Government of Canada	Gouvernement du Canada

Canadian Forestry Service	Service canadien des forêts

22149	Sutherland, B.J.	1986

PDF

STANDARD ASSESSMENT PROCEDURES FOR EVALUATING SILVICULTURAL EQUIPMENT: A HANDBOOK

B.J. Sutherland

GREAT LAKES FORESTRY CENTRE
CANADIAN FORESTRY SERVICE
GOVERNMENT OF CANADA
1986

Canada

Catalogue No. Fo42-92/1986E
ISBN 0-662-15003-1

Additional copies of the text of this handbook are available at no charge from:

Communications Services
Great Lakes Forestry Centre
Canadian Forestry Service
Government of Canada
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7

ABSTRACT

This report provides step-by-step data collection and compilation instructions for documenting pretreatment site conditions, conducting detailed work studies of most mechanized silvicultural operations, and assessing the results of site preparation and planting operations. Examples and sample calculations are provided.

RÉSUMÉ

Le rapport indique, point par point, comment recueillir et rassembler les données nécessaires pour décrire les conditions des sites en vue de leur traitement préalable, effectuer des études détaillées reliées à la plupart des opérations sylvicoles mécanisées et évaluer les résultats des travaux de préparation des sites et de plantation. Des exemples et des modèles de calcul sont fournis.

ACKNOWLEDGMENTS

The author gratefully acknowledges the assistance of the following: C.R. Smith, J-D. Leblanc, F.F. Foreman and D.J. Kennington of the Mechanization of Silviculture Unit at the Great Lakes Forestry Centre (GLFC); L.F. Riley, Research Manager, Forest Resources, GLFC; former GLFC staff member D.A. Cameron; and M. Ryans of the Forest Engineering Research Institute of Canada.

TABLE OF CONTENTS

(cont'd)

TABLE OF CONTENTS (cont'd)

(cont'd)

TABLE OF CONTENTS (concl.)

INTRODUCTION

As the variety and complexity of silvicultural equipment increases, it becomes more difficult for the forest manager to decide upon the appropriate tool to meet his/her objectives. Because of soaring equipment costs and the increasing pressure to regenerate larger areas more efficiently it is critical that all equipment decisions be supported by sound technical information. Such information must be based on equipment performance under defined conditions and with standardized measurements. Therefore, the widespread use of standardized and systematic Canadian silvicultural equipment evaluation procedures is highly desirable. Such procedures, the Standard Assessment Procedures for Evaluating Silvicultural Equipment (SAP), have been developed by the Great Lakes Forestry Centre (GLFC) of the Canadian Forestry Service (CFS). Information generated by these procedures enables the comparison of equipment in quantitative terms, permits the comparison of results with site preparation prescriptions, and promotes the improvement of operations through better use of existing machinery or the development of new machinery.

A preliminary version of SAP was first developed by GLFC staff in the early 1970s. Since then the procedures have been modified to incorporate elements of other proven and widely used systems (Anon. 1969, Berard et al. n.d.). In addition to being consistent with other equipment evaluation systems, SAP can be adapted for use in all eight forest regions of Canada (Rowe 1972). The procedures are designed to obtain information with minimum effort while preserving accuracy. In its simplest form, SAP involves recording, before treatment, site conditions that are likely to affect and/or be changed by the equipment, recording, through work study, the events of the treatment operation, and recording the results obtained in relation to the objectives of the treatment.

Use of SAP to obtain the necessary information on short-term operational trials is described. Step-by-step instructions are included in the Appendices, along with tally sheet formats. The pretreatment and work study sections are generally applicable to most mechanized silvicultural operations; the post-treatment assessment provides examples of procedures for assessing the results of scarification and tree planting operations.

PRETREATMENT ASSESSMENT

Factors recorded in the pretreatment survey are those that may affect forward progress of the equipment and its ability to function as a silvicultural implement. The following parameters are generally acknowledged as being the most important: residual tree stem diameter and frequency;

brush and minor vegetation type and frequency; stump diameter, height, frequency, age and species; slash weight or volume and age; soil type, depth, and stoniness; duff depth; soil moisture; and slope. In addition, two other categories of measurement are used: ground condition and roughness, which are adapted from the Swedish system of terrain classification (Anon. 1969). Ground condition is based on the parameters of soil moisture, soil type, and stone content. Ground roughness is based on height and frequency of obstacles. Appendix I contains information on pretreatment assessment; calculation of slash loading; tally rules for the line-intersect slash measurement; and determination of ground roughness. Formulae, tables and graphs required for calculations are presented.

On the assumption that the forest manager is interested in determining how well a tool can treat one or more representative site types, the objective of the pretreatment assessment is to describe each test site or block with sufficient accuracy to achieve a reliable estimate of both the average and the range of site conditions. A test block may have to be divided into strata when major variations in site characteristics occur within the block. Any treatment block or stratum therein should be larger than 5 ha for operational purposes.

Prior to block layout, field reconnaissance of potential test areas is essential. Not only does it provide a visual impression of site variables but it also allows a comparison of sites. This is a critical step, since choosing highly variable sites or sites that are not comparable will confound data analysis and reduce the value of the study. For example, if two different sites are selected to study the effect of slash loading on tool penetration, the presence of a second variable, e.g., stump height, that differs markedly between the two sites can obscure the effect of the primary variable (slash loading).

Site variation, both between and within sites, may prolong the search for suitable test blocks. This additional effort is frequently well rewarded.

TIME STUDY

The time study evaluates how efficiently the equipment is performing under a well defined set of conditions.

Essentially, the time study identifies the type and duration of all equipment activity and inactivity during the designated period of evaluation. The breakdown of these "operating" and "non-operating" times can be as fine or as broad as is required to evaluate the equipment. The SAP time study is based on the standard Canadian Pulp and Paper Association (CPPA) system (Berard et al. n.d.), modified specifically for the evaluation of silvicultural equipment with the assistance of the Forest Engineering Research Institute of Canada (FERIC) (Fig. 1).

Because most silvicultural equipment is not self-propelled and requires a prime mover, it is necessary to assign operational delays either to the prime mover or to the silvicultural equipment. In this way, the silvicultural equipment is assessed as much as possible on its own merits and is not penalized because of the actions and/or condition of the prime mover.

In SAP, total scheduled machine time is broken into three main categories: productive machine time; down time for active repair; and service and down time as a result of other delays (≤ 15 min) such as nonproductive operating time, waiting for mechanics or parts and miscellaneous delay. These are standard categories used by industry in long-term production evaluations. In many cases the use of continuous time chart recorders and a daily log book may be sufficient for assessment in operations in which detailed information on productive time is not required.

Whereas SAP reports productivity according to the aforementioned three main categories (Fig. 1), most evaluations are short term in nature and require more detailed description to enable greater analysis. For example, the isolation of identifiable activities such as the cleaning of debris could aid in reducing the adverse effect of the activity or could result in a change of procedure, which would increase the efficiency of the operation. For this reason, productive machine time is further broken down into time elements such as maneuvering, travel, problems with obstacles, delays ≤ 15 min and effective productive time, which is the time that the implement performs the work for which it was designed (Fig. 1). The detailed breakdown of productive machine time into its components can be accomplished only through time study.

A further objective of the time study is to obtain a representative event record for the operation. Each test area should be monitored by time study so as to cover the variety of site conditions present and to sample the range of delay-causing activities, which can be highly unpredictable with some equipment. Ideally, timing should be continuous, starting at the beginning of the scheduled operating time and continuing for the duration of the scheduled operation.

As a minimum, at least two shifts or 16 hours of operating time are required for sufficient short-term time

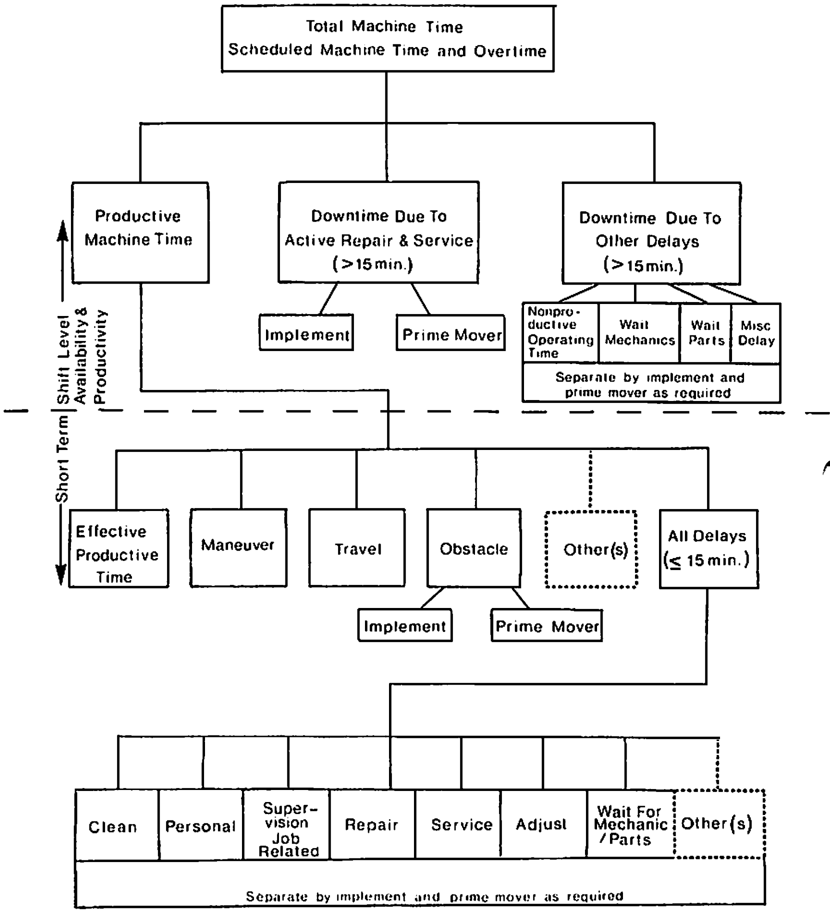


Figure 1. Machine time elements

study coverage. Various constraints on the observer may reduce the time available for conducting the study. Nevertheless, as close to 100% of scheduled operating time as possible should be timed. Appendix II provides a step-by-step procedure for collecting time study information. Definitions of machine time elements are provided and can be used to summarize data and arrive at values of utilization and availability.

POST-TREATMENT ASSESSMENT

The post-treatment assessment is a fundamental part of SAP. In this assessment, the results of the treatment are evaluated against the original site prescription. The prescription should be formulated at the outset of the study and contain detailed information on the biological objectives of a proposed treatment.

It is beyond the scope of this assessment procedure to describe a post-assessment format that will cover all tools and all situations. However, a basic format is presented as an example of typical assessment requirements and, with minor modifications to suit local conditions, this should be suitable for most mechanical site preparation equipment and field planting machines.

Site Preparation

Site preparation can be conducted with various goals in mind. Sutton (1984) stated that "site preparation may be needed to effect any of the following purposes singly or in combination: reduction or redistribution of slash (for access, reduction of fire hazard, or sanitation); reduction of competition from residual vegetation; soil cultivation; exposure of mineral soil; drainage; and the facilitation of regeneration operations, thereby improving quality. Mechanical methods include bulldozing, shearing, crushing, chopping, disking, bedding, etc. Such treatments affect initial control of weeds. They also facilitate subsequent planting or seeding by rendering slash less impeditive. The effect produced by any given treatment is highly site specific; and on any given site, the effect produced by any given treatment is specific to site condition".

With this in mind, one must evaluate site preparation by specifying, first of all, what the desired result should be and then by measuring those features that are deemed desirable. For example, if a prescription calls for microsites with a mixture of mineral soil and organic material as opposed to pure mineral soil exposure, then the assessor must be able to quantify the desired condition and establish ranges for acceptable microsites. The assessed result is then compared with the intended result or prescription, to determine how well it has produced the desired features. In addition, the assessment should indicate how well the machinery has performed in relation to site conditions and equipment operation.

In the case of site preparation for planting, effectiveness can be measured by the number and quality of planting spots, the quantity and quality of soil disturbance and the coverage of an area in terms of row spacing and width of scarification. As in the pretreatment survey, the accuracy of measurement should be at a minimum of 10% significance level and 15% confidence interval for critical variables such as mineral soil exposure or number of planting spots created.

Appendix III describes the information to be obtained when techniques similar to those described for the pretreatment stage are used. Again, a step-by-step procedure is provided for conducting the field work and collecting the information, and sample tally formats are provided.

Mechanical Planting

For production planting equipment, the rating of numbers of planting attempts per unit of time, combined with a biological prescription that defines acceptably planted trees and suitable microsites, inter-tree and inter-row spacing, will provide standards against which machines can be compared on an operational basis. With developmental or experimental planting equipment it may be desirable to collect additional information that can be used to help explain less than satisfactory results that are due to mechanical or operational problems. Such cause-and-effect relationships require that more detail be collected in addition to basic performance information. SAP can be used for certain cause-and-effect evaluations and at the same time can provide basic performance information.

Appendix IV describes a step-by-step field procedure to collect and assess information on planting microsite and spacing with the help of a comprehensive tally format.

SUMMARY

SAP utilizes techniques that are proven and widely accepted by other organizations involved in the evaluation of silvicultural equipment. The adoption of equipment assessment procedures that promote the presentation of results in a standardized form, suitable for comparison, regardless of regional variations, will encourage more efficient and cost-effective use of silvicultural equipment in Canada.

LITERATURE CITED

Anon. 1969. Terrain classification for Swedish forestry. Skogsarbeten Drottningqatan 97. 113 60 Stockholm. Rep. No. 9. 10 p. + appendices.

Bäckström, Per-Ove. 1970. Performance and cost of mechanized tree planting. R. Coll. For., Stockholm, No. 19.

Bélisle, J., *Ed.* 1980. Field manual for describing soils. Ont. Inst. Pedol., Univ. Guelph, Guelph, Ont. 30 p.

Bérard, J.A., Dibblee, D.H.W., and Horncastle, D.C. n.d. Standard definitions for machine availability and utilization. Can. Pulp Pap. Assoc., Woodlands Sect., Montreal, Que. WSI 2428 (B-1). 2 p.

Brown, J.K. 1974. Handbook for inventorying downed woody material. USDA For. Serv., Intermount. For. Range Exp. Stn., Ogden, Utah. Gen. Tech. Rep. INT-16. 24 p.

Cameron, D.A. 1980. Operational testing of planting machines in the boreal forest of Ontario. III. Timberland Tree Planter. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-317. 36 p. + appendices, illus.

Cunningham, G.C. 1958. Forest flora of Canada. Dep. North. Aff. Nat. Resour., For. Br., Ottawa, Ont. Bull. 121. 144 p.

Folkema, M.A., Giguère, P., and Heidersdorf, E. 1981. Shift level availability and productivity: revised manual for collecting and reporting field data. For. Eng. Res. Inst. Can., Montreal, Que. 13 p.

McRae, D.J., Alexander, M.E. and Stocks, B.J. 1979. Measurement and description of fuels and fire behavior on prescribed burns: a handbook. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-287. 44 p. + appendices, illus.

Payandeh, B., and Beilhartz, D.W. 1978. Sample size estimation made easy. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-275, 19 p. + appendices.

Riley, L.F. 1975. Operational testing of planting machines in the boreal forest of Ontario. I. Reynolds-Lowther Heavy Duty Crank Axle Planter. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-219. 37 p. + appendices, illus.

Rowe, J.D. 1972. Forest regions of Canada. Dep. Environ., Can. For. Serv., Ottawa, Ont. Publ. 1300. 172 p.

