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Boreal Caribou Habitat Restoration Operational Toolkit for British Columbia

Submitted to:
BC Science and Community Environmental Knowledge (SCEK) Fund's Research and Effectiveness Monitoring Board (REMB)

REPORT

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Purpose of the Toolkit

The toolkit has been prepared as an operational handbook and is intended to guide implementation of reclamation techniques that will contribute to the restoration of caribou habitat. It is meant to help guide operators and reclamation specialists with activities occurring within boreal caribou range in BC with a toolkit of measures to address the vegetation as well as the human and predator accessibility within ranges. The toolkit contains information and guidance for:

- addressing regulatory considerations;
- reclamation of new disturbance and historical linear footprint;
- restoration both in and outside of tenure or permit holders approvals;
- approved access control treatments and specifications; and
- monitoring of treatment applications to determine success.

The toolkit is a living document, to be updated regularly as habitat restoration objectives, guidance, targets, and regulations evolve because of learnings from monitoring of current caribou habitat restoration programs and studies.

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1.0 INTRODUCTION

The “Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population in Canada” (Environment Canada 2012) sets a recovery goal of achieving self-sustaining populations of caribou in all ranges where they currently exist. Recovery goals can be achieved by maintaining or increasing the current caribou population size and distribution, and through the protection and/or restoration of critical habitat so that each range consists of a minimum 65% undisturbed habitat (EC 2012). Undertaking actions to reclaim boreal caribou habitat through restoration efforts is identified as a recovery tool within the federal recovery plan.

To maximize restoration efficiency of disturbances, it is important that objectives and treatment types used are streamlined within industries and caribou ranges to the extent possible. The province of British Colombia (BC) reviewed what’s known about restoration in order to devise a plan for the province (Golder 2012a). The Boreal Caribou Habitat Restoration Toolkit has been developed by reviewing ongoing habitat restoration programs occurring within Alberta, summarizing the learnings from implementation of restoration tools in that province, as well as through a workshop with BC regulators to ensure consistency with BC forest management, reclamation and wildlife management practices (Appendix A). It is meant to help guide reclamation activities occurring within boreal caribou range in BC by providing a toolkit of measures intended to promote desired vegetation response and address human and predator accessibility within ranges.

Restoration and/or reclamation conditions may be attached to Oil and Gas Commission (OGC) permit applications for individual oil and gas operators to mitigate impacts from new developments within boreal caribou ranges. The purpose of the Operational Restoration Toolkit is to provide guidance to individual operators and regulators for how to implement and meet the interim reclamation operating practices with the *Interim Operating Practices for Oil and Gas Activities in identified Boreal Caribou Habitat in British Columbia* (BC MOE 2011). The toolkit is not intended to direct strategic planning for province-wide restoration efforts, but rather to assist in the planning and on-the-ground implementation of site-specific restoration activities. Operators should anticipate and plan for restoration activities during planning for project construction to minimize costs incurred during the reclamation phase.

This toolkit contains a summary of habitat restoration treatments that are specific to oil and gas disturbance features within boreal caribou habitat, designed to limit humans/predators/primary prey (i.e., moose and deer) access, and to allow for regeneration to native species. This toolkit includes summary tables with treatment objectives and recommended prescriptions. Consideration is given to the site type (i.e., upland/lowland) for treatment selection, associated measures to consider with restoration treatments, and includes figures and photos of restoration treatments.

Note that this toolkit is focused primarily on boreal caribou habitat restoration on linear disturbances created by oil and gas development. The mining and forestry industries already have criteria to restore their sites; reclamation policies for those industries beyond their current reclamation criteria are outside the scope of this toolkit. Existing reclamation criteria that apply to facilities and well pads have not been specifically detailed within this toolkit. In addition, the assumption is that facilities and well pads do not create access corridors that are utilized for benefit by predators and primary prey.

2.0 CARIBOU HABITAT RESTORATION OBJECTIVES

Caribou related research suggests that predators and primary prey are utilizing linear corridors for their own benefits, resulting in detriments for caribou (Festa-Bianchet et al. 2012; Latham et al. 2011a,b). In response to this research, the focus for caribou habitat restoration has been to establish treatments that will reduce or eliminate benefits that linear disturbances provide to predators and primary prey. These treatments include access control that is effective in the short term, while contributing to setting the vegetation response on a trajectory to restore the site to the equivalent pre-disturbed habitat. The Canadian Association of Petroleum Producers (CAPP) has recently endorsed the following (Wayne Thorp, pers. comm.) for treatment applications designed to restore caribou habitat:

"Application of techniques on anthropogenic disturbances that deter predation, primary prey and human use in the near term, that supports long term habitat recovery".

Based on this definition, the objectives of habitat restoration treatments are:

- Access control targeting human and predator access along linear disturbance features such as seismic lines, pipelines and roads, including during reclamation of recently abandoned dispositions such as lease roads and pipeline rights-of-way (ROWs).
- Directly restore habitat by promoting the rate of recovery of naturally occurring and introduced vegetation, which may require tree/shrub seedling planting.

Ultimately, the goal is to create a restored landscape, which can be defined as "disturbed caribou range is returned to functional habitat that can support self-sustaining caribou population without ongoing intervention (e.g., predator control)" (Golder 2014).

3.0 HABITAT RESTORATION: PLANNING

Although reclamation success of a restored site is influenced by construction practices used during site development, for the purposes of this operational tool kit, the focus is on the reclamation and restoration component of a site once it is abandoned.

For recently abandoned sites being reclaimed for the purposes of obtaining a Certificate of Reclamation (CoR), inventories are done on-site, usually when there is a relative low cover or growth of vegetation present.

For legacy features such as seismic lines that are being considered for reclamation and restoration treatments, particularly for large scale restoration initiatives, inventories usually involve remote sensing to spatially map linear disturbances and the level and trajectory of natural regrowth. In addition to the amount of natural regrowth, field truthing of candidate treatment sites is completed. Data is collected on classifying the type(s) of disturbance (roads are considered severe disturbance whereas a cutline is often minimal disturbance), level of human (e.g., all-terrain vehicle) and wildlife (game trails) use, width and orientation of a line (impacts light penetration and moisture level), compaction level (impacted from construction practices), soil mineral layer (nutrients) and microsite availability, adjacent site type/forest attributes (very wet to very dry, upland/transitional/lowland), woody material level/availability/fuel loading considerations from a fire management perspective, and historical seeding practices which often has resulted in competing vegetation to tree and desired shrub seedlings.

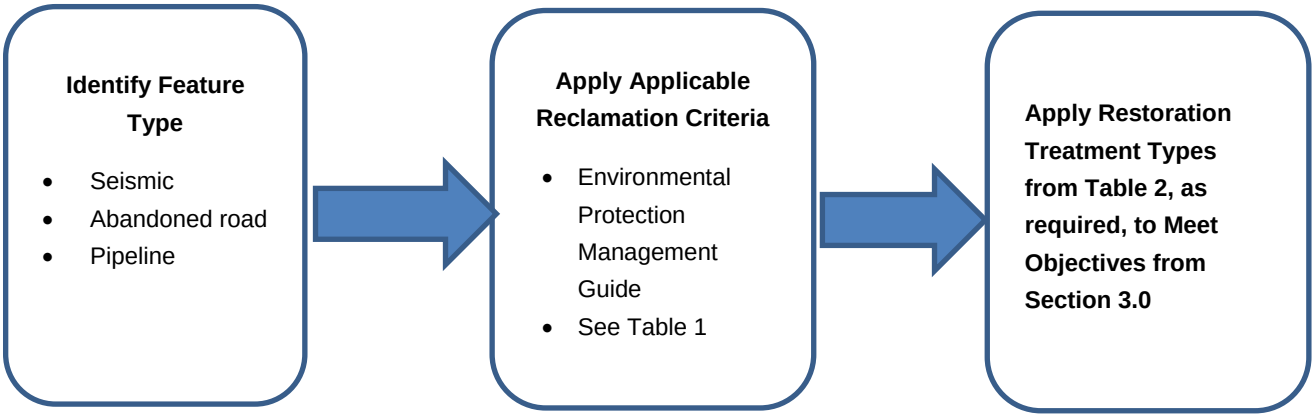
Following the initial knowledge of site conditions, treatment sites and prescriptions are determined and often strategically located into priority areas for restoration and to areas where human access control treatments will prevent repeated use. This ensures that the 'right lines for restoration' are selected. For large scale restoration programs, future development plans in the area (e.g., forestry harvest plans, known project development areas), provincial priority areas (WHAs), as well as a focused plan to create large, contiguous intact habitat areas should be consulted.

Treatment prescriptions for linear corridors differ significantly from commonly used silviculture practices employed during the restoration of larger polygon features such as well-sites and forestry cutblocks. Considerations to be taken into account during planning for restoration and types of treatments on linear features include:

- surrounding forest stand attributes;
- upland, lowland or transitional site;
- what the type of disturbance is and original clearing methods (seismic, cutline, road, pipeline);
- level of reuse of a disturbance (e.g., ongoing compaction from ATV use), soil compaction, soil characteristics;
- woody material availability;
- width of disturbance, light levels and shade effect from the adjacent site;
- human and/or predator use; and
- moisture and nutrient regime.

The habitat restoration sequence of events after a site has been abandoned is illustrated in Diagram 1.

Diagram 1: Reclamation to Restoration Flowchart



The first consideration for habitat restoration is whether a site can be left to revegetate by natural means, without implementing seed or seedling planting programs. Although the objective of controlling human, predator and primary prey use may still require treatments, silviculture-type treatments such as seedling planting may not be necessary for setting the site on a trajectory to quickly re-establish native vegetation if the site has suitable moisture and nutrients, is not compacted (low disturbance), has sufficient micro-sites for seed, and sufficient light is reaching the surface.

To help guide reclamation and restoration practitioners to determine whether silviculture-type treatments are necessary, Tim Vinge of Alberta Environment and Sustainable Resource Development (ESRD) Land Management Branch developed a treatment matrix for linear restoration. The table has been modified to BC's Biogeoclimactic Ecosystem Classification (BEC) subzones that are present in boreal caribou habitat range, and is presented, by subzone, in Appendix B, Tables 1 to 6.

The treatment matrix tables include a list of potential vegetation treatments (if required), target species, vegetation cover and number of species, which are based on site characteristics such as site type, moisture/nutrient regime, and presence/absence of site preparation. This treatment matrix is recommended for use in the implementation of treatments to meet the reclamation criteria summarized in Appendix B. The habitat restoration prescription types, objectives, and specifications in Table 1 should be implemented in consideration of the measures in Appendix B, Tables 1 to 6, when required, to address the caribou specific restoration objectives outlined in Section 3.0. Recommended prescription type depends on feature type and the site conditions, and should be determined by a qualified professional in the reclamation and/or silvicultural discipline who is familiar with the material and the restoration objectives.

