Ministry of Forest Lands and Natural Resource Operations

ECOSYSTEM RESTORATION PROGRAM
- Intensive Monitoring Protocols -

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Acknowledgements & Foreword

This document could not have been completed without the combined efforts of many people. From 2009 to 2013 the Science Committee of the Rocky Mountain Trench Ecosystem Restoration program gave the basic form to the protocols. These individuals are:

Deb Mackillop, Research Ecologist, Science Branch, Ministry of Forests, Lands and Natural Resource Operations (MFLNRO)
Ken Walburger, Range Officer, Rocky Mtn. District, MFLNRO
Al Neal, Provincial ER Team Leader, Range Branch, MFLNRO
Randy Harris, District ER Team Leader, Rocky Mtn. District, MFLNRO
Kari Stuart-Smith, Forest Scientist Canfor, Kootenay Operations

From this group the product was circulated, in 2013 and 2014, for input from many other people who have expertise in range management and Ecosystem Restoration monitoring. From MFLNRO we received feedback from Shawna Larade, Leanne Colombo, Larry Ingham, John Krebs, Irene Manley (Wildlife Tree patches) and Tara Szkorupa. Further insight was gained from Hillary Page at the Nature Conservancy of Canada and Tim Ross at Ross Range and Reclamation Services.

Note that the majority of the Introduction chapter has been lifted from a previous draft document circulated internally within MFLNRO as Atherton and Hurlbutt (2007) – **NDT4 Ecosystem Restoration Monitoring Implementation Plan.** Although edited by B.J. Randall Harris, the work of Don Hurlbutt and Carol Atherton must be acknowledged here.

Note also that these protocols refer to a new database, ERPRO, which will be field tested in 2015. This Access database provides a singular storage point for the data collected under these protocols. It contains data similar to VPRO, but is designed to: (a) capture re-measurement data from monitoring plots; and (b) link this information to landscape level planning. The database was built by FORSITE consultants of Salmon Arm (Randy Spyksma and Gary Corrie as lead developers) under a contract with the Rocky Mountain Trench Natural Resource Society, with Dan Murphy as the contract administrator.

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1.0 Introduction

The Ecosystem Restoration (ER) program of the Ministry of Forests Lands and Natural Resource Operations (MFLNRO) is a relatively new program, operating provincially since 2006. It combines several areas of expertise such as range, wildlife and fuel management into one process. As such, it is necessary to standardise the measuring of outcomes so as to ascertain the ability of the program to meet desired objectives. Much of the piloting work for these intensive monitoring protocols were carried out in the Rocky Mountain District where a formal ER program has been in place since 1998. However, these protocols are designed for use throughout the Dry Forest Ecosystems of British Columbia, and across land ownerships of crown, BC parks, conservation lands, and privately held conservation properties. The protocols described here are adapted from the first "Effectiveness Monitoring" protocol paper, which was produced for the Terrestrial ER Program in the BC Ministry of Environment (Machmer and Steeger 2002). This original protocol has been fleshed out by existing protocols already existing in MFLNRO that measure range, grass, tree and other ecosystem attributes.

Note that the data described in this protocol can be compiled either in the field, on the Forest Service paper forms, or directly into the ERPRO database. ERPRO is an Access database developed by the provincial ER program to store all analysis and monitoring data that is collected under this protocol. ERPRO is similar to VPRO, but is designed to measure fuel and forage production, and incorporates the re-measurement of plot data. This allows end-users to track the health and productivity of a range unit or pasture over time.

1.1 Effectiveness Monitoring Objectives

The goals of the Ministry of Forests, Lands and Natural Resource Operations *Ecosystem Restoration Effectiveness Monitoring (EM)* program are as follows:

1. To create an EM framework that is consistent with the goals of the ER program, which can be applied throughout the province by all proponents of the ER program.
2. To monitor the effects of ER treatments on the flora and fauna in treatment areas.
3. To (a) provide ER program managers and practitioners with empirical data to evaluate the effectiveness and efficiency of ER treatments; and (b) to determine if restoration program goals and objectives are being met.
4. To use this data to adapt practices and procedures to better meet the program goals.
5. To (a) assess fuel loading and burn behaviour to determine if the ER program is decreasing fire hazards through its treatments; and (b) to allow calibration of predictive fire models so fire risk can be easily assessed on a landscape level.

To clarify this further, Machmer *et al*. (2002) divided the above mentioned goals into 13 specific monitoring objectives, prioritizing them as either high, medium or low (Table 1.1). Faced with a limited budget, the NDT4 Steering Committee for the Rocky Mountain Trench ER program pared the 13 monitoring objectives into to four high priority objectives. As documented in Blue Print for Action (2006), these high priority objectives would be examined prior to implementing other objectives:

1. Monitor stand structure and over story vegetation by crown closure, tree density, diameter, species and decay class.
2. Monitor under story structure and composition: grass, herb and shrub percent cover by species, so as to ascertain species richness and composition.
3. Monitor forage production: kilograms per hectare by species of plants and if site was grazed or ungrazed.
4. Monitor status of invasive plant species: percent cover by species, number of species.

Some discretion is left to ER practitioners and proponents as to which is more beneficial: (a) implement a higher level of monitoring in a given treatment area; or (b) carry out monitoring for the other objectives. However, it is critical that all practitioners and proponents use consistent data collection and storage approaches so that all data can be analysed and compared in a robust, scientifically credible manner.

Table 1.1 The 13 specific monitoring objectives as outlined by Machmer *et al.* (2002).