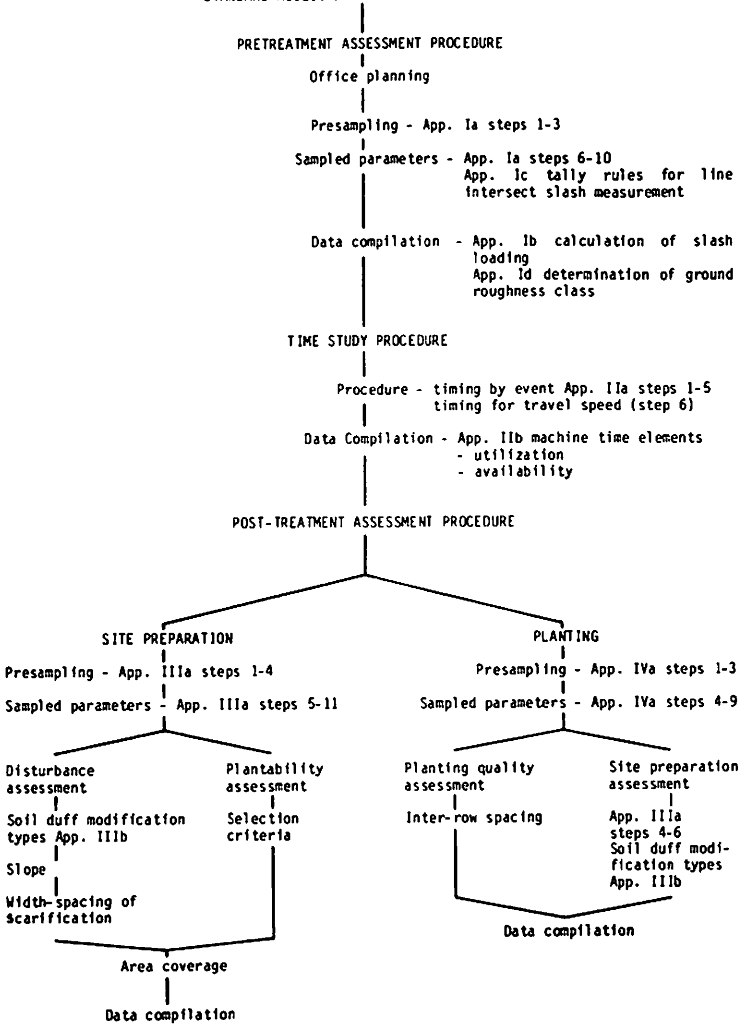
Smith, C.R., Ryans, M., and Leblanc, J-D. 1985. Evaluation of the effect of tree-length and full-tree harvesting on the performance of scarifiers. Gov't of Can., Can. For. Serv., Sault Ste. Marie, Ont. 49 p. + appendices, illus.

Sutton, R.F. 1984. Vegetation management in Canadian forestry. Gov't of Can., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X369.

Van Wagner, C.E. 1968. The line intersect method in forest fuel sampling. For. Sci. 14:20-26.

Van Wagner, C.E. 1982. Practical aspects of the line intersect method. Dep. Environ., Can. For. Serv., Petawawa, Ont. Inf. Rep. PI-X-12. 11 p.

STANDARD ASSESSMENT PROCEDURE FLOW CHART



GUIDE TO APPENDICES

For the convenience of the reader the appendices have been divided into sections which are listed below. Each page of these sections is marked with a black tab which lines up with the headings.

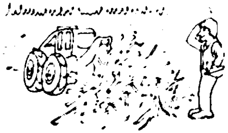
APPENDICES

APPENDIX I

PRETREATMENT ASSESSMENT

SOIL DEPTH CAN
BE IMPORTANT IN
TOOL SELECTION

TOO MANY RESIDUALS
POOR VISIBILITY



HEAVY SLASH CAN
AFFECT PERFORMANCE

WET SITES CAN AFFECT
TRAFFICABILITY

Ia PRETREATMENT ASSESSMENT PROCEDURE

Office Planning

Prior to treatment, information should be gathered that will help to organize the operation, clarify objectives of both the pre- and post-assessment, and provide background for later reporting. Data collected can be summarized, if normally distributed, through calculations of means, ranges and standard deviations. Tests of significance can be conducted between pairs of values. If the data are not normally distributed, then other statistical techniques must be considered.

The following information should be provided:

(a) Project number and equipment to be used
(b) Provincial administrative region and district
(c) Forest management unit
(d) Base map and block numbers
(e) Forest section name and number (after Rowe 1972)
(f) Site region number
(g) Net area treated = total area less area not to be treated
(h) Treatment objectives

Precut stand characteristics, when available, should be recorded.

(a) Forest type (species composition by percent coverage)
(b) Age class
(c) Height (m)
(d) Site class
(e) Stocking
(f) Area (ha)
(g) Type and date of cut
(h) Additional observations

Equipment and Crew

Black pencil (H or 2H)
Pretreatment tally sheets (See tally sheet No. 1)
Waterproof tally paper for rainy days (21½ x 35½ cm)
Clipboard (for 21½ x 28 cm paper)
50-m tape

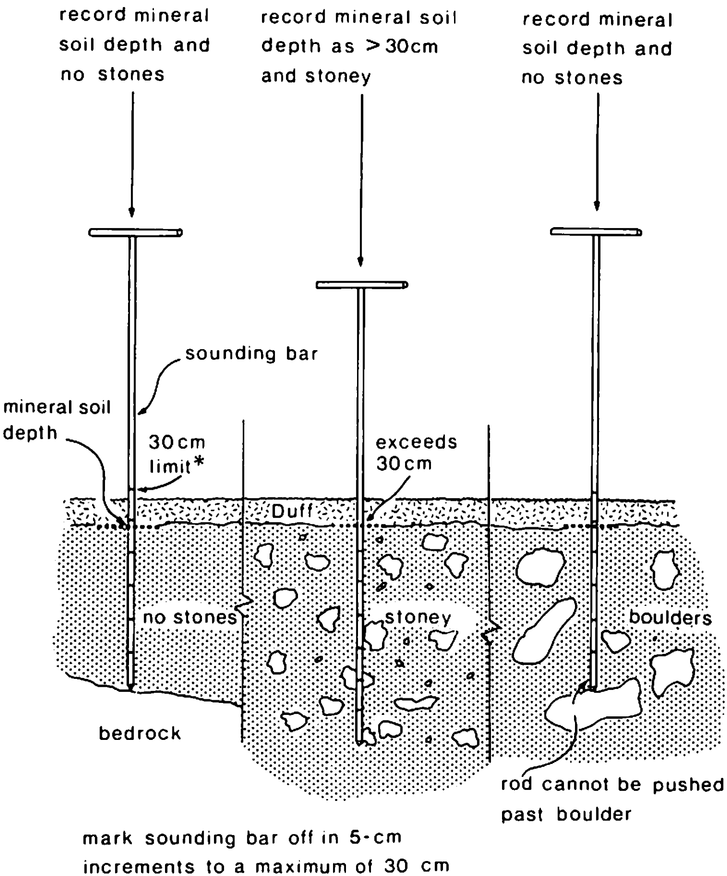


Figure 2. Mineral soil depth and stoniness measurement

Sounding bar (1.2 cm diam x 1.2 m, solid steel, marked off in 5-cm gradations, T handle--local fabrication) (See Fig. 2)
Two colors of flagging tape
Metre stick
15-cm rule
Shovel (D handle)
Compass
Calipers (40-60 cm)
Portable calculator
Two-person crew (one assessor and one tally person)

Presampling

Presampling of critical site parameters will allow a calculation of the minimum sample size required to obtain averages within acceptable significance levels and confidence limits. For certain parameters the presample may be adequate, and consequently the need for further data collection will be eliminated. The determination of sample size is a function of the variability in the site parameters to be considered.

Various sample units are used but the basic unit is a 2-m x 2-m quadrat for statistical purposes. Quadrats are clustered in transects randomly dispersed throughout the block and located by means of a baseline(s). The following steps describe the presampling procedure:

Step 1. Location of baseline and establishment of grid system

This work may be done in the office if maps and/or photos are available. In the absence of prior information, conduct a preliminary survey of the block and then establish a baseline bisecting the long axis of each block or stratum therein. If the block is irregularly shaped, establish two or more baselines, i.e., sufficient to ensure adequate coverage of the area (Fig. 3). Mark the baseline with flagged stakes at 60-m intervals. At each 60-m interval and at right angles to the baseline estimate and record, to the nearest 20 m, the width of treatable area to the block boundaries on either side of the baseline.

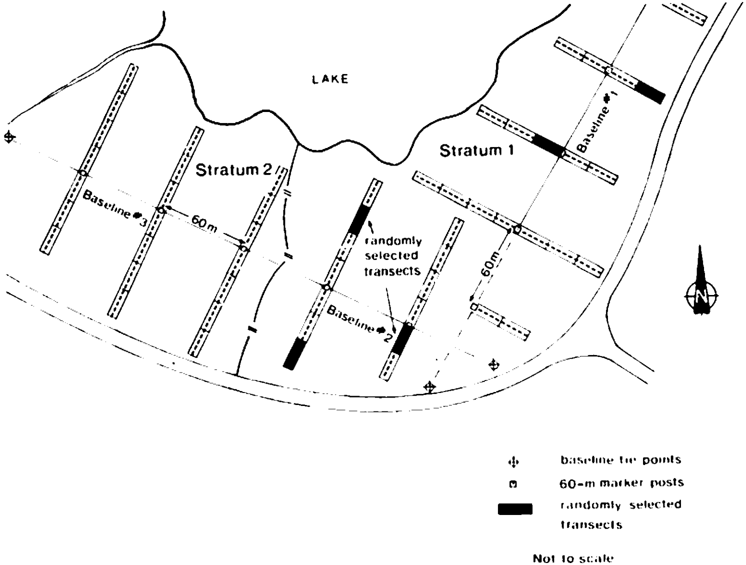


Figure 3. Layout of blocks, baselines and transects (pre-treatment assessment)

Step 2. Random selection of quadrat transects

From the information in Step 1 prepare a rough grid map of each block. Divide the lines crossing at 60-m intervals into 20-m segments. Number the segments serially beginning in one corner. Randomly select five segments (each 20 m) out of the total. These first five transects will represent a presample from which the total sample size will be estimated. Additional segments as required will be drawn at random.

Step 3. Presample for sample size estimation

Conduct a complete sample on the 10 transects selected in Step 2 following the procedures outlined in steps 4 - 10. Calculate means and variances and determine sample size according to Payandeh and Beilhartz (1978) or in accordance with other appropriate sample size determination procedures. Randomly select additional quadrat transects according to the minimum sample size calculated for each *critical* variable. Do not increase the number of quadrats for less important variables. Distribute the additional variables to be measured evenly over the total number of additional quadrats sampled. See Example 1 for sample variables and calculations.

Example 1. Sample Size Calculation

Problem: The following parameters, depth of slash, number of slash pieces 5 cm in diameter, and number of pieces 5 cm in diameter, are measured on a presample of five transects. Slash parameters are measured by means of a modified version of the line intersect method (Van Wagner 1968, 1982) that requires an offset of 10 additional quadrats for each transect (Fig. 4). In all, N = 100 quadrats are presampled. From Payandeh and Beilhartz (1978) the total number of quadrats[1] required is calculated by means of the formula:

[1]Using a confidence interval of ±15% around the sample mean with a 90% probability that the true mean will fall within this range.

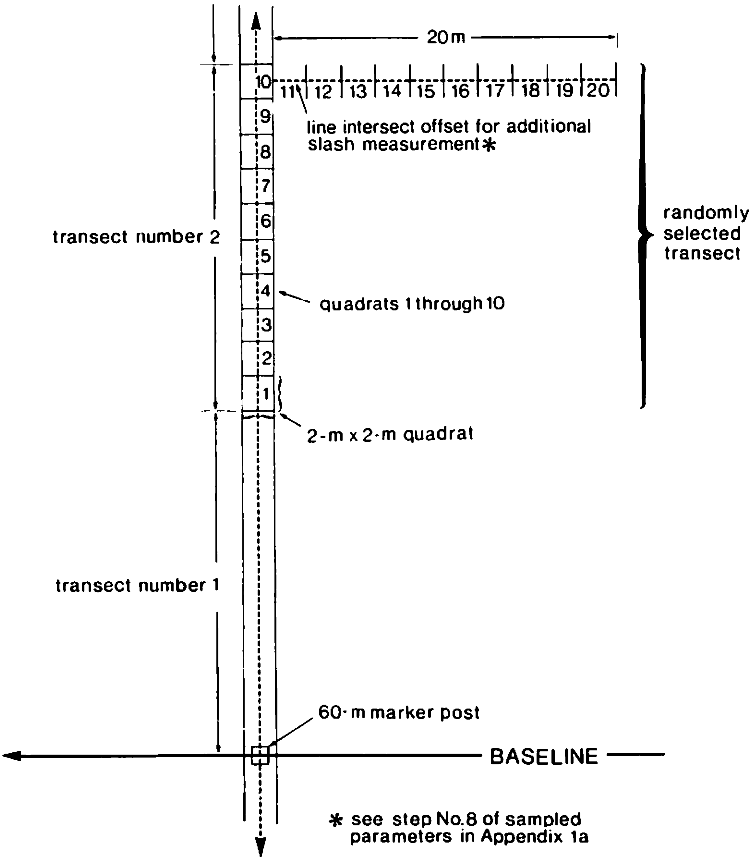


Figure 4. Transect layout (pretreatment assessment)

$$n = \frac{t^2_{(\alpha,\ df)}s^2}{d^2}$$

where: n = total no. of quadrats required

$t_{(8,\ df)}$ = t value @ 10% significance level and n-1 degrees of freedom. Look up t value in Table 1.

Under n-1, 100-1 = 99 degrees of freedom

t_{60} = 1.671, t_{120} = 1.658

Therefore, $t_{99} \doteq 1.665$

d = confidence interval which is 15% of the sample mean = .15 x $(\Sigma y)/n$

S^2 = sample variance

$$S^2 = \frac{\Sigma y^2 - \frac{(\Sigma y)^2}{n_1}}{n_1 - 1}$$

where: y = the value of the measured characteristic on an observation

n_1 = no. of presamples of y

For the parameter "Depth of Slash":

$t_{(.1,\ 99)}$ = 1.665

S^2 = 2209

$(\Sigma y)/n$ = 62 d = .15 x $(\Sigma y)/n$ = 9.30

$$n = \frac{(1.665)^2\ (2209)}{(9.30)^2}$$

n = 70.80 or 71

The total number of quadrats required to measure depth of slash is 71.

On the basis of Table 2, the variable "slash pieces >5 cm" needs to be measured on a further 188-100 = 88 quadrats. Distribute the additional quadrats by randomly picking five additional 20-m transects.

Table 1. Percentage points of the t-distribution[a]

Degrees of freedom	.2(20%)	.1(10%)	.05(5%)	.02(2%)	.01(1%)
1	3.078	6.314	12.706	31.821	63.657
2	1.866	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	2.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
20	1.325	1.725	2.086	2.528	2.845
25	1.316	1.708	2.060	2.485	2.787
30	1.310	1.697	2.042	2.457	2.750
40	1.303	1.684	2.021	2.423	2.704
60	1.296	1.671	2.000	2.390	2.660
120	1.289	1.658	1.980	2.358	2.617
	1.282	1.645	1.960	2.326	2.576

[a]This table is reproduced, with the permission of Professor D.R. Cox, from Biometrika, vol. 32, p. 311.

