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PROTOCOL FOR OPERATIONAL BRUSHING EVALUATIONS

(FIRST APPROXIMATION)

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PROBE builds on the concepts presented in other vegetation management research design protocols, particularly those by Herring and Pollack (1985), Hays (1990, unpubl.) and Northern Interior Vegetation Management Association (1990, unpubl.). The author wishes to make special acknowledgement of their contribution. PROBE includes options for monitoring habitat conditions using the procedures of the Habitat Monitoring Committee (1990), as well as options for assessing impacts of broadcast applications of prescribed fire and mechanical site preparation, using modifications of procedures described by Trowbridge *et al.* (1986) and Curran and Thompson (1991, unpubl.), respectively.

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1 INTRODUCTION

An expanding brushing program in the southern Interior of British Columbia has created a need for better information on the short- and long-term effectiveness of vegetation management treatments that have been applied on an operational basis. Qualitative evaluations of treatments were useful to operational foresters in the formative stages of the program, but today have little value in defending prescriptions before the public. A quantitative, technically valid, and yet simple monitoring system is now necessary to meet the needs of operational staff.

In the past, several *ad hoc*, quantitative methods for evaluating operational vegetation management treatments were developed and implemented in the southern Interior. Each method, however, had specific objectives for evaluating specific vegetation management treatments. The narrow scope and lack of consistency among evaluation methods gave operational foresters limited opportunities for comparing results among sites and treatments. Development of a standardized monitoring system was subsequently requested.

This Land Management Handbook presents a design protocol that defines minimum standards for an objective, low intensity monitoring system. It is called PRotocol for Operational Brushing Evaluations, or PROBE. The purpose of PROBE is to provide a monitoring framework for use in a wide array of vegetation complexes, ecosystems (site series), and operational vegetation management treatments. The framework standardizes installation location, response measurements and statistical analyses.

PROBE is intended solely for voluntary operational monitoring. It provides for extensive, quantitative evaluations of common treatments in the most frequently treated vegetation complexes; and is detailed enough that an individual who is familiar with research plot layout and monitoring can easily complete a high quality installation. A large number of PROBE installations can be readily established by a variety of individuals. PROBE is *not* designed for qualitative evaluation of the extent and success of all vegetation management activities in operational programs, nor is it designed to replace replicated research trials which may have different or more detailed objectives. PROBE should be considered an adjunct to both program-level evaluations *and* research trials, and used to fill rapidly the large information gap on the effectiveness of operational treatments.

The PROBE method satisfies the basic objective of most operational brushing evaluations, which is to determine the effects of vegetation management treatments on:

- the survival and growth of crop trees
- the abundance of target non-crop species

This it does by comparing crop tree and non-crop vegetation response in a designated treated area (called after this ‘‘Treatment’’ and abbreviated ‘‘T’’), with response in a designated control area (‘‘Control’’ and abbreviated ‘‘C’’). When the user selects Treatment and Control plots, criteria are provided to ensure that the plots are located in areas that are similar in ecosystem characteristics and site history. Thirty-six tree-centred subplots are located in each of the Treatment and Control plots in which assessments are made. The subplots are assessed immediately before treatment and at pre-determined intervals up to 10 years after treatment.

The condition of wildlife habitat can be monitored within the PROBE framework, in addition to the basic assessments of target crop tree growth and target non-crop vegetation abundance. To that end, PROBE includes an option for assessing the abundance and distribution of all vascular plant species, using procedures developed by the Habitat Monitoring Committee (1990).

In addition to brushing treatments, site preparation treatments can also be monitored using PROBE. PROBE is best suited to broadcast treatments, such as broadcast burning or mechanical site preparation (MSP) using a brush blade. PROBE is less well suited to selective site preparation treatments, such as disc trenching or excavating, where treatments are applied in rows or to small, discrete microsites. Where PROBE is run to evaluate the effects of prescribed fire and MSP on the vegetation community, pre- and post-treatment conditions are evaluated using modifications of procedures described by Trowbridge *et al.* (1986) and Curran and Thompson,[1] respectively. The results are used to quantify treatment intensity, in much the same way as application rate quantifies the intensity of a herbicide treatment.

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[1] Curran, M. and S. Thompson. 1991. Measuring soil disturbance following mechanical site preparation. B.C. Min. For., Nelson, B.C. Unpubl. report.

The Treatment and Control for a particular complex/ecosystem/treatment combination are replicated at least three times, once on each of three sites (i.e., three installations). Each installation serves as a block in a randomized block design (RBD). Comparisons of crop tree performance and non-crop vegetation abundance are then made between the Treatment and Control using Analysis of Variance (ANOVA). This approach requires that all blocks within the RBD be identical in treatment, plot layout and measurements. It is a powerful approach, in that conclusions may be drawn about treatments across a broad range of sites. Anyone establishing PROBE installations must be aware, however, that even a small, apparently slight deviation from the protocol may make a particular installation unusable to the whole (W. Bergerud, pers. comm., June 1991, B.C. Min. For., Victoria, B.C.). The procedures outlined in this protocol help to ensure that methods and measurements are standard and comparable. Complementary annual training sessions are also necessary to ensure that consistency is maintained among ''probers.''

In addition to comparing treatment means using ANOVA, the neighbourhood approach is used to build predictive models, which relate the performance of crop trees to the degree of crowding by neighbouring non-crop vegetation (Goldberg and Werner 1983; Weiner 1984; Wagner and Radosevich 1991). More specifically, simple regression models are constructed to relate the size, and possibly survival, of target crop trees to indices of non-crop vegetation competition. The competition indices are calculated from easily measured non-crop vegetation parameters, including height, cover and, for hardwoods only, density.

Two other monitoring systems are currently in use in the northern Interior of British Columbia: (1) Operational Herbicide Monitoring (OHM);[2] and (2) Unified System of Vegetation Monitoring (Northern Interior Vegetation Management Association (NIVMA).[3] OHM is designed for the establishment of benchmark installations, and includes detailed measurements of crop trees, competing vegetation, wildlife forage and environmental conditions. NIVMA is less comprehensive and objective. Its aim is to provide operational foresters with a simple, subjective monitoring system and a broad, shared database (NIVMAN). NIVMA is intended to complement OHM, so that forest managers are provided with both an extensive database (i.e., NIVMA) and objective treatment comparisons (i.e., OHM) (L. Herring, pers. comm., March 1991, B.C. Min. For., Prince George, B.C.).

The monitoring system presented in this report fulfils similar objectives to those of NIVMA and OHM. However, PROBE is more objective than NIVMA and less comprehensive than OHM, and hence represents a compromise between the two. NIVMA's system is unsuitable for the southern Interior for several reasons: (1) it does not permit objective evaluations of treatment effectiveness because a control is not required; (2) it does not meet the objectives of the Habitat Monitoring Committee (1990) for monitoring wildlife habitat; and (3) methods of data analysis are unclear. OHM also is considered unsuitable because of the large sample size and large number of variables it investigates. The monitoring system for the southern Interior, as with NIVMA's system in the north, however, would benefit from additional information gathered in OHM benchmark installations.

2 ESTABLISHMENT PROCEDURE

2.1 Introduction

This section describes the installation establishment procedure, which consists of three steps:

1. site selection
2. location of Treatment and Control plots based on similarity criteria
3. location of subplots within Treatment and Control plots

2.2 Site Selection

Site selection for operational brushing evaluations should be guided by the vegetation complexes, ecosystems and treatment regimes that are a high priority in the Kamloops and Nelson Forest Regions. The high priority vegetation complexes represent the early seral vegetation communities which are considered to compete with

[2] Hayes, W.J. 1990. Operational monitoring in the Prince George Forest Region. B.C. Min For., Prince George, B.C. Unpubl. report.

[3] Northern Interior Vegetation Management Association (NIVMA). 1990. Unified system of silviculture monitoring. Prince George, B.C. Unpubl. report.

conifers in the southern Interior, as identified by Kimmins and Comeau (1990). The species characterizing those vegetation complexes are listed in Appendix 1. The high priority ecosystems are the site series of medium soil moisture regime (i.e., submesic, mesic, subhygric) and medium soil nutrient regime within the Biogeoclimatic Ecosystem Classification zones (Lloyd *et al.* 1990; Braumandl and Curran 1992) in which the vegetation complexes occur (Kimmins and Comeau 1990). The high priority treatments to be targeted by PROBE include all brushing and most site preparation treatments operational in the southern Interior. Sites selected should have been disturbed (i.e., harvested or site prepared) within the past 15 years.

Common complexes, ecosystems and treatment regimes in the Kamloops and Nelson Forest Regions are summarized in the sampling matrix shown in Table 1. Each cell within the sampling matrix represents a complex/ecosystem/treatment combination. Planted tree species are not included for the sake of simplicity. An example of one such combination is Dry Alder Complex/mesic site in the Montane Spruce zone, to which ground foliar glyphosate is applied at a rate of 2.14 kg a.i./ha to release interior spruce. The program objective is to replicate each combination (cell) three times.

Some combinations shown in Table 1 are rarely used, but are shown for completeness. These combinations will be given low priority through inter-region co-ordination. The regions will direct site selection to ensure that high priority combinations are sampled and that there is no unnecessary replication.

2.3 Treatment and Control Plot Location

Each installation should consist of a maximum of one Treatment and one Control plot. These are located in areas representative of the average treatment, and are homogeneous in ecosystem and site history. The Treatment and Control plots are located on the same opening where possible, to minimize between-plot variation. They must be similar to one another in the criteria described in Table 2. To ensure Treatment and Control plots are comparable, all ecosystem characteristics must be evaluated in concert (W. Hayes, pers. comm., June 1991, Prince George, B.C.). Buffer zones or areas that differ from the average conditions of the opening (e.g., gullies, creeks, rock outcrops, highly disturbed) must be avoided. The Treatment and Control plots must be located at least 30 m from treatment edges (e.g., timber edge, landings, roads). Where the treatment is an aerial herbicide application, however, (at least a minimum of) 50 m is required.

The Treatment and Control plots can be laid out in either a square or rectangular configuration. The dimensions of a square plot are 90×90 m (0.81 ha). Where a rectangular configuration is more suitable, any other dimensions may be used, provided the area is at least 0.80 ha (e.g., 120×70 m $= 0.84$ ha). The same plot configuration should be used for both the Treatment and Control within an installation, where possible. These plot dimensions include a 20-m surrounding buffer (Figure 1). The area in the plot which includes the buffer is referred to as the ‘‘treatment plot,’’ and that which does not include the buffer is referred to as the ‘‘measurement plot.’’

The four corners of the Treatment and Control plots should be permanently marked with pressure-treated fence posts. The top of the posts are painted red in the Control and blue in the Treatment. Each post is marked with an aluminum tag detailing the installation number, treatment, corner, and distance and bearing to the two adjacent corners. Before treatment, the Control perimeter is clearly marked at 3-m intervals with winter-weight pink and blue flagging, and the Treatment perimeter with yellow or lime-green flagging. In the case of aerial herbicide, the corners are marked with large, orange, plastic garbage bags, or according to instructions provided by the pilot.

A point of commencement (POC) is located at an easily recognizable point and marked with an aluminum tag on a pressure-treated fence post. The tag details the installation number, date of establishment, Ministry contact, and distance and bearing to the first subplot in each of the Treatment and Control.

2.4 Subplot Location

Within each Treatment and Control plot, 36 tree-centred, circular subplots are located in a square 6×6 grid (or a rectangular grid such as 9×4, depending on the plot configuration). This is done by systematically locating six gridlines, each comprised of six gridpoints, inside the measurement plot. The first gridpoint, which marks the beginning of the first gridline, is randomly located inside one of the measurement plot corners.

