolia*	very moist to wet; poorly drained sites	rich to very rich	M	steamside, pond and lake edges			Y	Y	Reproduces vegetatively from stump sprouts
Sitka alder	*Alnus viridis* ssp. *sinuata*	moist	tolerates low nutrient levels	M	streambanks, edges of wet meadows, well-drained upland forests		Y		Y	Nitrogen fixing; good for poor soils
Saskatoon	*Amelanchier alnifolia*	dry to moist	medium	M	open forest, meadows; moist gullies in grasslands, disturbed sites	Y		Y	Y	Easily propagated from wild seedlings or root cuttings
Red-Osier Dogwood	*Cornus stolonifera*	moist to wet	tolerates low nutrient levels	H	streamside, open forest, disturbed sites	Y	Y	Y	Y	Easily propagated from cuttings or layering from suckers. Excellent species for environmental plantings on moist soils.

Species	Latin	Soil moisture regime	Soil nutrient regime	Shade tolerance	Planting zone	Ecosystem Type: Coastal - Dry (CDF, CWH - dry)	Coastal - Moist/Wet (CWH - moist, wet)	Southern Interior - Dry (PP IDF MS)	Southern Interior - Moist (ICH)	Comments
Beaked Hazelnut	*Corylus cornuta*	moist but well-drained sites	medium	H	open forest, well-drained streamside, shady openings	Y	Y	Y	Y	
Black Hawthorn	*Crataegus douglasii*	moist	tolerates low nutrient levels	L	streamside, lake shores, open areas and forest edges, open deciduous forest	Y	Y	Y	Y	
Salal	*Gaultheria shallon*	dry to wet	tolerant of poor soils	H	coniferous forests, shoreline	Y	Y			Forms thickets; highly adaptable to a wide range of sites
Oceanspray	*Holodiscus discolor*	dry to moist sites	tolerates low nutrient levels	M	open areas, ravine edges	Y	Y	Y	Y	
Black Twinberry	*Lonicera involucrata*	wet to moist sites to rocky slopes	medium	H	streamside, forests and openings, seepage areas, edges of wetlands		Y	Y	Y	
Dull Oregon-grape	*Mahonia nervosa*	dry to moist	poor to rich	H		Y	Y			
Mock Orange	*Philadelphus lewisii*	moist rich sites to dry rocky soils	tolerates low nutrient levels	M	open forest, forest edges, open brushy areas	Y	Y	Y	Y	
Pacific Ninebark	*Physocarpus capitatus*	moist to wet	tolerates low nutrient levels	M	streamside, forest edges	Y				
Cascara	*Rhamnus purshiana*	moist to wet	medium to very rich	H	mixed forest, south aspect	Y	Y		Y	Grows with red alder and vine maple at the coast
Black gooseberry	*Ribes lacustre*	moist to dry to wet	poor to rich	M	streamside, forest, open seepage areas, dry areas	Y	Y	Y	Y	Often grows on rotting wood

Species	Latin	Soil moisture regime	Soil nutrient regime	Shade tolerance	Planting zone	Ecosystem Type				Comments
						Coastal - Dry (CDF, CWH - dry)	Coastal - Moist/Wet (CWH - moist, wet)	Southern Interior - Dry (PP IDF MS)	Southern Interior - Moist (ICH)	
Rose sp.	*Rosa spp.*	dry to moist	medium	M	streamside, open habitats, seepage areas	Y		Y	Y	
Salmonberry	*Rubus spectabilis*	moist to wet	tolerates low nutrient levels	H	streamside, forests, disturbed areas	Y	Y			Excellent erosion control due to rapidly spreading underground roots
Willow	*Salix* spp.	wet to dry	tolerates low nutrient levels	M	streamside, lakeshore, alluvial areas, open forests	Y	Y	Y	Y	
Blue Elderberry	*Sambucus cerulea*	moist to meisic	tolerates low nutrient levels	M	along watercourses				Y	
Red Elderberry	*Sambucus racemosa*	moist to wet sites	medium to rich	H	streamside, shaded forests, moist clearings and open forests	Y	Y		Y	
Soopalallie	*Shepherdia canadensis*	dry to moist	tolerates low nutrient levels	M	open forests, openings	(Y)		Y	Y	Nitrogen fixing; good for poor soils
Pink spirea	*Spiraea douglasii*	moist to wet	tolerates low nutrient levels	H	streambanks, lake margins, wet open forests	Y	Y		Y	Readily takes over wet areas due to creeping underground stems
Snowberry	*Symphoricarpus albus*	dry to moist	medium	M	ravines, open forests	Y		Y	Y	Considered poisonous
Western Yew	*Taxus brevifolia*	moist	medium	H	moist depressions and ravines	Y	Y	(Y)	Y	Seeds are poisonous
Huckleberry spp.	*Vaccinum spp.*	moist	tolerates low nutrient levels	M+	Under coniferous trees	Y	Y	Y	Y	
Highbush Cranberry	*Viburnum edule*	wet to moist sites	medium	L	streambanks, seepage areas, wet forests	Y			Y	
Herbs:										

Species	Latin	Soil moisture regime	Soil nutrient regime	Shade tolerance	Planting zone	Ecosystem Type				Comments
						Coastal - Dry (CDF, CWH - dry)	Coastal - Moist/Wet (CWH - moist, wet)	Southern Interior - Dry (PP IDF MS)	Southern Interior - Moist (ICH)	
Oak Fern	*Gymnocarpium dryopteris*	moist to very moist	poor to rich	H	moist forest	Y	Y	Y	Y	
Sword Fern	*Polystichum munitum*	moist to very moist	medium to rich	H	moist forest	Y	Y			
Deer Fern	*Blechnum spicant*	moist to wet	medium to rich	H	moist to wet forests, streambanks, under alder		Y		Y	
Lady fern	*Athyrium dryopteris*	moist to wet	rich	H	moist to wet forests, streambanks, gullies, clearings	Y	Y	Y	Y	
Bunchberry	*Cornus canadensis*	moist to very moist	medium to rich	H	moist forest		Y	Y	Y	
Five-leaved bramble	*Rubus pedatus*	moist to very moist	poor to medium	H	moist forest, streambanks		Y		Y	
Twinflower	*Linnaea borealis*	dry to moist	poor to rich	H	open and dense forest, rocky shorelines	Y	Y	Y	Y	