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NEW ZEALAND

PROJECT REPORT

A SURVEY METHOD FOR ASSESSING SITE DISTURBANCE

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Project Report

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NEW ZEALAND

SURVEY METHOD FOR ASSESSING SITE DISTURBANCE

A procedure for estimating site disturbance caused by production thinning, harvesting, or mechanical site preparation

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INTRODUCTION

Site disturbance can be defined as any abrupt change in the chemical, biological and physical characteristics of a site. Changes may be caused by the following processes:

- soil compaction - which increases soil strength, which may impede the growth of roots, and reduce oxygen flow to the roots (aeration) and infiltration of rainfall.

- soil puddling or smearing - when the soils are wet which causes breakdown of the soil structure, resulting in decreased soil strength, and reduction of oxygen flow to the roots and infiltration of rainfall.

- soil, litter, and/or slash mixing - which can lead to increased nutrient availability in the short term, but also exposes soils to the erosive forces of rainfall.

- soil and litter displacement - which can result in soil nutrient depletion, changes in soil microclimate, and soil water retention where these layers are removed. Also exposes soils to the erosive forces of rainfall.

In the forest, site disturbance can be caused by earthworks, machine travel and tree removal associated with road construction and maintenance, production thinning, clearfell logging, and mechanical site preparation. Disturbance can occur at the landing, along roads and trails, in the residual stand or in the cutover, and at the edges of waterways.

Site disturbance may result in both on-site and off-site impacts, where the latter may not be immediately obvious and may occur some distance from the forest. The major primary impacts of site disturbance are as follows:

- increased soil erosion
- increased sedimentation
- changes in site nutrient pools
- changes in crop productivity
- changes in soil quality
- negative public perceptions

Assessment of the type and degree of disturbance resulting from operations within forests will allow forest managers and workers to:

(i) measure the impacts of specific practices,
(ii) help identify the potential for detrimental onsite or offsite impacts, and
(iii) provide a measure of machine and system performance at achieving environmental goals.

This Project Report outlines a survey method to assess site disturbance, and presents an example of pre-assessment planning and data analysis for a ground-based setting.

DISTURBANCE ASSESSMENT IN NEW ZEALAND

Only a small number of site disturbance assessments have been performed in New Zealand. These studies have included both production thinning and clearfell situations.

Firth *et al.* (1984) evaluated the use of aerial photographs, combined with ground reconnaissance, to assess the extent of disturbance on four clearfell blocks. The advantages of this approach compared to ground survey were that larger areas could be rapidly assessed, and that deep disturbance features could be easily identified. However, the identification of less severe disturbance, or disturbance on sites without distinct colour differences between surface and subsoils required additional ground survey for validation.

In another study, Bryan *et al.* (1985) used the point transect method to assess harvesting damage caused by ground-based extraction following harvesting on erosion prone land.

The most extensive study was performed by Murphy (1984), in which the line transect method was used at 17 sites throughout New Zealand. The sites included clearfelled and production-thinned stands, where ground-based (skidder and tractor) or highlead cable hauler systems had been used.

Recently, McMahon (1995) evaluated the accuracy and consistency of the point transect and the grid point intercept methods of assessment. The grid point intercept method (Curran and Thompson 1991) was developed by British Columbia Ministry of Forestry to assess compliance with regulatory disturbance limits. McMahon (1995) found that this method was consistently less accurate than the point transect method, raising some doubt as to the use of some survey methods for assessing compliance, particularly where prosecution may result. The assessment procedure presented here was based on the findings of that study.

There are no statutory requirements to perform disturbance assessments in New Zealand. However, as previously mentioned, valuable information on the impacts of operations, and the potential for adverse impacts can be gained by forest managers and/or workers if assessments are carried out. Site disturbance is one of several impacts of forest operations which can be monitored to allow optimisation of planning and operational decisions. Discussion of the framework by which impact monitoring or environmental auditing can be performed and interpreted is beyond the scope of this document.

OVERVIEW OF THE SURVEY METHOD

The different tasks required to complete a survey, and the respective page numbers in this report, are shown in Figure 1.

First, the area to be surveyed must be identified and the area measured. Not all of this area may be stocked, because of the presence of streams, uneven planting, or indigenous vegetation. Therefore, the net stocked area needs to be measured.

The disturbance assessment comprises the classification of disturbance types at one metre intervals, along transects orientated at right angles to the extraction direction. The spacing of the transects determines the total number of observation points within the survey area. The appropriate transect spacing is determined to ensure a standard level of error in the percentage disturbance estimates.