TABLE 1. Sample matrix for Probe installations in the Kamloops and Nelson Forest Regions

		TREATMENT[a]												
Complex	**Zone**	**M**	**GGA**	**CSG**	**CSS**	**HS**	**BBT**	**G**	**SG**	**CG**	**BB**	**BM**	**CS**	**BrB**
Pinegrass	IDF	—[b]	X[c]	—	—	—	—	—	X	X	X	X	X	X
	MS	—	X	—	—	—	—	—	X	X	X	X	X	X
	ESSF	—	X	—	—	—	—	—	X	X	X	X	X	X
Fireweed	ICH	X	X	—	—	—	—	—	X	X	X	X	—	—
	MS	X	X	—	—	—	—	—	X	X	X	X	—	—
	ESSF	X	X	—	—	—	—	—	X	X	X	X	—	—
Fern	ICH	X	X	—	—	—	—	—	X	X	X	X	—	—
Dry Alder	MS	X	X	X	X	X	X	—	X	X	X	X	—	X
	ESSF	X	X	X	X	X	X	—	X	X	X	X	—	X
Wet Alder	ICH	X	X	X	X	X	X	—	X	X	X	X	—	X
	ESSF	X	X	X	X	X	X	—	X	X	X	X	—	X
Mixed Shrub	ICH	X	X	—	—	—	—	—	X	X	X	X	—	X
	ESSF	X	X	—	—	—	—	—	X	X	X	X	—	X
Dry Shrub	IDF	X	X	—	—	—	—	—	X	X	X	X	—	X
	ICH	X	X	—	—	—	—	—	X	X	X	X	—	X
Ericaceous Shrub	ESSF	X	X	—	—	—	—	—	—	—	X	X	—	X
Subalpine Herb	ESSF	X	X	—	—	—	—	—	X	X	X	X	—	—
Aspen	IDF	X	X	X	X	X	X	X	X	X	X	X	—	X
	ICH	X	X	X	X	X	X	X	X	X	X	X	—	X
	MS	X	X	X	X	X	X	X	X	X	X	X	—	X
Cottonwood	IDF	X	X	X	X	X	X	X	X	X	X	X	—	X
	ICH	X	X	X	X	X	X	X	X	X	X	X	—	X
Mixed Hardwood	IDF	X	X	X	X	X	X	X	X	X	X	X	—	X
	ICH	X	X	X	X	X	X	X	X	X	X	X	—	X
	MS	X	X	X	X	X	X	X	X	X	X	X	—	X
Willow	IDF	X	X	X	X	X	—	—	X	X	X	X	—	X
	ICH	X	X	X	X	X	—	—	X	X	X	X	—	X
	MS	X	X	X	X	X	—	—	X	X	X	X	—	X
	ESSF	X	X	X	X	X	—	—	X	X	X	X	—	X
Domestic Grasses	IDF	X	X	—	—	—	—	—	X	X	X	X	X	—
	MS	X	X	—	—	—	—	—	X	X	X	X	X	—

[a] M = manual cut (or bend fireweed)
GGA = spray glyphosate, ground or aerial application
CSG = manual cut and swab stump with glyphosate
CSS = manual cut and later spray sprouts with glyphosate
HS = hack-and-squirt or e-z-ject with glyphosate
BBT = basal bark treatment using triclopyr ester
G = girdle
SG = sheep grazing
CG = cattle grazing
BB = broadcast burn
BM = mechanical bunch-and-burn
CS = chain scarifier
BrB = brush blade

[b] — = not applicable

[c] X = sample of 3 required

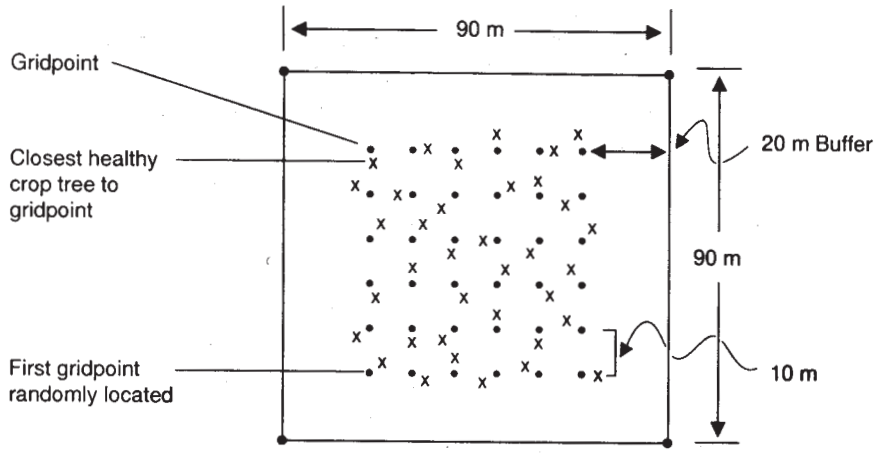


FIGURE 1. Treatment or Control plot design.

TABLE 2. Criteria for selecting comparable Treatment (T) and Control (C) plots

Characteristic	Similarity criteria
Ecosystem	
Mesoslope position	same class (crest, upper slope, middle slope, lower slope, toe, depression, level)
Slope	± 10% (e.g., if slope in T is 50%, then slope in C can range from 40 to 60%)
Aspect	± 45° (e.g., if aspect in T is 180°, then aspect in C can range from 135° to 245
Elevation	± 50 m
Soil texture	same broad class: sand, silt, clay, loam (e.g., loamy sand and silty sand are the same broad class)
Coarse fragment content	± 25%
Soil moisture regime	same class (submesic [SM], mesic [M] or subhygric [SHG])
Site series	same
Vegetation complex	same dominant species
Site history	
Timber type	same dominant tree species
History	same (year and type of site prep. and planting treatment)

The remaining gridpoints are systematically located at 10-m intervals. Gridpoints are marked with either pin-flags or wooden pickets, which are red in the Control and blue in the Treatment plot.

The closest, healthy tree of the target crop species to each gridpoint serves as the subplot centre. The target crop species must be well represented in both the Treatment and Control to ensure that 36 subplots can be located in each. Overlap of subplots is acceptable because competitive effects are evaluated on individual tree basis. When selecting target crop trees, keep in mind the objectives of the treatment. A conifer release prescription may specify, for example, the minimum size of crop tree that is treated. The distance and azimuth from the gridpoint to the target crop tree are recorded at the time of crop tree selection, to facilitate both relocation and development of the installation map (see Section 6).

The presence of two target crop species planted in discrete areas of an opening may necessitate the establishment of two separate installations. Where the two target crop species are intimately mixed, however, one installation may be used to evaluate both. In this situation, a subplot is centred on each target crop tree (i.e., two subplots) so that each Treatment and Control plot has 72 rather than 36 subplots.

The tree-centred subplots are permanently marked with rebar stakes located 50 cm due north of the target seedling. Where two target species are intimately mixed, a rebar stake is used to mark each subplot. The stakes are 1 m tall and hooked at the top end to reduce the risk of damage to wildlife and cattle. The hooked end of each stake is painted (red in Control, blue in Treatment), flagged with winter-weight pink, and marked with an aluminum tag. The aluminum tags identify the installation number, treatment, and subplot number (consecutive 1–36, or where two species are intimately mixed, 1–72). Each target crop tree and target non-crop specimen (see Section 3.3.2) are also marked with aluminum tags, which are loosely wired onto a lateral branch. The aluminum tags are numbered consecutively throughout the installation. The first numbers are assigned to the target crop tree and target non-crop specimens in subplot 1 in the Control, and the last numbers to those in subplot 36 in the Treatment. To avoid injury to the treatment crew, rebar stakes and aluminum tags should not be installed in the Treatment plot until after the treatment has been completed.

3 ASSESSMENTS

3.1 Introduction

In all installations, assessments should be made of two community components: (1) crop trees; and (2) target non-crop vegetation. Habitat for wildlife or cattle may also be assessed using the procedures described by the Habitat Monitoring Committee (1990). Where the treatment is prescribed fire or mechanical site preparation, pre- and post-treatment forest floor and fuel conditions should be assessed using the procedures of Trowbridge *et al.* (1986) or Curran and Thompson,[4] respectively. The results of those assessments are used to quantify the intensity of site preparation treatments. This section describes the sampling strategy for each component.

Assessments are made within two different sized circular crop tree centred subplots. Competitive effect of target non-crop vegetation is evaluated in either 10 m^2 ($r=1.78$ m) subplots when mean crop tree height is ≤ 2 m, or 20 m^2 ($r=2.52$ m) subplots when mean crop tree height is >2 m. Mean height is determined when crop trees are selected (see Section 2.4). The same subplot size is used for all subplots within an assessment period. Crop tree density and stocking, non-crop vegetation treatment efficacy, and wildlife habitat are evaluated in 50 m^2 ($r=3.99$ m) subplots.

3.2 Target Crop Trees

One target crop species is usually selected for each installation. Two may be selected, however, where the species are intimately mixed (see Section 2.4). The target species selected is defined by the program objectives, and may be either a conifer or a hardwood. Planted crop trees are preferred over naturals. Where naturally regenerated trees are selected, however, all target crop trees must be the same age.

3.2.1 Growth

Crop tree growth is assessed in all subplots in each of the Treatment and Control. Measurements are seedling height (cm), height increment (cm), root collar diameter (mm), crown diameter (cm), crown length (cm), vigour, condition, damage, and height (%) and competitive status relative to surrounding non-crop vegetation. If shoot elongation is still occurring at the time of the baseline assessment, height to the top whorl and previous year's height increment are measured. Vigour, competitive status, and condition of foliage, leader and stem are assessed with procedures described by Herring and Pollack (1985). Damage cause is described according to Silviculture Survey damage codes (B.C. Ministry of Forests 1989). It is

[4] Curran and Thompson, 1991.

described only where it potentially can affect crop tree performance. The field data form (PROBE form 2) and details on recording conventions are located in Appendix 2. Vigour, condition, damage and competitive status codes are located in Appendix 3.

3.2.2 Density and stocking

Density of all conifer species and stocking of well-spaced and free-growing trees are determined in all subplots in each of the Treatment and Control. The subplots are 50 m^2 (r=3.99 m) and centred on the target crop tree. A modification of the standard Silviculture Surveys procedure is used (B.C. Ministry of Forests 1989). This involves completion of the FS 657 (Silviculture Survey) and FS 658 (Silviculture Survey Plot) forms (see Appendix 4 for forms and recording conventions). The FS 659 form (Silviculture Survey Summary) is not used because the data are summarized and analyzed using SAS programs (see Section 11).

3.3 Target Non-crop Vegetation

Species may be selected as targets for measurements if they (1) represent a competitive threat to crop trees, and (2) occur in at least 80% (i.e., 29 out of 36) of the subplots in each of the Treatment and Control. Target species are selected following an assessment of species composition in the Treatment and Control plots. To do this, all potential non-crop species present in each subplot are tallied at the time of crop tree selection. A minimum of one and maximum of five target non-crop species are selected.

In some cases, the abundance of a non-crop species that was not selected as a target in the baseline assessment can increase dramatically after treatment, posing a competitive threat to crop trees. Clearly, pre- and post-treatment measurements of such species are beneficial, although it is impractical to measure all species based on the possibility of their increased abundance. Rather, Research Silviculturists can identify non-crop species that are *likely* to increase in abundance following treatment, before the baseline assessment, using their experience and results of previous trials. With this approach, some important species shifts may be missed. However, the abundance, vigour and distribution of all vascular plant species will be monitored in the eight subplots serving as Habitat Monitoring plots (see Section 3.4), which can provide sufficient information for the qualitative assessment of species shifts.

3.3.1 Competitive effect

The competitive effect of target non-crop species on target crop tree performance is assessed in a 10 or 20 m^2 circular subplot (10 m^2 if crop tree $\leq$2 m tall; 20 m^2 if crop tree $>$2 m tall), which is centred on the target crop tree. The modal height, cover and density (hardwoods only) of target non-crop vegetation are assessed in all tree centered subplots in each of the Treatment and Control. More specifically, the following are measured: subplot total cover (%) and subplot modal height (cm); for each target species, cover (%) and modal height (cm); and for target hardwood species (i.e., paper birch, trembling aspen and black cottonwood), density (stems per plot). The field data form (PROBE form 3) and details on recording conventions are in Appendix 2.