Table 2. Sample size calculation: summary

Measured variable	No. of presamples N	Mean $\frac{(\Sigma y)}{n}$	Sample variance S^2	d^2	t value	t^2	Total no. of samples required n
Depth of slash (cm)	100	62	2209	86.49	1.671	2.79	71
No. of pieces of slash 1.0 cm ≤5.0 cm diam	100	9.13	25.5	1.88	1.671	2.79	38
No. of pieces of slash >5.0 cm diam	100	2.12	6.81	0.10	1.671	2.79	188

Note: If presampling determines that sufficient sampling has already been conducted, as is the case for the variables "depth of slash" and "number of pieces of slash" in the above example, no further sampling is required.

The desired accuracy of the sample mean has a bearing on sample size. If greater accuracy is required, the size of the confidence interval can be decreased, e.g., from 15% of the sample mean to 10% of the sample mean. In reworking the previous calculation of depth of slash with a confidence interval of 10%, d would become 6.20, all other values would remain the same, and the total number of samples n would increase to 160.

If adjacent blocks appear to be similar to the area in which presampling was conducted, do not conduct additional presampling. Apply the sample size as previously determined. Presample strata and blocks (>5 ha) that are obviously different. The existence of strata within blocks may not be apparent until initial sampling is completed.

Step 4. With a two-person crew and a list of the randomly chosen transects, the start of the first transect is located by chaining to the predetermined starting point along the baseline and then perpendicular to the baseline to the appropriate 20-m interval. Crew person No. 1 starts at this point and lays the tape 20 m further along the perpendicular line. This represents the center line of the five 2 m x 2 m quadrats. Crew person No. 1 returns to the start and with calipers, sounding bar, shovel and metre stick in hand is ready to start assessing (Fig. 4).

Step 5. Crew person No. 2 is responsible for the tally. Refer to tally sheet No. 1, Appendix Ie for a description and example of tally format. Crew person No. 1 relays information to the tally person starting with block, baseline, transect number, and segment or quadrat.

Sampled Parameters

Step 6. The order of measuring the various parameters can vary; however, a systematic approach is recommended that will minimize the time spent per segment. The following parameters are then measured.

<u>Slash</u>

Slash volume and/or weight is determined by means of a modified version of the line-intersect method (see Appendix Ib). Cross-sectional diameters are recorded at the point at which the chain intersects the slash on the transect center line (Fig. 5). See Appendix Ic for tally rules (McRae et al. 1979).

Material 1-5 cm in diameter is tallied on a frequency basis only while the sound diameters of pieces > 5 cm are measured and recorded by 2-cm classes. Diameters of more than 98 cm are recorded as "99". As an aid to keeping track of the count of small-diameter slash, use of a "tally whacker" or other hand-operated recording device is recommended. Record the *length* of all stems crossed by the transect center line > 5 cm in sound diameter by the following length classes: 0-2 m, 2.1-4 m, 4.1-6 m, 6.1-8 m, >8 m.

Measure *slash depth* by recording height to the nearest 5 cm of the highest intercept within 15 cm of a metre stick placed at the center of the quadrat (Fig. 6). The piece of slash used to obtain this measurement must be ⩾ 1 cm in diameter at point of intercept. Do not press down on slash pieces. Record whether conifer (1) or deciduous (2) *slash* is predominant in the quadrat.

<u>Mineral soil depth</u>

Measure mineral soil depth to the nearest 5 cm to a maximum of 30 cm with sounding rod placed at the center of the 2-m segment. Push sounding rod down for 30 cm or until it can be pushed no further. If mineral soil is deeper than 30 cm, record 35.

Figure 5. Line-intersect slash measurement

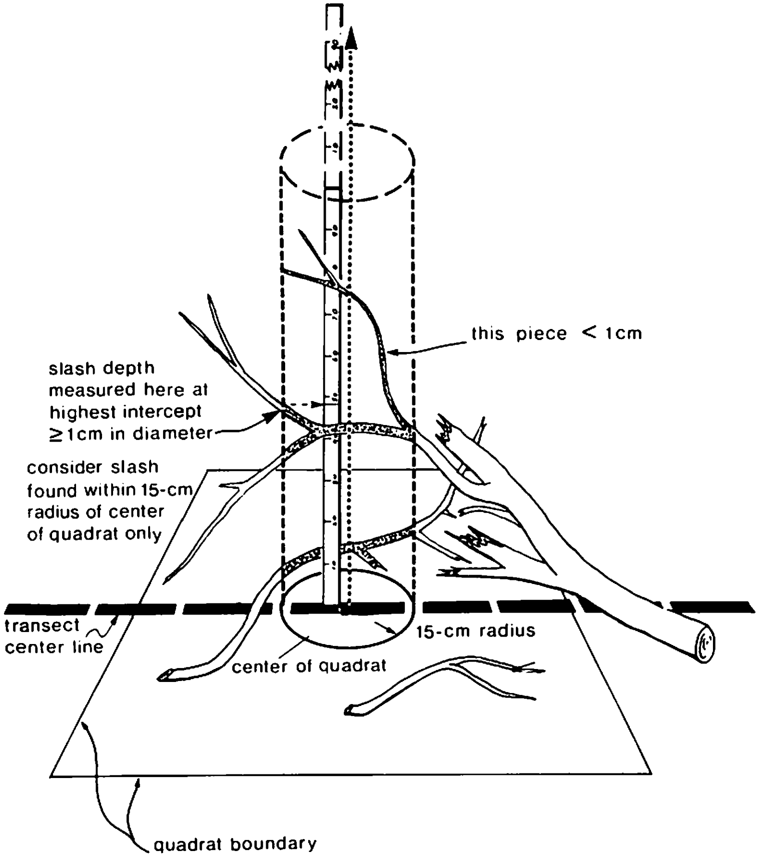


Figure 6. Slash depth measurement

Stoniness

When measuring mineral soil depth, record if stones or boulders are present in the top 30 cm of mineral soil (Fig. 2). If the rod can be forced past obstructing stones then record soil as stoney. If the rod cannot be pushed beyond an obstruction then this represents soil depth. Note that in heavy-textured or stoney soils considerable force may have to be applied to the sounding rod for penetration. If the sounding location is situated on a root or stump, the assessor can offset an appropriate amount.

Duff depth

Measure the depth of the combined litter (L), fermentation (F), and humus (H) layer to the nearest 1 cm. Select a measuring point closest to the center of the quadrat to represent the average thickness of duff on the quadrat.

Ground roughness

Ground roughness is based on the height/depth and frequency of obstacles (Anon. 1969) within the quadrat. Record the *type* of ground roughness (i.e., 1 = raised obstacle such as a boulder or hummock, 2 = depression such as a hole or wheel rut) and the *height/depth* class 10-30, 31-50, 51-70, 71-90, 91-110, 111-150 and 150 cm. Over 50% of any obstacle to be counted must lie inside the quadrat. See Appendix Id for tally procedure and for determination of the final ground roughness class. Although recorded separately, stumps are normally included in the determination of ground roughness.

Stumps

Measure *average diameter* at the top of butt flare or top of stump, whichever is lowest. Measure *height* to highest point on stump from the lowest ground level within 0.5 m of stump. Record height by 2-cm classes for all stumps $\leq$ 1.5 m tall and > 5 cm in diameter. (Note that the center point of the stump must be inside the quadrat boundary to be counted.) Record by species, using a suitable numbering code.

Minor vegetation

Record percentage of quadrat covered to the nearest 10%. Ground vegetation includes woody stems (i.e., trees, brush, and shrubs ≤1.5 m tall), ferns and seed plants but not lichens, liverworts, mosses, horse tails or club mosses (cf. Cunningham 1958). Additional data on minor vegetation may be recorded if they were of use in the identification of moisture regime. The importance of minor vegetation as an obstruction to silvicultural equipment is limited.

Record the predominant species in the quadrat by a suitable numbering code.

Brush

Count all stems within the quadrat (including tree species) >1.5 m tall and ≤5 cm in diameter at breast height (DBH). Record the predominant species in the quadrat by means of a suitable numbering code.

Residuals

Record by species using a numeric code and measure DBH of all stems (including trees and brush) >5 cm DBH and >1.5 m tall, by 2-cm DBH classes. (Note: residual heights can be measured at a later time on an established diameter/height frequency curve.)

This completes the data collection on one 2-m x 2-m quadrat.

Step 7. The assessor now advances 2 m and repeats the quadrat assessment, i.e., steps 4-6. At the end of the 20-m line, 10 segments have been recorded and are represented by 10 lines of entries on the tally sheet.

Step 8. To complete the slash assessment an additional 20-m transect is laid out perpendicular to the first transect line starting from the 10th quadrat (Fig. 4). Carry out slash line-intersect and depth measurements only on every 2-m segment of this line. Continue numbering the 2-m segments on the tally sheet consecutively up to 20.

Step 9. Ground moisture

Record ground moisture once per transect in the following classes: very dry to moderately dry (0), moderately fresh (1), fresh (2), very fresh (3), moderately moist (4), moist (5), very moist (6), moderately wet (7), wet (8) and very wet (9) (Bélisle 1980). Ground moisture is also recorded at the time of equipment operation.

Step 10. Ground condition

This last step in the preassessment stage involves the determination of ground condition classes, which are defined on the basis of soil type or texture and ground moisture (Anon. 1969), parameters that can vary throughout the treatment area. A soilpit is established to represent each major change in either soil texture or ground moisture in the treatment block. The classifications should refer to conditions prevailing at the time of operations. Determine soil texture and moisture according to Bélisle (1980) and select a ground condition class from the grid in Figure 7. Ground condition classes are rated from 1 to 5 according to Figure 7, where 1 indicates the easiest and 5 the most difficult conditions for the operation of silvicultural equipment.

Class 1. *Very good.* Gravelly and sandy moraine on dry or arid sites.
Gravely moraine on fresh sites.
Gravel on dry, fresh or moist sites.

Class 2. *Intermediate (Good).* Sandy moraine on fresh sites.
Sandy-loamy moraine on dry-to-fresh sites.
Sand and coarse loam on dry and fresh sites.

Class 3. *Average.* Sandy moraine on moist-to-wet sites.
Sandy-loamy moraine on fresh-to-moist sites.
Loamy moraine on dry-to-fresh sites.
Sand on moist-to-wet sites.
Coarse loam on fresh-to-moist sites.

Class 4. *Intermediate (Poor).* Sandy-loamy moraine on moist-to-wet sites.
Loamy moraine on moist sites.
Coarse loam on fresh-to-wet sites.
Silt on fresh-to-moist sites.
Clay on fresh-to-moist sites.

Class 5. *Very poor.* Loamy, silty, clayey moraine on wet sites.
Loam, silt and clay on wet sites.
Peatlands.

Additional Comments

Exclusive of block and baseline layout time, the assessment of site conditions on each 20-m transect will require approximately 0.5 working hours for a trained crew of two in easy site conditions, with little variation in ground

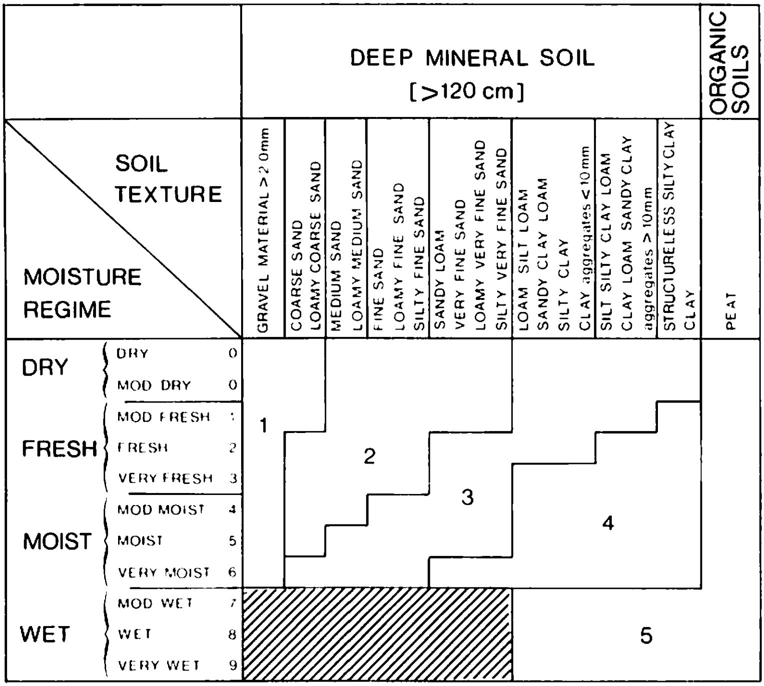


Figure 7. Ground condition class (after Bélisle 1980)

conditions and good visibility. On rough sites with heavy debris loads or dense underbrush, as much as one working hour per transect may be required.

The description of site conditions can be supplemented by photographs. Additional photos can be taken after site treatment to provide a "before and after" record. Obtain a photograph of the site at each transect line in the presample by positioning the camera at the start of the transect and facing toward the 20-m end of the tape. Record the photo number and corresponding transect number and rephotograph from the same position after site treatment.

Slope is best measured during the post-treatment assessment when access for the tally person and mobility are improved.

Ib CALCULATION OF SLASH LOADING

1. Placing of sample lines at right angles to each other is necessary to obtain dependable results (Fig. 4).

   Slash loading can be calculated as a volume in m^3/ha or by weight in kg/m^2.

2. Determine the volume or weight of slash on each quadrat of the transect as follows:

$$\text{Volume}\ (m^3/ha) = \frac{1.234 \times n(dq)^2}{L}$$

where n = number of stems per diameter class per 2-m length
dq = quadratic mean diameter (cm) by species (See Table 2.)
L = 2 m (segment length)

$$\text{Weight}\ (Kg/m^2) = \frac{.1234 \times n(dq)^2 \times S}{L}$$

where S = the specific gravity of the tree species.

Refer to Table 3 to obtain the quadratic mean diameter class values and specific gravity by species for the three diameter classes tallied 0-5 cm, 5.1-7 cm and > 7.1 cm. In the field tally, slash is often identified as either coniferous or deciduous, with the exact species unknown. To arrive at the most appropriate quadratic diameter class, use the species composition of the previous stand to obtain weighting of diameter class values. For example, if the stand composition was 70% black spruce and 30% jack pine, the quadratic diameter class selected for the quadrat would be as follows:

Assume diameter size class 1-5 cm
quadratic diameter class for black spruce = 1.7878
quadratic diameter class for jack pine = 1.9060
weighted diameter class = 1.9060 x .30 + 1.7878 x .70 = 1.8232

3. Upon calculation of the volume or weight by diameter size class of slash on each quadrat, determine the average for the transect and then the average for all transects on the block.

Table 3. Diameter class and specific gravity for common boreal species

Species	Diameter size class (cm)	Quadratic mean diameter (dq)	$(dq)^b$	Specific gravity $(S)^b$
Jack pine	1-5	1.9060	3.6354	.5027
Black spruce	1-5	1.7878	3.1963	.5241
Deciduous[a]	1-5	1.8868	3.5599	.4867
Jack pine	5.1-7	6.0976	37.1807	.4955
Black spruce	5.1-7	5.9878	35.8541	.5088
Deciduous[a]	5.1-7	5.7660	33.2468	.4664
Jack pine	7.1+	diam	$(diam)^2$	.4
Black spruce	7.1+	diam	$(diam)^2$	.4
Deciduous[a]	7.1+	diam	$(diam)^2$	.4

[a] Deciduous refers to a 50/50 mix of poplar and white birch.
[b] Values of quadratic mean diameter and specific gravity calculated from D.J. McRae and B.J. Stocks, Forest Fire Research Unit, Great Lakes Forestry Centre, Sault Ste. Marie, Ont. (unpubl. data, 1985)

Ic TALLY RULES FOR LINE-INTERSECT SLASH MEASUREMENT[2]

Rule 1. Included in this tally are downed, dead woody material (twigs, stems, branches, and bolewood) from trees and shrubs. Dead branches attached to boles of standing trees are omitted because they are not downed fuels. Material is considered downed when it has fallen to the ground or is severed from its original source of growth.