Table 1: Habitat Restoration Prescription Types (Restoration Techniques)

Type of Mitigation Prescription	Objective(s)	Specifications	Positive Experiences with this Technique	Considerations to take into account	Ideal Timing for Treatment	References
Mechanical site preparation: Mounding and/or ripping using an excavator	▪ Create microsites in areas where it is deemed to be effective for enhanced survival and growth of planted seed and seedlings, and natural regrowth of woody species ▪ Access control	▪ For access control purposes, mounds should be created using an excavator. The holes left behind by the mounds should generally be approximately 0.75 m deep, if feasible. The excavated material is positioned right beside the hole, creating the mounds. ▪ Ripping should focus on upland sites where excessive moisture is not a concern. ▪ Troughs created by ripping should be positioned to reduce erosion potential. ▪ Target density of mounding for access control and/or microsite creation purposes can vary from 600 to 2,000 mounds/hectare (ha), depending on the size of the hole and mound. ▪ When completing in synergy with seedling planting, seedlings are generally planted near the hinge of the mound: – Slightly higher up from the hinge for lowland and transitional sites – At or slightly lower than the hinge for upland sites	▪ For the purposes of enhancing microsites for planted seedlings, mounding is a well-researched site preparation technique in the silviculture industry. It is commonly used in wetter, low-lying areas to create higher, better-drained microsites for seedlings ▪ Mounding treed fen and bog areas can enhance a site to promote natural revegetation over time, as higher, drier spots are created that seed can eventually settle into and germinate ▪ Mounding has been used as an access control measure on decommissioned roads, seismic lines, and pipelines to discourage off-road vehicle activity. It is effective immediately following implementation ▪ Ripping is a standard site preparation method that has been modified in this case for tighter workspaces	▪ Sufficient frost is required to access sites in the winter when crossing lowland areas: This varies from winter to winter ▪ Research regarding machines that can operate in lowlands during non-frozen conditions is underway in NE Alberta	▪ Winter (frozen-ground conditions)	▪ Macadam and Bedford 1998 ▪ Roy *et al.* 1999 ▪ MacIsaac *et al.* 2004 ▪ Golder 2010 ▪ OSLI 2012a, 2012b ▪ Nexen 2013 ▪ CRRP 2007b ▪ Archuleta and Baxter 2008 ▪ USDA 2009 ▪ BC MFR 2014a ▪ BC Forest Service 1998 ▪ BC MOF 2000 ▪ BC MFR 1998
Tree/shrub seedling planting	▪ access control ▪ erosion control ▪ reduce line-of-sight ▪ restore habitat	▪ Tree/shrub species are determined based on site conditions, the adjacent forest stand and restoration objectives (e.g., low palatability for ungulates). Coniferous tree species (Spruce sp., Pine sp.) are recommended to meet caribou habitat needs. Considerations for the use of shrubs: – Alder is generally planted because it forms an effective access control and line of sight break in a relatively quick period of time – Alder has a similar palatability rating for ungulates as conifer species (CRRP 2007b) – Willow is avoided due to the high palatability rating for ungulates (CRRP 2007b) ▪ Shrub and tree seedlings are often planted together, depending on site conditions and anticipated natural revegetation of both species	▪ Seedling planting is considered a long-term restoration treatment due to the length of time it takes to establish effective hiding cover and access deterrents ▪ Seedlings should ideally be sourced at least six months prior to planned planting dates ▪ Seedlings and/or seed for growing seedlings may not be available for every species prescribed and therefore seed may need to be collected and grown in the nursery ▪ Seedling planting during winter is generally restricted to lowland and transitional sites with organic soil that have been treated with mechanical site preparation immediately prior to planting ▪ Seedling planting density for reclamation purposes has generally been based on adjacent site type and quickly providing hiding cover; it can range from 2000 to 2500 stems/hectare	▪ Use of frozen seedlings need to consider preparation of nursery stock, storage, planting temperature, and use of snow packing following planting to avoid winter freeze/thaw seedling mortality	▪ Seedlings can be planted frozen sites in the winter (OSLI 2012; MEG 2014; Cenovus 2013) ▪ Non-frozen stock are generally planted as summer stock in consideration of the Least Risk Timing Windows for caribou	▪ AENV 2010, 2011 ▪ BC MFR 1998 ▪ Cenovus 2013 ▪ CRRP 2007b ▪ DES 2004 ▪ Golder 2005, 2010, 2011, 2012b, 2012c ▪ MEG 2014 ▪ OSLI 2012a, 2012b ▪ Nexen 2013 ▪ NEIPC 2010
Spreading of woody material	▪ control of human access during snow free periods ▪ erosion control ▪ protect planted seedlings from extreme weather, wildlife trampling, and damage from ATVs ▪ provide site nutrients when the wood decomposes ▪ provide microsites for natural seed ingress	▪ Spread woody material evenly across the entire corridor or polygon feature ▪ Ensure woody material is consistently dense enough on the ground to discourage ATV and wildlife use ▪ The Guide to Fuel Hazard Assessment and Abatement in British Columbia (2012) recommends woody loads do not exceed 99 tonnes/ha (~175 m^3/ha). An exemption may be allowed for larger volumes from the local fire centre under Section 25 or 26 of the Wildfire Regulation. ▪ Vinge and Pyper recommend applying between 60 to 100 m^3/ha of woody material to reclaimed sites to mimic the natural range of variability for woody material in the forest ▪ Implement at sites left for natural recovery when woody material is available as well as sites that are planted with seedlings	▪ The length of a treated segment is dependent on sufficient quantities of woody material available. Longer segments are a more effective treatment at controlling human access since ATV riders will be less inclined to attempt to travel through the woody material or traverse around it in adjacent forest stands if the woody material continues for an extended distance ▪ Woody material can also conserve soil moisture, moderate soil temperatures, provide nutrients after it decomposes, prevent soil erosion, provide a source of seed for natural revegetation, provide microsites for seed germination and protection for introduced tree seedlings, and protect seedlings from wildlife trampling and browsing ▪ Spreading of woody material is effective as an access control immediately following implementation ▪ Woody material can be brought to a site from another location that has identical tree species	▪ Potential for fuel loading is a concern. The BC MFLNRO specifies acceptable levels of woody material while considering fire management objectives. Consultation with the local fire centre is recommended prior to treatment (stay under 99 tonnes/ha) ▪ Storage and use of woody materials may be compromised if bark beetle is a concern in the area and would be discussed with the local forest officer ▪ Storage of woody material for extended periods without increasing fire hazard can be challenging and should be discussed with district fire managers as part of the planning process when using woody materials	▪ Winter (frozen-ground conditions)	▪ CRRP 2007b ▪ Enbridge 2010 ▪ Osko and Glasgow 2010 ▪ Golder 2010, 2011 ▪ Government of Alberta 2013 ▪ OSLI 2012a,2012b ▪ BC MFLNRO 2012 ▪ Pyper and Vinge 2012 ▪ Vinge and Pyper 2012

Table 1: Habitat Restoration Prescription Types (Restoration Techniques)

Type of Mitigation Prescription	Objective(s)	Specifications	Positive Experiences with this Technique	Considerations to take into account	Ideal Timing for Treatment	References
Tree-felling/ Tree Bending	▪ access control ▪ reduce line-of-sight ▪ reduce shade effect	▪ Bend (hinge) mature trees partially across the line with an excavator while treating the features for mounding purposes or spreading woody material ▪ Fell mature trees across the line on upland and transitional sites (e.g., white spruce, pine, aspen, and black spruce) – An excavator is preferred for felling trees by pushing them over, if site conditions are suitable for excavator access – Trees can be felled with a chain saw if site access is suitable to address safety concerns ▪ Trees are to be felled perpendicular to the line. Trees are not to be felled parallel to the line to reduce a fire hazard ▪ Treatment locations to occur approximately every 20 m on lowland and upland sites ▪ At each treatment location, 2 or more trees to be felled, from opposite sides of the line, to create an access control and line of sight break – Treatment locations should occur where sufficient sized timber is present. Before using merchantable timber, consultation between the province of BC's MFLNRO and the local forestry company would need to occur to decide approval process and tracking method for species and number cut – Treatment locations should be as frequent as possible to discourage wildlife use, understanding that locations will be variable depending on forest stand adjacent to line – More trees to be felled near access points and intersections to restrict access and predator movement. Additional trees can be felled along identified lines where the adjacent trees are of suitable height (depends on width of line, need to cover across entire corridor)	▪ Tree-felling and tree bending across the line is mimicking natural processes that occur in the forest. ▪ Tree-felling from the adjacent eco-site can reduce the shade effect on the corridor, leading to more sunlight and warmer soils, creating an enhanced environment for plant growth	▪ Tree-felling will result in tree mortality. Tree bending may keep trees alive with longer term needle cover ▪ Potential for fuel loading is a concern. The BC MFLNRO specifies acceptable levels of woody material while considering fire management objectives. Consultation with the local fire centre is recommended prior to treatment. ▪ Felling and bending is difficult to implement using hand fallers due to difficulties with access, and safety considerations. Mechanical equipment and site safety supervision should be considered ▪ A permit may be required to fall trees that are outside the restoration site	▪ Winter (frozen-ground conditions)	▪ Cody 2013 ▪ Cenovus 2013 ▪ CRRP 2007b ▪ Neufeld 2006 ▪ MEG 2014 ▪ Keim et al. 2014
Installing fences	▪ access control	▪ Fences can be installed at intersections with linear corridors and/or along a corridor where predator/human access control and line-of-sight breaks are required ▪ Where natural topography or bends in the corridor do not break the line-of-sight, fences can be placed to limit sight lines ▪ Wooden panels should be pre-constructed off-site, fastening the panels together at the treatment site to create a fence	▪ Fences could also be established using poles and geotextile or similar style decomposable matting. ▪ Gates can be installed on fences if desired to allow some access.	▪ Fences are logistically challenging to establish in areas without pick-up access. ▪ Used infrequently in the past and unknown efficacy. ▪ Installing fences during summer may be difficult to implement due to access availability	▪ Winter (frozen-ground conditions)	▪ CRRP 2007a

4.0 HABITAT RESTORATION: FIELD SPECIFICATIONS

The mitigation prescriptions identified in Appendix B, Tables 1 to 6 are discussed in more detail below and include specifications for restoration techniques such as mechanical site preparation (i.e., mounding, ripping), tree/shrub seedling planting, spreading of woody material, tree-felling/tree bending and installing fences. It is recommended that a qualified reclamation and/or silviculture professional visit the treatment locations prior to activities commencing and/or be present on site during the execution of these treatments to provide professional advice/support on how treatments can be successfully implemented.

4.1 Mechanical Site Preparation

Mechanical site preparation is a tool that is generally used to modify a site to promote enhanced revegetation. The intent of site preparation is to alter the growing characteristics of planted tree/shrub seed, seedlings and naturally occurring native plant species to increase survival and improve early growth rates, and to discourage human and wildlife use of the treated area. Although there are many forms of mechanical site preparation available, the narrow workspace associated with most linear features limits the tools that are available. For legacy seismic features, two primary site preparation methods are considered.

Excavator Mounding

Mounds are generally created under frozen ground conditions using an excavator. The bucket/rake attachment is specifically designed to flip the soil in a manner that creates a more suitable planting site and/or an access control. The size of the mound will vary depending on:

- soil moisture;
- competing vegetation;
- the topographic location of the site;
- frost levels (material may be dug out in varying sizes of frozen chunks);
- size of the bucket/rake attachment; and
- site deactivation objectives (access control or micro-site creation or a combination thereof).

The density of the mounds (mounds per hectare [mds/ha]) will vary and is directly related to the size of the mounds. The larger the mounds, the less dense the mounds will be. Photo 1 illustrates mounding at 1,200 mds/ha and should be considered regular sized mounding for micro-site creation. The holes and mounds should be larger for more effective access control if mounding is the only treatment at the site.

For access control purposes, mound holes should generally be 0.75 m deep from the ground surface to the bottom of the excavation. Photos 2 to 5 illustrate the mounding process. Photos 2 and 3 depict an upland site before and after mounding were completed. Photos 4 and 5 show mounds the following summer, in a lowland site, planted with black spruce seedlings. Mounding site preparation should consider recreating a hump and hollow terrain within wetland (fen, bog, transitional sites) areas (Appendix C).