3.3.2 Efficacy of treatment

Efficacy of treatment is evaluated on one tagged specimen of each woody target non-crop species located within each 50 m^2 crop tree-centred subplot. Usually, the closest, healthy specimen to the crop tree is chosen. However, care must be taken to ensure that the specimen meets the target criteria (e.g., minimum size) specified in the treatment prescription. For example, where the prescription calls for girdling all hardwood stems $>$5 cm dbh, select only target specimens with at least 5 cm dbh. Non-woody species are not tagged for this evaluation because of the difficulty in relocating specimens from year to year. Rather, treatment efficacy at controlling non-woody species is evaluated simply as change in percent cover and modal height (see Section 3.3.1).

In baseline assessments only, the location (distance [dm] and azimuth) of each tagged woody specimen is described. In baseline and subsequent re-assessments, the total height (cm), leader height (cm),

vigour, condition and phenology (see Appendix 3) are recorded. Leader height may be difficult to determine, particularly if elongation is not complete at the time of the assessment. Where elongation appears to be 80% complete, record the current year's leader height. Otherwise, record the previous year's leader height. Leader condition is assessed for the leader whose height is measured. Phenology recorded before treatment assists in the interpretation of efficacy results, and that recorded after treatment provides a qualitative assessment of treatment-imposed stress. In re-assessments only, the number and length (cm) of sprouts (all woody shrubs and hardwoods) or suckers (aspen only), damage cause, and ECW rating are also recorded. The field data form (PROBE form 4) and details on recording conventions are in Appendix 2.

3.4 Wildlife Habitat (Optional)

All vascular plant species can be monitored throughout the 10-year re-measurement period according to procedures recommended by the Habitat Monitoring Committee (1990). They are monitored in four 50 m^2 crop tree centred subplots ($r = 3.99$ m), which are randomly selected from the 36 subplots in each of the Treatment and Control (total of eight plots per installation). This entails completion of the Project Description Form (EM-1), Site Description Form (EM-2), Vegetation Description Form (EM-3) and Herbicide/Fertilizer Form (EM-5). The field forms are given in Appendix 5. For details on completing the field forms, refer to the Habitat Monitoring Committee (1990).

Form EM-1 is used to describe the location, goals and objectives of the project area, and Form EM-2 to describe the ecosystem and habitat monitoring sample plot layout.

Form EM-3 is used to record the vegetation characteristics of the habitat monitoring sample plots. For each species, the stratum, percent cover, distribution and vigour are recorded. Optional attributes that may also be recorded include phenology, impact assessment, stem count, total percent cover over all strata, strata height, and the number of dead trees.

On form EM-5 are described treatment application details (e.g., method of treatment, environmental conditions at time of treatment), as well as the impact and recovery of a maximum of six dominant shrub species. The form was designed to record herbicide and fertilizer treatment assessments, but is used for all treatments assessed in PROBE installations. Impact and recovery of herbaceous species is assessed as in percent cover, and recorded on the Vegetation Description Form (EM-3).

Pre-treatment assessment involves completion of forms EM-1, EM-2, EM-3, and EM-5A. Post-treatment assessment involves completion of forms EM-3 and EM-5B (Impact Assessment) at the end of the first full growing season following treatment (i.e., first re-assessment), and EM-5C (Recovery Assessment) at the end of the third (i.e., second re-assessment) and fifth (i.e., third re-assessment) growing seasons. Assessments in the selected habitat plots are made of the same target non-crop species evaluated using PROBE form 4. The Impact Assessment consists simply of plot tallies of the number of stems of each target shrub and hardwood species. The Recovery Assessment consists of plot tallies of the number of stems and basal sprouts in each pre-defined Assessment Category.

3.5 Prescribed Fire (Optional)

Pre- and post-burn conditions should be assessed using procedures modified from Trowbridge *et al.* (1986). Modification to those procedures is in the sample design only, not in the data collection. This section provides a brief summary of the procedures; for more detail, refer to the original handbook by Trowbridge *et al.* (1986). A copy of the fuel assessment form is in Appendix 6.

Before the burn, environmental conditions and vegetation are assessed in both the Treatment and Control according to procedures described in Sections 3.1, 3.3 and, optionally, 3.4. Gridpoints serve as subplot centres. In the Treatment plot only, pre- and post-burn estimates of slash loading, forest floor depth and mineral soil exposure also are made. Re-measurements are done as soon after the burn as possible because rain or snow can disturb the forest floor.

3.5.1 Sample design

Slash load and mineral soil exposure are estimated by the line intersect method, where each of the six gridlines serves as a 50-m line transect (i.e., n=6). In addition, forest floor depth is estimated and burn-pins inserted at each of the 36 systematically located gridpoints.

3.5.2 Slash load

Pre- and post-burn slash load is estimated along each of the six 50-m gridlines (transects). The slope is determined at the beginning of each gridline. The number of slash pieces (twigs, branches, small stems) ≤7 cm in diameter are then tallied according to the following size classes and sample line lengths:

Diameter size class (cm)	Portion of sample line tallied (m)
0–0.5	0–5
0.6–1.0	0–10
1.1–3.0	0–15
3.1–5.0	0–20
5.1–7.0	0–25

The size class is the actual diameter of each piece at the point of intersection with the gridline. The percent species composition of all pieces ≤7 cm in diameter is estimated after the count for a particular line is completed. The diameter and species of all intersecting pieces >7 cm in diameter are determined along the entire 50-m gridline. To relocate the same measurement point on a piece after the burn, a nail is driven into that point, leaving approximately 1 cm of the nail exposed. Special tally rules for pieces of all diameters are summarized in Appendix 6.

After the burn, sampling of the ≤7 cm size classes is repeated according to the same procedures as in the pre-burn. All >7 cm nailed pieces are tallied with the pre-burn procedures, even if the pieces are smaller than 7 cm or have moved off the gridline. Exposed roots, or pieces that are not nailed but have moved onto the gridline, are not measured.

3.5.3 Forest floor and mineral soil exposure

Before the burn, four depth-of-burn pins are inserted at each of the 36 gridpoints (total of 144 pins). The four pins are located 1 m from the gridpoint, one in each cardinal direction. The pins are placed in undisturbed forest floor so that the crossbar is level with the surface of the litter, moss layer or decayed log. The depth of litter or moss layer is measured where the depth-of-burn pins are inserted.

After the burn, the depth-of-burn pins are re-located and the ash is scraped away. The bottom of the crossbar to the top of the unburned forest floor, and the top of the unburned forest floor to the mineral soil surface, are measured.

To estimate percent mineral soil exposure along the full length of each gridline, the length of exposed mineral soil is measured, divided by 50 and then multiplied by 100.

3.5.4 Planting

After post-burn fuel sampling, the opening is operationally planted. In the Treatment plot, gridpoints are relocated by a compass and chain and marked with pin-flags or wooden stakes. In the Treatment and Control plots, the closest seedling to each gridpoint is selected as the target crop tree. The tree-centred subplots are marked with rebar stakes, located approximately 50 cm due north of the target trees.

3.6 Mechanical Site Preparation (Optional)

Soil disturbance after mechanical site preparation should be measured according to a modification of the Gridpoint-Intercept method described by Curran and Thompson.[5] This section briefly summarizes the procedures; for more detail, refer to the original handbook.[6] The soil disturbance survey forms and Soil Disturbance Cause codes are in Appendix 7.

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[5] Curran and Thompson, 1991.

[6] *Ibid.*

Before mechanical site preparation, environmental conditions and vegetation are assessed in both the Treatment and Control according to procedures described in Sections 3.1, 3.3 and, optionally, 3.4. Gridpoints serve as subplot centres. After site preparation and planting, soil disturbance is assessed in both the Treatment and Control plots.

3.6.1 Planting

After mechanical site preparation is completed, the opening is operationally planted. In the Treatment plot, gridpoints are relocated by a compass and chain and marked with pin-flags or wooden stakes. In the Treatment and Control plots, the closest seedling to each gridpoint is selected as the target crop tree. The tree-centred subplots are marked with rebar stakes, located approximately 50 cm due north of the target trees.

3.6.2 Sampling design and disturbance survey

After planting is completed, soil disturbance is estimated along the six gridlines (i.e., n=6). It is evaluated at four observation points in each tree-centred subplot. The four points are located 1 m from the target tree, one in each cardinal direction. The Soil Disturbance Cause code is recorded for each point on Form 1-MSP (grid intercept survey). In addition, slope gradient is measured at the beginning of each gridline. The survey results are summarized separately for the Treatment and Control on Form 3A-MSP (Calculation Card Gridpoint-Intercept). The MSP forms are in Appendix 7.

4 RECORDS

PROBE and Silviculture Survey forms must be completed for each basic installation. As options, habitat monitoring, prescribed fire assessment, and mechanical site preparation soil disturbance survey forms may also be completed. The list of forms and the appendices in which they and their coding instructions are located are given in Table 3.

5 PHOTOGRAPHS

Photographs are taken during the baseline assessment, immediately after treatment, and at each post-treatment assessment. Coloured, 35 mm slide film and a wide-angle lens (28–35 mm) are used. The date the photograph was taken, installation number, installation location, treatment (T or C), subplot number and subject must be recorded on each slide. The information can be written either directly on the slide after it has been developed, or on a whiteboard which is included in the picture.

A minimum of four photographs are taken in each of the eight habitat monitoring sample plots. During each assessment, photographs are taken from the same points, which are recorded during the baseline assessment (see photographic record in Appendix 2). The points should be carefully chosen to afford a good view of the subject. The four photographs show: (1) target crop tree, (2) general habitat condition, (3) target non-crop specimens (more than one photograph may be necessary, depending on the proximity of the specimens to one another), and (4) overview of ground cover (optional). In addition, one photograph is taken toward the centre of the plot from each of the four corner posts in the Treatment and Control.

6 MAPPING

A location (1:20 000) and installation (1:1000) map are drafted for each installation. The location map shows the location of the installation on the appropriate Forest Cover map. The map notation must be permanently included on the Forest Cover mylar in the appropriate Forest District. The installation map shows the POC, Treatment plot, Control plot, gridpoints, subplots and important topographical and man-made features.

TABLE 3. List of forms for operational brushing evaluations

Form number	Description	Appendix
Mandatory		
PROBE-1	Project description	2
PROBE-2	Crop tree growth	2
PROBE-3	Target non-crop vegetation	2
PROBE-4	Target specimens	2
PROBE-5	Photographic record	2
FS 657, 658	Silviculture survey	4
Optional		
Habitat Monitoring:		
EM-1	Project description	5
EM-2	Site description	5
EM-3	Vegetation description	5
EM-5A	Herbicide/fertilizer	5
EM-5B	Herbicide impact assessment	5
EM-5C	Herbicide recovery assessment	5
Prescribed Fire Assessment:		
PF-4	Fuel assessment	6
Mechanical Site Preparation Soil Disturbance Survey:		
1-MSP	Grid intercept survey	7
3A-MSP	Calculation Card Gridpoint-Intercept	7

7 TIMING

Ideally, sites should be selected during the fall before installation establishment. Establishment and baseline assessments are best done just before treatment, and hence will depend on the type of treatment being imposed. For example, assessments may best be done in early summer (e.g., mid-late July) for brushing treatments or late summer (e.g., mid-late August) for site preparation treatments. Subsequent assessments are conducted during the period of full vegetative development and before frost incidence (i.e., between July 15 and August 31). They are conducted five times over a 10-year period:

1. Baseline — immediately before treatment.
2. First re-assessment — one growing season following treatment.
3. Second re-assessment — three growing seasons following treatment.
4. Third re-assessment — five growing seasons following treatment.
5. Fourth re-assessment — 10 growing seasons following treatment.

All measurements are completed during each re-assessment, except crop tree stocking and density, which are assessed only during the baseline, third and fourth re-assessments.

8 MAINTENANCE

Signs are erected on or near the POC at the time of plot installation. Maintenance of the installations is done during each re-assessment. At that time, missing corner posts, subplot centres and tags are replaced. Corner posts and subplot stakes are re-painted and re-flagged where necessary.

9 PERSON-DAY REQUIREMENTS

The time estimate for establishment of a new PROBE installation is given in Table 4. An extra day or two will be required if a prescribed burn assessment or mechanical site preparation soil disturbance survey is required. The time estimate for a re-assessment is 2–3 days, depending on whether or not a silviculture survey is required. The estimates are based on a two-person crew familiar with the sampling procedures.