Rule 2. Only twigs or branches lying above the duff layer are counted (Fig. 8).

Rule 3. If the sampling line intersects the end of a piece, tally only if the central axis is crossed (Fig. 9). If the line exactly intersects the central axis, tally every other such piece.

Rule 4. Do not tally any particle with a central axis that coincides perfectly with the sampling line (Fig. 10). (This should happen rarely.)

Rule 5. If the sampling line intersects a curved or angular piece more than once, tally each intersection (Fig. 11).

Rule 6. Wood slivers and chunks left after logging are measured as individual slash pieces. Only the sound portion of rotten logs is to be measured. Wood is considered rotten when it yields easily to a kick or is probed with the calipers.

Rule 7. Do not tally undisturbed stumps. Uprooted stumps are tallied as ground roughness, not as slash.

Rule 8. Be sure to look up from the ground when sampling because downed material can be tallied up to any height, provided that it is not rooted.

---

[2] (cf. Brown 1974, McRae et al. 1979).

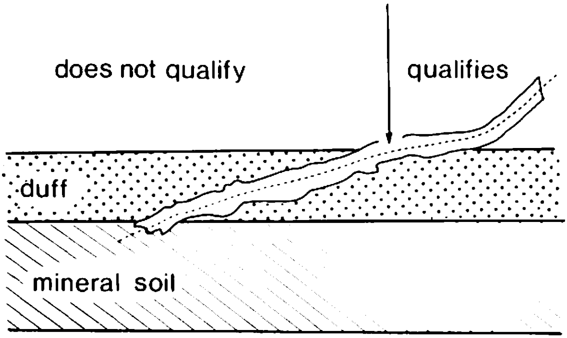


Figure 8. Line-intersect tally rule No. 2

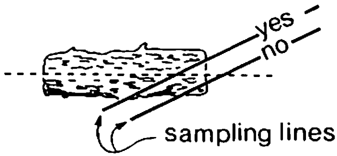


Figure 9. Line-intersect tally rule No. 3

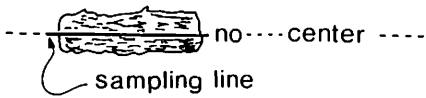


Figure 10. Line-intersect tally rule No. 4

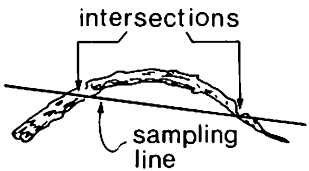


Figure 11. Line-intersect tally rule No. 5

NOTE: Figures 8-11 after Brown (1974)

Id DETERMINATION OF GROUND ROUGHNESS CLASS[3]

1. Each classification is based on the total number of observations in each transect (i.e., 10 2-m x 2-m quadrats or a total area of 40 m^2).

2. Obstacles or depressions are recorded in height classes 10-30, 31-50, 51-70, 71-90, 91-110, 111-150 and > 150 cm. Over 50% of any obstacle to be counted must lie inside the quadrat. Measure as follows:

A 1-m stick is used as illustrated (Fig. 12).

Obstacles: If a transect lies on a slope, the quadrat border is determined by the line at right angles to the end of the metre stick. Obstacles are measured in the same manner.

Depressions: Depressions should be well defined and have clear edges, and should be *at least 20 cm deep* by reference to the ground surface. Depressions with a mean diameter more than six times the depth are not taken into consideration unless the edges are very steep (Fig. 13).

Groups of Stones: A stone, the center of which lies nearer to the center of a larger stone than the height of the latter, is not counted (Fig. 14).

A stone that has its center nearer than twice its height to the periphery of another but larger stone is not counted if its height is less than a quarter of the height of the larger stone (Fig. 15).

---

3 (cf. Anon. 1969)

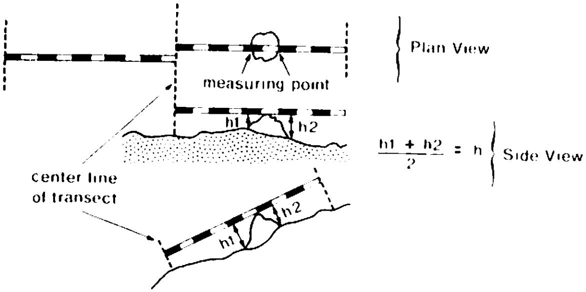


Figure 12. Obstacle measurement

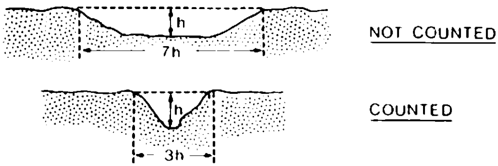


Figure 13. Depression measurement

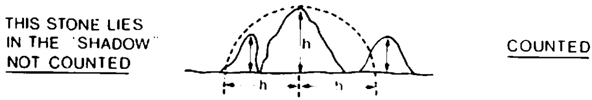


Figure 14. Group of stones measurement

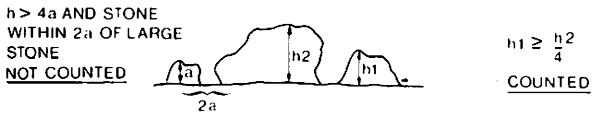


Figure 15. Group of stones measurement

NOTE: Figures 12-15 after Anon. (1969)

3. Work out results using the following sample tally.

Height classes and mean height (h) in cm for both raised obstacles and depressions.

	10-30 20	31-50 40	51-70 60	71-90 80	91-110 100	111-150 130	150 Actual	
Count for 40 m^2 transect	⊠ ⊠ ∴	⊠ ·	∴					Total
Total(T)	23	11	3					37(X)
Mean vol per ht class (h^3)	0.008	0.064	0.216	0.512	1.000	2.197	4.913	
Total volume ($T.h^3$)	0.184	0.704	0.648					1.536 (V)
			(V/X) Average volume per obstacle					.0415 (Y)

4. Read the ground roughness class from Figure 16.

5. From Figure 16 the ground roughness class is 4, described below as Intermediate.

Class 1. *Very even ground surface.* Obstacles in height class H20 (10-30 cm) are allowed to a moderately frequent[4] extent; obstacles in height class H40 (31-50 cm) and over may occur as isolated phenomena, provided that H10 are infrequent.

---

[4] Frequency classes

Frequency classes	Spacing	Obstacles per ha
Frequent	1.6 m	4000
Moderately frequent	1.1-5.0 m	4000-400
Infrequent	5.1-16.0 m	400-40
Isolated	> 16.0 m	> 40

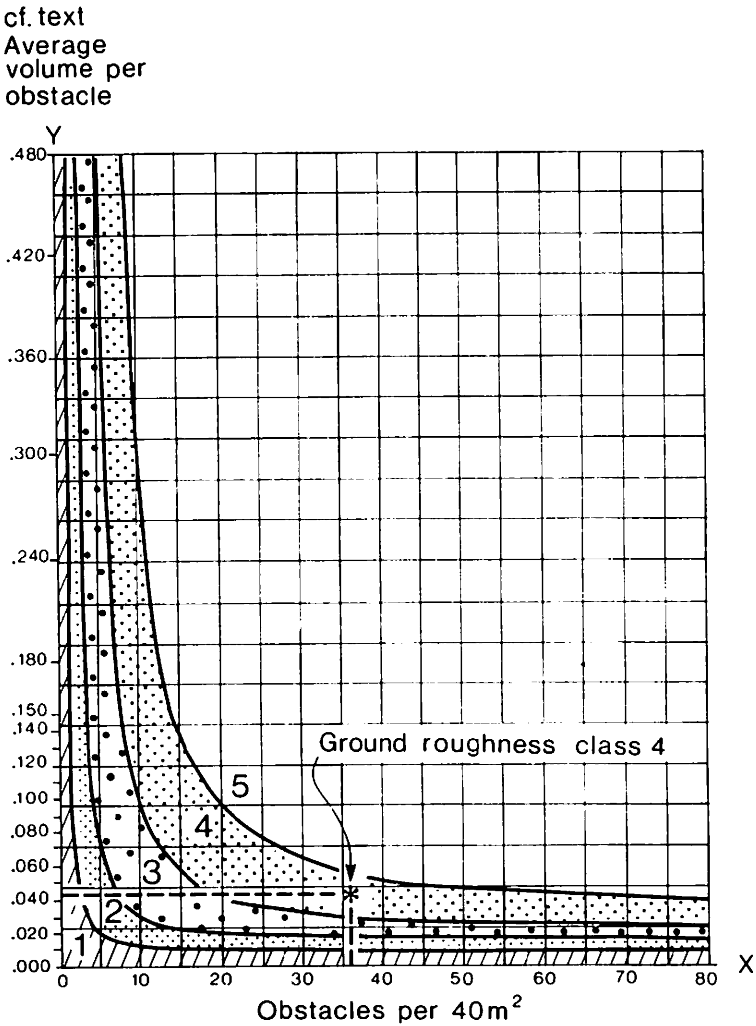


Figure 16. Ground roughness classification diagram (after Anon. 1969)

Class 2. *Intermediate.* Only H20 may be frequent. H40 occurs infrequently, provided that H20 occurs with no more than moderate frequency. The difficulty of the terrain is judged mainly by these height classes. Obstacles of greater height may occur as isolated phenomena.

Class 3. *Somewhat uneven surface.* Here, H20 may occur frequently (without regard to other height classes). H40 may occur in moderate frequency. H60 (51-70 cm) may occur but must be infrequent or isolated. Higher obstacles may occur only as isolated phenomena.

Class 4. *Intermediate.* H20 and H40 may occur frequently, H60 with moderate frequency, provided that H20 and H40 are also no more than moderately frequent. Higher classes should be infrequent.

Class 5. This class comprises all ground surfaces whose roughness is greater than in Class 4.

Tally Sheet No. 1

MEASURED BY: NOTES BY: DATE: TOOL:

BLOCK	BASELINE	TRANSECT NO	QUADRAT	SLASH: COUNT < 5	SLASH: DIAM cm	SLASH: LENGTH	SLASH: DIAM cm	SLASH: LENGTH	SLASH: DIAM cm	SLASH: LENGTH	SLASH: DIAM cm	SLASH: LENGTH	SLASH: DIAM cm	SLASH: LENGTH	SLASH: DIAM cm	SLASH: LENGTH	SLASH: DIAM cm	SLASH: LENGTH	SLASH: SLASH DEPTH cm	SLASH: CONDITION	MIN SOIL DEPTH cm	STONE YES(1) NO(2)	DUFF DEPTH cm	MOISTURE	GROUND ROUGH: TYPE	GROUND ROUGH: HT/DEPTH	GROUND ROUGH: TYPE	GROUND ROUGH: HT/DEPTH	STUMP: SPECIES	STUMP: DIAM cm	STUMP: HT cm	STUMP: SPECIES	STUMP: DIAM cm	STUMP: HT cm	STUMP: SPECIES	STUMP: DIAM cm	STUMP: HT cm	STUMP: SPECIES	STUMP: DIAM cm	STUMP: HT cm	MINOR VEG: SPECIES	MINOR VEG: % COVER	BRUSH: SPECIES	BRUSH: COUNT	RESIDUAL: SPECIES	RESIDUAL: DIAM cm	RESIDUAL: HT m	RESIDUAL: SPECIES	RESIDUAL: DIAM cm	RESIDUAL: HT cm
1	01	001	01	15	08	1	06	3											25	1	35	2	10	2	1	1	2	2	4	8	10	1	10	12	1	30	20				04	8	01	36	1	06	3			
			02																																															
			03																																															
			04																																															
			05																																															
			06																																															
			07																																															
			08																																															
			09																																															
			10																																															
			11																																															
			12																																															
			13																																															
			14																																															
			15																																															
			16																																															
			17																																															
			18																																															
			19																																															
			20																																															
1	01	002	01																					1																										

sample tally

Ie TALLY SHEET FORMAT

The following is a sample format organizing an 80-column computer data collection form for preassessment. Variations in the format may be necessary to accommodate local conditions. For all data sets a form similar to this should be prepared as part of the field data file, as this information is essential for compilation and analysis. Include a record and explanation of all values and codes recorded.

Column	Description	Possible Values
1	Block number	1-9
2,3	Baseline number	01-99
4,5,6	Transect number	001-999
7,8	Quadrat number	01-20
9,10	Count, slash, diameters $\geq$ 1 cm and $\leq$5 cm	01-99
11,12	diam (cm) slash > 5 cm	6-8-10....98,99
13	code, slash length	1, 3, 5, 7, 9
.	repeat diam and length	
.		
.		
31	" " " "	
32,33,34	depth (cm), slash	000-005-010...400,999
35	type, slash (1-conifer, 2-hdwd)	1,2
36,37	depth (cm), mineral soil	00-30,35
38	code, stones (1-yes, 2-no)	1,2
39,40	depth (cm), duff	00-45,99
41	code, moisture regime	0-9
42	code, type, ground roughness (1-raised obstacle, 2-depression)	1,2
43	code, ht, depth, ground roughness	1,7
44	code, type, ground roughness	1,2
45	code, ht, depth, ground roughness	1-7
46	code, (local), species of stump	0-9
47,48	diam (cm), stump	6-8-10...98,99
49,50	height (cm), stump	0-2-4-6...98,99
.	repeat species, diam and height	
.		
.		
65	" " " " "	
66,67	code, species of minor vegetation	11-50
68	code, percent cover, minor vegetation	0-9
69,70	code, species of brush	51-99
71,72	count brush, number of stems	00-99
73	code, species of residual	0-9
74,75	diam (cm), residual	6-8-10...98,99
76	code (local), height class, residual	0-9

Column	Description	Possible Values
77	code, species of residual	0-9
78,79	diam (cm), residual	6-8-10...98,99
80	code (local), height class, residual	0-9

* * * * * * * * * * * * * * * *

Additional Notes (useful to copy and use in the field with tally sheet)

1. Number consecutively all tree, stump, brush and minor vegetation species starting with the larger plants as follows:

Code	Species
1	spruce
2	pine
.	
.	
.	
99	etc.

2. Ground roughness

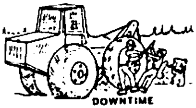
Code	H + 1 depth class
1	> 10 < 30 cm
2	> 30 < 50 cm
.	
.	
.	
7	> 150 cm

3. Slash length

Code	Length
1	0 ≤ 2 m
2	> 2 ≤ 4 m
5	> 4 ≤ 6 m
7	> 6 ≤ 8 m
9	> 8 m

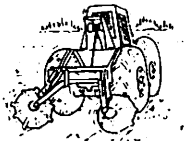
APPENDIX II

TIME STUDY

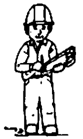


DOWNTIME
-ACTIVE REPAIR-

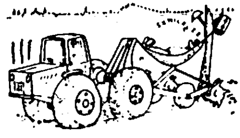
NONPRODUCTIVE
OPERATING TIME
-STUCK-



PRODUCTIVE
MACHINE TIME



OBSTACLE
-CLEARING DEBRIS-



DOWNTIME
-PERSONAL-

IIa TIME STUDY PROCEDURE

Equipment and Crew

Black pencil (H or 2H)
Time study board with multiple stopwatch holders (e.g., Meylan Quick-Click)
Stopwatches--three plus one spare (30 minute, crown activated, .01 minute)
Tally paper (See tally sheet No. 2.)
Waterproof tally paper for rainy days (21½ x 28 cm paper)
Wristwatch
Flagged pins (two per 40-m timed interval)
Usually a one-person job
With faster machines, i.e., > 4 km/hr travel speed, a second person may be required to establish the 40-m strips for the calculation of travel speed or to act as an alternate in consulting time studies.