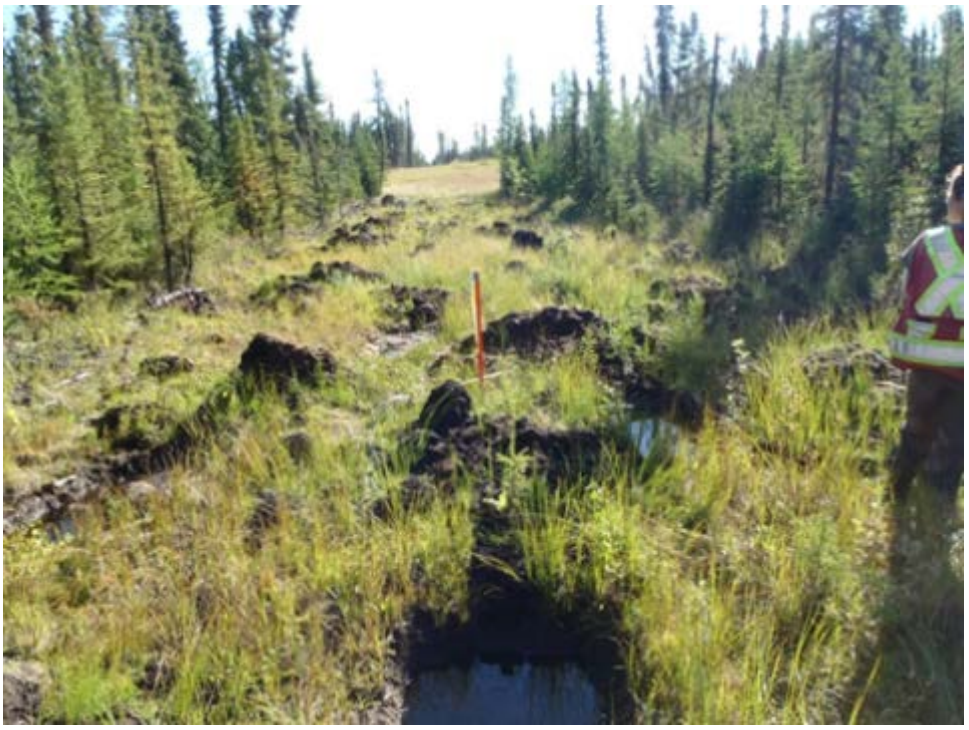


Photo 1: **Seedling Planting on a mounded area in a lowland site: Approximately 1200 mds/ha. (Photo courtesy of Canadian Natural Resources Ltd.)**

Photo 2: **Before Excavator Mounding in upland site. (Photo courtesy of Canadian Natural Resources Ltd.)**

Photo 3: **Post treatment in upland site following excavator mounding. (Photo courtesy of Canadian Natural Resources Ltd.)**

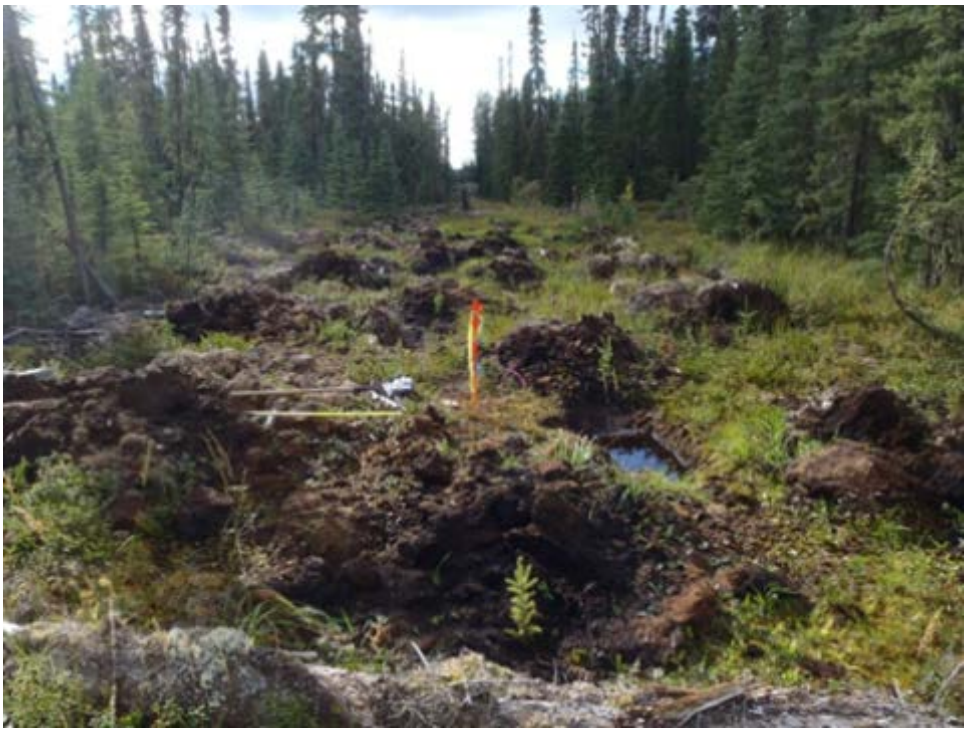


Photo 4: **Seedling Planting on a mounded treatment area in a lowland site. (Photo courtesy of Canadian Natural Resources Ltd.)**

Photo 5: Typical mound planted with a seedling in a lowland site: One growing season. (Photo courtesy of Canadian Natural Resources Ltd.)

For more information regarding mounding, refer to the following links:

- http://www.for.gov.bc.ca/hfp/publications/00078/
- http://www.for.gov.bc.ca/hfp/training/00009/microsite.htm

Ripping

Ripping is a site preparation method that is typically completed using a large dozer when treating cutblocks. Given the narrow work space associated with many linear features, the site is ripped with the bucket/rake attachment attached to the excavator, or a specialized ripping tooth is mounted to an excavator (Photo 6). Ripping of sites is typically used on upland areas of a linear feature to create micro-sites or address soil compaction concerns (Archuleta and Baxter 2008). When ripping a site located on a slope it is critical to ensure the troughs are placed in a manner that reduces rilling erosion potential (i.e., perpendicular to the slope).

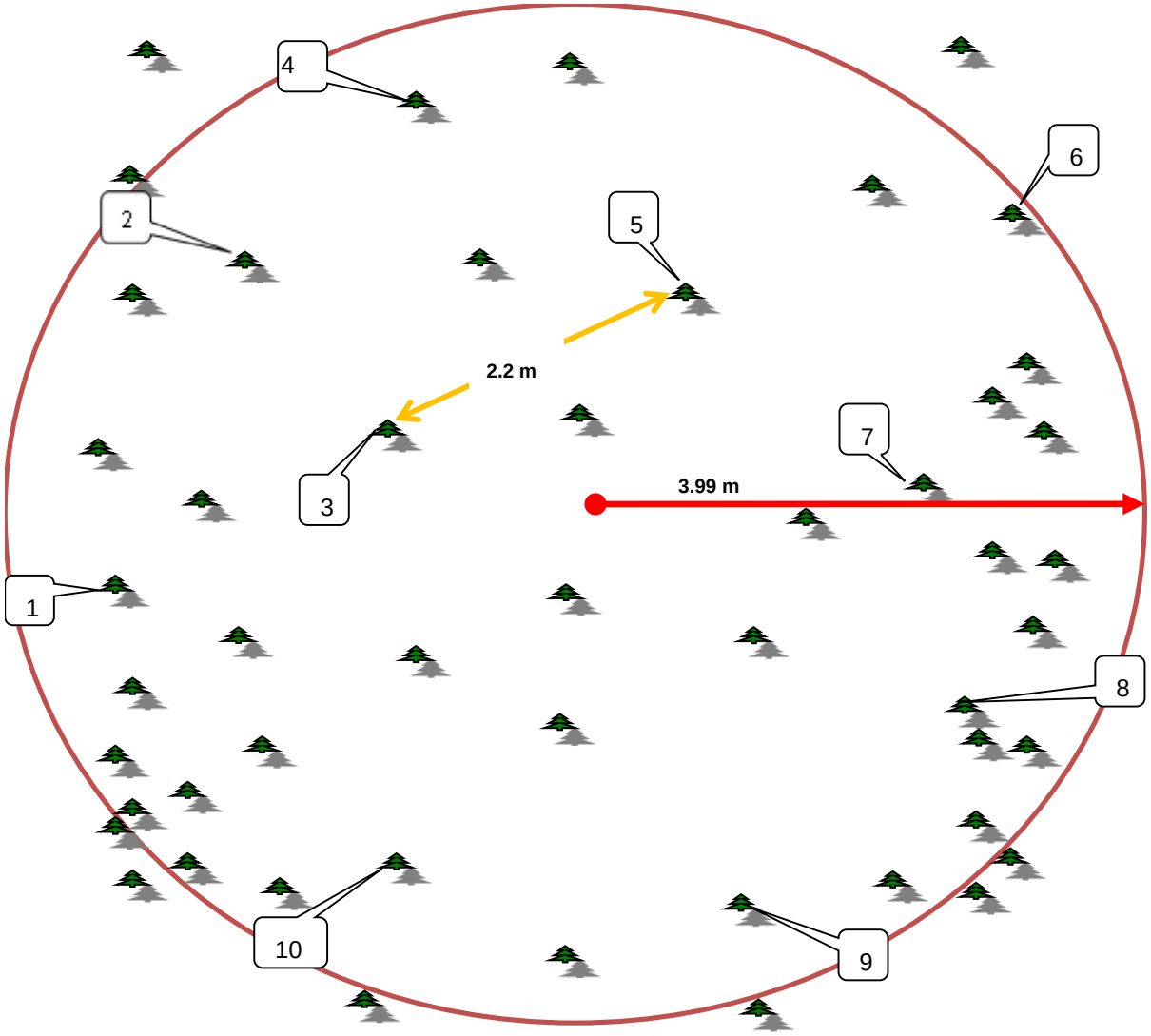
Photo 6: Excavator Ripping in an upland site. (Photo courtesy of Canadian Natural Resources Ltd.)

4.2 Tree/Shrub Seedling Planting

Sites that require intervention to place them on a revegetative trajectory to provide consistent cover of native species are planted with seedlings, with a focus on coniferous species. Although they grow relatively slower than deciduous species, coniferous species provide a year round line of sight break over the long term and are more compatible with caribou habitat selection.

Target density for tree and shrub species varies by species, but is generally 2,500 well-spaced stems/hectare (ha), based on reclamation criteria for oil and gas sites (AENV 2011). Target species are considered well-spaced if they are present approximately every 2 m. The 'well-spaced' measurement is used to determine the consistency of the regeneration on a site because linear sites may have sufficient regeneration along the edges, but less regeneration in the middle of the corridor. Sites could have many target species growing very closely together, which would show a high density in a vegetation ground plot. Well-spaced species, however, could be less dense, with wide gaps between seedlings. Diagram 2 illustrates an example regeneration plot measuring both total and well-spaced seedlings.

Diagram 2: Sample of a regeneration plot with 8,000 stems/ha (40 trees in plot) with 2,000 well-spaced stems/ha (10 well-spaced trees in plot)



Tree and shrub species prescribed for planting are determined based on the site conditions, adjacent forest stand cover, and restoration objectives, as outlined in Appendix B, Tables 1 to 6. Tree and shrub seedlings are planted concurrently depending on anticipated natural vegetation of the site.

Seedling planting generally occurs prior to March 15 (winter planting), and in late July or early August (summer planting), outside the Least Risk Timing Windows for industrial operations occurring inside boreal caribou ranges. Recent success has indicated that winter planting of seedlings is a viable treatment option which allows planting to occur concurrently with site preparation. Considerations for the use of winter planting include:

- availability of qualified contractors experienced with the treatment;
- frozen seedling availability and storage needs:
  - seedlings must be individually wrapped prior to cold storage instead of in bundles.
- planting temperature and seedling survival (species specific); and
- snow cover following planting to avoid mortality during freeze/thaw events.

Lowland and some transitional sites can require mounding prior to planting (Photos 4 and 5). Transitional sites requiring mounding are determined during the field truthing field visit unless the site is already scheduled for mounding for access control purposes. Winter planting will always require mounding immediately prior to planting.

For more information on seedling planting, including species available, size, and seed zones requirements, refer to the following links:

- http://prrd.bc.ca/services/environmental/weed_control/documents/NEIPC_Reveg_manual_PeaceLiard_April2010.pdf
- Ministry of Forests and Range Nursery Services Section: http://www.for.gov.bc.ca/nursery/branch.htm
- Forest Nursery Association of BC: http://www.fnabc.com/

4.3 Spreading of Woody Material

Spreading of woody material occurs as an access control and/or site preparation technique (Table 1, Appendix B; Tables 1 to 6). Spreading woody material can be implemented at sites left for both natural recovery and on sites planted with seedlings. Woody material is spread evenly across the entire feature being restored or deactivated. To promote natural regeneration of native plant species, woody material should not exceed 400 tonnes/ha according to recommendations by Osko and Glasgow (2010). However, BC MFLNRO 2012 recommends woody loads do not exceed 99 tonnes/ha, but larger volumes may be required to form an effective access control to discourage ATV use and will have to be spread consistently dense enough to discourage ATV use. In BC, an exemption may be sought for larger volumes of woody material from the local fire centre under Section 25 or 26 of the BC Wildfire Regulation. District fire officers should also be consulted as to the best method to avoid creating a fire hazard while storing woody debris prior to using it for restoration activities. Photo 7 illustrates a seismic line prior to a woody material spreading treatment and Photos 8 and 9 show examples of sites after woody material spreading treatments are complete.

Photo 7: **Seismic line before woody material spreading treatment has been applied. (Photo courtesy of Brian Coupal)**

Photo 8: **Seismic line after undergoing woody material spreading treatment. (Photo courtesy of Brian Coupal)**

Photo 9: Typical site after undergoing woody material spreading and ripping / mounding treatment. (Photo courtesy of Canadian Natural Resources Ltd.)