TABLE 4. Estimate of crew-day requirements (2 persons) per installation

Activity	Crew-days (10-hour day)
Site location, Treatment and Control boundary layout	1
Subplot layout, crop and target specimen tagging	1
Crop tree and target non-crop specimen assessments (PROBE-2, -4)	0.5–1
Percent cover, modal heights (PROBE-3), posts, POC	0.5–1
Habitat assessments (all EM forms), photos	1
Silviculture survey (FS 567 and 658)	1
Rebar installation, site description, access notes (PROBE-1)	0.5
Approximate number of crew-days	**5–7**

10 RESPONSIBILITIES

The establishment, monitoring and data entry of PROBE installations are contracted out. The Stand Tending Co-ordinators are responsible for the administration of the contracts and co-ordination of the program. The specific responsibilities of the co-ordinators are:

- identification of program objectives, through the construction of the sampling matrix;
- approval of candidate sites, on the basis of program objectives;
- selection of qualified contractors;
- administration of contracts;
- maintenance of records library, including PROBE and habitat monitoring databases, annual reports, and slides (the habitat monitoring information is also included in a provincial database, which is maintained by the Habitat Monitoring Committee [1990];
- dissemination of annual reports to the Forest Districts; and
- co-ordination of field trips with District Silviculturists to discuss monitoring results.

The Research Silviculturists are responsible for annual training, consulting, analysis and reporting; and the District Silviculturists, or appropriate designates, are responsible for selection of candidate sites for PROBE installations.

The PROBE Contractors are responsible for site selection (with assistance from District Silviculturists), layout, assessment and data entry. In addition, the PROBE Contractors must maintain contact with the District

Silviculturists and the brushing or site preparation contractors throughout the establishment and treatment phases, to ensure that Control plots are not mistakenly treated. As soon as a PROBE installation has been established, the PROBE Contractors must send the District Silviculturists the following: (1) a description of general location and opening number; (2) a Forest Cover map showing location of POC and Treatment and Control plots; and (3) a description of how the installation is marked on the ground (e.g., colour of corner posts, rebar and flagging).

11 ANALYSES

11.1 Introduction

The Research Silviculturists are responsible for data analysis and reporting within their region. Crop tree and non-crop vegetation data are analyzed with the use of *t*-tests, ANOVAs, regression techniques and contingency tables. The habitat data are summarized according to procedures described by the Habitat Monitoring Committee (1990). Prescribed fire and soil disturbance data are summarized according to procedures described by Trowbridge *et al.* (1986) and Curran and Thompson.[7]

11.2 *T*-tests

Within an installation, *t*-tests are used to compare crop tree performance and target non-crop vegetation abundance between the Treatment and Control. Subplots located within the Treatment and Control plots are used as treatment units (i.e., n=36). Because the treatments were not randomly assigned to randomly selected subplots, however, this represents ''pseudo-replication'' (Hurlbert 1984). The true treatment units are not the 36 subplots, but rather the Treatment and Control plots in which they are located, which are not replicated on-site. Consequently, the validity of the *t*-test depends on the assumption of no between-plot variation. The criteria for selection of comparable Treatment and Control plots help to ensure that between-plot variation is indeed minimal.

The variables that will be tested using *t*-tests are:

- Crop tree - total height, height increment, diameter, diameter increment, crown volume, relative height, stocking, density
- Non-crop vegetation
  - All vegetation - cover, modal height
  - Target species - cover, modal height, density (hardwoods only)
  - Tagged target specimen - total height, height increment, sprout number, sprout length, ECW control rating

where crown volume = crown length $\times$ (crown diameter/2)^2. Means and standard errors are summarized in tables and boxplots.

11.3 Analysis of Variance

Each complex/ecosystem/treatment combination (cell) will be replicated three times (i.e., three installations). Once this has been accomplished, the combination is analyzed as a RDB using two-way ANOVA (see Appendix 8 for ANOVA table). With data pooled from three or more installations, broad inferences may be made about a particular treatment across a wide range of sites.

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[7] Curran and Thompson, 1991.

The variables which will be tested using ANOVA are:

- Crop tree - relative height growth rate, relative diameter growth rate, stocking, density
- Non-crop vegetation
  - All vegetation - cover, modal height
  - Target species - cover, modal height, density (hardwoods only)
  - Tagged target specimen - total height, height increment, sprout number, sprout length, ECW control rating

where relative height (or diameter) growth rate = $(\text{height}_{(x)} - \text{height}_{(x-1)})/\text{height}_{(x-1)}$. Means and standard errors are summarized in tables and boxplots.

11.4 Regression Analysis

For each installation, simple regression models are constructed which relate the performance of crop trees (dependent variable) to a competition index (independent variable). The crop tree performance variables tested include height, height increment, diameter, crown volume, and vigour. The competition indices are calculated according to the non-crop vegetation abundance measures (see Section 3.3.1). The indices are expected to reflect the amount of competition a target crop tree experiences from neighbouring vegetation. The competition indices which will be tested are given in Table 5.

The best models are selected based on the distribution of residuals and the coefficient of determination (r^2).

TABLE 5. Competition indices

Competition index	Description
C_T	Subplot total cover
H_T	Subplot modal height
CH_T	$C_T \times H_T$
CRH_T	CH_T/crop tree height
C_{Sx}	Species specific cover
H_{Sx}	Species specific modal height
D_{Sx}	Species specific density (hardwoods)
CH_{Sx}	$C_{Sx} \times H_{Sx}$
DH_{Sx}	$D_{Sx} \times H_{Sx}$
CRH_{Sx}	CH_{Sx}/crop tree height
DRH_{Sx}	DH_{Sx}/crop tree height

11.5 Contingency Tables

Contingency tables are constructed to investigate relationships among the following categorical variables:

- Crop tree - vigour, condition, damage cause, and competitive status
- Non-crop specimen - condition and damage cause

12 DATA MANAGEMENT

The Research Silviculturists are responsible for data management within their region. The PROBE Contractors must send the Research Silviculturists floppy discs and either originals or clear photocopies of the field forms. The Contractors should retain one copy of all data on file. Results from all installations will be summarized annually, and reports made available through the Research Silviculturists and Stand Tending Coordinators in the Kamloops and Nelson Forest Regions.

Data collected on PROBE forms (PROBE-1, PROBE-2, PROBE-3, and PROBE-4) and Silviculture Survey cards (FS 657 and 658) are entered into a database using PROBE Data Entry System Software, which is an application of Alpha Four (Alpha Software Corporation 1991). The data are analyzed by the Research Silviculturists using SAS programs (SAS Inc. 1985) specifically developed for PROBE. Data collected on Habitat Monitoring forms (EM-1, EM-2, EM-3, EM-5A, EM-5B, EM-5C) are entered and summarized using the Habitat Monitoring Data Base System (Habitat Monitoring Committee 1990).

13 PERSONNEL QUALIFICATIONS

Typically, work can be completed by a two-person crew consisting of one professional and one technician. The professional must have experience in layout of research trials, field forestry sampling, ecosystem classification, and plant identification. Experience in evaluating brushing operations and prescriptions is an asset, and an education background in forestry (e.g., B.S.F. or R.P.F.) or botany (e.g., B.Sc.) is preferred. The technician must be familiar with field forestry sampling.

14 LIST OF MATERIALS

Supplies:

- pressure-treated fence posts (POC and corner posts, 9 per installation)
- 1 m tall rebar (sample plot centres, 72 per installation)
- wooden stakes or pin-flags (gridpoints, 72 per installation)
- blue and red tree-marking paint
- metal tags (~200 per installation)
- wire
- nails or staples
- blue, pink, and yellow or lime-green flagging
- numbered aluminum tags (no. target species $\times$ 72 subplots per installation)
- film (~60 exposures per installation)
- data forms

Equipment:

- compass
- clinometer
- 50 m nylon chain or tape
- hip chain + thread
- calipers
- height pole
- metric scale rule
- 1.78, 2.52 and 3.99 m plot cords
- shovel
- axe
- plant press
- 35 mm camera + wide-angle lens
- whiteboard + felt pen
- clipboard

Maps and references:
- topographic map
- subzone map
- forest cover map
- planting unit map
- site history records
- site identification guide (Lloyd *et al.* 1990; Braumandl and Curran 1992)
- plant guides (e.g., Angove and Bancroft 1983)

APPENDIX 1. Species composition of major vegetation complexes in the southern Interior of British Columbia (from Kimmins and Comeau 1990)

Species composition of major complexes of competing vegetation in the southern Interior (from Kimmins and Comeau 1990). (Zones indicated in parentheses are those in which the complex has limited occurrence.)

Complex	Major species	Biogeoclimatic zone	Sites
Pinegrass	*Calamagrostis rubescens*	IDF, ICH, MS, PPBG, SBS, ESSF	Dry to Fresh
Fireweed	*Epilobium angustifolium*	(IDF), ICH, MS, ESSF	Dry to Wet
Fern	*Athyrium filix-femina* *Dryopteris assimilis* *Pteridium aquilinum*	ICH	Fresh to Wet
Dry Alder	*Alnus viridis* ssp. *sinuata* *Epilobium angustifolium* *Calamagrostis rubescens*	ICH, MS, SBS	Dry to Fresh
Wet Alder	*Alnus viridis* ssp. *sinuata* *Alnus incana* ssp. *tenuifolia* *Rubus parviflorus* *Lonicera involucrata* *Calamagrostis canadensis* *Athyrium filix-femina* *Dryopteris assimilis*	ICH, (MS), ESSF	Wet
Mixed Shrub	*Rubus parviflorus* *Rubus ideaus* *Lonicera involucrata* *Acer glabrum* *Alnus viridis* ssp. *sinuata* *Paxistema myrsinites* *Sambucus racemosa* *Oplapanax horridus* *Menziesia ferruginea* *Salix* spp. *Cornus sericea* *Athyrium filix-femina* *Pteridium aquilinum*	ICH, ESSF	Fresh to Wet
Dry Shrub	*Ceanothus velutinus* *Paxistima myrsinites* *Shepherdia canadensis* *Symphoricarpos albus* *Holodiscus discolor* *Physocarpus malvaceus*	ICH, IDF	Dry to Fresh
Ericaceous Shrub	*Rhododendron albiflorum* *Menziesia ferruginea* *Vaccinium membranaceum*	ICH, IDF	Dry to Moist
Subalpine Herbs	*Valeriana sitchensis* *Luzula* spp. *(Epilobium angustifolium)*	ESSF	Fresh to Wet
Aspen	*Populus tremuloides*	IDF, ICH, MS	Various

APPENDIX 1. (continued)

Complex	Major species	Biogeoclimatic zone	Sites
Cottonwood-Shrub	*Populus balsamifera* *Lonicera involucrata* *Cornus sericea* *Sambucus racemosa* *Rubus parviflorus* *Alnus viridis* ssp. *sinuata* *Alnus incana* ssp. *tenuifolia* *Calamagrostis canadensis*	IDF, ICH	Floodplains
Mixed Hardwood-Shrub	*Populus tremuloides* *Populus balsamifera* *Betula papyrifera* *Salix* spp. *Alnus viridis* ssp. *sinuata* *Alnus incana* ssp. *tenuifolia*	IDF, ICH, MS	Various
Willow	*Salix* spp.	IDF, ICH, MS, ESSF	Moist to Wet
Introduced Grasses	Domestic grasses	(PPBG), IDF, (ICH), MS, (ESSF)	Various

APPENDIX 2. PROBE forms and coding instructions

PROBE Form 1: Project Description

Date:	Year-month-date of original data collection.
Project number:	Number assigned by the project co-ordinator.
Project co-ord.:	Name/position title.
Assessors:	Name/company.
Agency:	Ministry, licensee or other group responsible for the installation.
Region:	Code to designate forest region.
District:	Code to designate forest district.
Mapsheet/opening:	Forest Cover mapsheet and opening number.
Origin:	Target crop tree origin (P=planted, N=natural).
Location:	Brief description of where the installation is located in the geographic area and in the opening, and where the POC is located.
History symbol:	Harvesting, site preparation, planting, and stand tending. Record year and method.
Planting history:	Planting administration number, report number and unit. Date (year and month) trees were planted. Species, seedlot, nursery, stock type and stock size.
Site description:	BGC subzone and ecosystem association (site series). Azimuth (aspect), slope, slope position, elevation, site class. Soil texture, soil type, humus type.
Target species:	Maximum of two crop species. Maximum of five non-crop species.
Subjective evaluation:	Was the treatment effective at reducing competition? Was the treatment effective at improving crop tree performance? Comments.