Monitoring Objective	Priority
1. Monitor tree density, size, and species composition.	High
2. Monitor cover and species composition of native grass, herb, and shrub species.	High
3. Monitor number and cover of non-native and noxious weed species.	High
4. Monitor existing density and cover of rare plants.	Low
5. Monitor the species richness and population density of endemic wildlife.	High
6. Monitor number and population density of vertebrate species of special interest.	High
7. Monitor forage production.	High
8. Monitor wildlife tree densities and sizes.	High
9. Monitor large-sized coarse woody debris.	Medium
10. Monitor the integrity of riparian and wetland areas.	Medium
11. Monitor soil fertility.	Low
12. Monitor soil erosion and compaction.	Low
13. Monitor insect and disease incidence.	Medium

1.2 Layers of Monitoring

EM is comprised of three layers, as called for in Machmer *et al.* (2002) and extended by Page and Machmer (2006). The Rocky Mountain Trench Ecosystem Restoration program accepts these two reports as the keystone documents for EM; this consensus was recognized by the provincial ER program in 2012. The reports set out specific objectives and outline methods for an EM program. However, they do not define Routine Monitoring protocols beyond photo plots. A summary from page 14 of Machmer *et al.* (2002) notes:

> *Based on our review, it appears that considerable monitoring of restoration treatments has already been undertaken, but results of these efforts have not consistently been documented, summarized, and communicated to promote adaptive management. Future monitoring efforts might benefit from a more strategic and consistent approach, particularly in light of reduced provincial funding projections in future years. Such an approach might involve three tiers:*

I. *Intensive monitoring at a subset of operational restoration sites to quantify treatment effects on key resources;*
II. *Routine monitoring at the majority of operational restoration sites to provide qualitative ecosystem recovery data that can support intensive findings; and*
III. *Parallel research studies involving replicated treatments and controls to investigate causal mechanisms underlying monitoring results*.

A distinction must be made between "Implementation" and "Effectiveness" Monitoring. *Implementation Monitoring (IM)* simply assesses whether the treatments carried out in a given unit comply with the ER prescription, including terms that were laid out in agreed upon contracts. There is no long-term storage of this data. IM asks the question: "were the goals of the ER plan fully achieved?" *Effectiveness Monitoring*, on the other hand, assesses the degree to which ER practices are achieving specific objectives of the ER program. Here, the question is asked: "what was the biological response to a given treatment, and was that response in-line with meeting set ER objectives?" Routine monitoring, a component of EM that is outlined in a separate protocol, is designed to be a general review of sites on an on-going basis; it gathers information that is similar to intensive monitoring, but with less detail and cost. The results of intensive monitoring can be extrapolated to larger parts of the landscape if routine monitoring data show similar measures of species cover, production or crown closure. Intensive and routine monitoring are not the same thing, but the program aims to upgrade implementation and routine monitoring protocols so they can be integrated with intensive monitoring and research programs.

Research projects are regarded as one-off questions, and are best addressed through the provincial ER program and Science Branch staff.

1.3 Monitoring Effort and Design

Since no two treatment units are identical, the level of monitoring to be applied must be decided for each Logical Burn Unit (LBU) on an individual basis. It is expected that a level of routine monitoring will be made on every treatment unit, and that it will be tied in with contract or Rangeland FREP monitoring. The decision to apply intensive monitoring will be made at the program level by the District Ecosystem Restoration Program Operations Committee.

The ability to monitor effectiveness of ER work is contingent upon funding, resources, and time allocation. Available funding for the ER program will vary from year to year, therefore the monitoring program must be able to expand or contract based on funding for each fiscal year. As a general guideline, it is recommended that 6-10% of a program's budget be allocated for monitoring (Machmer *et al.* 2002). It is hoped that all ER partners will pay funding into one multi-year contract or program to address all the factors listed above.

The standard design for the ER program is to have 15 plots created per installation. The plots should be distributed along a 100 to 200 metre grid, across a fairly homogenous portion of the LBU being treated. Additionally, each installation should have three control plots established in a biologically equivalent area (i.e., same aspect, elevation, Biogeoclimatic zone and slope), in an adjacent, untreated unit. Control plots provide data that help to remove the impacts of weather from treatment results. For each District it is suggested that two intensive monitoring installations be established per Biogeoclimatic zone. One intensive monitoring installation should document units that have had heavy tree removal treatments (e.g. logging, thinning mastication). The other installation should

document units where tree removal has been light (e.g. slash and pile burn, slash and scatter, prescribe burn as is).

Intensive monitoring plots should be measured at least one year before treatment, and then at years one, three, five and ten following the treatment (after Machmer *et al.* 2002, Blueprint for Action 2006). Note that plots may have to be re-measured up to 15 years after the treatment to show significant changes to the plant community (after Blueprint for Action 2013). Ensure that site description and soil data (i.e., FS882 pp. 1-2) are gathered at the time of plot establishment; all subsequent re-measurements should only count tree, understory and forage production.

2.0 Protocols for Intensive Monitoring

The current configuration of intensive monitoring protocols consists of nine data categories (Table 2.1). These categories were designed to address most of the monitoring objectives as outlined by Machmer et al. (2002; Table 1.1) in the most efficient yet scientifically robust manner possible. The detailed protocols for these monitoring categories are outlined in the sub-sections below. High quality monitoring data depends heavily upon consistency and continuity in data collection and data entry techniques. As such, a concerted effort must be made to: (a) minimize the number of persons collecting/entering data (Machmer et al. 2002); or (b) ensure that only a few individuals are responsible for training staff and/or contractors in proper data collection/entry techniques.