4.4 Tree Felling/Bending

Trees are felled strategically on all scheduled tree-felling sites where there is sufficient timber that will fell across the corridor (consider width of corridor and height of trees in adjacent stands). Felled trees can consist of both merchantable and non-merchantable trees. Merchantable trees have a Diameter at Breast Height (DBH) equal to or more than 15 centimetres [cm]. The number of felled trees at each site can vary depending on the available timber in the adjacent eco-site; it is expected to range from two to four trees per site (Photos 10 and 11). Sites are expected to average approximately 15 to 20 m apart except at access points, where they should be closer together. Trees are felled strategically on areas of the line that are relatively narrow or have a relatively thick adjacent forest cover, when available.

Photo 10: Seismic corridor before tree felling. (Photo courtesy of Cenovus Energy)

Photo 11: Seismic corridor after tree felling. (Photo courtesy of Cenovus Energy)

It is recommended to use an excavator to fell and to bend trees across the line, either by pushing them with the bucket, or digging under the roots and lifting the one side of the tree (Photos 12, 13, and 14) (Cenovus 2013; Cody 2013; MEG 2014).

Photo12: Typical felled / bent tree site: Non-merchantable black spruce trees both bent and felled perpendicular to the line. Line was also mounded. (Photo courtesy of MEG Energy)

Photo 13: Typical felled / bent tree site: Non-merchantable black spruce trees both bent and felled perpendicular to the line. Line was also mounded and ripped in areas. (Photo courtesy of MEG Energy)

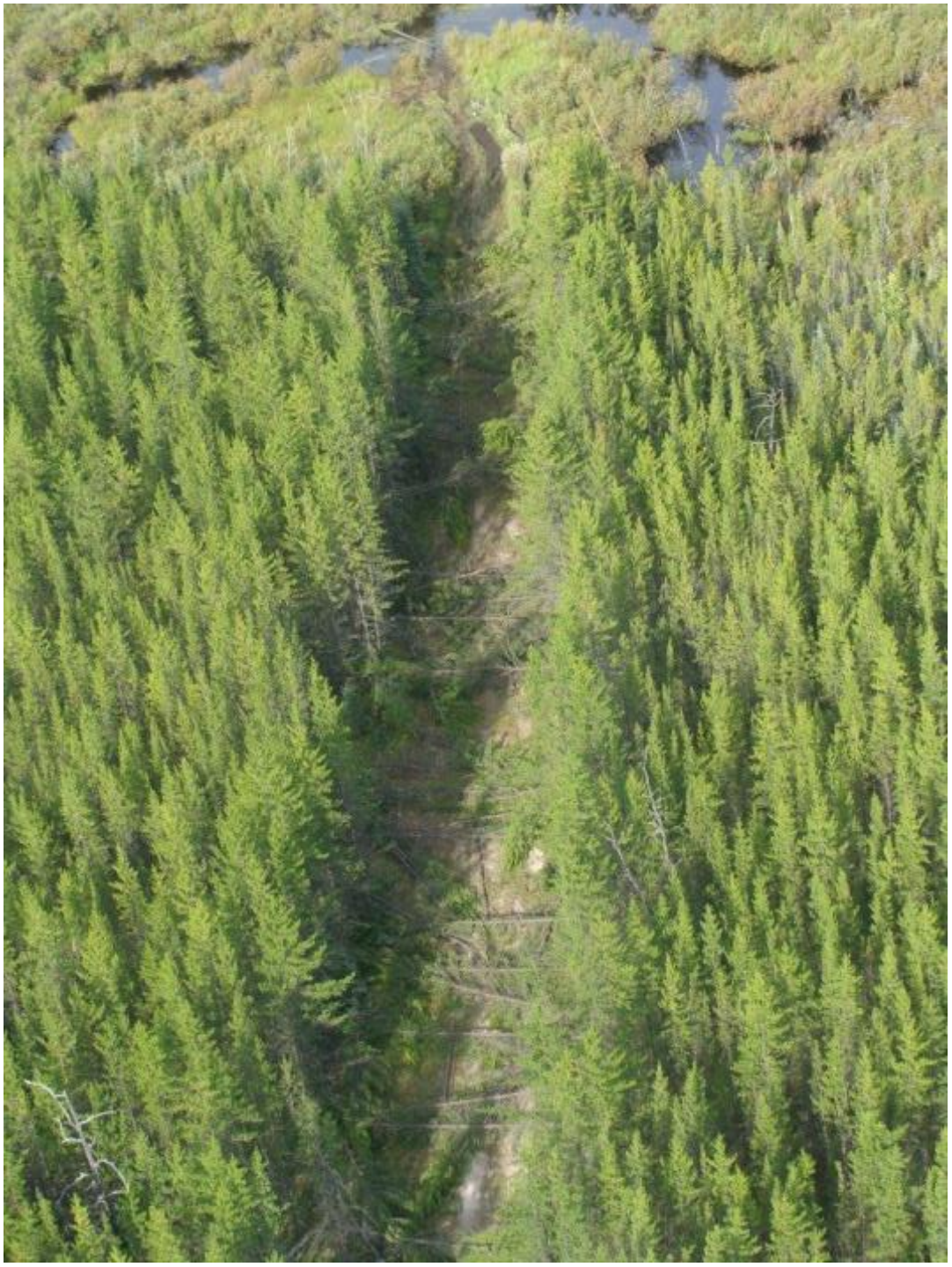


Photo 14: Typical felled / bent tree site: Aerial view. (Photo courtesy of Cenovus Energy)

Tree-felling and bending treatments can be completed in both winter and summer field programs, depending on the equipment used and available access. Tree-felling can be combined with mounding and tree planting programs to achieve access control at the same time as longer term vegetation recovery.

4.5 Installing Wooden Fences

Fences may be used as a method to control access on a linear feature. Fences can be installed on linear features where natural topography and existing vegetation are not blocking the line-of-sight. It is recommended that fences are made of decomposable materials such as rough, untreated lumber similar to those constructed for the Suncor/ConocoPhillips Canada Little Smoky Caribou Habitat Restoration Pilot Project (Photo 15; CRRP 2007a). The fences are constructed in panels approximately 2 m by 3 m and then hauled to the sites where the panels are fastened together to create the fences. Installing gates on the fences allows human access where needed for safety purposes.

Photo 15: Wooden fence created from panels and installed on a narrow site on the linear feature. (Photo courtesy of Brian Coupal)

5.0 PERMITTING AND CONSULTATION REQUIREMENTS

Based on consultation with government regulators and oil and gas industry representatives at a Caribou Habitat Restoration Toolkit workshop in Fort St. John, British Columbia on October 7, 2014, the following key steps were identified to obtain regulatory approval, planning permission and consent, and other authorizations required to conduct habitat restoration activities:

- For regulatory requirements for the reclamation of recently abandoned sites, permit holders must meet the decommissioning, abandonment and/or restoration requirements of the individual activity regulations. Application of access control treatments meets the spirit of the Interim Operating Practices for Oil and Gas Activities in Identified Boreal Caribou Habitat in British Columbia – 2011 (BC MOE 2011) and treatments implemented may be added to regular reclamation reporting requirements. Habitat restoration treatments on legacy linear development features that are owned by the province, however, may not be covered under the current regulatory framework.
- An application should include any potential utilization of merchantable timber for tree-felling purposes and notification of the retention of any coarse woody debris/slash from clearing sites. Companies may implement treatments on their own lease since treatments can be considered part of their reclamation obligations. Approval to treat third-party leases would need to be provided by the third-party lease holder. The Forest Tenure holder should be consulted to obtain approval for use of merchantable timber.
- First Nations groups should be consulted, with consultation requirements based on advice of the OGC First Nations Liaison Officers.
- Trap-line holders must be notified and consulted to ensure treatments do not impede their access or disrupt their trap-lines.
- Crossing agreements must be obtained from pipeline companies prior to crossing their pipelines with heavy machinery.

Pipelines

The restoration of caribou habitat, focusing on linear features, includes pipeline ROW. The restoration of pipeline ROWs have several challenges that are not encountered with seismic line or abandoned road restoration. While the restoration objectives of treatment types are the same, the following considerations need to be taken into account.

- Pipeline ROWs are corridors that are still in use and therefore, there are operational access considerations when planning for treatments. A companies' pipeline operation and maintenance division should be consulted regarding access requirements prior to treatments.
- There is a lack of consensus among pipeline companies regarding potential integrity issues with planting seedlings over the pipe. Company pipeline integrity division should be consulted prior to planting seedlings over the buried pipe area.

- Pipelines often parallel other pipelines, roads or infrastructure with various permit holders operating under different regulations (e.g., National Energy Board regulated versus provincially regulated). Different regulations often mean different reclamation and restoration expectations and standards. It should be determined prior to treatment if the pipeline is provincially or federally regulated, and approval conditions, if relevant, reviewed.
- The travel side of pipeline ROWs are often used as winter travel corridors after they are constructed resulting in repeated clearing for these purposes. Company pipeline operations and maintenance division should be consulted regarding historic and current use of the pipeline ROW for access purposes.
- A pipeline crossing agreement is required if heavy machinery needs to cross a pipeline to access a treatment site.

6.0 TREATMENT MONITORING

After treatments are completed, treatment sites should be monitored for both revegetation growth and effectiveness as an access control. It is recommended to complete monitoring programs on treated sites after the first growing season following treatment, and again following the third growing season. Introduced vegetation should be growing to the site conditions at that time, and assumptions can be made regarding revegetation trajectories. When monitoring, companies are encouraged to utilize the same monitoring methods to increase the statistical power of the monitoring. Example datasheets are provided in Appendix D for monitoring programs.

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APPENDIX A

Appendix A Relevant Regulations and Guidelines

RELEVANT REGULATIONS AND GUIDELINES

Environmental Protection Management Guide

The Environmental Protection and Management Guide (EPMG) (BC OGC 2013) for new construction or reclamation of existing projects occurring within caribou range, Ungulate Winter Ranges (UWRs), and Wildlife Habitat Areas (WHAs) includes the following sections relevant to caribou habitat restoration programs.

Section 3 Riparian Management Areas

The measures outlined are intended to minimize impacts on stream channel processes, aquatic ecosystems, water quality, shoreline and littoral values and wildlife habitat and vegetation adjacent to streams, lakes and wetlands. Examples include:

- Falling and removal of trees should be away from or parallel to the stream, not across it.
- Avoid depositing slash and unstable debris in the stream.
- Retain sufficient vegetation along streams.
- Retain windfirm trees with roots embedded in the bank and within 10 m of the channel.
- Retain key wildlife habitat attributes adjacent to wetlands and lakes.

Section 4 Wildlife and Wildlife Habitat

The measures outlined are intended to minimize impacts on wildlife population dynamics and growth. Examples include:

- Only operate during the appropriate least-risk timing window for terrestrial and aquatic species. For caribou, the least-risk timing windows are from July 16 to October 14 and November 16 to January 14. The most critical time period for caribou is May 15 to July 15 (BC OGC 2013).
- Activities occurring in designated Wildlife Habitat Areas, Ungulate Winter Range, and Fisheries Sensitive Watershed require detailed mitigation strategies.

Section 8 Forest Health

The measures outlined are intended to assist in reducing mountain pine beetle and spruce bark beetle. Examples include:

- Ensure operators know the best time of year to identify infested wood to ensure it is not accidentally used.
- Haul away infested wood rather than leaving it on the ground.

Section 9 Conserving Soils

The measures outlined are intended to minimize new soil disturbance, enhance restoration opportunities and reduce restoration costs. Examples include:

- Utilize the minimum area for the activity.
- Choose previously disturbed sites, when possible.
- Operate in frozen conditions.

- Use matting or overburden and geotextiles in muskeg.

Section 11 Restoration Practices

Permit holders must meet the decommissioning, abandonment and/or restoration requirements of the individual activity regulations. Focus should be on:

- Stabilizing slopes to minimize erosion and ensure drainage patterns similar to pre-disturbance.
- Restore surface soil.
- Establish ecologically appropriate vegetative cover.

Section 11 Revegetation

The measures outlined are aimed at re-establishing a native, self-sustaining plant community that is compatible with surrounding land uses. Examples include:

- Use native species to improve ecological function and wildlife habitat values.
- Conserve and replace topsoil and subsoil.
- Eliminate compaction that could inhibit root growth.
- Prepare a firm seedbed to regulate seed depth and enhance germination.
- Use drill seeding where possible.