PROBE Form 1: Project Description

Date:

Project Number:

Project Co-ordinator: Name:

Position Title:

Assessors: Name:

Company:

Agency:

Region: District Map sheet, opening no.: - Origin:

Location:

History symbol:

Planting history:

Planting admin. no.: Report no.: Unit: Date planted:

Species: Seedlot: Nursery: Stock type: Stock size:

Site description:

BGC subzone / ecosystem association: /

Azimuth: Slope: Slope position: Elevation: Site class:

Soil texture: Soil type: Humus type:

Target Species:

Crop species:

Non-crop species:

Subjective evaluation: (Pre-treatment: Is treatment needed? Post-treatment: Was treatment effective?)

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PROBE Form 2: Crop Tree Growth

Date:	Year-month-date of original data collection.
Project number:	Number assigned by the project co-ordinator.
Location:	Geographical area in which the installation is located.
Treatment:	T (Treatment) or C (Control).
Subplot:	Subplot number (1–36).
Species:	Species, identified by first four letters of the genus and first three letters of the species (e.g., *Pseudotsuga menziesii* is PSEUMEN)
Total height:	If terminal bud set, measure to bottom of bud. If not set, measure to base of top whorl. Measured to nearest 1 cm on a metre stick or 10 cm on a height pole.
Leader height:	Measured from base of terminal bud to base of lower node. If terminal bud set, measure current year's height increment. If not set, measure previous year's height increment. Measured to nearest 1 cm on a metre stick, or nearest 10 cm on a height pole.
Crown diameter:	Average of two perpendicular measurements, measured to nearest 1 cm.
Crown length:	Measured from the base of the terminal bud (or top whorl if bud not set) to the bottom of the lowest laterals which support needles or leaves. Measured to nearest 1 cm on a metre stick, or 10 cm on a height pole.
Stem diameter:	Measured at root collar to nearest 0.1 cm using calipers.
Relative height:	Height of crop tree relative to modal height of surrounding vegetation (%).
Competitive status:	See Appendix 3.
Condition/damage:	See Appendix 3. Only record damage cause if it is considered to be a threat to crop tree performance.
Vigour:	See Appendix 3.

PROBE Form 2: Crop Tree Growth

Date: ________ Page __ of __

Project Number: ________ Location: ________ Treatment: ________

Subplot	Tag No.	Species	Total Height (cm)	Leader Height (cm)	Crown Diam. (cm)	Crown Length (cm)	Stem Diam (cm)	Relative Height (%)	Comp. St.	Cond. Foliage	Cond. Leader	Cond. Stem	Damage Cause Animal	Damage Cause [illegible]	Damage Cause Disease	Damage Cause Insect	Vigour

[illegible]

PROBE Form 3: Target Non-crop Vegetation

Date:	Year-month-date of original data collection.
Project number:	Number assigned by the project co-ordinator.
Location:	Geographical area in which the installation is located.
Treatment:	T (Treatment) or C (Control).
Subplot:	Subplot number (1–36).
Species:	In all subplots, percent cover and height are measured for all potentially competitive vegetation, all hardwoods, all shrubs, and all herbs. They are also measured for up to five selected target species. The target species are identified by the first four letters of the genus and first three letters of the species (e.g., *Betula papyrifera* is BETUPAP).
Cover:	Estimated to nearest 5%.
Height:	Modal height is estimated to nearest 10 cm. It is the most frequent height of individuals in the subplot.
Density:	Number of stems in the subplot for hardwoods (> 10 cm tall) only. Hardwoods include *Betula papyrifera, Populus tremuloides*, and *Populus balsamifera* ssp. *trichocarpa*.

PROBE Form 3: Target Non-crop Vegetation Date: Page __ of __

Project Number: Location: Treatment number:

Subplot	Species	Cover (%)	Height (cm)	Density (#/plot)
	ALL			
	HARDWD S			
	SHRUB S			
	HERBS			
	ALL			
	HARDWD S			
	SHRUB S			
	HERBS			
	ALL			
	HARDWD S			
	SHRUB S			
	HERBS			
	ALL			
	HARDWD S			
	SHRUB S			
	HERBS			

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PROBE Form 4: Target Specimens

Date:	Year-month-date of original data collection.
Project number:	Number assigned by the project co-ordinator.
Location:	Geographical area in which the installation is located.
Treatment:	T (Treatment) or C (Control).
Subplot:	Subplot number (1–36).
Species:	Species with woody stems only. The species are identified by the first four letters of the genus and first three letters of the species (e.g., *Betula papyrifera* is BETUPAP).
Distance:	Distance from the main stem of the target crop tree to the main stem (or middle of clump) of the target specimen, measured to nearest dm.
Azimuth:	Azimuth from crop tree to middle of target specimen.
Total height:	Height to top of tree. Measured to nearest 1 cm on a metre stick, or 10 cm on a height pole.
Height increment:	Height increment can be difficult to measure because elongation may not yet be complete and last year's node may be hidden. Where elongation appears to be 80% complete, record the current year's leader height; otherwise record previous year's leader height. Measured to nearest 1 cm on a metre stick, or 10 cm on a height pole.
Sprout number:	Total number of adventitious shoots.
Sprout length:	Average sprout length to nearest 10 cm.
Vigour:	See Appendix 3.
Condition/damage:	See Appendix 3. If two or more damaging agents occur on the same specimen, record the most damaging agent. Only record damage cause if it is considered to be a threat to target specimen performance.
Phenology:	See Appendix 3.
ECW rating:	Linear scale of 0–100, in which 0% is healthy and 100% is dead.

PROBE Form 4: Target Specimens

Date: ______ Page __ of __

Project Number: ______ Location: ______ Treatment number: ______

Subplot	Tag No.	Species	Distance (dm)	Azimuth	Total Ht. (cm)	Leader Height (cm)	Number of Sprouts	Avg. Sprout Length (cm)	Vigor	Cond.			Damage Cause				Phenol.		ECM Rating (%)
										Foliage	Leaf/Shoot	Stem	Animal	Non-biol.	Disease	Insect	Vegetative	Generative	

PROBE Form 5: Photographic Record

Date: Year-month-date of original data collection.

Project number: Number assigned by the project co-ordinator.

Location: Geographical area in which the installation is located.

Treatment: T (Treatment) or C (Control).

Corner photos: Number of the photo taken at each of the four corners in the Treatment and Control plots.

Habitat plot photos

Subplot number: Number of subplot.

Photo number: Photo number (given on slide jacket).

Photo azimuth: Direction of photo.

Location: Location in which the photo was taken relative to the crop tree (distance and azimuth from camera to crop tree).

Probe Form 5: Photographic Record

Date: _____ Page: _____ of: _____

Project Number: _____ Location: _____ Treatment: _____

Corner Photos:

Corner	Photo number
SE	
SW	
NE	
NW	

Habitat Plot Photos:

Subplot number: _____ Photo number: _____ Photo azimuth: _____
Distance/azimuth from camera to crop tree: _____
Crop tree condition: _____
General habitat: _____
Target species: _____
Target species: _____
Target species: _____
Target species: _____
Target species: _____

Subplot number: _____ Photo number: _____ Photo azimuth: _____
Distance/azimuth from camera to crop tree: _____
Crop tree condition: _____
General habitat: _____
Target species: _____
Target species: _____
Target species: _____
Target species: _____
Target species: _____

Subplot number: _____ Photo number: _____ Photo azimuth: _____
Distance/azimuth from camera to crop tree: _____
Crop tree condition: _____
General habitat: _____
Target species: _____
Target species: _____
Target species: _____
Target species: _____
Target species: _____

Subplot number: _____ Photo number: _____ Photo azimuth: _____
Distance/azimuth from camera to crop tree: _____
Crop tree condition: _____
General habitat: _____
Target species: _____
Target species: _____
Target species: _____
Target species: _____
Target species: _____

APPENDIX 3. Codes for competitive status, vigour, condition, damage, phenology, and tree symbols

Competitive Status Codes (from Herring and Pollack 1985)

Competitive status is a qualitative assessment of the height of the target crop tree relative to the height of surrounding vegetation. The three codes are:

1 **Overtopped**. Leader of crop tree is currently overtopped by surrounding vegetation.

2 **Threatened**. Leader of crop tree is roughly equivalent to height of surrounding vegetation. It is likely to be overtopped within two growing seasons.

3 **Free-to-grow**. Leader of crop tree is well above surrounding vegetation and is unlikely to become threatened.

Vigour Codes (from Herring and Pollack 1985)

Crop tree vigour is a qualitative assessment which integrates shoot growth, caliper thickness, leaf area, needle length and foliage colour. The five codes are:

0 **Dead**.

1 **Moribund**. Near death; little or no visible shoot growth.

2 **Poor**. Little or possibly etiolated shoot growth; few and/or short needles; small caliper.

3 **Moderate**. Moderate shoot growth, leaf area, needle length, and caliper.

4 **Good**. Vigorous shoot growth; high leaf area; long needles; deep green colour; thick caliper.

Condition Codes (modified from Herring and Pollack 1985)

Foliage Condition

A	Defoliated
B	Browsed
D	Dead lateral buds
E	Semi-chlorotic
F	Decomposing
G	Galls
H	Healthy
L	Delignification
M	Mottled
N	Necrotic
O	Other
R	Reflushed
V	Stunted needles
Y	Chlorotic

Leader Condition

A	Missing
B	Browsed
C	Curled
E	Etiolated
F	Forked
H	Healthy
N	Not flushed
O	Other
R	Reflushed
S	Broken
T	Dead terminal bud
Z	Stunted needles on leader

Stem Condition

A	Girdled
B	Bent
C	Cut
D	Dead
F	Forked
G	Gall
H	Healthy
K	Crooked
L	Leaning
M	Piece missing (e.g., scar, lateral missing)
O	Other
P	Peeled
S	Smashed, crushed or trampled
U	Buried
Z	Blistered

Damage Cause Codes (from B.C. Ministry of Forests 1989)

Animal Damage

- AB Bear
- AC Cow
- AD Deer
- AE Elk
- AH Hare or rabbit
- AM Moose
- AP Porcupine
- AS Squirrel
- AU Unknown
- AV Vole
- AW Sheep
- AX Bird
- AZ Beaver

Insects

- IA Aphids
- IB Bark beetles
- ID Defoliators
- IP Pitch mass insects
- IS Shoot insects
- IU Unknown
- IW Weevils
- M Mites

Non-Biological

- CV Vegetation competition
- NB Fire
- ND Drought
- NF Flooding
- NG Frost
- NH Hail
- NK Fumekill
- NL Slash/debris
- NR Redbelt
- NS Slide
- NU Unknown
- NW Windthrow
- NY Snow or ice
- TC Chemical
- TD Treatment damage
- TL Logging
- TP Planting
- TR Pruning
- TS Skidroad
- TT Thinning/spacing

Disease

- DA Foliage diseases
- DD Stem rot
- DF Brooming
- DL Leader and branch dieback
- DM Dwarf mistletoe
- DP Bark diseases (superficial)
- DR Root diseases
- DS Stem diseases
- DU Unknown

Phenology Codes (from Dierschke 1972)

Vegetative

Deciduous tree or shrub

0 Closed bud
1 Buds with green tips
2 Green leaf out but not folded
3 Leaf unfolding up to 25%
4 Leaf unfolding up to 50%
5 Leaf unfolding up to 75%
6 Full leaf unfolding
7 First leaves turn yellow
8 Leaf yellowing up to 50%
9 Leaf yellowing over 50%
10 Bare

Conifer

0 Closed bud
1 Swollen bud
2 Split bud
3 Shoot capped
4 Shoot elongate
5 Shoot full length, lighter green
6 Shoot mature, equally green

Generative

Deciduous and conifer

0 Without blossom buds
1 Blossom buds recognizable
2 Blossom buds strongly swollen
3 Shortly before flowering
4 Beginning flowering
5 In bloom up to 25%
6 In bloom up to 50%
7 Full bloom
8 Fading
9 Completely faded
10 Bearing fruit

Tree Symbols (from Lloyd *et al.* 1990)

Scientific name	Common name	Symbol
Abies amabilis	amabilis fir	Ba
Abies lasiocarpa	subalpine fir	Bl
Betula papyrifera	paper birch	Ep
Betula occidentalis	water birch	Ew
Chamaecyparis nootkatensis	yellow-cedar	Yc
Larix lyallii	alpine larch	La
Larix occidentalis	western larch	Lw
Picea engelmannii	Englemann spruce	Se
Picea engelmannii x *glauca*	hybrid white spruce	Sxw
Picea glauca	white spruce	Sw
Picea mariana	black spruce	Sb
Pinus albicaulis	whitebark pine	Pa
Pinus contorta	lodgepole pine	Pl
Pinus monticola	western white pine	Pw
Pinus ponderosa	ponderosa pine	Py
Populus tremuloides	trembling aspen	At
Populus balsamifera ssp. *trichocarpa*	black cottonwood	Act
Pseudotsuga menziesii	Douglas-fir	Fd
Thuja plicata	western redcedar	Cw
Tsuga heterophylla	western hemlock	Hw
Tsuga mertensiana	mountain hemlock	Hm

APPENDIX 4. Silviculture survey forms and coding instructions (from B.C. Ministry of Forests 1989)

FS 657: Silviculture Survey

Only a subset of the information on this form must be completed. That information is listed below under the major section headings. Basic Site Information does not need to be recorded on this form because it is recorded on PROBE-1 and EM-2.