Table 2.1 Intensive monitoring categories, the purpose of these categories, and the specific monitoring objectives achieved. Refer to Table 1.1 for a description of the monitoring objectives.

Intensive Monitoring Category	Purpose	Monitoring Objectives Achieved
Plot Site Characteristics	Document plot establishment/re-measurement dates, describe topographic characteristics, and accurately relocate the monitoring plot.	NA
Stand Structure	Document structural attributes of surrounding forest, and record presence of wildlife trees.	1, 8, 13
Overstory Cover	Document canopy cover (i.e., crown closure) of surrounding forest.	1, 8, 13
Understory Cover	Document ground cover (i.e., herbs & grasses), ungulate use and presence of rare and non-native plants.	2, 3, 4, 9, 12
Shrub Cover	Document presence and cover of shrub species.	2
Forage Production	Document productivity of forage plants by functional group.	7
Badger Use	Document presence of/use by badgers.	5, 6
Soils	Determine type of soil present. This will help inform (a) site productivity, (b) site history (e.g., historically a grassland or forest), (c) susceptibility of soil to erosion, and (d) the type ER procedure used (e.g., what type of mechanical equipment will be used for thinning).	11, 12
Coarse Woody Debris	Document presence/formation/loss of course woody debris.	9

2.1 Plot Site Characteristics

➔ Use "Site" tab in ERPRO or FS882(1) or FS 1138(1)

Intensive Monitoring Protocols:

1. At each treatment (and control) site, randomly locate and permanently mark a plot center, 1 plot for every 3 ha.
    a. There must be a minimum of 5 plots per installation, up to a maximum of 15.
    b. Plots should be randomly chosen after Treatment Units have been determined, and after an analysis of forest type has led to stratification by tree density into sub-units (high, moderate, or low tree cover).
    c. The Treatment Unit is to be tied to an Ecosystem Restoration Prescription, with a consistent treatment applied over the full area that is sampled by the plots in the installation.

2. At each plot center, record:
    a. The date (Day, Month, Year)
    b. Name(s) of examiner(s) (Last, First; Last, First; etc.)
    c. If this is a Control site (Yes/No) (Not in FS882)
    d. The following site characteristics:
        i. UTM Zone/Easting (m)/Northing (m) using GPS
        ii. Elevation (m), Slope (%), Aspect (°)
        iii. Meso-Slope Position, Surface Shape
        iv. BEC Zone/Subzone/Variant/Site Series

3. Randomly select 5 plots from each installation. At the center of these plots, take one photo in each of the cardinal directions (N, S, E, W) to photo-document changes to stand structure and understory cover, as per Appendix I.
    a. Include a white piece of paper (field notebook size) with the cardinal direction and plot number in each photo (at the bottom right-hand side of the photo) and database the photos with this information (Plot# - Direction; e.g., the file for Plot#2 facing north at Fusee would be saved as: "Fusee 2-N.jpg").

4. Record the following measures in the "Plot Representing" field:
    a. Forest/Range Type (i.e., Closed Forest, Open Forest, Open Range, etc.),
    b. whether this a control site (Yes/No), and
    c. the Treatment Unit and Treatment Type.

5. Record any additional comments relevant to the site or plot characteristics/descriptions in the "Notes" field.

2.2 Stand Structure – including Wildlife Trees

➔ Use "Overstory Canopy Cover" and "Understory Tree Cover" tabs in ERPRO or FS882(4) or FS 1138 (3) FS205 for layer 1/ 2 trees, FS 658 for layer 3/4

Intensive Monitoring Protocols:

1. At each of the plot centres, establish nested fixed-radius plots (Figure 1) to sample each layer as follows:
    a. 5.64 m radius (record trees in these size classes as subplot 1)
        i. 4R/Regeneration (<1.3 m height)
        ii. 3S/Sapling (≥1.3 m height and <7.5 cm dbh)
    b. 11.28 m radius (record trees in this size class as subplot 2)
        i. 1M/Mature (7.5 – 30 cm dbh)
    c. 25.23 m radius (record trees in this size class as subplot 3)
        i. 1D/Dominant (>30 cm dbh)
2. Record species, diameter at breast height (cm),
3. Record wildlife tree class (WTC) (see "wood-condition", defined in section 6 – Tree Attributes for Wildlife, p.10 of LMH 25) for each tree in layers 1D/1M.
    a. Conifers (8 classes)
        i. Live
            1. Classes 1, 2
        ii. Dead (Hard → Spongy → Soft)
            1. Classes 3, 4, 5, 6, 7, 8
    b. Native broad-leaved deciduous (5 classes)
        i. Live
            1. Classes 1, 2
        ii. Dead (Hard → Spongy → Soft)
            1. Classes 3, 4, 7
4. Record wildlife use under the blank (other) field on the FS882 (4) form. Use codes from LMH25, section 6 – Wildlife Use (p 11) and User (p 13) codes (e.g., cavity nesting bird = CB).
5. Record any additional comments relevant to stand structure for each plot.

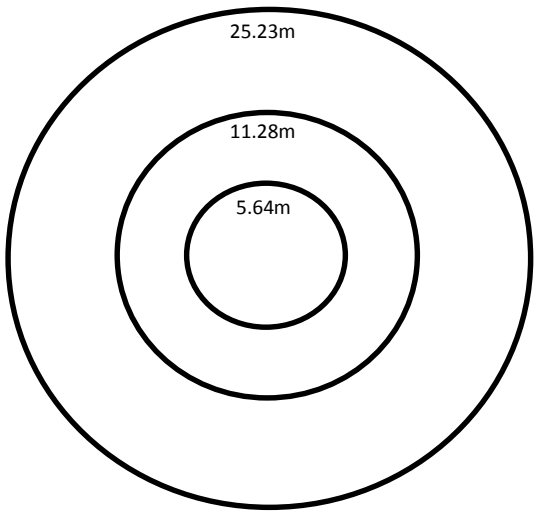

Figure 2.1 Nested plot configuration for Stand Structure measurements.