For further reference, the EPMG can be obtained online at: http://www.bcogc.ca/node/5899/download

INTERIM OPERATING PRACTICES FOR OIL AND GAS ACTIVITIES IN IDENTIFIED BOREAL CARIBOU HABITAT IN BRITISH COLUMBIA

The Operating Practices (OPs) (BC MOE 2011) were developed by BC government staff and oil and gas industry representatives to standardize operating practices in caribou ranges designed to reduce impacts on boreal caribou life processes and habitat. Examples of relevant OPs to the restoration tools include:

- Recommended methods to reduce line-of-sight along linear features, including:
  - Using woody material spread across the feature or piled;
  - creating earthen berms;
  - tree and shrub seedling planting;
  - willow staking; and
  - excavator mounding (in UWR).
- Permanently decommission infrastructure as soon as possible and implement interim reclamation programs.
- Use minimum-disturbance techniques such as track pads, matting, use of existing linear features and operating in frozen ground conditions.

- Avoid activity within designated WHAs between April 15 to June 30.

For further reference, the OPs are located online at:

http://www.env.gov.bc.ca/wld/speciesconservation/bc/documents/Operating%20Practices.pdf

PROVINCIAL FUEL HAZARD ASSESSMENT AND ABATEMENT IN BRITISH COLUMBIA – 2012 (BC MFLNRO 2012)

- Industrial activities must not increase the risk of a fire starting, and/or if a fire did start, must not increase fire behaviour or fire suppression requirements.
- Fuel loads should be reduced to the extent practicable; exemptions from local fire centers may be sought when abatement measures are not practicable.
- To determine whether a fire hazard needs to be abated, the fuel hazard rating must be assessed by using fuel hazard charts for dispersed fuels or piled fuels (as appropriate) and determining the fuel factor number (based on type and amount of debris, slope and aspect). Tables are provided in the document.

For further reference, the Provincial Fuel Hazard Assessment and Abatement in British Columbia – 2012 is located online at:

http://bcwildfire.ca/Industry_Stakeholders/Industry/Hazard%20Assess%20%20Abate%20Guidance%20Doc%20FINAL%20with%20all%20Links%20April%202012.pdf

APPENDIX B

BC Treatment Matrix Tables

Treatment Matrix for Linear Restoration - DRY COOL BOREAL WHITE AND BLACK SPRUCE

Site Type	BWBSdk Site Series[a]	Site Series name [a]	Moisture Regime [a]	Nutrient Regime [a]	Limiting Factors[a]	Disturbance Level	CWD Level	Siteprep	Mound density/ha	Planting Density	Final Minimum Stem Density	Stocksize	Vegetation Treatment	Target Species	Vegetation Coverage	Number of Species
Moderately Dry	102	Pl – Kinnikinnick – Lingonberry	xeric to subxeric	very poor to poor	Productivity limited by growing season drought; removal of LFH will further limit productivity	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Moderately Dry	102	Pl – Kinnikinnick – Lingonberry	xeric to subxeric	very poor to poor		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry	103	SwPl – Soopolallie – Toadflax	submesic	poor to rich	Drought may limit productivity during dry growing seasons	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine or White spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry	103	SwPl – Soopolallie – Toadflax	submesic	poor to rich		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine or White spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry to Fresh	104a	Sb – Labrador tea – Step moss, freely drained phase	submesic to mesic	very poor to poor	Lack of soil nutrients	High - No LFH	150 m^3/ha	mound	500	none	2000	none	natural or applied seed	Lodgepole pine or Black spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry to Fresh	104a	Sb – Labrador tea – Step moss, freely drained phase	submesic to mesic	very poor to poor	Lack of soil nutrients; cold soil temperatures where thick insulating moss layers exist	Low - LFH present	75 to 100 m^3/ha	mound	1200	Pl 800 SPH Sb 400 SPH	1000	small	plant/ natural seed	Lodgepole pine or Black spruce	25% woody or herbaceous	Combined 5 species
Slightly Dry to Fresh	101a	Sw – Soopolallie – Step moss, mesic phase	submesic to mesic	medium to rich	Soil temperature and soil nutrients; fine textured soils may limit soil aeration and rooting depth	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Slightly Dry to Fresh	101a	Sw – Soopolallie – Step moss, mesic phase	submesic to mesic	medium to rich	Soil temperature and soil nutrients; fine textured soils may limit soil aeration and rooting depth	Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist	101b	Sw – Soopolallie – Step moss, subhygric phase	subhygric	medium	Soil temperature and soil nutrients; fine textured soils may limit soil aeration and rooting depth	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Moist	101b	Sw – Soopolallie – Step moss, subhygric phase	subhygric	medium	Soil temperature and soil nutrients; fine textured soils may limit soil aeration and rooting depth	Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	104b	Sb – Labrador tea – Step moss, imperfectly/poorly drained phase	subhygric to hygric	very poor to poor	Lack of soil nutrients; high water tables limit soil aeration and thus root development	High - No LFH	150 m^3/ha	mound	500	none	2000	none	natural or applied seed	Black spruce	25% woody or herbaceous	Combined 3 species
Moist to Very Moist	104b	Sb – Labrador tea – Step moss, imperfectly/poorly drained phase	subhygric to hygric	very poor to poor	Lack of soil nutrients; cold soil temperatures where thick insulating moss layers exist; high water tables limit soil aeration and thus root development	Low - LFH present	75 to 100 m^3/ha	mound	1200	Sb 1200 SPH	1000	small	plant/ natural seed	Black spruce	25% woody or herbaceous	Combined 5 species
Moist to Very Moist	110	Sw – Currant – Horsetail	subhygric to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites. Rooting depth and aeration may be limited by high water tables, increasing windthrow hazard and limiting productivity	High - No LFH	150 m^3/ha	mound	500	none	1000	└□└□└n	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	110	Sw – Currant – Horsetail	subhygric to hygric	medium to rich		Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	111	Sw – Mountain alder – Horsetail	subhygric to hygric	very rich	Water table may rise with removal of trees, reducing suitable planting microsites. Rooting depth and aeration may be limited by high water tables, increasing windthrow hazard and limiting productivity. Very high vegetation competition may limit Sw establishment.	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	111	Sw – Mountain alder – Horsetail	subhygric to hygric	very rich		Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	112 (Fm02)	AcbSw – Mountain alder – Dogwood	subhygric to hygric	very rich	Periodic flooding and very high vegetation competition may limit Sw establishment.	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	Balsam poplar or White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	112 (Fm02)	AcbSw – Mountain alder – Dogwood	subhygric to hygric	very rich		Low - LFH present	75 m^3/ha	mound	1200	Acb 1200 SPH or Sw 1200 SPH	1000	large	plant/ natural seed	Balsam poplar or White spruce	25% woody or herbaceous	combined 5 species
Wetland	Wb	Wetland bog	hygric to subhydric	very poor to poor	Soil temperature, drainage and nutrients	Same Low/High	10 - 50 m^3/ha	mound	1200	Sb 1200 SPH	1000	medium	plant/ natural seed	Black spruce	25% woody or herbaceous	Combined 3 species
Wetland	Wf	Wetland fen	subhydric	poor to rich	Soil temperature and drainage	Same Low/High	10 - 50 m^3/ha	mound	1200	Sb 1200 SPH or Lt 1200 SPH	1000	medium	plant/ natural seed	Black spruce or Tamarack	25% woody or herbaceous	Combined 3 species

[a] DeLong, C., A. Banner, W. H. MacKenzie, B. J. Rogers, and B. Kaytor. 2011. A field guide to ecosystem identification for the Boreal White and Black Spruce Zone of British Columbia. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Land Manag. Handb. No. 65. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh65.htm

Treatment Matrix for Linear Restoration - MOIST COOL BOREAL WHITE AND BLACK SPRUCE

Site Type	BWBSmk Site Series [(a)]	Site Series name [(a)]	Moisture Regime [(a)]	Nutrient Regime [(a)]	Limiting Factors [(a)]	Disturbance Level	CWD Level	Siteprep	Mound density/ha	Planting Density	Final Minimum Stem Density	Stocksize	Vegetation Treatment	Target Species	Vegetation Coverage	Number of Species
Moderately Dry	102	Pl – Kinnikinnick – Lingonberry	xeric to subxeric	very poor to medium	Productivity limited by growing season drought; removal of LFH will further limit productivity	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Moderately Dry	102	Pl – Kinnikinnick – Lingonberry	xeric to subxeric	very poor to medium		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry	103	SwPl – Soopolallie – Wildrye	submesic to mesic	medium to rich	Drought may limit productivity during dry growing seasons	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine or White spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry	103	SwPl – Soopolallie – Wildrye	submesic to mesic	medium to rich		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine or White spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry to Fresh	104a	Sb – Labrador tea – Step moss, freely drained phase	submesic to mesic	very poor to poor	Lack of soil nutrients	High - No LFH	150 m^3/ha	mound	500	none	2000	none	natural or applied seed	Black spruce or Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry to Fresh	104a	Sb – Labrador tea – Step moss, freely drained phase	submesic to mesic	very poor to poor	Lack of soil nutrients; cold soil temperatures where thick insulating moss layers exist	Low - LFH present	75 to 100 m^3/ha	mound	1200	Sb 800 SPH Pl 400 SPH	1000	small	plant/ natural seed	Black spruce or Lodgepole pine	25% woody or herbaceous	Combined 5 species
Slightly Dry to Fresh	101	Sw – Lingonberry – Step moss	submesic to mesic	medium to rich	Few limiting factors; fine textured soils may limit soil aeration and rooting depth	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Slightly Dry to Fresh	101	Sw – Lingonberry – Step moss	submesic to mesic	medium to rich		Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	104b	Sb – Labrador tea – Step moss, imperfectly/poorly drained phase	subhygric to hygric	very poor to poor	Lack of soil nutrients; high water tables limit soil aeration and thus root development	High - No LFH	150 m^3/ha	mound	500	none	2000	none	natural or applied seed	Black spruce	25% woody or herbaceous	Combined 3 species
Moist to Very Moist	104b	Sb – Labrador tea – Step moss, imperfectly/poorly drained phase	subhygric to hygric	very poor to poor	Lack of soil nutrients; cold soil temperatures where thick insulating moss layers exist; high water tables limit soil aeration and thus root development	Low - LFH present	75 to 100 m^3/ha	mound	1200	Sb 1200 SPH	1000	small	plant/ natural seed	Black spruce	25% woody or herbaceous	Combined 5 species
Moist to Very Moist	110	Sw – Currant – Horsetail	subhygric to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites.	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	110	Sw – Currant – Horsetail	subhygric to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites. Sites with deep LFH (> 10 cm) have reduced rooting availability in mineral soil; increases windthrow hazard and limits productivity	Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	111	Sw – Mountain alder – Horsetail	subhygric to hygric	rich to very rich	Water table may rise with removal of trees, reducing suitable planting microsites.	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	111	Sw – Mountain alder – Horsetail	subhygric to hygric	rich to very rich	Water table may rise with removal of trees, reducing suitable planting microsites. Sites with deep LFH (> 10 cm) have reduced rooting availability in mineral soil; increases windthrow hazard and limits productivity	Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	112 (Fm02)	AcbSw – Mountain alder – Dogwood	subhygric to hygric	rich to very rich	Periodic flooding and very high vegetation competition may limit Sw establishment.	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	Balsam poplar or White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	112 (Fm02)	AcbSw – Mountain alder – Dogwood	subhygric to hygric	rich to very rich		Low - LFH present	75 m^3/ha	mound	1200	Acb 1200 SPH or Sw 1200 SPH	1000	large	plant/ natural seed	Balsam poplar or White spruce	25% woody or herbaceous	combined 5 species
Wetland	Wb	Wetland bog	hygric to subhydric	very poor to poor	Soil temperature, drainage and nutrients	Same Low/High	10 to 50 m^3/ha	mound	1200	Sb 1200 SPH	1000	medium	plant/ natural seed	Black spruce	25% woody or herbaceous	Combined 3 species
Wetland	Wf	Wetland fen	subhydric	poor to rich	Soil temperature and drainage	Same Low/High	10 to 50 m^3/ha	mound	1200	Sb 1200 SPH or Lt 1200 SPH	1000	medium	plant/ natural seed	Black spruce or Tamarack	25% woody or herbaceous	Combined 3 species