Admin.:

Region, District, location, mapsheet/opening no., administration no. (=PROBE Project Number), examiner, date and history symbol.

Site and Survey Factors:

For objectives of survey, enter PROBE next to ''other.''

Ecological Classification:

BGC zone, subzone, variant, site series, edatopic grid.

Acceptable Tree Characteristics:

List all conifer species occurring within the installation.

Survey Parameters:

For target only, determine from the regional stocking standards the stocking standard/ha, maximum/plot, inter-tree spacing, and minimum stocking standard.

FS 658: Silviculture Survey Plot

Plot no.:	Subplot number (1–36).
Layer:	Planted or natural.
Total trees:	Determine by adding total conifers and hardwood density, which is recorded on PROBE Form 3.
Total conifers:	Total conifer density.
Species:	Record total density of each species in the plot.
Total W:	Number of well-spaced trees.
Total FG:	Number of free-growing trees, as defined in Appendix 3.

FS 659: Silviculture Survey Summary

This form is not used because the data is summarized using PROBE computer programs.

Province of British Columbia Ministry of Forests

SILVICULTURE SURVEY

USE THIS FORM IN THE FIELD TO ESTABLISH SPECIFIC STANDARDS FOR THE SURVEY. RECORD PLOTS ON THE FORM FS 658. SUMMARIZE PLOTS ON FORM FS 659. REFERENCE CARD FS 660 PROVIDES PROCEDURES.

ADMIN.

REGION	DISTRICT	LOCATION		MAP SHEET/OPENING NO.		
ADMINISTRATION NO.		LICENCE NO.	LICENSEE	C.P. NO.	BLOCK	HISTORY SYMBOL
STRATUM	STRATUM AREA (ha)	AIR PHOTO NOS.	EXAMINER	DATE Y M D		

OBJECTIVES OF SURVEY (CHECK APPLICABLE BOX) ☐ STOCKING ☐ PLANTABILITY ☐ FREE GROWING ☐ BRUSHING ☐ OTHER _____

SITE AND SURVEY FACTORS

SITE ELEVATION: MINIMUM _____ MAXIMUM _____ AVERAGE _____ ASPECT _____ SLOPE POS. _____ SLOPE %: MINIMUM _____ MAXIMUM _____ AVERAGE _____

TERRAIN: ☐ EVEN ☐ ROLLING ☐ GULLIED ☐ BROKEN DERIVED SITE CLASS: ☐ GOOD ☐ MEDIUM ☐ POOR ☐ LOW

SOIL LFH (cm) _____ HUMUS FORM _____ SOIL TEXTURE _____ ROOTING DEPTH (cm) _____ SOIL DEPTH (cm) _____ DRAINAGE: ☐ GOOD ☐ FAIR ☐ POOR

COARSE FRAGMENTS: ☐ LOW (< 35%) ☐ MODERATE (35-70%) ☐ HIGH (> 70%)

ECOLOGICAL CLASSIFICATION FOR MOST PREDOMINANT AREA OF STRATUM: BGC ZONE _____ SUBZONE _____ VARIANT _____ SITE SERIES _____ EDATOPIC GRID: Moisture _____ Nutrients _____

ACCEPTABLE TREE CHARACTERISTICS

CHECK (√) STATUS: A = ACCEPTABLE, U = UNACCEPTABLE	A	U	SPECIES	SIZE/AGE	QUALITY (Condition, Free-Growing Criteria)

SURVEY PARAMETERS		STOCKING STANDARD/ha	MAXIMUM PLOT	INTER-TREE SPACING IDEAL	INTER-TREE SPACING MINIMUM	MINIMUM STOCKING STANDARD	DISTANCE BETWEEN PLOTS	m	LINES	m
To assess well-spaced trees or spots	TARGET					WELL-SPACED STEMS/ha	PLOTS	RADIUS	m	
	PLANTING							AREA	m²	
	EXPECTED SURVIVAL %	PLANTING STOCKING STANDARD =	TARGET STOCKING STANDARD / EXPECTED SURVIVAL RATE (%)			+ NATURAL FILL-IN RATE (stems/ha) =		MULTIPLIER		

FILE ORIGINAL IN DISTRICT OFFICE ON OPENING FILE

FS 657 H(2) 90/4

Province of British Columbia Ministry of Forests

BASIC SITE INFORMATION

INFORMATION ESTIMATED DURING INITIAL WALK THROUGH OF STRATUM

DESCRIPTION OF ACCEPTABLE PLANTABLE SPOTS

SCREEFING DEPTH _____ (cm) SCALP SIZE _____ × _____ (cm) ACCEPTABLE PLANTING MEDIUM _____

TREE SPECIES PLANTERS MUST RECOGNIZE _____ MINIMUM HEIGHT FOR TREES TO BE VISIBLE _____ (cm) PLANTING DIFFICULTY (from FS 660 and 703): ☐ EASY ☐ MODERATE ☐ DIFFICULT ☐ SEVERE

VISUAL ESTIMATE OF SITE CONDITIONS

ESTIMATED SLASH COVER _____ % AVERAGE SLASH HEIGHT _____ (cm)

SLASH CLASS: ☐ HIGH ☐ MEDIUM ☐ LOW ☐ NIL

SLASH DISTRIBUTION: ☐ CONTINUOUS ☐ PATCHY ☐ SCATTERED

ESTIMATED BRUSH COVER _____ % AVERAGE BRUSH HEIGHT _____ (cm)

BRUSH SEVERITY: ☐ HIGH ☐ MEDIUM ☐ LOW ☐ NIL

BRUSH DISTRIBUTION: ☐ CONTINUOUS ☐ PATCHY ☐ SCATTERED

SNAGS: ESTIMATED DENSITY _____ /ha

WORK HAZARD: ☐ HIGH ☐ MEDIUM ☐ LOW ☐ NIL

MACHINE TRAFFICABILITY: ☐ GOOD ☐ MEDIUM ☐ LOW ☐ NIL

SOIL COMPACTION HAZARD: ☐ HIGH ☐ MEDIUM ☐ LOW ☐ NIL

INDICATE THE PRESENCE OR ABSENCE OF THE FOLLOWING:

WATER BODIES	☐ YES ☐ NO	TYPE	
HIGH WATER TABLE	☐ YES ☐ NO	DEPTH	
FISHERIES VALUES	☐ YES ☐ NO	TYPE	
WILDLIFE VALUES	☐ YES ☐ NO	TYPE	
RANGE USE	☐ YES ☐ NO	TYPE	
PEST DAMAGE	☐ YES ☐ NO	TYPE	
RECREATION VALUES	☐ YES ☐ NO	TYPE	
OTHER RESOURCE VALUES	☐ YES ☐ NO	TYPE	

ACCESS

	LAND				AIR			WATER
	2WD	4WD	ATV	WALK	FLOAT	LAND	HELI	
DISTANCE								
	(km)				(hrs.)			(km)

TRAVEL TIME

_____ HOURS FROM _____ (Location)

POTENTIAL ROAD CONSTRUCTION AND MAINTENANCE PROBLEMS (Show details on map)

SLIDE - Width _____ (m) CULVERTS Number Length Diameter

WASHOUT - Length _____ (m) _____ _____ _____

NEW ROAD - Length _____ (m) _____ _____ _____

ACCOMMODATION ☐ HOTEL ☐ CAMPSITE (NAME) _____ ☐ NONE ☐ OTHER _____

OTHER (DESCRIPTION OF MAJOR LIMITING SITE FACTORS, TREATMENT OBJECTIVES AND INSAMBY PEST OR SITE PROBLEMS)

FS 657 H(3) 90/4

Province of British Columbia Ministry of Forests

SILVICULTURE SURVEY PLOT

Page _____ of _____

REPORT NO. | SURVEY TYPE | OPENING NO. | STRATUM | POINT OF COMMENCEMENT | LINE

BEARING (AZIMUTH)	PLOT NO.	EAV LAYER	TOTAL TREES	TOTAL CONIFERS	WELL-SPACED SPECIES						TOTAL W	TOTAL FG	LEADER HEIGHT (m)	TOTAL HEIGHT (cm)	AGE (yrs)	PLANTABLE	PREPARABLE	COMPETING VEGETATION SPECIES	% COVER	HEIGHT (m)	COMMENTS

COMMENTS: (prescriptions, snags, watercourses, wildlife, stand damage, etc.)

DATA ON THE LEADER HEIGHT, TOTAL HEIGHT AND AGE OF WELL SPACED TREES, MAIN COMPETING VEGETATION AND INVENTORY COMPONENT SHOULD BE RECORDED ON THE FIRST PLOT ESTABLISHED IN THE STRATUM, AND EVERY FOURTH PLOT THEREAFTER. PEST TYPE, INCIDENCE AND SEVERITY SHOULD BE NOTED IN THE COMMENTS SECTION, WHEN OBSERVED.

FS 656 SIL 90/4

APPENDIX 5. Habitat monitoring forms (from Habitat Monitoring Committee 1990)

Province of British Columbia
Ministry of Forests
Ministry of Environment

PROJECT DESCRIPTION FORM (EM-1)

(FOR USE WITH THE "PROCEDURES FOR HABITAT MONITORING MANUAL")

PROJECT IDENTIFICATION

(1) PROJECT ID NAME

2. PROJECT ID NUMBER

(3) PROJECT COORDINATOR

4. STARTING DATE Y M D

(5) AGENCIES

PROJECT LOCATION

(6) NTS SHEET NTS SHEET OR BCGS (Forest Cover) Map No. BCGS (Forest Cover) Map No.