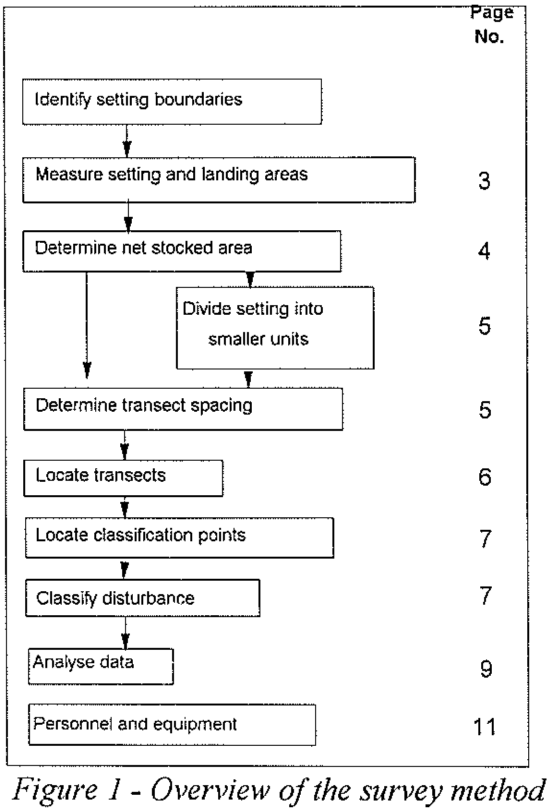


Figure 1 - Overview of the survey method

The disturbance type at each observation point is classified using the classification scheme provided. There are 15 disturbance types within the scheme, which differs from that often used in the past (usually comprising four to six types). Despite appearing complex, the scheme presented here is easy to use. The information produced will tell you more about the range of disturbance within an area, as well as allowing identification of the potential for adverse impacts.

The survey method can be used to assess disturbance within a setting. It can also be applied to smaller areas within settings, where the total area of interest is measured in a similar way to the setting.

MEASUREMENT OF SETTING AND LANDING AREAS

Definitions

A setting is the portion of a forest stand or compartment where wood is extracted to one landing. The area is expressed as the horizontal area, and therefore slope is not considered. The landing is included in the setting area.

A landing (also dump or skid site) is a selected or prepared area to which logs are extracted, processed, loaded or stockpiled. The landing also includes adjacent areas of concentrated log waste. In the case of two stage extraction, both landing and processing areas should be summed. Permanent or unplanted road surfaces crossing the landing are excluded from the measured area.

Both setting and landing areas are determined by first mapping their boundaries, and then measuring the area from the map.

Settings and landing boundaries can be mapped by:

- ground survey using: (1) compass, clinometer and tape measure/hip chain; or (2) a Global Positioning System (GPS) unit

- analysis of aerial photographs, using a stereoplotter, taken after the operation has been completed.

For landings only

- *using single aerial photographs, taken after the operation has been completed.*

Setting and landing areas can be measured by:

- using a planimeter.

- overlaying the setting map with grid squares of known area, counting the number which fall within the boundaries.

- digitising the setting boundaries using spatial analysis computer software, such as DIGI.

Setting boundaries shown on planning documents may not be strictly adhered to, and therefore validation by field measurement or aerial photograph analysis may be necessary.

All areas are expressed as horizontal measurements. Therefore, use of the simple ground survey method requires the slope component to be removed from the distance measurements using:

horizontal distance

= slope distance x cosine (slope angle)

This conversion is not required if a GPS unit is to be used.

Typically, forest resources are mapped at a scale of 1:10000, which would be a suitable base for this exercise. Ideally, a scale of 1:5000 would likely provide more accurate estimates.