2.3 Overstory (Canopy) Cover – aka Crown Closure

➔ Use "Overstory Canopy Cover" tab in ERPRO or LMH 25 FS205 or FS882 page 3or FS1138(4)

Intensive Monitoring Protocols:

1. Perform an ocular estimate of canopy cover to represent crown closure for each 25.23 m radius plot:
    a. A layer (trees > 10m height)
    b. B layer (trees and shrubs < 10m height)
2. Record heights and ages of two co-dominant 1M trees in each plot.
3. Record any additional comments relevant to crown closure for each plot.
4. Record height to live crown in metres. Height to live crown is the height to the general bottom of the canopy, **not** height to first live limb.

2.4 Understory Cover

➔ Use "Understory Cover (Daubenmire)" tab in ERPRO or FS505G – species coding shall follow LMH 25

Intensive Monitoring Protocols:

1. At each of the plot centers:
    a. Mark plot centre with a 15cm spike and a pigtail wire
        i. Record UTM coordinate.
        ii. Nail a plastic tree tag to the closest >15cm DBH tree to plot centre.
            1. Face tag toward plot centre.
            2. Spray paint tree marked, with blue or orange marking paint at breast and stump height
    b. Establish four random 25 m transects (A, B, C, D) radiating out from plot center, forming spokes that are separated by 90° (bearing A randomly selected; Figure 2).
        i. Record the bearing of each transect from plot center.
        ii. Mark each transect end with metal stakes that are flush with the ground.
    c. Permanently mark (w/15cm spikes) five Daubenmire frame locations on the right side of each transect at 5, 10, 15, 20 and 25 m from plot center (n = 20 frames total).
    d. In each Daubenmire frame, estimate:
        i. % herb and grass cover, by species, including non-native vegetation and rare or endangered species
            1. Ignore trees and shrubs. Use LMH 25 – Table 3.1 to determine if it should be counted as a shrub or herb.
        ii. Average height of vegetation
        iii. Presence of cattle, deer, elk and sheep feces (Yes/No)
        iv. Use Table 3.1, "List of low woody species", in the Vegetation section of LMH 25 to determine if a species should be counted as a shrub or herb.
    e. Rare or endangered plants:
        i. If a rare or endangered plant covers < 5%, count individual plants to provide a density measure.
    f. Non-native vegetation:
        i. If a non-native species covers < 5%, count individual plants to provide a density measure.
2. Record any additional comments relevant to understory cover for each plot, including weeds and rare/endangered plants outside of the Daubenmire frames.

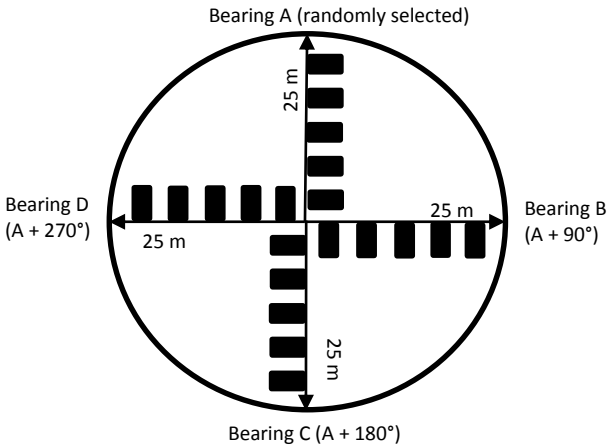

Figure 2.2 The 25 m transect spokes for Understory Cover measurements, each measured from the center of the randomly placed study plots. Quadrats are located at the 5, 10, 15, 20 and 25m marks of each transect (5 quadrats per transect, 20 quadrats per plot).

2.5 Shrub Cover

➔ Use "Shrub Cover "tab in ERPRO or FS505G – species coding shall follow LMH 25

Intensive Monitoring Protocols

1. 1 For each of the transect segments (A, B, C, D) used to estimate understory cover (Figure 4):
    a. Use the line-intercept method (Bonham 1983) to estimate % shrub cover along each one metre segment to 25m.
    a. Record all shrubs, by species, that intersect transect lines to the nearest centimeter.
    b. Use Table 3.1, "List of low woody species", in the Vegetation section of LMH25 to determine if a species should be counted as a herb or shrub.
3. Record any additional comments relevant to shrub cover for each plot/transect.

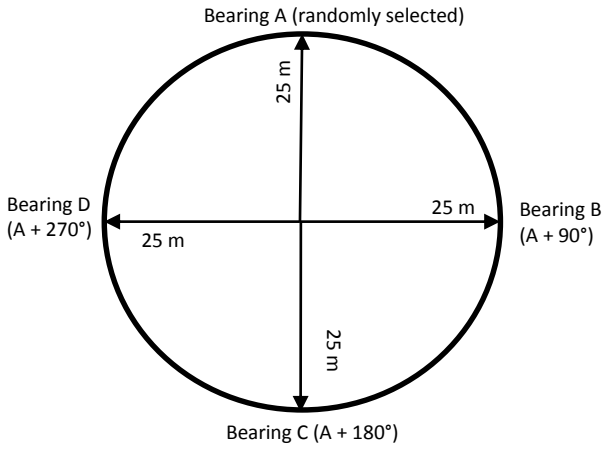

Figure 2.3 The 25 m length transect spokes for Shrub Cover measurements, each measured from the center of the randomly placed study plots.