(7) MoE Sub-region Management Unit / Subunit

(8) MoF District Name Code Stock Range Name Code

Range Unit Name Code Pasture Name Code

9. GEOGRAPHIC LOCATION

PROJECT GOALS AND OBJECTIVES

10. SITE HISTORY

(11) PROJECT GOALS (enter letters by priority, followed by species codes; maximum of 4)

PRIORITY 1
PRIORITY 2
PRIORITY 3
PRIORITY 4

A. Improve suitability for wildlife
B. Improve suitability for livestock
C. Improve suitability for timber
D. Reduce fire hazard
E. Other (specify in Comments)

(12) PROJECT OBJECTIVES (enter letters by priority; maximum of 4)
PRIORITY 1 PRIORITY 2 PRIORITY 3 PRIORITY 4

A. Increase forage quantity
B. Increase forage quality
C. Increase forage availability
D. Change plant species composition
E. Alter range condition
F. Remove decadent plant material
G. Stimulate sprouting/suckering
H. Increase or maintain snow interception cover
I. Increase thermal cover
J. Increase security cover
K. Reduce volatile fuels
L. Improve animal movement
M. Stimulate germination/seedlings
N. Improve conifer release
O. Increase timber growth rate
P. Reduce tree stocking (stems/hectare)
Q. Open forest canopy
R. Assess forage utilization
S. Assess herbicide effects
T. Control erosion
U. Provide nesting habitat
V. Other (specify in Comments)

(13) HABITAT TECHNIQUE UTILIZED (enter letters by priority; maximum of 4)
PRIORITY 1 PRIORITY 2 PRIORITY 3 PRIORITY 4

A. Prescribed burning
B. Livestock grazing - season-long
C. Short duration grazing
D. Rest rotation grazing
E. Deferred rotation grazing
F. Reverse rotation grazing
G. No livestock grazing
H. Slashing
I. Site Rehabilitation
J. Juvenile spacing
K. Precommercial thinning
L. Commercial thinning
M. Coppice
N. Improvement cut (sanitation)
O. Selection cut
P. Shelterwood cut
Q. Seed tree cut
R. Clearcut
S. Tillage and scarification
T. Seeding and planting
U. Fertilizer application
V. Herbicide application
W. Water level manipulation
X. Other (specify in Comments)

PROJECT SUMMARY

(14) SIZE OF TREATMENT AREA ha 15. TOTAL PROJECT COST

16. COMPLETION DATE Y M D 17. SUMMARY / EVALUATION REPORT Available Date Y M

18. COMMENTS

FS 1169 H-R 91/1
ENV 2061

○ = mandatory for data system

Province of British Columbia
Ministry of Forests
Ministry of Environment

SERIES ☐☐ FORM ☐☐☐☐☐

SITE DESCRIPTION FORM (EM-2)

(FOR USE WITH THE "PROCEDURES FOR HABITAT MONITORING MANUAL")

PROJECT IDENTIFICATION AND SAMPLING

① DATE Y M D ① PROJECT ID Name Number

③ SURVEYOR ④ SITE NO.

⑤ SAMPLING (circle appropriate technique, type and timing)

Technique
- A. Reconnaissance with single macroplot only
- B. Reconnaissance with single macroplot and nested microplots
- C. Multiplot with macroplots only
- D. Multiplot with macroplots and nested microplots

Type
- A. Control
- B. Treatment

Timing (measurement number) ☐
- 0. Initial measurement pre-treatment
- 1. First measurement post-treatment
- 2. Second measurement post-treatment
- 3. Third measurement post-treatment

LOCATION OF TIE POINT AND TIE LINE

6. TIE POINT LOCATION: PHOTO NO. and COORDINATES
Flight Line Photo # X Y

7. TIE POINT COMMENTS

8. TIE LINE BEARING ° 9. TIE LINE DISTANCE m

SAMPLE LOCATION (MACROPLOT 1)

⑩ NTS SHEET ⑪ BCGS (Forest Cover) Map No. Polygon No. ⑫ MACROPLOT RADIUS m

⑬ UTM SYSTEM
Zone Easting Northing

14. MACROPLOT LOCATION: PHOTO NO. AND COORDINATES
Flight Line Photo # X Y

MULTIPLOT DETAILS

15. STRIP BEARING ° ⑯ MACROPLOT INTERVAL (distance between plots) m 17. SAMPLE STRIP COMMENTS

⑱ NUMBER OF MICROPLOTS per MACROPLOT 19. MICROPLOT RADIUS m 20. PHOTOGRAPHIC RECORD

BIOPHYSICAL DESCRIPTION

		MACROPLOT # 1	MACROPLOT # 2	MACROPLOT # 3	MACROPLOT # 4
㉑ ASPECT (°)					
㉒ SLOPE (%)					
㉓ ELEVATION (m)					
㉔ ECOLOGICAL MOISTURE REGIME (see ✱)					
25. SURFACE SUBSTRATE (% cover)	decaying wood				
	bedrock				
	cobbles & stones				
	mineral soil				
	organic matter				
	water				
	TOTAL	100%	100%	100%	100%

✱ ECOLOGICAL MOISTURE REGIME

A. very xeric
B. xeric
C. subxeric
D. submesic
E. mesic
F. subhygric
G. hygric
H. subhydric
I. hydric

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ENV 2062

Ⓞ = mandatory for data system

26. SITE POSITION MACRO

A. apex
B. face
C. upper slope
D. middle slope
E. lower slope
F. valley floor
G. plain

27. SITE SURFACE SHAPE

A. concave
B. convex
C. straight

28. TERRAIN CLASSIFICATION

A. mapped
B. field interpreted
Year

1.						
2.						
3.						

29. BIOGEOCLIMATIC CLASSIFICATION Zone Sub Var Ph

30. SITE ASSOCIATION Assoc S Type P

31. FOREST COVER MAP Primary Species Secondary Species *Age Class

*Height Class *Stocking Class *Canopy Closure *Site Class

32. ECOLOGICAL CLASSIFICATION Ecoregion Ecosection

Biophysical Habitat Class Phase

33. SOIL CLASSIFICATION Year Soil

A. mapped
B. field interpreted

Percent (x 10)	Classification	Texture	Drainage

34. WILDLIFE CAPABILITY Map Year
Capability Rating

Winter Range Capability Rating
Summer Range Capability Rating
Environmental Conditions

HERBACEOUS STANDING CROP

MACROPLOT(MA) NO.	MA 1				MA 2			
MICROPLOT(MI) NO.	MI 1	MI 2	MI 3	MI 4	MI 1	MI 2	MI 3	MI 4
35. PRODUCTION ESTIMATE (g)								
36. PRODUCTION CLIPPED (g)								

MACROPLOT(MA) NO.	MA 3				MA 4			
MICROPLOT(MI) NO.	MI 1	MI 2	MI 3	MI 4	MI 1	MI 2	MI 3	MI 4
35. PRODUCTION ESTIMATE (g)								
36. PRODUCTION CLIPPED (g)								

*AGE CLASS
1. 1-20 years
2. 21-40
3. 41-60
4. 61-80
5. 81-100
6. 101-120
7. 121-140
8. 141-250
9. 251+

*CANOPY CLOSURE
0. 0-5%
1. 6-15
2. 16-25
3. 26-35
4. 36-45
5. 46-55
6. 56-65
7. 66-75
8. 76-85
9. 86-95
10. 96-100(+)

*HEIGHT CLASS
1. 0-10.4 m
2. 10.5-19.4
3. 19.5-28.4
4. 28.5-37.4
5. 37.5-46.4
6. 46.5-55.4
7. 55.5-64.4
8. 64.5+

*SITE CLASS
L=LOW
P=POOR
M=MEDIUM
H=HIGH

*STOCKING CLASS
(see Table 11 in Manual)

37. COMMENTS

Province of British Columbia
Ministry of Forests
Ministry of Environment

VEGETATION DESCRIPTION FORM (EM-3)

(FOR USE WITH THE "PROCEDURES FOR HABITAT MONITORING MANUAL")

SERIES ☐☐ FORM ☐☐☐☐☐

① DATE Y M D ② PROJECT ID Name Number

⑦ SPECIES LIST (circle one)
A. vascular and non-vascular plants (complete)
B. vascular only (complete)
C. partial list

3. SURVEYOR ④ SITE NO. ⑤ TIMING (Mass. No.) ⑥ MACROPLOT NO.

9. STRATUM	A0 VETERAN	A1 DOMINANT TREES	A2 MAIN CANOPY	A3 TREES	A TOTAL TREES	B1 TALL SHRUBS	B2 LOW SHRUBS	B TOTAL SHRUBS	C HERBS	D MOSSES, LICH, LIV. SEEDLINGS	Z ALL STRATA	10. OPTIONAL ATTRIBUTES
FIELD NAME OR COLLECTION # / 8. ENTRIES: CENSUS, SPECIES, ☐	P P D V	P P D V	P P D V	P P D V	P P D V	P P D V	P P D V	P P D V	P P D V	P P D V	P P D V	
11. TOT. % COV.												
12. STRAT. HT.	*	*	*	*	*	*	*	*	*	*	*	*
13. DEAD TREE												
14. COMMENT 1												
COMMENT 2												

FS 1171 HR 91/1
EN/2083

○ = mandatory for data system

Province of British Columbia
Ministry of Forests
Ministry of Environment

SERIES ☐☐ FORM ☐☐☐☐☐

HERBICIDE / FERTILIZER FORM (EM-5A)

(FOR USE WITH THE "PROCEDURES FOR HABITAT MONITORING MANUAL")

PROJECT IDENTIFICATION AND SAMPLING

① DATE Y M D ② PROJECT ID Name Number

③ SURVEYOR ④ SITE NO ⑤ TREATMENT APPLIED
A. herbicide
B. fertilizer

⑥ KEY PLANT SPECIES Plants Tagged ☐
Primary
Secondary

⑦ CONTROL AREA DESIGNATED ☐

8. PROJECT COMMENTS

HERBICIDE OR FERTILIZER USED

⑨ CONTRACTOR

CHEMICAL COMPOSITION Trade Name Composition

⑩ ACTIVE INGREDIENT (a.i.)

11. CARRIER
A. water
B. oil
C. other (specify in Comments)

12. OTHER ADDITIVES ⑬ ACTUAL TREATMENT AREA ha

APPLICATION DETAILS (complete 14, 15 OR 16)

14. SPOT HERBICIDE APPLICATION
Method
A. foliar
B. ground
C. stem injection
D. cut stump
E. spot-gun
F. other (specify in Comments)

Equipment Make/Model
Mix Concentration: Active Ingredient g/l or % Grid Size m
Additive g/l or %
Spray Mix Coverage: ml / spot Prescribed Application Rate: g of a.i. / spot

15. BROADCAST HERBICIDE APPLICATION
Method
A. helicopter
B. fixed wing
C. tanker truck
D. other (specify in Comments)

Equipment Make/Model
Mix Concentration: Active Ingredient g/l or %
Additive g/l or %
Application Ground Speed km / h Flying Height m Swath Width m
Sprayer Output l / min Spray Mix Coverage l / ha Application Rate kg of a.i. / ha

16. FERTILIZER APPLICATION
Method
A. helicopter
B. fixed wing
C. tanker truck
D. manual
E. other (specify in Comments)

Equipment Make/Model
Prescribed Application Rate kg / ha Actual Application Rate kg / ha

⑰ APPLICATION COVERAGE:
Missed Areas
A. none missed
B. slightly missed
C. significant portions missed

Overlap Areas
A. no overlap
B. slight overlap
C. significant overlap

18. APPLICATION COMMENTS

FS 1173A HER 91/1 - ext
ENV 2065A

○ = mandatory for data system

ENVIRONMENTAL CONDITIONS DURING APPLICATION

19. TEMPERATURE
at start ___ °C
at finish ___ °C

20. HUMIDITY
at start ___ %
at finish ___ %

21. WIND Speed ___ km / h Direction ___ °

22. PRECIPITATION DURING PREVIOUS WEEK Type: A. none B. rain C. snow Amount ___ mm Date(s) M D, M D

23. PRECIPITATION ON DATE OF APPLICATION Type: A. none B. rain C. snow Amount ___ mm

24. PRECIPITATION DURING FOLLOWING WEEK Type: A. none B. rain C. snow Amount ___ mm Date(s) M D, M D

25. FOLIAGE MOISTURE CONDITION: A. dry B. slightly wet C. wet

26. SOIL SURFACE CONDITION: A. dry B. wet C. frozen D. snow-covered

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SERIES ☐☐ FORM ☐☐☐☐☐

HERBICIDE IMPACT ASSESSMENT (EM-5B)

(FOR USE WITH THE "PROCEDURES FOR HABITAT MONITORING MANUAL")

(27) DATE Y M D (28) PROJECT ID Name Number

(30) SITE NO.

(29) SURVEYOR (31) TIMING (Measurement No.)