[(a)] DeLong, C., A. Banner, W. H. MacKenzie, B. J. Rogers, and B. Kaytor. 2011. A field guide to ecosystem identification for the Boreal White and Black Spruce Zone of British Columbia. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Land Manag. Handb. No. 65. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh65.htm

Treatment Matrix for Linear Restoration - MOIST WARM BOREAL WHITE AND BLACK SPRUCE

Site Type	BWBSmw Site Series [a]	Site Series name[a]	Moisture Regime [a]	Nutrient Regime [a]	Limiting Factors [a]	Disturbance Level	CWD Level	Siteprep	Mound density/ha	Planting Density	Final Minimum Stem Density	Stocksize	Vegetation Treatment	Target Species	Vegetation Coverage	Number of Species
Moderately Dry	102	Pl – Kinnikinnick – Lingonberry	xeric to subxeric	very poor to medium	Productivity limited by growing season drought; removal of LFH will further limit productivity	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Moderately Dry	102	Pl – Kinnikinnick – Lingonberry	xeric to subxeric	very poor to medium		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry	103	SwPl – Soopolallie – Wildrye	submesic	poor to medium	Drought may limit productivity during dry growing seasons	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine or White spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry	103	SwPl – Soopolallie – Wildrye	submesic	poor to medium		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine or White spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry to Very Moist	104	Sb – Lingonberry – Step moss	submesic to hygric	very poor to poor	Poorly structured soil (compacted or massive) and/or high water table limits soils aeration and thus root development	High - No LFH	150 m^3/ha	mound	500	none	2000	none	natural or applied seed	Black spruce or Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry to Very Moist	104	Sb – Lingonberry – Step moss	submesic to hygric	very poor to poor		Low - LFH present	75 to 100 m^3/ha	mound	1200	Sb 800 SPH Pl 400 SPH	1000	small	plant/ natural seed	Black spruce or Lodgepole pine	25% woody or herbaceous	Combined 5 species
Slightly Dry to Fresh	101	Sw – Trailing raspberry – Step moss	submesic to subhygric	medium to rich	Few limiting factors; fine textured soils may limit soil aeration and rooting depth	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Slightly Dry to Fresh	101	Sw – Trailing raspberry – Step moss	submesic to subhygric	medium to rich		Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Fresh to Moist	110	Sw – Oak fern – Sarsaparilla	mesic to subhygric	rich	Few limiting factors; cold air drainage causing frost damage to young trees can occur on lower to toe slopes	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Fresh to Moist	110	Sw – Oak fern – Sarsaparilla	mesic to subhygric	rich		Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	111	Sw – Currant – Horsetail	subhygric to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites.	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	111	Sw – Currant – Horsetail	subhygric to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites. Sites with deep LFH (> 10 cm) have reduced rooting availability in mineral soil; increases windthrow hazard and limits productivity	Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	112 (Fm02)	AcbSw – Mountain alder – Dogwood	subhygric to hygric	rich to very rich	Periodic flooding and very high vegetation competition may limit Sw establishment.	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	Balsam poplar or White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	112 (Fm02)	AcbSw – Mountain alder – Dogwood	subhygric to hygric	rich to very rich		Low - LFH present	75 m^3/ha	mound	1200	Acb 1200 SPH or Sw 1200 SPH	1000	large	plant/ natural seed	Balsam poplar or White spruce	25% woody or herbaceous	combined 5 species
Wetland	Wb	Wetland bog	hygric to subhydric	very poor to poor	Soil temperature, drainage and nutrients	Same Low/High	10 to 50 m^3/ha	mound	1200	Sb 1200 SPH	1000	medium	plant/ natural seed	Black spruce	25% woody or herbaceous	Combined 3 species
Wetland	Wf	Wetland fen	subhydric	poor to medium		Same Low/High	10 to 50 m^3/ha	mound	1200	Sb 1200 SPH or Lt 1200 SPH	1000	medium	plant/ natural seed	Black spruce or Tamarack	25% woody or herbaceous	Combined 3 species

[a] DeLong, C., A. Banner, W. H. MacKenzie, B. J. Rogers, and B. Kaytor. 2011. A field guide to ecosystem identification for the Boreal White and Black Spruce Zone of British Columbia. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Land Manag. Handb. No. 65. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh65.htm

Treatment Matrix for Linear Restoration - MURRAY WET COOL BOREAL WHITE AND BLACK SPRUCE

Site Type	BWBSwk1 Site Series [a]	Site Series name[a]	Moisture Regime [a]	Nutrient Regime [a]	Limiting Factors [a]	Disturbance Level	CWD Level	Siteprep	Mound density/ha	Planting Density	Final Minimum Stem Density	Stocksize	Vegetation Treatment	Target Species	Vegetation Coverage	Number of Species
Moderately Dry	102	Pl – Lingonberry – Reindeer lichen	xeric to subxeric	very poor to medium	Productivity limited by growing season drought; removal of LFH will further limit productivity	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Moderately Dry	102	Pl – Lingonberry – Reindeer lichen	xeric to subxeric	very poor to medium		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry	103	SwPl – Soopolallie – Showy aster	submesic	poor to rich	Drought may limit productivity during dry growing seasons	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine or White spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry	103	SwPl – Soopolallie – Showy aster	submesic	poor to rich		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine or White spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry to Moist	104	Sb – Huckleberry – Lingonberry	submesic to subhygric	very poor to poor	Poorly structured soil (compacted or massive) and/or high water table limits soils aeration and thus root development	High - No LFH	150 m^3/ha	mound	500	none	2000	none	natural or applied seed	Black spruce or Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry to Moist	104	Sb – Huckleberry – Lingonberry	submesic to subhygric	very poor to poor		Low - LFH present	75 to 100 m^3/ha	mound	1200	Sb 800 SPH Pl 400 SPH	1000	small	plant/ natural seed	Black spruce or Lodgepole pine	25% woody or herbaceous	Combined 5 species
Slightly Dry to Fresh	101	SwBl – Huckleberry – Feathermoss	submesic to mesic	poor to medium	Few limiting factors; fine textured soils may limit soil aeration and rooting depth	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Slightly Dry to Fresh	101	SwBl – Huckleberry – Feathermoss	submesic to mesic	poor to medium		Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Fresh to Very Moist	110	Sw – Oak fern – Sarsaparilla	mesic to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites.	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Fresh to Very Moist	110	Sw – Oak fern – Sarsaparilla	mesic to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites. Sites with deep LFH (> 10 cm) have reduced rooting availability in mineral soil; increases windthrow hazard and limits productivity	Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	111	Sb – Lingonberry – Horsetail	submesic to subhygric	very poor to poor	Lack of soil nutrients; high water tables limit soil aeration and thus root development	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	Black spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	111	Sb – Lingonberry – Horsetail	submesic to subhygric	very poor to poor	Lack of soil nutrients; cold soil temperatures where thick insulating moss layers exist; high water tables limit soil aeration and thus root development	Low - LFH present	75 m^3/ha	mound	1200	Sb 1200 SPH	1000	large	plant/ natural seed	Black spruce	25% woody or herbaceous	combined 5 species
Wetland	Wb	Wetland bog	hygric to subhydric	very poor to poor	Soil temperature, drainage and nutrients	Same Low/High	10 to 50 m^3/ha	mound	1200	Sb 1200 SPH	1000	medium	plant/ natural seed	Black spruce	25% woody or herbaceous	Combined 3 species
Wetland	Wf	Wetland fen	subhydric	poor to medium	Soil temperature and drainage	Same Low/High	10 to 50 m^3/ha	mound	1200	Sb 1200 SPH or Lt 1200 SPH	1000	medium	plant/ natural seed	Black spruce or Tamarack	25% woody or herbaceous	Combined 3 species

[a] DeLong, C., A. Banner, W. H. MacKenzie, B. J. Rogers, and B. Kaytor. 2011. A field guide to ecosystem identification for the Boreal White and Black Spruce Zone of British Columbia. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Land Manag. Handb. No. 65. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh65.htm

Treatment Matrix for Linear Restoration - GRAHAM WET COOL BOREAL WHITE AND BLACK SPRUCE

Site Type	BWBSwk2 Site Series [a]	Site Series name[a]	Moisture Regime [a]	Nutrient Regime [a]	Limiting Factors [a]	Disturbance Level	CWD Level	Siteprep	Mound density/ha	Planting Density	Final Minimum Stem Density	Stocksize	Vegetation Treatment	Target Species	Vegetation Coverage	Number of Species
Moderately Dry	102	Pl – Lingonberry – Reindeer lichen	xeric to subxeric	very poor to medium	Productivity limited by growing season drought; removal of LFH will further limit productivity	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Moderately Dry	102	Pl – Lingonberry – Reindeer lichen	xeric to subxeric	very poor to medium		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry	103	SwPl – Soopolallie – Wildrye	submesic	poor to rich	Drought may limit productivity during dry growing seasons	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine or White spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry	103	SwPl – Soopolallie – Wildrye	submesic	poor to rich		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine or White spruce	25% woody or herbaceous	Combined 3 species
Slightly Dry to Very Moist	104	Sb – Huckleberry – Lingonberry	submesic to hygric	very poor to poor	Poorly structured soil (compacted or massive) and/or high water table limits soils aeration and thus root development	High - No LFH	150 m^3/ha	mound	500	none	2000	none	natural or applied seed	Black spruce or Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry to Very Moist	104	Sb – Huckleberry – Lingonberry	submesic to hygric	very poor to poor		Low - LFH present	75 to 100 m^3/ha	mound	1200	Sb 800 SPH Pl 400 SPH	1000	small	plant/ natural seed	Black spruce or Lodgepole pine	25% woody or herbaceous	Combined 5 species
Slightly Dry to Fresh	101	SwBl – Huckleberry – Feathermoss	submesic to mesic	poor to medium	Few limiting factors; fine textured soils may limit soil aeration and rooting depth	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce or Subalpine fir	25% woody or herbaceous	combined 5 species
Slightly Dry to Fresh	101	SwBl – Huckleberry – Feathermoss	submesic to mesic	poor to medium		Low - LFH present	75 m^3/ha	mound	1200	Sw 800 SPH Bl 400 SPH	1000	large	plant/ natural seed	White spruce or Subalpine fir	25% woody or herbaceous	combined 5 species
Fresh to Moist	110	Sw – Currant – Bluebells	mesic to subhygric	medium to rich	Few limiting factors	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Fresh to Moist	110	Sw – Currant – Bluebells	mesic to subhygric	medium to rich		Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	111	Sw – Currant – Horsetail	subhygric to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites. Rooting depth and aeration may be limited by high water tables, increasing windthrow hazard and limiting productivity	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	111	Sw – Currant – Horsetail	subhygric to hygric	medium to rich		Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Wetland	Wb	Wetland bog	hygric to subhydric	very poor to poor	Soil temperature, drainage and nutrients	Same Low/High	10 to 50 m^3/ha	mound	1200	Sb 1200 SPH	1000	medium	plant/ natural seed	Black spruce	25% woody or herbaceous	Combined 3 species
Wetland	Wf	Wetland fen	subhydric	poor to medium	Soil temperature and drainage	Same Low/High	10 to 50 m^3/ha	mound	1200	Sb 1200 SPH or Lt 1200 SPH	1000	medium	plant/ natural seed	Black spruce or Tamarack	25% woody or herbaceous	Combined 3 species

[a] DeLong, C., A. Banner, W. H. MacKenzie, B. J. Rogers, and B. Kaytor. 2011. A field guide to ecosystem identification for the Boreal White and Black Spruce Zone of British Columbia. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Land Manag. Handb. No. 65. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh65.htm

Treatment Matrix for Linear Restoration - KLEDO WET COOL BOREAL WHITE AND BLACK SPRUCE