Procedure (Assuming three-stopwatch time board)

Step 1. Wind watches

Step 2. Set up time board so that, when the lever is depressed, the watches operate sequentially, i.e., watch 1 stopped, watch 2 reset to zero, watch 3 running.

Step 3. Begin timing by depressing lever at start of work day. Note time on wristwatch and record on tally sheet No. 2. Refer to tally sheet No. 2 on page 51 for an example of tally format.

Step 4. At first change in circumstances, depress lever and read and record time to nearest 0.01 minute under the appropriate column. (Each represents a coded reason.) Events are recorded when they exceed 0.05 minutes. The following machine functions are coded on tally sheet No. 2.

Forward implement + forward or stop tractor
Forward implement + stop tractor
Stop implement + forward tractor
Stop implement + stop tractor
Reverse implement + reverse tractor
Stop implement + reverse tractor
Maneuver forward implement + forward tractor

The tally sheet is designed so that the actions of either the implement or the prime mover can be timed separately. Some implements can be uncoupled remotely from the prime mover by the operator by means of a cable or chain, usually when the prime mover is encountering difficulty in traversing the site. Once normal traction conditions return the tractor will winch in the implement. In other cases the implement may be self-powered (i.e., tree planter) and may not be operating, even though the tractor towing it is moving forward. A row can contain no more than one time event. Comments or additional information should be recorded whenever further clarification of a timed event is required. This will facilitate data interpretation once the suitable field work is completed. The number of time study elements used can be as extensive as necessary to ensure identification of the most significant cause of unproductive effort (Riley 1975). See Appendix IIb for the definition of machine time elements.

Step 5. Continue for the day depressing lever at each change of events. At 0.5- to 1.0-hour intervals note and record wristwatch time as a backup in the event that a stopwatch malfunctions.

Step 6. In addition to being timed by event the equipment will be timed over preset intervals in order to record normal travel speed. The time-study person will carry a quantity of flagged pins marked in pairs for future reference. At the appropriate time, as determined by a pre-established list of random times, the time-study person will insert a pin into the ground immediately behind the moving equipment and at the same time enter the time reading on tally sheet No. 2. (See example.) The time-study person will then follow immediately behind the scarifier, at a safe distance, and at the end of the preset time interval will mark the ground with the second pin of the marked pair and again record the time. At the end of the day or during a suitable break in the operations, the distance between these two flags will be measured to the nearest metre recorded with the corresponding time interval on the tally sheet. The time interval should be of sufficient duration to allow approximately 40 m between pins (4 km/hr = 67 m/min). It is important that the timed intervals be located away from block or stratum boundaries, or where turning or unusual maneuvering is required, so as not to affect normal travel speed. If, after a timed interval has been started, forward travel is stopped for an un-

Tally Sheet No. 2

(Sample Tally)

PROJECT: ______ LOCATION: ______ TALLY BY: ______ DATE: ______ P. __ of __

TOOL ______ BLOCK: ______ PLOT: ______ OPERATOR ______ WEATHER: ______

Pass No. (Time)	Productive	Other (non-productive)						Remarks	Dist. in subplot
	FORWARD impl. + FORWARD or STOP tractor	FORWARD impl. + STOP tractor	STOP impl. + FORWARD tractor	STOP impl. + STOP tractor	REVERSE impl. + REVERSE tractor	STOP impl. + REVERSE tractor	MANEUVER FORWARD + FORWARD tractor		
08:45	6.30								
				0.20				Pe[1]	
	5.05								
			0.15					PM[2] WFS[3]	
	3.60							Wet	
9:00	0.58							travel speed	42 m
	2.06								
							0.30		
	5.26								
					0.50				
9:46	7.39								
	6.40								
10:01	0.60							travel speed	40 m
	3.90								
			0.20					PM WFS	
						0.25		muck	
			0.35					PM WFS	
		0.42						winch in	
	3.80								

watch time → (points to 08:45)

watch time for timed interval → (points to 9:00 and 10:01)

distance travelled over timed interval → (points to 42 m)

Pe[1] = personal time
WFS[2] = winch free spool
PM[3] = prime mover time

usual delay (i.e., breakdown), then the timing interval is to be aborted and a new one selected once normal travel speed has been resumed. A minimum of five timed intervals should be collected within each block or stratum whenever the operating conditions change sufficiently to alter travel speed.

See Appendix IIb for the machine time formulas necessary to compute utilization and mechanical availability.

Additional Comments

In recent years electronic stopwatches have become increasingly popular as well as reliable and inexpensive. The use of a single electronic stopwatch with cumulative timer function can be used instead of the mechanical stopwatches.

Timing devices used in this procedure must allow for continuous timing of activities and operate reliably in extreme environmental conditions such as rain or sub-zero temperatures. Stopwatches that record to the nearest .01 of a minute (centiminute) are used because of the ease of data compilation.

Time study demands the timer's complete attention for the duration of the scheduled operating day. A second person who may have other duties in the operation can spell the timer off for brief periods during the day.

During the time study, when the equipment is on site, there is a good opportunity to carry out a complete description of the equipment in its field condition. In addition to make and model number, it is especially important to record modifications to standard equipment such as a larger engine in a prime mover, addition of tire chains for better traction, extra weight added to the scarifier, etc. A good collection of photographs is extremely valuable.

Other factors that may affect equipment performance such as operator experience and weather conditions (i.e., rain and snow) are to be recorded.

The following notes may be copied and used in the field with the tally sheet.

Recommended time element definitions and short forms (Cameron 1980) are given below. Expand as necessary.

Acronym	Definition	Example
Wo	= work-oriented time	- clearing debris from equipment, stopping for instructions
IS	= inshift service time	- fueling, servicing implement
IR	= inshift repair time	- breakdown of implement
IM	= inshift moving time	- walking equipment to and from site
OL	= operational lost time	- implement stuck, changing operators, engine warmup
Pe	= personal time	- rest
PM	= prime mover time	- cool down, breakdown, servicing, starting, refueling, not available
NA	= nonavailable time (prime mover)	- prime mover stuck, breakdown, servicing, refueling, lunch

Note: All time study data sets should include a list and description of terms and abbreviations used in the data collection.

IIb MACHINE TIME ELEMENTS

Definition of Machine Time Elements and Formulae (Folkema et al. 1981)

SCHEDULED MACHINE HOURS (SMH): Nominal statement of intent for regular machine activity (e.g., 8-hour shift). It usually corresponds to operator's paid on-job time.

PRODUCTIVE MACHINE TIME or PRODUCTIVE MACHINE HOURS (PMH): That part of Total Machine Time during which the machine is performing its primary function.

ACTIVE REPAIR: Repair constitutes the mending or replacement of part(s) that have failed or malfunctioned. It also includes *modifications* or *improvements* to the machine.

SERVICE: Service is routine and preventive maintenance to retain the machine in satisfactory operational condition.

DELAY: That part of Scheduled Machine Time during which the machine is not performing its primary function for reasons other than active repair and service. Delay time is divided into:

NONPRODUCTIVE OPERATING TIME: Period of inshift time during which the machine's engine is running but the machine is doing something other than performing its primary function.

WAITING FOR MECHANIC(S): That inshift time during which the machine is broken down and is not under repair because mechanics are unavailable.

WAITING FOR PART(S): Period of inshift time during which the machine is broken down and is not under repair because parts are unavailable.

MISCELLANEOUS DELAY: Period of inshift time during which the machine engine is not running for reasons other than active repairs and service and/or waiting for repairs and service.

MACHINE TIME FORMULAE: $\text{utilization} = \frac{\text{PMH(inshift)} \times 100}{\text{SMH}}$

total time utilization = $\frac{\text{PMH(inshift \& outside of shift)}}{\text{SMH + overtime}}$ x100

mechanical availability = $\frac{\text{PMH}}{\text{PMH + repairs + service}}$ x 100

(PMH, repairs and service include both in- and out-of-shift activities)

CPPA availability = $\frac{\text{SMH-(repair+service+wait (parts+mechanic)}}{\text{SMH}}$ x100

(repair and service includes only inshift)

PMH = Productive Machine Hours

SMH = Scheduled Machine Hours

CPPA availability, by definition, is influenced not only by machine characteristics but also by operational factors (i.e., waiting for parts or mechanic). Mechanical availability, by definition, excludes these operational factors.

Definition of Short-term Study Time Elements (Smith et al. 1985)

Productive Machine Hours (PMH) recorded in continuous timing are broken down into the following elements.

EFFECTIVE PRODUCTIVE TIME (EPT): Begins when a site preparation or planting tool is in contact with the ground or is cycling and the prime mover begins *forward* travel. The EPT can be subdivided into *winching* if the tool is equipped with a quick disconnect hitch and is functioning effectively during the winching process.

MANEUVER (TURN): Occurs when a tool has finished a pass and begins to turn until the scarifier begins the next pass. For some tools this element includes raising the implement off the ground and lowering it at the end of the turn. If a winch is used, the time free-spooling and winching is included. Maneuver is broken down into the type of turn: run-by-run, operation in lands pattern, or broken pattern.

OBSTACLES: From the time that a stop is necessary because of an obstacle until scarification resumes. Depending upon the cause, the obstacle time is charged against the implement or the prime mover.

TRAVEL: The time spent travelling in the block or to the roadside between breaks, repairs, lunch, and start and end of shift. It also includes travelling between sites if less than 15 min.

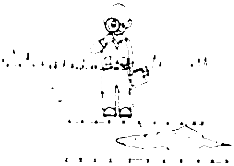
DELAYS: Includes those between 0.05 min and 15 min. Delays over 15 min are not considered part of productive time. Delays are any down time and nonproductive operating time.

TRAVEL SPEED: Average operating speed consisting of EPT for both implement and prime mover over a measured distance.

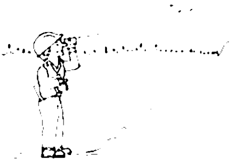
APPENDIX III

POST-TREATMENT ASSESSMENT

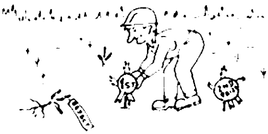
SOIL DISTURBANCE



PLANTABILITY



SLOPE



PLANTING QUALITY

IIIa POST-TREATMENT ASSESSMENT PROCEDURE: SITE PREPARATION

Equipment and Crew

- Black pencil (H or 2H)
- Post-treatment tally sheets. See tally sheet No. 3.
- Waterproof tally paper for rainy days (21½ x 35½ cm paper)
- Clipboard (for 21½ x 35½ cm paper)
- Two 2-m rods (2-cm diam marked off at 20-cm and 1-m intervals)
- 50-m tape
- Compass
- Sunto clinometer
- Protractor
- Hand planting tools if prescription is plantable microsites
- Two-person crew (one assessor and one tally person)

The following is an example of a method of assessing site preparation for planting or seeding. The assessment includes a measurement of net and gross soil *disturbance* which may include receptive seedbed, row spacing, reasons for missed scarification and amount of missed scarification, and an assessment of *plantability* on microsites which includes the rating of microsites for hand planting. The definitions and parameters used in this example are from Smith et al. (1985). Additions to and/or deletions from this procedure may be required to suit local requirements.

Presampling

For the disturbance assessment, follow the presampling system set out in Steps 1 to 3 of Appendix Ia. There is an additional requirement that each transect consist of 10 2-m x 2-m quadrats located *perpendicular* to the direction of machine travel (Fig. 17). Each quadrat is to be considered discrete. Therefore, the assessment of the quadrat is not affected by conditions in an adjacent quadrat. Data are summarized statistically on a quadrat basis for critical parameters.

If plantability is also to be assessed then a transect approximately 40 m long (the length depending on spacing prescription) will be established along the direction of travel (Fig. 18). Data are summarized statistically on a transect basis for critical parameters.

[redacted]

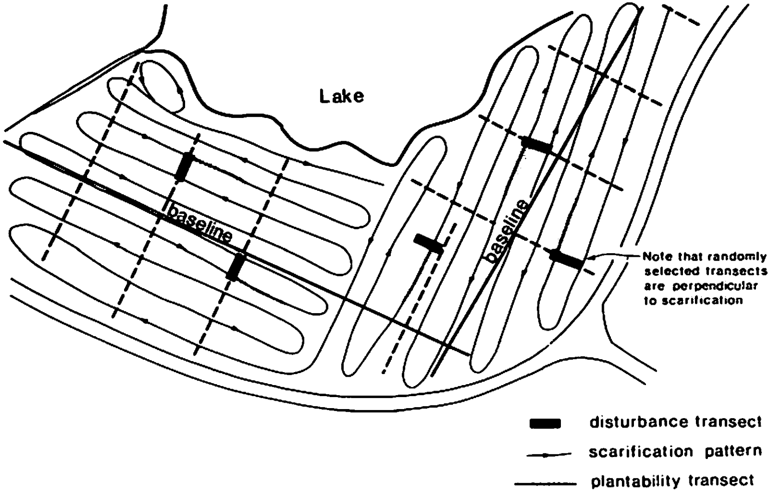


Figure 17. Orientation of transects (post-treatment assessment)

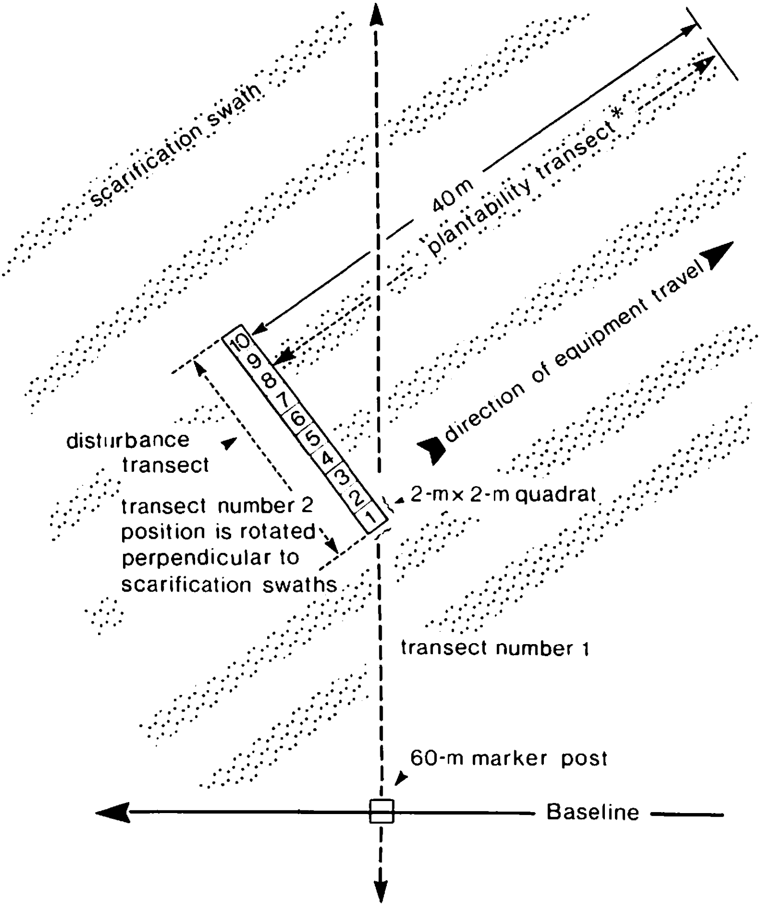


Figure 18. Layout of transects (post-treatment assessment disturbance and plantability)

Presampling will consist of five transects each for disturbance and plantability, randomly located in pairs. Proceed as follows.