2.6 Forage Production

➔ Use "Forage Production" tab in ERPRO or blank plot card

Intensive Monitoring Protocols:

1. Randomly place four 1 m x 0.5 m quadrats in each of the 25.23 m radius plots (4 quadrats per plot).
    a. Record bearing and distance of randomly placed quadrats.
    b. Note: New randomly located production quadrats must be placed each subsequent year, at the end of the previous year to capture full growth in the next year.
        i. Ensure production quadrats do not overlap Daubenmire frame locations.
    c. Clip herbaceous vegetation and current annual growth of shrubs to ground level in mid-July, after peak growth is reached.
        i. Note: Kinnikinick (*Arctostaphylos uva-ursi*) should not be clipped, as it is not of direct interest for ecosystem restoration.

2. Bag samples, separated by functional group: Bunchgrasses (rough fescue, bluebunch wheatgrass, Idaho fescue, stipa spp.), Pinegrass, Other Grasses, Forbs, Rushes/Reeds, Shrubs and Invasive plants (for species see Field Guide to Noxious and Other Selected Weeds of British Columbia *Fourth Edition, 2002)*. Shrub production will be determined on a site specific basis with a separate methodology.
        i. Store in a paper bag, air-dried for 48 hours, then oven-dried at 70°C to constant mass.
        ii. Weigh samples:
            1. Record Total Weight, with bag, to nearest 1 mg.
            2. *Record Bag Weight to nearest 1mg.*
        iii. ERPRO will calculate the weight of each functional group in kg/ha.
            1. Raw data will be entered into ERPRO, and averages will be calculated/stored within the database (1 row of data = 1 plot).
    (a) ERPRO calculations work as follows: For each plot, ERPRO will determine the weight of each functional group in kg/ha.
        1. For each quadrat, calculate Vegetation Weight (g/0.5m^2), by functional group, by subtracting the Bag Weight from the Total Weight.
        2. Calculate the Mean Functional Group Weight (g/0.5m^2) by averaging the Vegetation Weight for each functional group.
        3. Multiply the Average Vegetation (g/0.5m^2) by 20 to determine weight in kg/ha for each functional group.
3. Establish four 1m x 2m production cages adjacent to each of the production quadrats:
    a. At the same time as the production quadrats, clip a 1 m x 0.5 m area within these cages to ground level.
    b. Place new cages in new locations prior to the growing season, in which clipping will occur and will be interspersed among the plots.
    c. Follow above methods for bagging/weighing samples.
4. Record any additional comments relevant to forage production for each plot/transect.

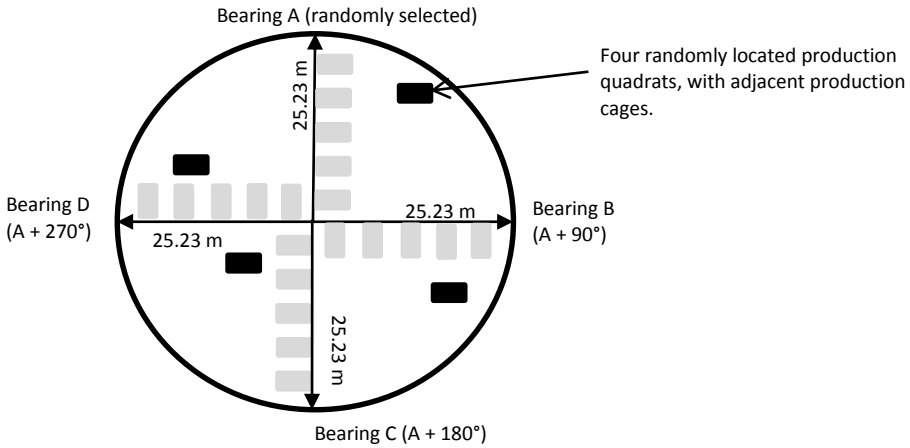

Figure 2.4 The 25 m transect spokes with Daubenmire frames (grey) and randomly located production quadrats and exclosure cages (black). One production quadrat and exclosure cage should be placed per quadrant, as divided by the four transect spokes.

2.7 Badger Use

➔ Use "Badger Use" tab in ERPRO or blank plot card

Intensive Monitoring Protocols:

1. Count all badger dens along a transect drawn between two fixed points on the ground.
    a. Record presence of fresh holes (i.e., used within the past year) (Yes/No)
    b. Count the number of badger feeding holes
        i. NOTE: Badger feeding holes are defined as squirrel holes that have been enlarged by a badger, where the hole is wide at the opening, and dead-ends or narrows within ~30cm of the surface.
    c. Make special note of natal dens, assumed to be dens >2 metres deep.
    d. Noted number and distance from Point of Commencement of all badger and ground squirrel burrows within 5 metres of the transect line.