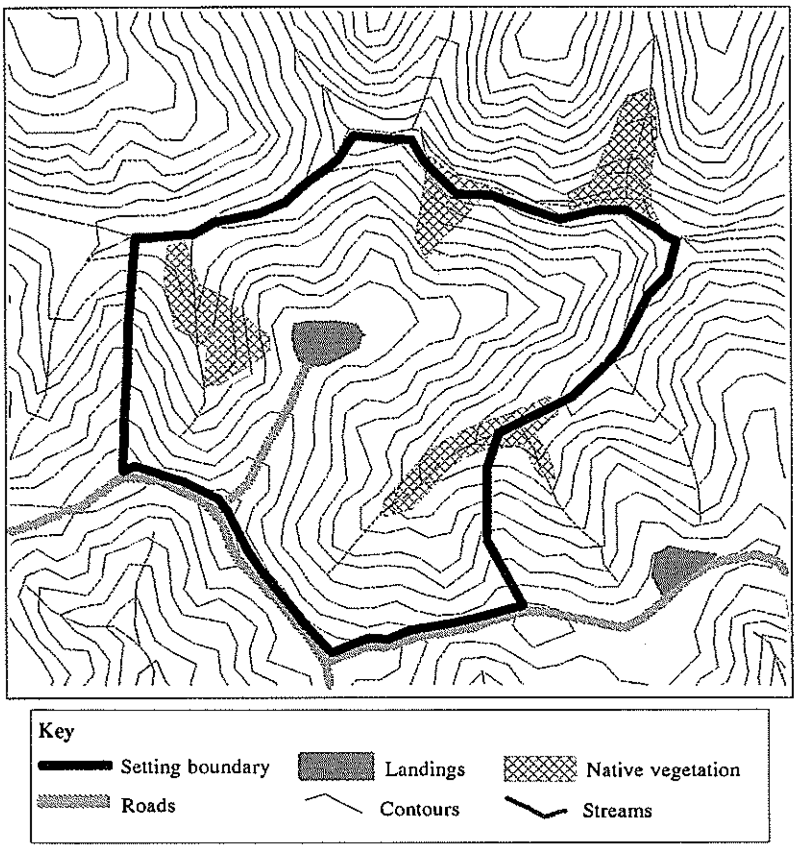
Single aerial photographs are only used for measurement of landing areas, as landings are small and level. Using single photographs for settings introduces errors into area estimates because of distortion on the photograph.

DETERMINATION OF THE NET STOCKED AREA

The net stocked area (NSA) is: *the area of planted land (ha) within a setting which excludes landings, unstocked areas, such as wetlands, rock outcrops, roads, and protected streamside management zones.*

It is within the NSA that the disturbance assessment is performed, and therefore percentage disturbance levels are expressed relative to the NSA. Specific methodology to assess disturbance within unstocked areas, such as streamside margins, is not covered here.

An example of NSA determination for a cable hauler setting is shown in Figure 2.



Net stocked area (NSA) = Setting Area - (area of landing, road and native vegetation)

Figure 2 - An example of determining the net stocked area from a topographic map

The areas occupied by roads can be determined from the total road length and average road width, measured in the field or from aerial photograph stereo pairs. Native vegetation and unstocked areas are measured using the methods to measure the setting area.

SUBDIVIDING THE SETTING

After measuring the setting and net stocked areas, the surveyor may have identified specific areas, such as streamside zones (excluding indigenous vegetation), wet areas, and different soil types, as well as areas having received different harvesting or site preparation treatments. To identify the levels of disturbance within these areas, the setting can be divided into smaller homogenous units. Subdivision of the setting will also be necessary where the dominant extraction direction changes, and where the survey area may be large and difficult to survey.

Subdivision can be planned prior to the field visit, particularly on larger settings where the entire setting cannot be easily viewed. On smaller settings, which can be viewed in their entirety, subdivision can be carried out in the field.

Once at the study setting, identify the boundaries between the units using hip chain cotton.

DETERMINING TRANSECT SPACING

A certain number of classification points within a setting or unit is required to ensure a specified error limit on the disturbance results (Table 1). For instance, if 2500 classification points are used, then the disturbance results will have a maximum error of 2% (for example, deep disturbance = 6 ± 2%, undisturbed = 70 ± 2%)

Table 1 - Classification point requirements for a setting according to error limits. Does not depend on the area to be surveyed

Absolute error (%)	No. of classification points
1	10000
2	2500
3	1111
5	400

The level of maximum absolute error that is best for a specific survey will depend on the purpose for which the survey is being carried out. If the results of several surveys were to be compared, then a high level of accuracy is desirable (2% to 3%). However, if the survey is being carried out to provide routine monitoring, then a less accurate result may be appropriate (5%). Ultimately, the decision as to what is appropriate will be decided by the organisation doing the survey. It must be kept in mind, that if, for instance, compaction was found to comprise 3% with a maximum absolute error of 5%, little can be reliably said about the result. Therefore, the magnitude of the error should be less than the smallest likely result.

Having decided on the most appropriate error limit, the transect spacing can be estimated from the following equation:

$$\text{Required transect spacing (m)} = \left(\frac{\text{survey area (ha)}}{\text{no. of classificaton points (Table 1)}} \right) \times 10{,}000$$

Two rules apply with the determination of transect spacing:

1. If a setting has been subdivided to allow comparison between different units, then each unit will need to have a transect spacing determined independently. Thus, the area of each unit will be used in the calculation.

   Example 1:

   A setting is subdivided into two units (Unit A = 4.3 ha, Unit B = 7.1 ha), and I want to compare the results for the two units, and have a 2% error in my estimates:

   Using Table 1, I require 2500 classification points for each unit.