Step 1. The baseline and offsets established during the pre-assessment are located.

Step 2. With a two-person crew and a list of randomly chosen transects the start of the first disturbance transect is located by chaining to the predetermined starting point along the baseline and then perpendicular to the baseline to the appropriate 20-m interval (Fig. 17). Crew person No. 1 starts at this point and lays the tape 20 m at right angles to the direction of equipment travel. This represents the center line of the five 2-m x 2-m quadrats (Fig. 18). Crew person No. 1 returns to the start and, with the two 2-m rods and a planting tool if required, is ready to start assessing.

Step 3. Crew person No. 2 is responsible for the tally. Refer to tally sheet No. 3, Appendix IIIc for a description and example of tally format. Crew person No. 1 relays information to the tally person starting with block, baseline, transect number, and quadrat that he or she is about to assess.

Step 4. Starting at the first quadrat the assessor lays both 2-m rods on the ground perpendicular to the tape so that the tape crosses the center line or 1-m point of each rod and the rods are situated at the zero point of the tape and at 2 m. The assessor first determines whether or not there was implement *passage* through or over the quadrat, i.e., the quadrat lies within a prepared row. Record yes (1), no (2).

Sampled Parameters

Step 5. Disturbance assessment involves the determination of total ground disturbance and micro-disturbance.

Disturbance assessment

Total disturbance: The total disturbed area in the quadrat of soil and/or duff (LFH layer) disturbed by the *implement* is measured to the nearest 5% and recorded. It should be noted that a 20-cm x 20-cm patch represents 1% of the quadrat area. This procedure is repeated for the total combined disturbance from *other* sources (including logging, implement prime mover, and natural causes) (Fig. 19).

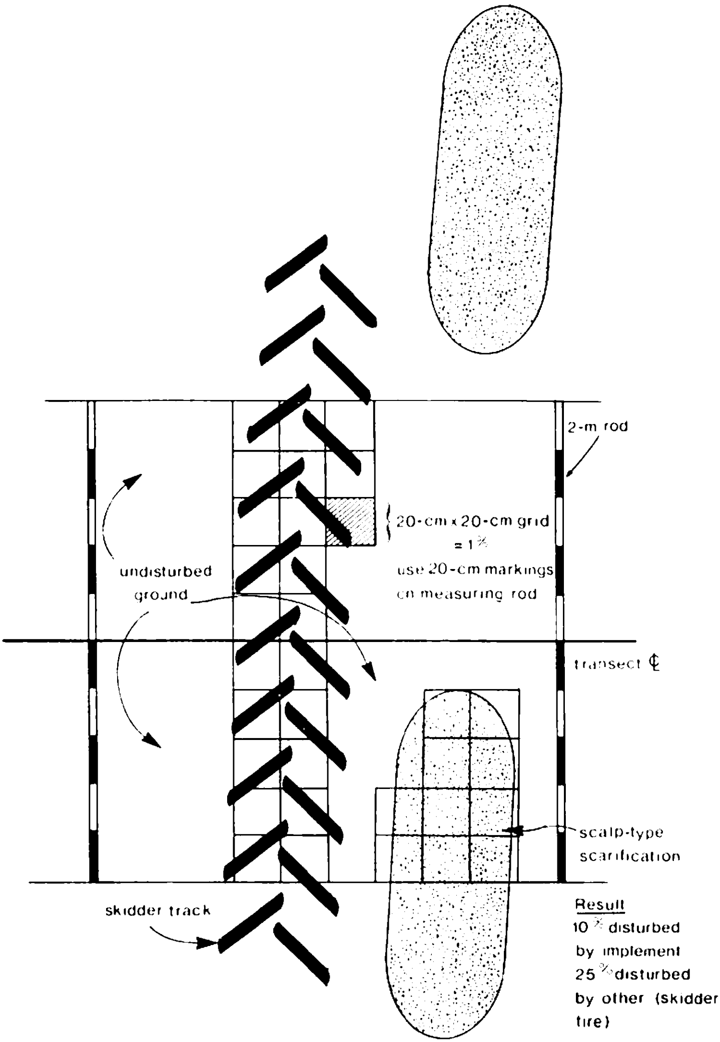


Figure 19. Percent total disturbance

Disturbances for the above measurements are defined as follows:

a) exposed or dislocated mineral soil

b) reduced, compressed (< ½ undisturbed depth), or dislocated duff

c) exposed rock previously covered by duff and/or mineral soil

Note: Dislocated slash, vegetation or rock are not included.

Micro-disturbance: The percentage of area resulting from disturbance by the *implement* is measured to the nearest 1% and recorded under the appropriate *"Soil/ Duff Modification Type"* as coded in Appendix IIIb. As many soil duff modification types as are necessary to describe the quadrat are tallied.

In the case of scalp or intermittent type scarifiers only those portions within the 2-m x 2-m quadrat should be assessed.

If no desirable modification types can be found in the quadrat then the major *reason* is recorded, such as ground not scarified, bedrock, debris, stump, roots, depressions or holes, residuals or, if the reason is not evident, an unknown category. A suitable numbering code should be used for the tally sheet.

Where it is a concern, the amount of disturbance from other causes should be recorded separately and the same modification types used. Under *origin,* the cause of other disturbance (e.g., prime mover, logging activity, natural causes or unknown) should be recorded with a suitable numbering code.

It is possible to derive an estimate of receptive *seedbed* in this assessment by selecting soil/duff modification types that correspond to the definition of seedbed. If seedbed only is required, this completes the tally on the 2-m x 2-m quadrat.

This completes the data collection on one 2-m x 2-m quadrat.

Step 6. The assessor now advances 2 m, reestablishing the rearmost 2-m rod to the farthest side of the next quadrat in 'leap frog' fashion, and repeats steps 3 to 5. At the end of the 20-m line, 10 segments have been recorded and are represented by 10 line entries on the tally sheet.

Step 7. Slope

After completion of the five disturbance quadrats, slope readings can be taken where each pass crosses the transect. Crew person No. 1 is positioned where the pass crosses the quadrat. Crew person No. 2 extends a tape along the line of equipment travel a distance of 20 m. Crew person No. 1 then takes a slope reading using the clinometer and sighting crew person No. 2. The reading is recorded, to the nearest percentage, as a plus or minus slope relative to the direction of equipment travel (Bäckström 1970). Readings are taken consistently on the same side of the transect. Side slope perpendicular to the direction of travel is recorded if it exceeds 15%.

Step 8. Width and spacing of scarification

The width and spacing of scarification are measured, to the nearest 10 cm, along the 20-m transect length, with tight chaining. The following information should be recorded according to the scarification tool used.

Blade or corridor equipment: The *gross width* of a corridor, i.e., from the center of one berm to the center of the next (Fig. 20), is recorded to the nearest 0.1 m. The *net width* of the corridor, i.e., width of scarified soil, should then be recorded, and where appropriate, the *inter-pass spacing*, i.e., the untreated area from the center of one berm to the center of the next. Each pass and inter-row space is recorded consecutively until the last complete pass, which can be measured within the 20-m transect.

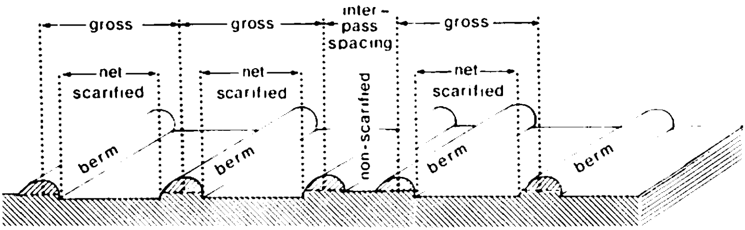


Figure 20. Blade or corridor scarifiers

Multi-furrow scarifiers: The overall *gross width* of a multi-furrow pass, i.e., the distance between the berms of the outermost scarifying heads, measured to the outside of the berm, is recorded. Within the pass the *gross* and *net width* of each furrow are recorded, the net width being the width of scarified soil within the furrow (Fig. 21). Overall gross width of the pass, gross and net width of each furrow within a pass, and the *inter-row* and *inter-pass* spacing are recorded consecutively by pass number.

Scalp or intermittent scarifiers: The *gross width* of scalp or intermittent scarifiers, i.e., the distance between the berms created by the outermost scarifying heads, measured to the outside edge of the scalp, is recorded. Within the pass, the *net width* and *net length* of the closest attempt to the transect line within each scarified row are recorded (Fig. 22). The net length and width refer to the scarified portion of the attempt. The *inter-row* and *inter-pass* spacing and the *within-row* spacing between consecutive scalps are recorded consecutively.

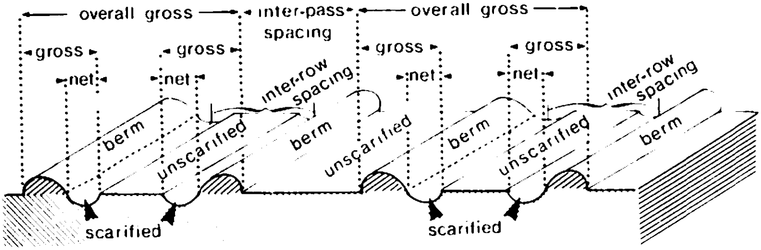


Figure 21. Multi-furrow scarifiers

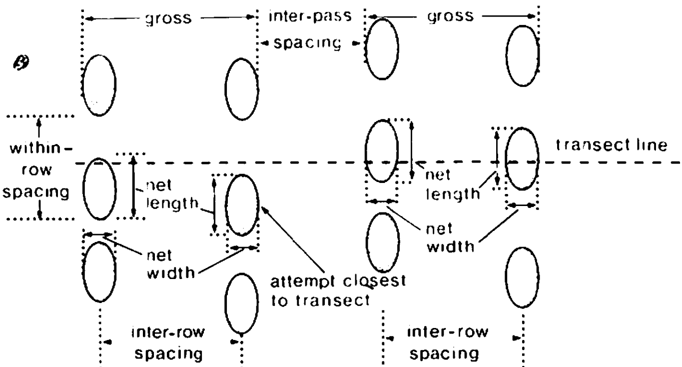


Figure 22. Scalp or intermittent scarifiers

Coverage intensity is worked out from inter-row spacing for continuous-type scarifiers. In the case of scalp-making or intermittent scarifiers, the number of scalps or attempts per lineal distance is required and can be worked out from the within-row spacing.

This completes the tally if disturbance only is to be considered. If, in addition, plantability is to be rated, one proceeds to Step 9.

Step 9. Plantability assessment

Planting spot selection depends on a variety of factors. For example, level or raised microrelief can dictate choice of planting spot as can duff depth and vegetative competition. The various criteria for the selection of a plantable spot must be established previously and be applied in relative order of importance so that one can choose the best available spot.

Plantable microsites are assessed along and within the swaths or passes and not on a quadrat basis. The transect is located along the direction of equipment travel so that consecutive planting attempts can be assessed and thus simulate, as closely as possible, a true operational situation of a hand planter advancing along a swath. The length of the assessment transect is determined by pre-established spacing criteria. Twenty planting attempts per transect are a suggested minimum. If, for example, the prescribed spacing is 2 m x 2 m with a range of plus or minus 0.5 m, then the length of the transect is 20 m x 2 m = 40 m long.

The procedure is to locate the last most complete furrow or line of scalps that crosses the disturbance transect line and to lay out the plantability transect along the direction of equipment travel (Fig. 18).

Starting at the intersection of the center of the furrow and the center line of the disturbance transect, the chain is extended 40 m. This represents the center line of the plantability transect for one row of trees. For furrows that are wider than one row of trees (e.g., blade scarification), where up to three rows of trees can be planted, the plantability assessment must be applied to all three rows and preferably tallied in the same sequence as is operationally prescribed for hand planters.

Starting at the zero end of the chain, what appears to be the best plantable or marginally plantable microsite is selected, according to previously established criteria and within a target area of ± 0.5 m from the starting point (Fig. 23). This is considered the *first choice plantability microsite* and is verified by inserting the planting tool to check for adequate soil penetration. In addition, the position is marked by a chaining pin which acts as a guide to spacing and can be particularly useful when more than one row of planting microsites is possible in a swath. If penetration is insufficient or the first choice is rated non-plantable by any of the selection criteria described below, a second choice plantability microsite must be described within the same target area and recorded on the same line of the tally sheet. This second choice must not be equal to, nor must it be a better planting chance than, the first attempt. Several attempts may be required before a second choice is located. If a plantable or marginally plantable microsite cannot be found, then the best non-plantable microsite will be recorded as the second choice.

Microsites are described as being plantable, marginally plantable or non-plantable as indicated in the following example. Descriptive information is recorded on tally sheet No. 3.

Selection criteria (example): In order of importance, a plantable or marginal microsite consists of an area approximately 30 cm^2 that was created by the implement only, with level microrelief, raised or on a side slope, the soil/duff modification type consisting of classes 10, 11, 12, 20, 21 or 22 (See Appendix IIIb) and the spot clear of debris, with no competing vegetation.

Note: According to local definitions (P) refers to a plantable condition, (M) to a marginally plantable condition and (NP) to a non-plantable condition.

Origin:	Created by implement (P)	1
	Created by prime mover (logging or prepared) (NP)	2
	Created by harvesting (NP)	3
	Natural disturbance (NP)	4
	No disturbance (NP)	5
	Unknown	6

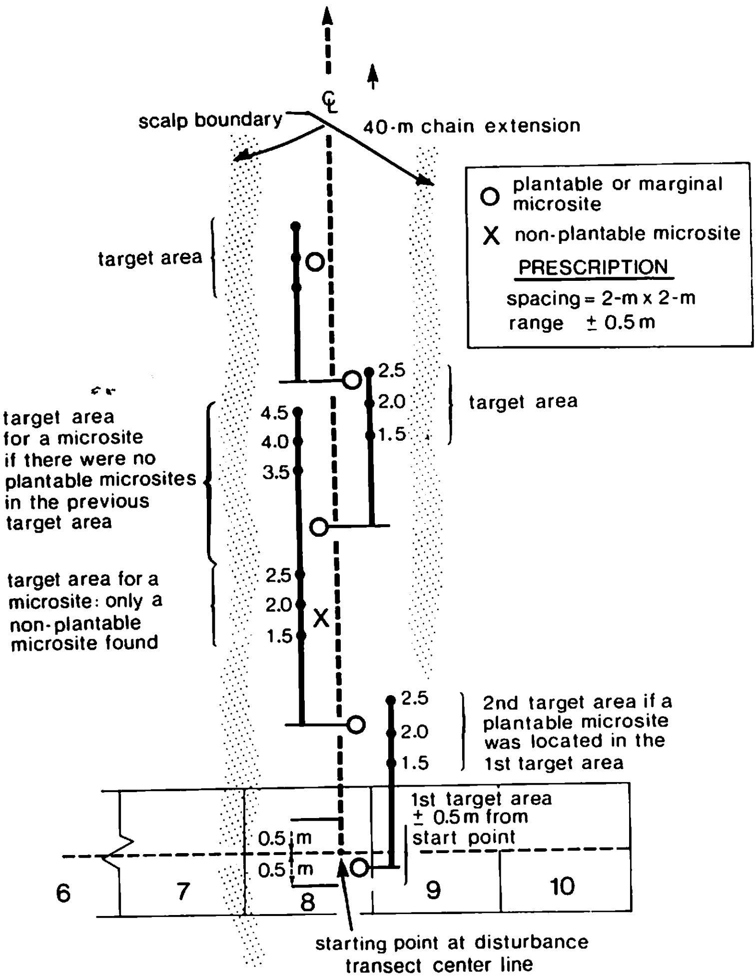


Figure 23. Location of plantability microsites

Microrelief: Level (mineral soil/duff interface) (P) 1
Raised (P) 2
Side slope (P) 3
Hollow (lowest portion of scalp) (NP) 4

Micro-disturbance: For each microsite selected the soil/duff modification type which best describes the attempt is recorded (Appendix IIIb).