Site Type	BWBSmw Site Series[(a)]	Site Series name [(a)]	Moisture Regime [(a)]	Nutrient Regime [(a)]	Limiting Factors [(a)]	Disturbance Level	CWD Level	Siteprep	Mound density/ha	Planting Density	Final Minimum Stem Density	Stocksize	Vegetation Treatment	Target Species	Vegetation Coverage	Number of Species
Moderately Dry	102	Pl – Crowberry – Lingonberry	xeric to subxeric	very poor to medium	Productivity limited by growing season drought; removal of LFH will further limit productivity	High - No LFH	75 to 100 m^3/ha	none	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Moderately Dry	102	Pl – Crowberry – Lingonberry	xeric to subxeric	very poor to medium		Low - LFH present	75 to 100 m^3/ha	light surface	none	none	2000	none	natural or applied seed	Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry to Moist	103	Sb – Huckleberry – Lingonberry	submesic to subhygric	very poor to poor	Poorly structured soil (compacted or massive) and/or high water table limits soils aeration and thus root development. Removal of thin LFH will further limit productivity	High - No LFH	150 m^3/ha	mound	500	none	2000	none	natural or applied seed	Black spruce or Lodgepole pine	25% woody or herbaceous	Combined 3 species
Slightly Dry to Moist	103	Sb – Huckleberry – Lingonberry	submesic to subhygric	very poor to poor	Poorly structured soil (compacted or massive) and/or high water table limits soils aeration and thus root development	Low - LFH present	75 to 100 m^3/ha	mound	1200	Sb 800 SPH Pl 400 SPH	1000	small	plant/ natural seed	Black spruce or Lodgepole pine	25% woody or herbaceous	Combined 5 species
Slightly Dry to Fresh	101	SwBl – Huckleberry – Feathermoss	submesic to mesic	medium to rich	Few limiting factors; fine textured soils may limit soil aeration and rooting depth	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce or Subalpine fir	25% woody or herbaceous	combined 5 species
Slightly Dry to Fresh	101	SwBl – Huckleberry – Feathermoss	submesic to mesic	medium to rich		Low - LFH present	75 m^3/ha	mound	1200	Sw 800 SPH Bl 400 SPH	1000	large	plant/ natural seed	White spruce or Subalpine fir	25% woody or herbaceous	combined 5 species
Moist to Very Moist	110	Sw – Currant – Horsetail	subhygric to hygric	medium to rich	Water table may rise with removal of trees, reducing suitable planting microsites. Rooting depth and aeration may be limited by high water tables, increasing windthrow hazard and limiting productivity	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	White spruce	25% woody or herbaceous	combined 5 species
Moist to Very Moist	110	Sw – Currant – Horsetail	subhygric to hygric	medium to rich		Low - LFH present	75 m^3/ha	mound	1200	Sw 1200 SPH	1000	large	plant/ natural seed	White spruce	25% woody or herbaceous	combined 5 species
Very Moist	111	Sb – Horsetail – Stepmoss	hygric	very poor to poor	Lack of soil nutrients; high water tables limit soil aeration and thus root development	High - No LFH	150 m^3/ha	mound	500	none	1000	none	natural or applied seed	Black spruce	25% woody or herbaceous	combined 5 species
Very Moist	111	Sb – Horsetail – Stepmoss	hygric	very poor to poor	Lack of soil nutrients; cold soil temperatures where thick insulating moss layers exist; high water tables limit soil aeration and thus root development	Low - LFH present	75 m^3/ha	mound	1200	Sb 1200 SPH	1000	large	plant/ natural seed	Black spruce	25% woody or herbaceous	combined 5 species
Wetland	Wb	Wetland bog	hygric to subhydric	very poor to poor	Soil temperature, drainage and nutrients	Same Low/High	10 to 50 m^3/ha	mound	1200	Sb 1200 SPH	1000	medium	plant/ natural seed	Black spruce	25% woody or herbaceous	Combined 3 species
Wetland	Wf	Wetland fen	subhydric	poor to medium	Soil temperature and drainage	Same Low/High	10 to 50 m^3/ha	mound	1200	Sb 1200 SPH or Lt 1200 SPH	1000	medium	plant/ natural seed	Black spruce or Tamarack	25% woody or herbaceous	Combined 3 species

(a) DeLong, C., A. Banner, W. H. MacKenzie, B. J. Rogers, and B. Kaytor. 2011. A field guide to ecosystem identification for the Boreal White and Black Spruce Zone of British Columbia. B.C. Min. For. Range, For. Sci. Prog., Victoria, B.C. Land Manag. Handb. No. 65. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh65.htm

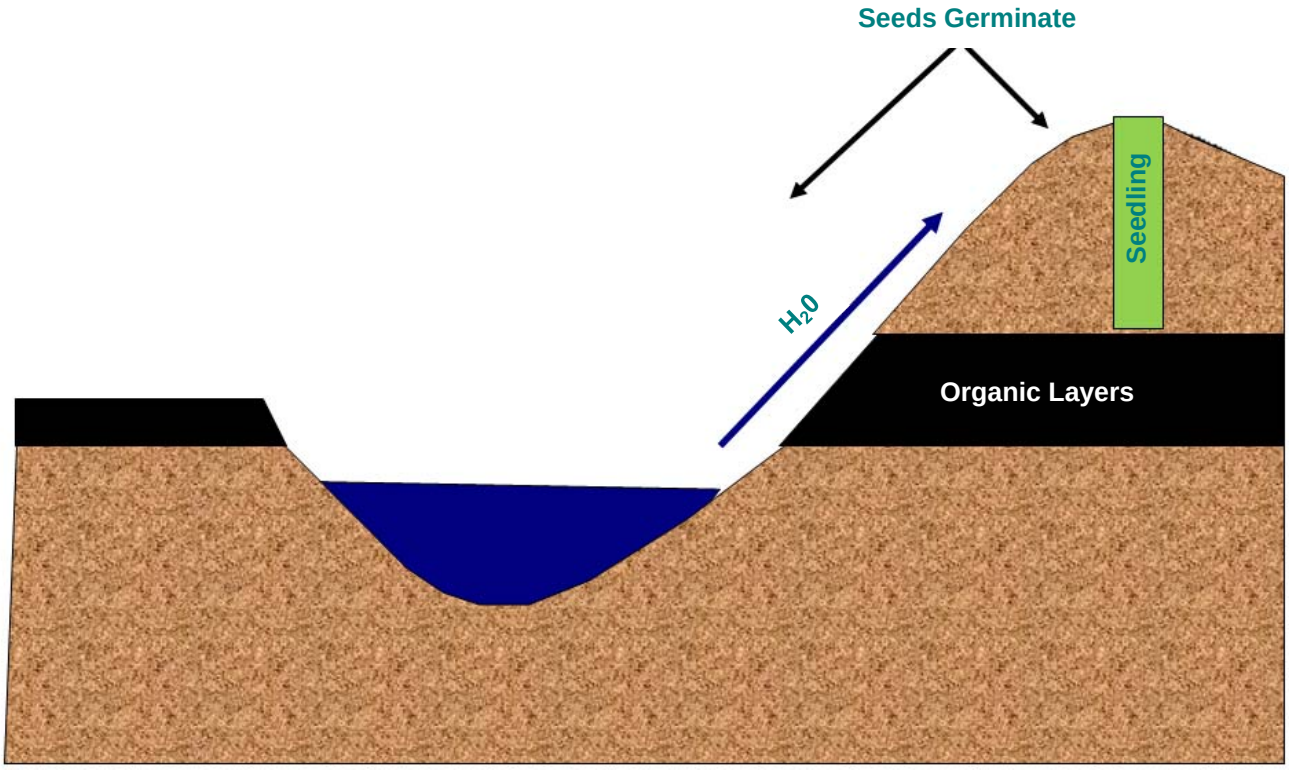
APPENDIX C

Appendix C Mounding Profile

January 2015
Report No. 1313720037

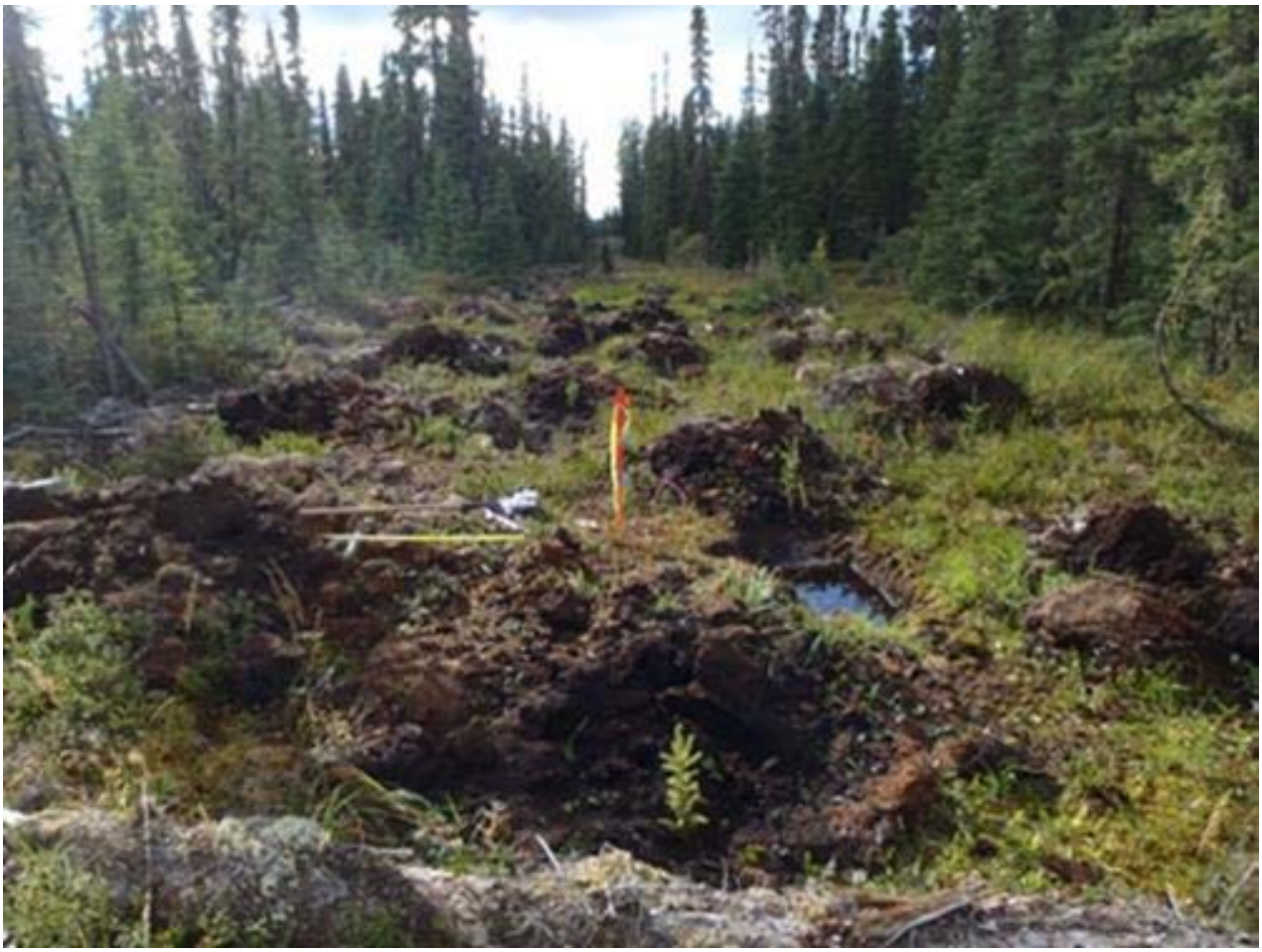
Golder Associates

Mounding Site Preparation Profile



Modified from T. Vinge 2013, Getting Online

Recreating Hump and Hollow Terrain



Mounding site preparation is used to recreate hump and hollow terrain features. Benefits are desirable wetland condition and high plant diversity.