2.8 Soils

➔ Use "Soils" tab in ERPRO or FS 118(2) or FS882(2) Soil Card - LMH 25, section 2

Per Randy Harris/Deb MacKillop:

1. One soil pit placed per plot, one plot per landform, soil type or stand density.
    a. When establishing the plot, dig 1 soil pit in a location that is representative of the majority of the 25.23 m plot.
    b. Ensure that the soil pit is located away from all other site measurement areas (i.e., transect lines, Daubenmires, pre-selected production quadrats, etc.)
        i. Record bearing and distance of soil pit from plot centre.
    c. Soil pits should be dug to 60cm in depth, unless root-restricting layers are encountered.
    d. Use FS882 soil cards to record soil characteristics/attributes, ensuring that the following fields are completed:

General

i. Plot number
ii. Terrain fields (Texture, Surficial Material, Surface Expression and Geomorph Processes – if applicable)
iii. Soil classification
iv. Humus Form
v. Rooting Depth
vi. Root Zone particle size
vii. Root restricting layers
viii. Seepage (if present)
ix. Drainage

Organic

x. L, F, H layers and depth

Mineral Horizons / Layers

xi. Horizon / Layers
xii. Depth
xiii. Texture
xiv. % Coarse Fragments

2.9 Coarse Woody Debris

➔ Use "Coarse Woody Debris" tab in ERPRO or FS882 (7) - LMH 25, section 7

Per Deb MacKillop:

1. Establish two 25 m CWD transects, using segments B & D (as established for Understory Cover) of each 25.23 m radius plot.
2. Following the procedures in Section 7 of LMH 25 (CWD), on each of transect B & D, measure:
    a. The diameter of all CWD (≥ 7.5 cm) at the point of intersection with each transect.
    b. The length of all CWD (≥7.5 cm) that crosses each transect.
    c. The species (where possible) of all CWD (≥ 7.5 cm) that crosses each transect.
3. MS Access will be used to auto-calculate CWD volume and piece density (by size class).

3.0 Literature Cited

Atherton, C. and D. Hurlburt. 2007. NDT4 Ecosystem Restoration Monitoring Implementation Plan. Ministry of Forests and Range, Rocky Mountain Forest District, unpublished.

B.C. Ministry of Forests and Range, and B.C. Ministry of Environment. 2010. Land Management Handbook 25 – Field Manual for Describing Terrestrial Ecosystems 2nd Edition.; Ministry Forests Lands and Natural Resource Operations. Available at: www.for.gov.bc.ca/hfd/pubs/docs/lmh/Lmh25-2.htm

Blueprint for Action. 2006. Rocky Mountain Trench Ecosystem Restoration Program: Blueprint for Action 2006. Available at http://trench-er.com/library/search

Blueprint for Action. 2013. Rocky Mountain Trench Ecosystem Restoration Program: Blueprint for Action 2013. Available at http://trench-er.com

Curran, M., I. Davis and B. Mitchell. 2000. Land Management Handbook 7 Silviculture Prescription Data Collection Field Handbook: Interpretive Guide for Data Collection, Site Stratification, and Sensitivity Evaluation for Silviculture Prescriptions, BC Forest Service Research Branch, Victoria, B.C.

Machmer, M. 2000. The ecological role of fire for cavity nesting birds. Final Technical Report to the Forest Renewal British Columbia and the BC Science Council, Burnaby, BC. 55pp. Aavailable at http://trench-er.com/library/search

Machmer, M. 2002. Effects of Ecosystem Restoration Treatments on Cavity-Nesting Birds, Their Habitat and Their Insectivorous Prey in Fire-Maintained Forests of Southeastern British Columbia. Proceedings of the "Ecology and Management of Dead Wood in Western Forests Symposium, Nov. 2-4, 1999, Reno, Nevada. USDA Forest Service Gen. Tech. Rep. PSW-GTR-181. pp. 121-133. Available at http://trench-er.com/library/search

Machmer, M. and C. Steeger. 2002. EFFECTIVENESS MONITORING GUIDELINES FOR ECOSYSTEM RESTORATION: Final Report, Submitted to: Habitat Branch, Ministry of Water, Land and Air Protection PO Box 9354, Stn. Prov. Govt., 3rd Floor South 2975 Jutland Road, Victoria, B.C. V8W 9M1. Available at http://trench-er.com/library/search

Machmer, M., H. Page and C. Steeger. 2002. An Effectiveness Monitoring Plan for NDT4 Restoration in the East Kootenay Trench. Submitted to Habitat Branch, Ministry of Water, Land and Air Protection. Forest Renewal British Columbia Terrestrial Ecosystem Restoration Program..Victoria, B.C. 52pp. Available at http://trench-er.com/library/search

Ministry of Agriculture. 2002. Field Guide to Noxious and Other Selected Weeds of British Columbia Fourth Edition. Available at http://www.agf.gov.bc.ca/cropprot/weedguid/weedguid.htm#noxious

Ministry of Forests. 2002. BC Field Guide to Noxious and Other Selected Weeds of British Columbia Fourth Edition. Available at http://www.for.gov.bc.ca/hra/Plants/publications.htm#IAPPtraining.

Page, H. 2014. Rocky Mountain Trench Ecosystem Restoration Monitoring Compilation. Available at http://trench-er.com/library/search

Page, H. and M. Machmer. 2006. An update to the Trench Effectiveness Plan for NDT4 Ecosystem Restoration in the East Kootenay Trench. Submitted to BC Ministry of Environment, 86pp. Available at http://trench-er.com/library/search

Ross, T.J. 1997. Vegetation Monitoring Program Final Report to the East Kootenay Trench Agriculture Wildlife Committee. EKTAWC, Cranbrook, B.C. 364pp. Available at http://trench-er.com/library/search

Ross, T.J. and B. Wikeem. 1993. Vegetation Monitoring Program Preliminary Report to the East Kootenay Trench Agriculture Wildlife Committee. EKTAWC, Cranbrook, B.C. 364pp. Available at http://trench-er.com/library/search

Appendix I – References for Intensive Monitoring

Reference Ia: District Standard Operating Procedure 8- Survey Standards for NDT4 stands

INTENT:
To supplement existing Silviculture Survey Guidebook standards and procedures when complying with Section 86 of the Forest Planning and Practices Regulation or Sections 45-47 of the Timber Harvesting and Silviculture Practices Regulation – reporting requirements.