Debris: The extent to which the microsite is covered with logging debris such as needles, bark, twigs, stems, roots, etc., is determined.

None 1
Partially covered requiring the planter to move a slight amount of material prior to planting (P) 2
Light (M) 3
Heavy (mostly or completely covered, requiring a planter to alter the site prior to planting) (NP) 4

Vegetative competition: No competing vegetation (P) 1
Competing herbaceous vegetation (M) 2
Competing woody vegetation (NP) 3

Penetration: The extent of planting tool penetration is recorded:

Full penetration (P) 1
Less than full penetration caused by:
bedrock or large boulder (NP) 2
stones (NP) 3
roots (NP) 4
debris (NP) 5
etc.

Plantability: Yes = 1 is recorded if all the above-mentioned criteria for a plantable or marginally plantable microsite are met on either of the first- or second-choice microsites in the target area. If non-plantable, no = 2.

Attempt (scalp): For trials in which scalp making or intermittent equipment is used the search for plantable microsites is limited to each scalp attempt. The attempt, numbered in consecutive order, in which the microsite target area is located is recorded.

This tally will indicate instances in which two microsite target areas exist in the same scalp and will provide a ready count of scalp attempts per transect.

Position: The position of the microsite refers to where the row is located in a furrow. When only one row of planting spots is possible (i.e., disc trenching), a (1) is entered at the start of the row. For corridors or wide swaths where two or more plantable spots are possible the following identification number is assigned:

Row closest to right-hand berm	(1)
Center row bordered by other rows	(2)
Row closest to left-hand berm	(3)

Location: The actual distance from the start of the transect to the microsite is recorded to the nearest 0.1 m, measured perpendicular to the center line of the transect.

This completes the tally for the first microsite target area located on the transect.

Step 10. The selection of the next microsite depends on the classification of the first microsite target area (i.e, plantable, marginally plantable or non-plantable). If plantable or marginally plantable, the assessor inspects a target area at a distance of 2 m from the first microsite plus or minus the 0.5-m range. If the first microsite target area failed to yield a plantable spot, the assessor then inspects an area *starting from the location of the non-plantable target area for a distance of 2.5 m*. The microsite is recorded as described in Step 9. Microsites are rated and each choice is marked on the ground until the end of the transect at 40.5 m from the start point.

This completes the plantability assessment. The markers for each microsite position are no longer required and can be either retrieved or discarded.

Step 11. <u>Area coverage</u>

After treatment, the total area treated must be delineated either on aerial photos or on maps, or it must be determined by measurement with tape and compass on the ground and mapped with the aid of a protractor. All areas not scarified within the block that are greater than 20 m^2 should be included. Overall times and machine production can then be related to net area treated (i.e., gross area less creeks, roads, swamp, landings, etc.).

Additional Comments

The time required to assess quality and quantity of soil disturbance as well as plantability is approximately 1.5 working hours for a trained crew (not including block layout). Considerably less time would be required if soil disturbance only were measured.

IIIb SOIL/DUFF MODIFICATION TYPES

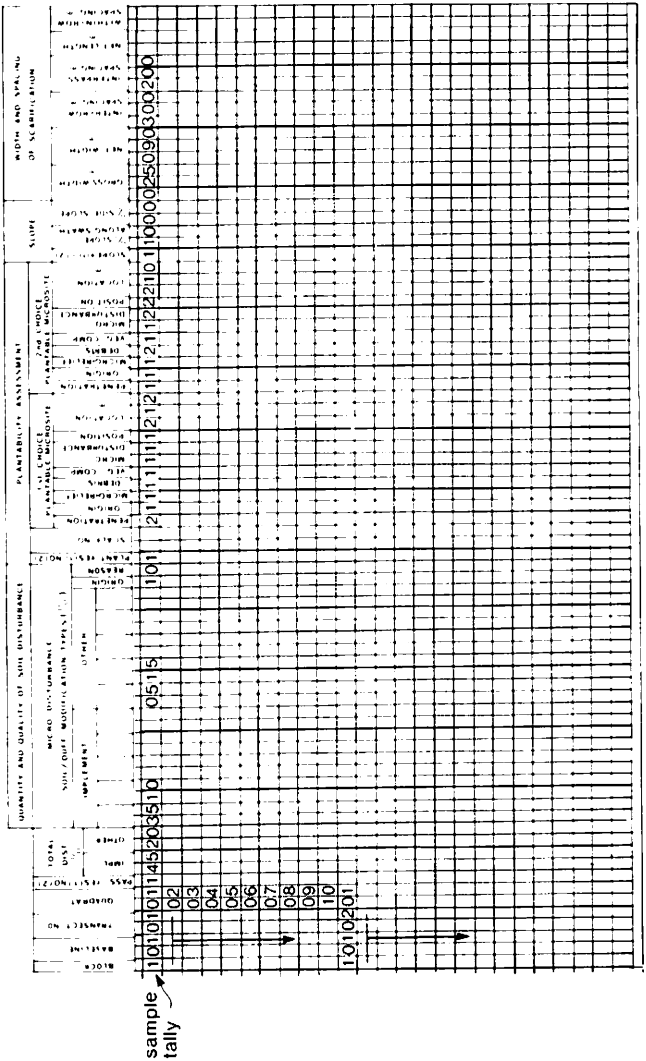
The following represent soil/duff modification descriptions, each of which can, in the case of plantability assessment, be rated as plantable (P), marginal (M) or non-plantable (NP). These descriptions and ratings of plantability are examples only (from Smith et al. 1985) and are arbitrarily defined for the purposes of equipment evaluation. They may vary with tree species and regional requirements.

Record the type number best describing the microsite.

<u>Type No</u>.

10	(P) Exposed mineral soil with a firm base, or
11	(P) Thin (≤1½ cm) *duff/mineral soil mix* which would readily settle to a firm base, or
12	(P) Thin (≤ 1½ cm) *duff* on firm mineral soil, or
20	(M) Mounded *mineral soil* on firm mineral soil, or
21	(M) Moderately thick (> 1½ cm ≤ 3 cm) *duff/mineral soil mix* on a firm base, or
22	(M) Moderately thick (> 1½ cm ≤ 3 cm) *duff* on firm mineral soil, or
30	(NP) Excessively deeply exposed parent *mineral soil,* i.e., 'c' horizon, or
31	(NP) Mounded *mineral soil* on thick duff or debris, or
32	(NP) Thick (>3 cm) *duff/mineral soil mix,* or
33	(NP) Thick (>3 cm) duff, or
34	(NP) Inverted sod layer, or
35	(NP) Other, includes mounded duff, exposed rock, water, etc.

IIIc TALLY SHEET FORMAT



Tally Sheet No. 3

The following is a sample format organizing an 80-column computer data collection form for post-assessment. Variations in the format may be necessary to accommodate local conditions. For all data sets a form similar to this should be prepared as part of the field data file, as this information is essential for compilation and analysis. Include a record and explanation of all values and codes recorded.

Column	Description	Possible Values
1	Block number	1-9
2,3	Baseline number	01-99
4,5	Transect number	01-99
6,7	Quadrat number	01-10
8	Code, tool passage through quadrat (1-yes, 2-no)	1,2
9,10	Percent total disturbance on quadrat by TOOL	00,05,10,15....95
11,12	Percent total disturbance on quadrat by OTHER	00,05,15,15....95
13,14	Percent micro-disturbance by IMPLEMENT by "soil/duff modification type"	00,01,02,03....99
15,16	Same as columns 13,14	
.		
.		
.		
21,22	" " " " "	
22,24	Percent micro-disturbance by OTHER by soil/duff modification type	00,01,02,03....99
25,26	Same as columns 25,26	
.		
.		
.		
31-32	" " " " "	
33	Code, dominant ORIGIN of OTHER micro-disturbance	0-8
34	Code, estimated REASON for NIL(0) micro-disturbance	0-9
35	Code, PLANTABILITY	1-2
36,37	Scalp number	1-97
38	Code, PENETRATION, planting tool, first choice	1-5
39	Code, ORIGIN, first planting choice	1-6
40	Code, MICRORELIEF, first planting choice	1-5
41	Code, DEBRIS, first planting choice	1-4

Column	Description	Possible Values
42	Code, VEGETATIVE COMPETITION, first planting choice	1-3
43,44	Code, MICRO-DISTURBANCE first planting choice	10-12,21,22 30-35
45	Code, POSITION, first planting choice	1-4
46,47,48	LOCATION, first planting choice, in decimetres from start of transect	000,001,002,003....200
49	Code, PENETRATION, planting tool, second choice	1-5
50	Code, ORIGIN, second planting choice	1-6
51	Code, MICRORELIEF, second planting choice	1-5
52	Code, DEBRIS, second planting choice	1-4
53	Code, VEGETATIVE COMPETITION, second planting choice	1-3
54,55	Code, MICRO-DISTURBANCE, second planting choice	10-12, 21-22 30-35
56	Code, POSITION, second planting choice	1-4
57,58,59	LOCATION, second planting choice, in decimetres from start of transect	000,001,002,003....200
60	Code, slope in direction of machine travel in swath (1 = positive, 2 = negative)	1,2
61,62	Percent slope along swath	00-60
63,64	Side slope, percent greater than 15	15-60
65,66,67	Gross width of corridor or swath Actual tight chain reading in decimetres on outside of berm from zero end of chain	000-200
68,69,70	Net width of corridor or furrow Actual tight chain reading in decimetres on edge of usable area from zero end of chain	000-209
71,72,73	Inter-row spacing of furrow or patch in decimetres Actual reading of tight chain	000-999
74,75,76	Inter-pass spacing of corridor or swath in decimetres actual reading of tight chain	000-999
77,78	Length of patch or scalp microsite in decimetres	00-99
79,80	Within-row spacing between patch or scalp in decimetres	00-99

Additional Notes (useful to copy and use in the field with tally sheet)

Implement (tool) Passage [Column 8]

Code	Description
1	Yes, tool passed *through* quadrat
2	No, tool passage *in* quadrat

ORIGIN, Other Micro-disturbance [Column 33]

Code	Description
0	Blank, not applicable
1	Unknown
2	Prime mover, scarification implement
3	Harvesting, skidding tractor
4	Harvesting, skidding, dragged load
5	Harvesting, felling/processing, etc.
6	Erosion, water
7	Natural, i.e., wind
8	Roads, landings, etc.

REASON for NIL Micro-disturbance [Column 34]

Code	Description
-	Blank, quadrat scarified
0	Unknown
1	Excessive slope
2	Local, non-negotiable ledge/precipice
3	Natural ground roughness, i.e., boulder field, erratics, etc.
4	Ground roughness from logging, i.e., erratic uprooted stumps/skidder ruts, etc.
5	Non-negotiable large stumps from logging
6	Excessive slash/logging debris
7	Residuals, not negotiable
8	Too wet, machinery mires
9	Fragile, not to be treated, i.e., thin/nil soil, wet/organic, etc.

Note: When assigning codes 1-9 the assessor must also consider obstacles off the quadrat in directions of travel. Maneuvering to avoid obstacles often leaves untreated area otherwise treatable.

Position planting choices [Column(s) 38,49]

Code	Description
1	Row closest to right-hand berm
2	Center row bordered by other rows
3	Row closest to the left-hand berm

ORIGIN [Column(s) 42,53]

Code	Description
1	Created by implement
2	Created by implement prime mover
3	Created by harvesting
4	Created by natural disturbance
5	No disturbance
6	Unknown

MICRORELIEF, [Column(s) 43,54]

Code	Description
1	Level (mineral soil/duff interface)
2	Raised
3	Side slope
4	Lower level (level area between level and hollow)
5	Hollow (lowest portion of scalp/furrow)

MICRO-DISTURBANCE [Column(s) 44-45, 55-56]

Code	Description
10	(P) Exposed mineral soil with a firm base, or
11	(P) Thin (≤1½ cm) *duff/mineral soil mix* which would readily settle to a firm base, or
12	(P) Thin (≤1½ cm) *duff* on firm mineral soil, or
20	(M) Mounded *mineral soil* on firm mineral soil, or
21	(M) Moderately thick (>1½ cm ≤ 3 cm) *duff/mineral soil mix* on a firm base, or
22	(M) Moderately thick (>1½ cm ≤ 3 cm) *duff* on firm mineral soil, or
30	(NP) Excessively deeply exposed parent *mineral soil;* i.e., 'c' horizon, or
31	(NP) Mounded *mineral soil* on thick duff or debris, or
32	(NP) Thick (>3 cm) *duff/mineral soil mix,* or
33	(NP) Thick (>3 cm) duff, or
34	(NP) Inverted sod layer, or
35	(NP) Other, includes mounded duff, exposed rock, water, etc.

DEBRIS [Column(s) 46,57]

Code	Description
1	None
2	Partially covered, requiring the planter to move a slight amount of material prior to planting
3	Light
4	Heavy, mostly or completely covered, requiring a planter to alter the site prior to planting

VEGETATIVE COMPETITION [Column(s) 47,58]

Code	Description
1	None
2	Competing herbaceous vegetation
3	Competing woody vegetation

PENETRATION [Column(s) 48,59]

Code	Desription
1	Full penetration
2	Limited by bedrock/giant boulder
3	Limited by stone/boulder
4	Roots
5	Debris

Slope type in direction of machine travel [Column 60]

Code	Description
1	Positive
2	Negative

APPENDIX IV

IVa POST-TREATMENT ASSESSMENT PROCEDURE: MACHINE-PLANTING

Equipment and Crew

Black pencil (H or 2H)
Post-treatment tally sheets. See tally sheet No. 4.
Waterproof tally paper for rainy days (21½ x 35½ cm paper)
Clipboard (for 21½ x 35½ cm paper)
50-m tape
Compass
Protractor
Two 2-m rods (2 cm diam marked off in 20-cm and 1-m intervals)
Two-person crew (one assessor and one tally person)

The assessment method involves inspection of planted seedlings along a series of randomly selected transects and is carried out in two stages, planting quality assessment and site preparation assessment. Planting quality assessment involves a tally of the number of planting attempts, quality of insertion, spacing between trees, reasons for poor planting, reasons for poor spacing, spacing between rows and microsite descriptions of planting spots, and is measured along the row for a distance of 40 m. Upon completion of the planting-quality assessment, a 20-m-long transect located perpendicular to the row is assessed for classification into soil/duff modification types, thereby providing a rating of site preparation.

The description of planting quality can vary according to tree species, site conditions, and established *quality and stocking* standards. The following specifications for planting quality are based on requirements and conditions in boreal Ontario and therefore are useful as an example only. The parameters measured, however, are general in nature, and could apply to most forest regions in Canada.