APPENDIX D

Appendix D Sample Monitoring Plot Datasheets

January 2015
Report No. 1313720037

Tree No.	Species	Type	Vigour	Treat	Ht (cm)	Leader1 (cm)	Leader2 (cm)
1							
2							
3							
4							
5							
6							
7							
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39							
40							
41							
42							
43							

Macro Site Data Form	
Line	
Plot	
Measurement No.	
Measurement Type	
Recleared	
Clearing Date	dd/mm/yy
Treat1	
Treat2	
Day	
Month	
Year	
Crew Leader	
Crew 2	
Crew 3	
Crew 4	
Hiding Cov #/15 NE	
Hiding Cov #/15 SW	
Vehicle Disturb.	
Vehicle Type	
Game Trail	
Windrow Height (m)	
Windrow Width (m)	
Roll Back Cover %	
Roll Back Depth (m)	
Line Soil Comp 01	
Line Soil Comp 02	
Line Soil Comp 03	
Line Soil Comp 04	
Line Soil Comp 05	
Line Soil Comp 06	
Line Soil Comp 07	
Line Soil Comp 08	
Line Soil Comp 09	
Line Soil Comp 10	
Adj Soil Comp 01	
Adj Soil Comp 02	
Adj Soil Comp 03	
Adj Soil Comp 04	
Adj Soil Comp 05	
Adj Soil Comp 06	
Adj Soil Comp 07	
Adj Soil Comp 08	
Adj Soil Comp 09	
Adj Soil Comp 10	

Subplot	1	2	3	4	5	6	7	8	9
Water %									
CobbleStones %									
Decaying Wood %									
Exposed Soil %									
Organic Matter %									
Total = 100%	0	0	0	0	0	0	0	0	0
Tree Ht (cm)									
Tree Cover									
Tree 1									
Tree Cov 1									
Tree 2									
Tree Cov 2									
Tree 3									
Tree Cov 3									
Tall Shrub Ht (cm)									
Tall Shrub Cover									
Tall Shrub 1									
Tall Shrub Cov 1									
Tall Shrub 2									
Tall Shrub Cov 2									
Tall Shrub 3									
Tall Shrub Cov 3									
Med Shrub Ht (cm)									
Med Shrub Cover									
Med Shrub 1									
Med Shrub Cov 1									
Med Shrub 2									
Med Shrub Cov 2									
Med Shrub 3									
Med Shrub Cov 3									
Low Shrub Ht (cm)									
Low Shrub Cover									
Low Shrub 1									
Low Shrub Cov 1									
Low Shrub 2									
Low Shrub Cov 2									
Low Shrub 3									
Low Shrub Cov 3									
Herb Cover									
Herb 1									
Herb Cov 1									
Herb 2									
Herb Cov 2									
Herb 3									
Herb Cov 3									
Grass Cover									
Moss Cover									
November 28, 2014									
Project No. 1313720037									
Moss 2									
Moss Cov 2									

Moss 3									
Moss Cov 3									
Lichen Cover									
Lichen 1									
Lichen Cov 1									
Lichen 2									
Lichen Cov 2									
Lichen 3									
Lichen Cov 3									

Subplot	1	2	3	4	5	6	7	8	9
Water %									
CobbleStones %									
Decaying Wood %									
Exposed Soil %									
Organic Matter %									
Total = 100%	100	100	100	100	100	100	100	100	100
Tree Ht (cm)									
Tree Cover									
Tree 1									
Tree Cov 1									
Tree 2									
Tree Cov 2									
Tree 3									
Tree Cov 3									
Tall Shrub Ht (cm)									
Tall Shrub Cover									
Tall Shrub 1									
Tall Shrub Cov 1									
Tall Shrub 2									
Tall Shrub Cov 2									
Tall Shrub 3									
Tall Shrub Cov 3									
Med Shrub Ht (cm)									
Med Shrub Cover									
Med Shrub 1									
Med Shrub Cov 1									
Med Shrub 2									
Med Shrub Cov 2									
Med Shrub 3									
Med Shrub Cov 3									
Low Shrub Ht (cm)									
Low Shrub Cover									
Low Shrub 1									
Low Shrub Cov 1									
Low Shrub 2									
Low Shrub Cov 2									
Low Shrub 3									
Low Shrub Cov 3									
Herb Cover									
Herb 1									
Herb Cov 1									
Herb 2									
Herb Cov 2									
Herb 3									
Herb Cov 3									
Grass Cover									
Moss Cover									
Moss 1									
Moss Cov 1									
Moss 2									
Moss Cov 2									
Moss 3									
Moss Cov 3									
Lichen Cover									
Lichen 1									
Lichen Cov 1									
Lichen 2									
Lichen Cov 2									
Lichen 3									
Lichen Cov 3									

Seismic Line Regeneration Survey

General Plot Information

* Datum is NAD83

Project No:	08-1372-0019	**Plot/Waypoint ID**		**Date (dd/mmm/yy)**	/ AUG / 08		
Time (24-hr)		**UTM Zone**		**UTM E ***		**UTM N ***	
Ecoregion		**TM7**		**Gen. Veg Class**	☐ Pine ☐ Aspen ☐ Sb-upland ☐ Sb-wetland ☐ _____		
Surveyor		**Field QA/QC**		**Camera**		**Plot Type**	☐ Seismic Line ☐ Control

Seismic Line Information

S/L Age Class (years)	☐ <5 ☐ 20 ☐ 40
S/L Width (m)	
Robel 1 (cm)	
Robel 2 (cm)	
Line-of-Site Distance Class (m)	☐ <20 ☐ 20-50 ☐ 50-100 ☐ 100-200 ☐ 200-400 ☐ >400
Evidence of Seismic Line Use	☐ none ☐ ATV ☐ Truck ☐ Heavy Machinery ☐ Other_____
Trail Width (m)	

Photo No. / Direction

Ground Surface		
Robel 1		
Robel 2		
Oblique Aerial		

Site and Soils Information

Slope (%)	
Aspect (deg)	
Hummocks Height (cm)	
Subsisdence (cm)	
Surface Organic Thickness (cm)	
Surface/Effective Texture	/
Slope Position	C U M L D T V
Moisture Regime	vx x sx sm m sg hg sd hd
Drainage	
Moltles/Gley	
Soil Class	
Ecophase/Wetland	

Incidental Wildlife Observations

	Species	Sign
Sp. 1		
Sp. 2		

Compaction Within Macroplot (9)												
Compaction Adjacent Ecosite (10)												

Surface Substrate - % cover of non-living matter; adds to 100% within 1.78 m radius plot

Water		**Mineral Soil**		**Cobbles & Stones**		**Bedrock**		**Decaying Wood**		**Organic Matter**	

Regeneration Plot - 1.78 m radius

Tallest Regeneration (or tallest tree within seismic line plots)				Regeneration <1.5 m				Regeneration 1.5-4.9 m [a]			Trees ≥5.0 m [a] (seismic line plots only)		
Species	**Ht. (m)**	**Diameter at Base (cm)**	**Total Age**	**Plot Size**	**Tally**	**Total**	**Mean Ht. (m)**	**Tally**	**Total**	**Mean Ht. (m)**	**Tally**	**Total**	**Mean Ht. (m)**
				full 1/4									
				full 1/4									
				full 1/4									
				full 1/4									

Adjacent Tree Canopy Attributes

	Adjacent (NE)	Adjacent (SW)
Ecosite Phase		
Overstory/Understory AVI		

Vegetation Cover - within 1.78 m radius plot

Vegetation Strata Cover			Dominant Species by Strata		All Other Shrubs			Other Species		
Strata	**Daubenmire Cover Classes [c]**	**Mean Ht. (m)**	**Species Code**	**% Cover**	**Species Code**	**Strata**	**% Cover**	**Species Code**	**Strata**	**% Cover**
Tall Shrub (1.5-4.9 m) (T)	1 2 3 4 5 6 7									
Low Shrub (<1.5 m) (S)	1 2 3 4 5 6 7									
Herb (H)	1 2 3 4 5 6 7									
Grass (G)	1 2 3 4 5 6 7									
Moss (M)	1 2 3 4 5 6 7									
Lichen (L)	1 2 3 4 5 6 7									
Epiphytes (E)	1 2 3 4 5 6 7									

Comments

[a] Full plot size only; [b] Recorded from leading species in control plots only; [c] Daubenmire classes: **1** = <1%; **2** = 1-5%; **3** = 6-25%; **4** = 26-50%; **5** = 51-75%; **6** = 76-95%; **7** = 96-100%.

Seismic Line Regeneration Survey

General Plot Information

* Datum is NAD83

Project No:	08-1372-0019	**Plot/Waypoint ID**		**Date (dd/mmm/yy)**	/ AUG / 08		
Time (24-hr)		**UTM Zone**		**UTM E ***		**UTM N ***	
Ecoregion		**TM7**		**Gen. Veg Class**	☐ Pine ☐ Aspen ☐ Sb-upland ☐ Sb-wetland ☐ _____		
Surveyor		**Field QA/QC**		**Camera**		**Plot Type**	☐ Seismic Line ☐ Control

Seismic Line Information

S/L Age Class (years)	☐ <5 ☐ 20 ☐ 40
S/L Width (m)	
Robel 1 (cm)	
Robel 2 (cm)	
Line-of-Site Distance Class (m)	☐ <20 ☐ 20-50 ☐ 50-100 ☐ 100-200 ☐ 200-400 ☐ >400
Evidence of Seismic Line Use	☐ none ☐ ATV ☐ Truck ☐ Heavy Machinery ☐ Other_____
Trail Width (m)	
Compaction Within Macroplot (9)	
Compaction Adjacent Ecosite (10)	

Photo No. / Direction

Ground Surface		
Robel 1		
Robel 2		
Oblique Aerial		

Incidental Wildlife Observations

	Species	Sign
Sp. 1		
Sp. 2		

Site and Soils Information

Slope (%)	
Aspect (deg)	
Hummocks Height (cm)	
Subsisdence (cm)	
Surface Organic Thickness (cm)	
Surface/Effective Texture	/
Slope Position	C U M L D T V
Moisture Regime	vx x sx sm m sg hg sd hd
Drainage	
Moltles/Gley	
Soil Class	
Ecophase/Wetland	

Surface Substrate - % cover of non-living matter; adds to 100% within 1.78 m radius plot

Water		**Mineral Soil**		**Cobbles & Stones**		**Bedrock**		**Decaying Wood**		**Organic Matter**	

Regeneration Plot - 1.78 m radius

Tallest Regeneration (or tallest tree within seismic line plots)				Regeneration <1.5 m				Regeneration 1.5-4.9 m [a]			Trees ≥5.0 m [a] (seismic line plots only)		
Species	**Ht. (m)**	**Diameter at Base (cm)**	**Total Age**	**Plot Size**	**Tally**	**Total**	**Mean Ht. (m)**	**Tally**	**Total**	**Mean Ht. (m)**	**Tally**	**Total**	**Mean Ht. (m)**
				full 1/4									
				full 1/4									
				full 1/4									
				full 1/4									

Adjacent Tree Canopy Attributes

	Adjacent (NE)	Adjacent (SW)
Ecosite Phase		
Overstory/Understory AVI		

Vegetation Cover - within 1.78 m radius plot

Vegetation Strata Cover			Dominant Species by Strata		All Other Shrubs			Other Species		
Strata	**Daubenmire Cover Classes [c]**	**Mean Ht. (m)**	**Species Code**	**% Cover**	**Species Code**	**Strata**	**% Cover**	**Species Code**	**Strata**	**% Cover**
Tall Shrub (1.5-4.9 m) (T)	1 2 3 4 5 6 7									
Low Shrub (<1.5 m) (S)	1 2 3 4 5 6 7									
Herb (H)	1 2 3 4 5 6 7									
Grass (G)	1 2 3 4 5 6 7									
Moss (M)	1 2 3 4 5 6 7									
Lichen (L)	1 2 3 4 5 6 7									
Epiphytes (E)	1 2 3 4 5 6 7									

Comments

[a] Full plot size only; [b] Recorded from leading species in control plots only; [c] Daubenmire classes: **1** = <1%; **2** = 1-5%; **3** = 6-25%; **4** = 26-50%; **5** = 51-75%; **6** = 76-95%; **7** = 96-100%.

Photo Log
Seismic Line Regeneration Survey

Project No.: 051-334027 **Date:** **Datum:** NAD83 **UTM Zone:** 11V

Required for all photographs (record plot ID if applicable)							Required for random seismic line oblique aerial photographs			
Plot ID	**Camera**	**Photo No.**	**Direction**	**Photo Description**	**UTM E ***	**UTM N ***	**Grid ID**	**S/L Age Class**	**Gen. Veg Class**	**Ecosite/ Wetlands**

Photo Log
Seismic Line Regeneration Survey

Project No.: 051-334027 **Date:** **Datum:** NAD83 **UTM Zone:** 11V

Required for all photographs (record plot ID if applicable)							Required for random seismic line oblique aerial photographs			
Plot ID	**Camera**	**Photo No.**	**Direction**	**Photo Description**	**UTM E ***	**UTM N ***	**Grid ID**	**S/L Age Class**	**Gen. Veg Class**	**Ecosite/ Wetlands**

* If the location description is vague or lacking, record UTM coordinates.

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