This replaces SOP #8 dated April 28, 2006, and is an interim district policy subject to revision if clarification is received from a Branch or Regional level and will be reviewed within 3 years.

PURPOSE:
To provide survey standards for post treatment assessments in the NDT4 Open Range/Open Forest management units to:

1. Evaluate post treatment stand structure and species composition;
2. Determine if prescribed cutting and residual stand structure objectives have been met;
3. Produce an updated map label and forest cover description;
4. Flag layers or stands that may require secondary treatment under a Ministry SMP;
5. Provide recommendations for secondary treatment based on the management objectives set out in a silviculture prescription; and
6. Assess the incidence of damage to trees from forest health factors.

SCOPE:
This policy applies to all NDT4 restoration post treatment and stocking or free growing assessments.

REQUIREMENTS:
Prescription holders are required to provide an update of the forest cover inventory prior to milestone deadlines as per regulation. Surveys must be completed to prescription or FSP standards.

Timing
'Open range' units may be declared 'free growing' immediately following successful completion of a harvest or stand management treatment. On units where the estimated post treatment residual density of layers 1&2 is less than 100 sph, a formal survey is not necessary. The inventory update (for example FS708C or its equivalent) can be based on information gathered during a walk-through inspection to check that all prescribed objectives have been met.

'Open range' stands where the residual density of layer 1&2 stems exceeds 100 sph can be declared 'free growing' immediately following a formal post treatment survey as for 'open forest' stands.

A post treatment assessment survey is required on all 'open forest' stands. The early free growing date will normally be two years. This period is to allow time to determine if the stand has been negatively impacted by such factors as snow or blow-down, sunscald, forest health factors or other causes. This date can be moved forward when a supplemental treatment under the ecosystem restoration program is scheduled sooner.

The final or free growing assessment can consist of a walk through where a formal post treatment assessment has been completed earlier. If the stand appears unchanged from the original assessment, the data may be used to describe the stand and assign new forest cover labels. If the stocking appears to have changed or the stand has been treated since the last assessment, a new survey is required.

Stratification
As the intent of the NDT4 standards is to establish fire maintained 'management units', stocking status for Open Range/Open Forest Standards Units (SU) can be assessed by the average stocking on a SU basis, further stratification is not required. Regardless, when mappable units exist, stratification can be applied where this reduces the sampling intensity required to derive an appropriate label.

Sampling intensity
Sample the SU to the intensity required to obtain a representative label using professional discretion. Key considerations in determining appropriate sampling intensity are SU size and variability. As a minimum, a sample design of one plot per 10 ha with a minimum of five plots per Standards Unit is required. Plots are to be "pre-located" using a method that ensures a non-biased selection of sampling. For example, the area could be covered with a grid such that plots are uniformly and systematically distributed over the unit.

In the rare event that the surveyor finds that plots continually fell in either the most open or in heavily treed clumps, and does not represent the area, plots should NOT be dropped. Rather, to ensure non-biased sampling, additional plots (5 plots recommended) are to be added and these should be pre-located in a non-biased manner.

Plot Measurements
Layer 1 and 2 stocking is to be combined and captured using appropriate BAF prism (typically BAF 2 to ensure an adequate number of sample trees). The prism used should be recorded (for example, on the FS657 'Front Card' or equivalent); use the same BAF for the entire unit. Layer 1&2 trees will be tallied by 5 or 10 cm diameter class. Density of layer 1&2 stems can then be determined by summing the calculation of average BA of diameter class/BA of mean tree of diameter class as per Table 1 or 2 (Excel versions of these Tables are available). Both average BA and density estimates are to be entered into the RESULTS system (could enter as 'Inventory' and no layer).

Diameters for the layer 1&2 stems can be estimated but some measurements should be taken to calibrate one's eye. The height and age of one 'modal' (representative) layer 1 or 2 tree per plot should be measured so that there are at least 5 samples of the first and second leading species per SU; more are to be taken if the variability is high. (Note: when the number of plots per SU exceeds five, measurements do not need to be taken on every plot…).

Species composition for the combined layer 1&2 can be based on ocular estimates (especially when stocking is relatively low) or may be based upon actual plot data (when densities are relatively high); use professional discretion.

Layers 3 and 4 stems can be grouped and densities estimated within a 5.64 m or a 3.99 m fixed radius sub-plot. Typically all stems are to be included in 'estimates' and 1 m would be used as 'countable' height when determining max density. Species composition can be based upon ocular estimates or plot estimates, height and age estimates are to be provided for representative trees. The combination of these two layers can be entered into RESULTS as the 'Silviculture' label with no layer specified.

When the sampling is occurring after a slashing/burning treatment, actual measurements of layer 3 and 4 is recommended.

Reference of Layers
Layer names and descriptions are defined as follows (similar to the Operational Planning Regulation):

Mature pole:> 12.5 cm dbh
Pole layer: 7.5 cm to 12.4 cm dbh
Sapling layer: 1.3m in height to 7.4 cm dbh
Regeneration layer: < 1.3 m in height

Note, when a silviculture prescription sets out suggested stocking by DBH classes or species composition objectives for the layer 1 stems, compliance with the prescription would need to be presented for verification so the combination of layers as described in the preceding would not be appropriate.