MACRO-PLOT	(32) ENTRIES			(33) IMPACT CATEGORY												34. MACROPLOT COMMENTS
				0		1		2		3		4		5		
	GENUS	SPECIES	C.S.	DOT COUNT	NO.	DOT COUNT	NO.	DOT COUNT	NO.	DOT COUNT	NO.	DOT COUNT	NO.	DOT COUNT	NO.	
PLOT 1																
PLOT 2																
PLOT 3																
PLOT 4																

		35. SAMPLE STRIP SUMMARY												TOTAL STEMS	36. SAMPLE STRIP COMMENTS
		%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	NO.	
SPECIES TOTALS AND PER-CENT															

FS 11708 HR 811 - wet
ENV 20653

☐ = mandatory for data system

Province of British Columbia
Ministry of Forests
Ministry of Environment

SERIES | | FORM | |

HERBICIDE RECOVERY ASSESSMENT (EM-5C)

(FOR USE WITH THE "PROCEDURES FOR HABITAT MONITORING MANUAL")

(37) DATE Y M D

(38) PROJECT ID Name Number

(39) SURVEYOR

(40) SITE NO.

(41) TIMING (Measurement No.)

MACRO-PLOT	(42) ENTRIES			(43) RECOVERY CATEGORY																44. MACROPLOT COMMENTS
				STEM CATEGORY								BASAL CATEGORY								
				0		1		2		3		0		1		2		3		
	GENUS	SPECIES	C.S.	DOT COUNT	NO.	DOT COUNT	NO.	DOT COUNT	NO.	DOT COUNT	NO.	DOT COUNT	NO.	DOT COUNT	NO.	DOT COUNT	NO.	DOT COUNT	NO.	
PLOT 1																				
PLOT 2																				
PLOT 3																				
PLOT 4																				

		45. SAMPLE STRIP SUMMARY																TOTAL STEM	TOTAL BASAL
		%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	NO.	NO.
SPECIES TOTALS AND PER-CENT																			

46. SAMPLE STRIP COMMENTS

FS 1170C HIR 91/1 - wet
ENV 2065C

○ = mandatory for data system

APPENDIX 6. Fuel Assessment form and tally rules (from Trowbridge *et al.* 1986)

Fuel Assessment Form

This form is completed according to procedures described by Trowbridge *et al.* (1986), with the following modifications:

Unique no: PROBE installation number

Plot: T (Treatment).

Line: Lines A, B, and C correspond to gridlines 1, 2, 3, respectively. Another copy of the form is required for gridlines 4, 5, and 6.

Depths: Pre-burn depth of mosses and litter (cm), depth of burn (cm), and post-burn duff depth (cm) are measured at 24 depth-of-burn pins located along each line (i.e., 6 gridpoints $\times$ 4 pins per gridpoint). Assume that 5 m, 10 m, 15 m, etc. correspond with gridpoint 1, 2, 3, etc., respectively. Enter depths for North/South pins under ‘‘in’’ and for East/West pins under ‘‘out.’’

Plot diagram: Ignore this diagram.

Slope: Measured at the beginning of each gridline.

Tally Rules (summarized from Trowbridge *et al.* 1986).

Tally rules that apply to all size classes are described in detail by Trowbridge *et al.* (1986). In brief, the eight rules are:

1. All pieces must be *downed, dead* woody material.
2. Where the gridline intersects the end of a piece, count the piece only if the line crosses its central axis.
3. Where the gridline *exactly* intersects the central axis of the end of a piece, tally every other such piece.
4. Where the central axis of a piece coincides *exactly* with the gridline, do ***not*** tally the piece.
5. Where the gridline intersects a curved or angular piece more than once, tally each intersection.
6. Where a piece has been shattered or is rotten, estimate its original diameter.
7. Tally a stump or root only if it is uprooted and not encased in soil.
8. Tally only those pieces whose central axis is above the F and H layers at the point of gridline intersection.

Unique No. P _ _ _ _ _ _ _ _ _ _ Plot ____

FUEL ASSESSMENTS

(Sections 4.4 and 6.1 in Handbook)

Recorded by Pre-fire _____ Date Pre-fire _____

Post-fire _____ Post-fire _____

Line		Species and diameters of slash pieces larger than 7 cm in diameter (indicate location of 5, 10, 15, 20 and 25 m marks)
A	Pre	sp
		dia
	Post	dia
B	Pre	sp
		dia
	Post	dia
C	Pre	sp
		dia
	Post	dia

Intersections by pieces smaller than 7 cm

class	0-0.5	0.6-1.0	1.1-3.0	3.1-5.0	5.1-7.0
length	5 m	10 m	15 m	20 m	25 m
A Pre					
A Post					
B Pre					
B Post					
C Pre					
C Post					

Species composition of slash < 7 cm

Species																							
Line A																							
Line B																							
Line C																							

Pre-burn depth of mosses and litter (cm)

Line	5 m		10 m		15 m		20 m		25 m	
	in	out	in	out	in	out	in	out	in	out
A										
B										
C										

Mineral soil exposure

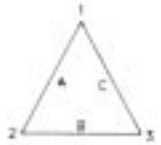
	A	B	C
pre-burn			
post-burn			

Depth of burn (cm)

A																							
B																							
C																							

Plot diagram

direction ⟷



slope

1 → 2 = %

2 → 3 = %

3 → 1 = %

Notes

Post-burn duff depth (cm)

Line	5 m		10 m		15 m		20 m		25 m	
	in	out	in	out	in	out	in	out	in	out
A										
B										
C										

APPENDIX 7. MSP Soil Disturbance Survey forms and Soil Disturbance Categories (from Curran and Thompson 1991, unpubl.)

1-MSP: Gridpoint-Intercept Survey

This form is completed according to procedures described by Curran and Thompson (1991, unpubl.), with the following modifications:

Treatment Unit (TU): T (Treatment) or C (Control).

TU size: Size of T and C plots (e.g., 0.80 ha)

Grid spacing: Ten metres between gridpoints, 1 m from gridpoint to point observation.

Gridpoint: Thirty-six gridpoints are evaluated in each T and C.

Slope: Measure slope at the beginning of each gridline. Enter the value at the appropriate gridpoint (e.g., 1, 7, 13, etc.).

Point observations: Four point observations of soil disturbance are made at each gridpoint. The points are located 1 m in each cardinal direction from the gridpoint. Provide comments, if necessary. Refer to ''Soil Disturbance Categories for MSP Areas'' in this Appendix.

Soil Disturbance Categories for MSP areas (Curran and Thompson 1991, unpubl.)

Object	Code	Description		
Most severe disturbance types				
Traversed	T	Traverse method disturbance: disturbance that would be measured by the traverse method (i.e., all types of haul roads regardless of whether they are being traversed or not, landings, fire guards, and backspur trails).		
Skidroad	R	Skidroad cutbank or running surface.		
	B	Skidroad berm/sidecast (counted to points where it is continuously 5 cm deep in mineral soil; 15 cm in woody debris).		
Heavy Machine Traffic		Soil type	Depth criteria	Disturbance type count
			(into mineral soil)	
	1	Cohesive	5–10 cm	High impact machine traffic, Wheel/ track impressions and rutting
	2	Cohesive	>10 cm	High impact machine traffic, Wheel/ track impressions and rutting
	3	Non-cohesive sandy[a]	>15 cm	High impact machine traffic displacement
			(into organic layer)	
	4	Organic	>20 cm	High impact machine traffic rutting

APPENDIX 7. (continued)

Object	Code	Description
MSP[b]	W	Wide Gouge: ≥5 cm deep gouge into mineral soil (over 80% of its area) that is >2 m in diameter in any orientation from the point.
	G	Deep Gouge: ≥30 cm deep gouge into the mineral soil at the point, regardless of length or width.
	S[c]	Wide Scalp: a 2.0 m diameter patch (or larger), where the forest floor has been removed from over 80% of the area in any orientation from the point.
	C[c]	Continuous Gouge: ≥5 cm deep gouge (at any place in the gouge's cross-section where the point lies) into the mineral soil that is >1.5 m **along one of its axes**, length or width in any orientation from the point.
Other	O[d]	Other types of disturbance. Minor scalps and gouges which do not fit into any of the above categories. **Light skidding disturbance should be classified as MSP disturbance or "L."**

Light Machine Traffic	Soil type	Depth criteria	Disturbance type count
L[d]	All	< above criteria	Light machine traffic disturbance not meeting any other criteria in this table (i.e., wheel/track impressions with intact forest floor and depth less than criteria for "1" or "2").

Less Severe and Possibly Beneficial Disturbance Types

	P[e]	Piles of slash debris that are not associated with landings (which are Traversed disturbance) and are 3.0×3.0 m or larger in size, greater than 50 cm deep, and less than 33% mineral soil. For example, piles and windrows form rough-bunching or windrowing.
	D[e]	Deposits: deposits and mixtures of forest floor and mineral soil that are not the sidecast of bladed structures such as haul roads, landings, and skidroads. Piles that are greater than 33% mineral soil are counted as Deposits.
Undisturbed	"-"	A forest floor with no mineral soil exposed or any impression from machine travel. Also includes surfaces beneath stumps or large coarse fragments, or natural bedrock surfaces. If an assessment beneath slash or large logs is possible, then it is made. Otherwise, these surfaces are recorded as undisturbed.

[a] "Non-cohesive sandy soils" have a very weak moist cast which is non-sticky and will not form a moist worm ≤4 mm (i.e., S, LS, and some SL textures).

[b] Classify disturbance based on the soil disturbance at the point. For MSP disturbance types, when the point lands on a scalp or gouge, assess the overall soil condition to see if it meets the spatial categories "W," "S," or "C."

[c] Disturbance categories counted as detrimental on more sensitive sites.

[d] The "Other" and "L" categories for MSP are different from "Other" and "L" categories in Field Guide Insert No. 5, "Measuring Soil Disturbance Following Timber Harvest."

[e] Disturbance categories not counted in MSP guidelines.

[-] Used for undisturbed so that these can appear as a horizontal line on the survey form.

Note: When a point can be classified into more than one category, place it in the most severe. (This table is ranked in order of severity from top to bottom.)

3A-MSP: Calculation Card Gridpoint-Intercept

This form is completed according to procedures described by Curran and Thompson (1991, unpubl.), with the following modifications:

Treatment unit: T (Treatment) or C (Control).

Transect: Corresponds with gridline, of which there are six in a Treatment unit.

Category tallies: For each gridline (transect), tally the number of point observations in each category. There are 24 point observations (6 gridpoints×4 observations/gridpoint) in each gridline (6 gridpoints/gridline).

Calculation procedure:

1. Enter the number of point observations (not gridpoints).
2. Calculate the mean number of points for each category (n=6).
3. Calculate the standard deviation (n=6).
4. Calculate the Mean% as: (Mean/24)×100.

Province of British Columbia | Ministry of Forests | Soil Disturbance Survey (Form 1-MSP) | Gridpoint-Intercept Survey

Surveyor	Date	BCGS opening	License/license #	CP	Block	TU

Block or TU size (ha)	Grid spacing (m)

		Point observations				
Grid point	**Slope**	North	South	East	West	Comments

Province of British Columbia | Ministry of Forests | Soil Disturbance Survey (Form 3A-MSP) | Calculation Card Gridpoint-Intercept

Surveyor	Date	BCGS opening	
License/license #	CP	Block	Treatment unit

Category Tallies																
Transect	R	B	1	2	3	4	L	O	T	W	G	C	S	P	D	-
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																
22																
23																
24																
25																
26																
27																
28																
29																
30																

MEAN																
STD																
MEAN %																

Calculation Procedure

1. Enter the number of gridpoints.
2. Enter the MEAN number of points calculated for the tally sheet.
3. Enter the STD calculated on the tally sheet.
4. Calculate MEAN %.

APPENDIX 8. Analysis of Variance table

ANOVA for a randomized complete block design with three replications

Source	df		SS	MS	F
Total	$pr-1$	5	SSTot		
Block	$r-1$	2	SSR	MSR	FR
Treatment	$p-1$	1	SSTr	MSTr	FTr
Error	$(r-1)(p-1)$	2	SSE	MSE	FE

r=block=3
p=treatment=2

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