Presampling

Assessment transects are located according to steps 1 to 3 of Appendix Ia, with the following exceptions: for planting-quality assessment, the transect is to be 40 m long and established along the direction of travel; data are to be summarized statistically on a transect basis for critical parameters. For site-preparation assessment, the transect is to consist of 10 quadrats, each 2 m x 2 m, located perpendicular to the direction of machine travel. Data are summarized statistically on a quadrat basis for critical parameters.

Presampling involves five transects each for planting quality and site preparation, randomly located in pairs. Proceed as follows.

Step 1. Locate the baseline and offsets established during the pre-assessment.

Step 2. With a two-person crew and list of randomly chosen assessment strips, locate the beginning of the first assessment strip by chaining to the predetermined point along the baseline and then perpendicular to the baseline to the appropriate 20-m interval. Either select the planted row that intersects the line closest to the starting point or, if these are parallel, choose the closest point within a row. Crew person No. 1 will then advance the tape 40 m along the row in the direction of machine travel. Do not establish a 40-m line near the end of a pass where equipment may be maneuvering. Crew person No. 1 will return tc the start and, with tally sheet No. 4 in hand, will be ready to start assessing.

Step 3. Crew person No. 2 is responsible for the tally. Refer to tally sheet No. 4 of Appendix IVb for a description and example of tally format. Crew person No. 1 relays information to the tally person starting with block, baseline and transect number. Measure the following:

Sampled Parameters

Step 4. Planting-quality assessment

Tree insertion: The assessor advances along the pass recording the distance, to the nearest 0.1 m, from the start of the transect to the planting attempt. Planting attempts are assessed on tally sheet No. 4, and the information is recorded by tree/attempt number (one per line) as follows:

Planting quality is divided into three categories: satisfactory (1), fair (2) and not planted (3) (Cameron 1980).

- *Satisfactory* - firmly planted (does not yield to a firm tug on its stem) to a depth between root collar and a third of the green foliage buried at ground level

- *Fair* - satisfactory limits exceeded but tree considered to have a 50% chance of surviving

- *Not planted* - tree considered to have little or no chance of surviving

- *Reasons for "Fair" and "Not planted"*

Loose - yields to a tug	1
Shallow - root collar well above ground level	2
Deep	3
Buried	4
Roots exposed	5
Minor injury	6
Major injury	7
Excessive lean	8
Slit not closed	9
Tree missing	10
Unknown	99

Assessment of quality of tree insertion refers to the operation of the planting mechanism regardless of microsite quality. For example, a seedling may have been satisfactorily planted but in an unsuitable microsite such as a hole.

Step 5. Plantability: Planting machines are designed to operate most effectively on cleared or site-prepared ground. The ability of the site preparation tool to clear debris and prepare plantable microsites is often critical to the achievement of successful and consistent planting quality.

The micro-environment within 30 cm^2 of the planted tree or attempt is rated by the microrelief or position of the tree in relation to ground level, microdisturbance as determined by the soil/duff modification types described in Appendix IIIb, presence of obstructions affecting planting equipment, competing vegetation at the planting spot and penetration of the planting device. Tally the following:

Microrelief: Record the class of planting attempt microrelief as follows:

Level (mineral soil/duff interface)	1
Raised	2
Side or slope	3
Hollow (lowest portion of scarification)	4

Micro-disturbance: For each planting attempt record the soil/duff modification type that best describes the spot.

Obstructions: There are various physical impediments to proper functioning of the planting device. These are coded as follows when they adversely affect planting quality:

None	1
Light debris	2
Heavy debris	3
Hole (stump)	4
Hole (boulder)	5
Roots	6
Stems	7

Vegetative competition: No competing vegetation	1
Competing herbaceous vegetation	2
Competing woody vegetation	3

Penetration: Record the extent of penetration by the planting devi:e:

Full penetration	1
Less than full penetration caused by:	
bedrock or large boulder	2
stones or boulders	3
roots	4
debris	5
compact soil	6
Excessive penetration caused by:	
muck (includes organic soil)	7
dry, light soil	8

Step 6. Damage from adjacent pass: Trees in planted rows are are sometimes adversely affected by the activity of the planting equipment and/or prime mover during adjacent passes. Identification of the cause of damage to a seedling can be difficult, but if the result is obvious, apply the following code:

Not damaged	1
Trampled	2
Gouged out by machines	3
Gouged out by slash/debris	4
Partially shaded by slash/debris	5
Heavily shaded by slash/debris	6
Buried by soil/slash debris	7

Step 7. Reason for excessive inter-tree spacing: The required spacing between satisfactory and fair planted seedlings is specified by local requirements as to acceptable minimum and maximum distances. For example, if the required inter-tree spacing is 2 m, then a range of plus or minus one half of this distance, from 1 to 3 m, may be considered acceptable. More than 3 m is excessive spacing; up to two reasons can be recorded, and coded as follows:

Spacing from last planted seedling acceptable	1
No reason, i.e., all conditions appear acceptable for planting	2
Adjacent pass	3
Excessive positive slope	4
Excessive negative slope	5
Excessive side slope	6
Localized ledge/precipice	7
Natural ground roughness, i.e., boulders, sink holes, etc.	8
Ground roughness from logging, i.e., uprooted stumps, skidder ruts, etc.	9
Stumps	10
Excessive slash, logging debris	11
Residuals	12
Brush, woody competition	13
Minor vegetation competition	14
Too wet, soft, mucky soil	15
Dry, flowing, compressible soil	16
Bedrock/thin soil	17
Machine (malfunction)	18

Note: In view of the number of variables that can affect the spacing of seedlings, the tally person should exercise care in identifying a cause. Increased familiarity with the equipment operation and site conditions will result in quicker identification as the tally progresses.

This completes the tally of planting quality, microsite preparation, non-plantable distance and damage from the adjacent pass. Repeat this procedure for each planting attempt in the 40-m transect.

Step 8. Site-preparation assessment

The proper functioning of a mechanical planting device is often highly dependent on the clearing of a uniform and obstruction-free path by scarification tools such as plows and scarifiers. For this reason, site preparation, independent of planting, is assessed to help explain less than satisfactory planting and to provide a rating of the effectiveness of the site preparation. If it is considered useful to assess site preparation, proceed as follows:

From the start of the planting quality transect, rechain a new 20-m transect perpendicular to the direction of equipment travel. Refer to steps 4 - 6, inclusive, in Appendix IIIa for instructions on soil disturbance quantity and quality. Record total disturbance and micro-disturbance on tally sheet No. 4.

This completes the planting-quality and site-preparation assessment for the presample. The information collected will be used to calculate sample size for those parameters deemed critical and the number of additional 20-m lines required.

Step 9. Inter-row spacing

After the planting operation the block is traversed at right angles to the direction of machine travel at least twice in order to measure inter-row spacing. Tight-chain the line and measure to the nearest 0.1 m between the center line of each planted row. Do not include rows closer than 20 m to block boundaries.

Additional Comments

The assessment of each 20-m strip requires approximately 25 minutes for a trained crew and includes the reassessment of the row for site preparation. Up to 40 minutes may be required if debris is heavy. The extra time is necessary to find planted seedlings under debris and otherwise to interpret what has happened when trees are not planted.

Site variability often dictates that planting machines be designed with a series of adjustments or settings that can be changed to suit the conditions at hand. This is especially true for manually fed planters in which variation can be due to human factors. Machine functions such as planting cycle speed, down pressure of planting dibble or packing wheel pressure may have to be adjusted mechanically, hydraulically or electrically to optimize the planting result. As part of the assessment information collected during field trials, machine settings can be recorded at the top of tally sheet No. 4. Machine settings can be a critical factor in achieving planting quality.

[redacted]

Tally Sheet No. 4

Block	Baseline	Transect No.	Tree No.	Location (m)	Planting Quality Assessment – Planting Quality: Tree Insertion	Reasons for Fair and Not Planted Max. of 2	Plantability: Micro Relief	Micro Disturbance	Obstructions	Veg. Comp.	Penetration	Damage Adj. Pass	Reasons for Excessive Inter-tree Spacing Max. of 2	Site Preparation Assessment: Quadrat	Passage Yes(1) No(2)	Total Dist. (%) Impl.	Total Dist. (%) Other	Micro Disturbance of Soil/Duff Modification Types (%) – Implement: 11	Implement: 12	Other	Origin	Reason	Inter Row Spacing (m)
1	01	01	01	160	2	06 09	2	1	1	1	1	64	00 00	01	1	90		05	040		0		020
			02																				
			03																				
			04																				

sample tally →

IVb TALLY SHEET FORMAT

The following is a sample format organizing an 80-column computer data collection form for post-assessment. Variations in the format may be necessary to accommodate local conditions and different planting machines. For all data sets a form similar to this should be prepared as part of the field data file, since this information is essential for compilation and analysis. Include a record and explanation of all values and codes recorded.

Column	Description	Possible Values
1	Block number	1-9
2,3	Baseline number	01-99
4,5	Transect number	01-99
6	BLANK	-
7,8	Planting attempt/tree number	01-99
9,10,11	Planting attempt location Reading of tape to nearest decimetre (dm)	000-200
12	Code, tree insertion quality of planting attempt	1-3
13,14	Code, reasons for fair or not planted	01-99
15,16	Code, reasons for fair or not planted	01-99
17	BLANK	-
18	Code, microrelief	1-5
19,20	Code, micro-disturbance	10-12,20-22,30-35
21	Code, obstructions	1-7
22	Code, vegetative competition	1-3
23	Code, penetration	1-8
24	Code, damage by adjacent/subsequent passes of machine	1-7
25,26	Code, excessive spacing between planting attempts, reason	01-20,99
27,28	Code, excessive spacing between planting attempts, reason	01-20,99
29,30	BLANK	-
31,32	Quadrat number	01-10
33	Code, tool passage through quadrat	1-2
34,15	Percent disturbance by tool	00,05,10,15....95
36,37	Percent disturbance by other than tool	00,05,10,15....95
38,39	Percent MICRO-DISTURBANCE by: Implement by "soil/duff modification type"	00,01,02,03....99
40,41	Same as columns 38,39	00,01,02,03....99

.
.
.

Column	Description	Possible Values
	" " " " "	"
48,49		
50,51	Percent MICRO-DISTURBANCE by OTHER THAN IMPLEMENT by "Soil/Duff modification type"	00,01,02,03....99
52,53	Same as columns 50,51	"
54,55	" " " " "	"
56,57	" " " " "	"
58,59	" " " " "	"
60,61	" " " " "	"
62	Code dominant ORIGIN of OTHER Micro-disturbance	0-9
63,64	Code, REASON for NIL Micro-disturbance	01-20,99
65	BLANK	-
66,67,68	Actual reading on tape, to nearest decimetre of centers of rows of planted trees	00-999

Additional Notes (useful to photocopy and use in the field with tally sheet)

PLANTING QUALITY [Column 12]

Code	Description
1	Satisfactory
2	Fair
3	Not planted

REASONS FOR FAIR OR NOT PLANTED [Column(s) 13-14,15-16]

Code	Description
01	Loose, yields to a tug (of 2.5 kg)
02	Shallow, root collar well above ground level
03	Too deep, more than 1/3 foliage buried
04	Buried
05	Roots exposed
06	Minor injury
07	Major injury
08	Excessive lean
09	Planting slit (hole) not closed
10	Tree missing
11	etc.
99	Unknown

MICRORELIEF [Column 18]

Code	Description
1	Level (mineral soil/duff interface)
2	Raised
3	Side or slope
4	Lower level
5	Hollow (lowest portion or scarification)

OBSTRUCTIONS [Column 21]

Code	Description
1	None
2	Light debris
3	Heavy debris
4	Hole, stump
5	Hole, stone/boulder
6	Roots
7	Stem, residual/brush
8	etc.

VEGETATIVE COMPETITION [Column 22]

Code	Description
1	None
2	Competing herbaceous competition
3	Competing woody vegetation
4	etc.

PENETRATION [Column 23]

Code	Description
1	Full penetration
2	Limited by bedrock/large boulder
3	Limited by stone/boulder
4	Limited by roots
5	Limited by debris
6	Limited by compact soil
7	Excessive penetration, muck
8	Excessive penetration, dry light soil

DAMAGE, FROM ADJACENT PASSES [Column 24]

Code	Description
1	Not damaged
2	Trampled by machinery
3	Gouged out by machinery
4	Gouged out by slash/debris
5	Partially shaded by slash/debris
6	Heavily shaded by slash/debris
7	Buried by soil/slash/debris
8	etc.

REASON, EXCESSIVE SPACING [Column(s) 25-26, 27-28]
(between satisfactory and fair planting attempts)

Code	Description
01	Spacing from last planted seedling acceptable
02	No reason, i.e., conditions acceptable to excellent for planting
03	Adjacent pass, see column 24
04	Excessive positive slope
05	Excessive negative slope
06	Excessive side slope
07	Localized ledge/precipice
08	Natural ground roughness, i.e., boulders, sink holes, etc.

09 Ground roughness from logging, i.e., erratic uprooted stumps, skidder ruts, etc.
10 Stumps
11 Excessive slash, logging debris
12 Residuals
13 Brush, woody competition
14 Vegetative competition
15 Too wet, soft mucky soil
16 Dry, flowing compressible soil
17 Bedrock/thin soil
18 Machine (malfunction)
19 etc.
99 Unknown

<u>TOOL PASSAGE</u> [Column 33]

Code	Description
1	Yes, tool passed through quadrat
2	No, tool did not pass through quadrat

<u>ORIGIN - Other Micro-disturbance</u> [Column 62]

Code	Description
O/blank	Not applicable
1	Unknown
2	Prime mover, planting system
3	Planting machine
4	Harvesting, skidding, tractor
5	Harvesting, skidding, dragged load
6	Harvesting, felling/processing, etc.
7	Erosion, water
8	Natural, i.e., wind, windthrow, etc.
9	Roads, landings, etc.

<u>REASON for NIL Micro-disturbance</u> [Column(s) 63,64]

<u>Code</u>	<u>Description</u>
-	Blank quadrat scarified
0	Unknown
1	Excessive slope
2	Local, non-negotiable ledge/precipice
3	Natural ground roughness, i.e., boulder field erratics, etc.
4	Ground roughness from logging, i.e., erratic uprooted stumps/skidder ruts, etc.
5	Non-negotiable large stumps from logging
6	Excessive slash/logging debris
7	Residuals, not negotiable

6 Excessive slash/logging debris
7 Residuals, not negotiable
8 Too wet, machinery mires
9 Fragile, not to be treated, i.e., thin/nil soil, wet/organic etc.

MICRO-DISTURBANCE [Column(s) 19,20]

Code	Description
10	(P) Exposed mineral soil with a firm base, or
11	(P) Thin ($\leqslant$ 1½ cm) *duff/mineral soil mix* which would readily settle to a firm base, or
12	(P) Thin ($\leqslant$ 1½ cm) *duff* on firm mineral soil, or
20	(M) Mounded *mineral soil* on firm mineral soil, or
21	(M) Moderately thick ($>$1½ cm $\leqslant$ 3 cm) *duff/mineral soil mix* on a firm base, or
22	(M) Moderately thick ($>$1½ cm $\leqslant$ 3 cm) *duff* on firm mineral soil, or
30	(NP) Excessively deeply exposed *mineral soil,* i.e., 'c' horizon, or
31	(NP) Mounded *mineral soil* on thick duff or debris, or
32	(NP) Thick ($>$3 cm) *duff/mineral soil mix,* or
33	(NP) Thick ($>$3 cm) duff, or
34	(NP) Inverted sod layer, or
35	(NP) Other, includes mounded duff, exposed rock, water, etc.