Minimum inter-tree spacing
All layer 1 stems regardless of spacing will be tallied as well spaced provided they meet the free growing damage criteria. The minimum inter-tree spacing for layer 2, 3, and 4 stems will default to 2 m unless stated otherwise in the prescription.

M value
There will no 'M' value or limit on the number of well spaced stems allowed in a layer or plot. All well spaced preferred and acceptable trees will be tallied.

Reserve Patches
Identified 'no work' reserve patches will not count towards well-spaced or total stocking densities.

Veterans
Veterans will not be tallied as a separate layer. All veterans should be included in Layer 1.

Forest Health considerations
Except as noted below or otherwise specified in the prescription. The 'Free Growing Damage Criteria' will apply to all tree layers.

Damage Criteria
Residual layer 1 stems with excessive logging damage:
Scar or wound > 30 cm^2 or
Is more than 3 cm deep or
The wood has been splintered,
Or as per the prescription
will not be considered well-spaced, but will contribute towards total stand density.

Data analysis
Stocking will be determined on a SU basis (or polygon, if the SU was stratified). As per other multi-layered surveys, statistical analysis is not required. Stocking status will be determined by comparing the average number of well spaced stems per hectare from the survey to the minimum-stocking standard for the SU stated in the prescription.

For Silviculture Prescriptions, compliance with stand structure, basal area retention and species composition objectives will be based on layer 1 stems only. Compliance with Stand management Prescription objectives will be based on all layers.

Maximum density
Maximum density standards for Open Range and Open Forest stands are set out in the KBLUP Implementation Strategy. Stands that exceed these standards but have less than 10000 countable sph (or 20000 countable if Pl dominated stand) should be flagged as needing treatment under the Ministry ecosystem restoration program.

Survey reports
The Free Growing survey report must meet the content requirements specified under the relevant legislation that pertains to the specific block.

REFERENCES:

Forest Planning and Practices Regulation Section 86 – Annual reports
Forest Practices Code Act of British Columbia Sec. 70 - Silviculture prescriptions
Operational Planning Regulation Section 39 - Content of prescriptions
Silviculture Practices Regulation Section 23 - Surveys required
Silviculture Practices Regulation Section 24 and 25 - Survey requirements
Silviculture Practices Regulation Section 28 - Reporting requirements
Establishment to Free Growing Guidebook - Nelson Forest Region
Silviculture Surveys Guidebook
1998 Draft Stocking and Free Growing Surveys
FRPA Practice Requirements, Professional Reliance
Kootenay-Boundary Land Use Plan Implementation Strategy - Management Guidelines for Fire Maintained (NDT4) Ecosystem Restoration

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Table AI.1.

BAF:	BAF value				
DBH class (midpoint)	Species	BA/tree	Tally	BA/ha (m2/ha)	Density (sph)
10		0.0079		d5*B1	"=e5/c5"
15		0.0177			
20		0.0314			
25		0.0491			
30		0.0707			
35		0.0962			
40		0.1257			
45		0.1590			
50		0.1964			
55		0.2376			
60		0.2827			
70		0.3848			
75		0.4418			
80		0.5027			
85		0.5675			

Table AI.2.

BAF:	BAF value				
DBH class (midpoint)	Species	BA/tree	Tally	BA/ha (m2/ha)	Density (sph)
11.25		0.0099		d5*B1	"=e5/c5"
20		0.0314			
30		0.0707			
40		0.1257			
50		0.1963			
60		0.2827			
70		0.3848			
80		0.5027			
90		0.6362			

Note: dbh class ranges for the above are :

7.5-15.0
15.1-25
25.1-35
Etc.

Reference Ib: Standards for Permanent Photo Plots in Ecosystem Restoration

Photo plots should represent the diversity found in your site. If you are dealing with a homogenous site it is appropriate to put in only a couple of plots. If you have a diverse site (most are) with varying degrees of fuel loading, under story/over story vegetation type, and density, be sure to create enough plots to accurately represent your area as a whole. Four or six plots per pasture of logical burn unit should be adequate. All soil pit sites for an Ecosystem Restoration Prescription should have a photo plot.

Once it has been established where the photo plot will lie, drive in a 6 inch nail. Stakes should be marked with flagging, a metal tag, or spray painted a bright colour. Ensure the tops are rounded to mitigate hazard for wildlife. Next to the rebar, insert a flagged "pig tail" pin for ease of identifying the spot on your next visit.

Record exact co-ordinates of the plot centre so that anyone would be able to later return to the site for future photo documentation; use the ddd. mm.mmm format on the GPS. Using a compass, establish North, South, East and West bearings. From your permanent stake, measure out a distance of 5 metres in each of the four cardinal directions. This is where you will place the yellow metre stick for photographing.

Take the four photos (N, S, E, W) while standing at the centre stake. Aim the camera so that the metre stick is centred in the view finder to ensure consistent before and after photos. Photos taken at this angle should give a good representation of both over story and under story cover as well as provide a good basis for fuel appraisal. Use 1x lense with digital camera or 50mm with slide or digital.

In the lower left hand corner of the picture include a photo card with the following information:

- Geographic
- Plot #
- Latitude
- Longitude
- Status (pre/post mechanical treatment and pre/post prescribed burn)
- Date
- Azimuth

Photos should be taken immediately prior to the burn to show the amount of fuels as well as immediately after the burn to show the degree of scorch.

It is recommended that you also mark on a map the approximate locations of the photo plots to aid in finding them in the future.

GEOGRAPHIC:_____

PLOT #:_____

LAT:_____

LONG:_____

STATUS:_____

DATE:_____

AZIMUTH:_____