   Thus, transect spacing for:
   Unit A = (Area(A) /2500) x 10,000
   = (4.3/ 2500) x 10,000
   = 17 m

   Unit B = (Area (B)/2500) x 10,000
   = (7.1/ 2500) x 10,000
   = 28 m

2. If a setting has been subdivided, but the surveyor is only interested in the results for the whole setting, then the transect spacing will be determined using the total setting area.

   Example 2:

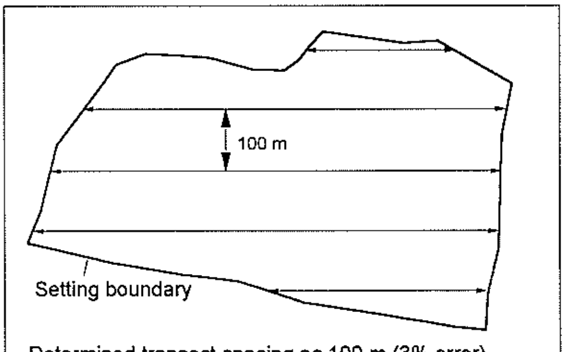
   A setting of total area of 11 ha has been subdivided into three units. I want to report my results for the setting with a 5% error in my estimates:

   Using Table 1, I require 400 classification points for the entire setting.

   Thus, transect spacing for:
   Unit A = (11 / 400) x 10,000
   = 275 m

If a setting has not been subdivided, then the transect spacing is calculated as shown in the second example.

Because of the often irregular shape of settings, the calculated transect spacing may have to be slightly adjusted to ensure the specified number of classification points. This can be done by manually overlaying a map of the setting with lines representing the transects at the estimated spacing (Figure 3). As the classification points occur at metre intervals along the transects, the total number of points within the setting can be estimated. Given this, the spacings can be modified as appropriate.



Determined transect spacing as 100 m (3% error)

By overlaying 100 m spaced transects over a setting map and measuring total length of transect;

length of transect = 950 m
@ 1 m spaced classification points
= 950 classification points

Need to decrease transect spacing to increase to 1111 sampling points required

Figure 3 - By overlaying setting boundary with transects, the number of classification points can be determined

LOCATING TRANSECTS

Two rules apply to the location of transects:

1. Transects are orientated at right angles to the dominant extraction direction. Note, there may be some

deviation from this within each setting or subdivided unit.

2. Transects should cover the entire setting or unit.

The first transect should be located no further than the transect spacing from the front (closest to the landing) of the setting or unit boundary. This distance should be decided before seeing the area to be assessed to eliminate bias. Subsequent transects should be spaced until the furthermost boundary is reached.

Example:

If the transect spacing was determined as 75 m, then the first transect should be arbitrarily located between zero and 75 m from the landing.

Transect orientations can be planned prior to visiting the study setting so that on reaching the setting the compass bearing for the transects is known.

LOCATION OF CLASSIFICATION POINTS

Disturbance is classified at one metre intervals along the transects, to allow small features, such as skid trails and ruts, to be identified.

Once a transect has been established, the first classification point should be located within the first metre of the transect (Figure 4). As with the location of the first transect, decide on a distance prior to starting the assessment. The subsequent classification points are best located using a tape measure, with the one metre intervals clearly marked with spray paint.

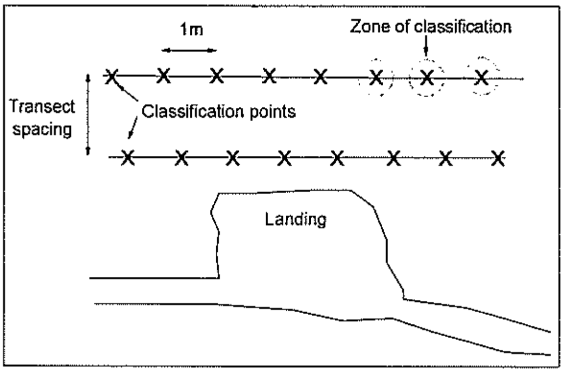


Figure 4 - Location of classification points on the transects

A hip chain is not recommended to locate the classification points, as it requires that the transect line must be able to be walked (it may be necessary to throw the tape over obstacles), the cotton does not always run freely, and the cotton stretches.

For each subsequent transect, the location of the first classification point should follow the same procedure, in this way ensuring that each transect is independent of the previous one (Figure 4).

CLASSIFYING THE DISTURBANCE

At each classification point, the dominant class or type of disturbance within a 30 cm radius is classified (Figure 4) using the scheme shown in Table 2. The disturbance classes and types are fully defined in the Appendix.

The scheme consists of five classes of disturbance, some of which are divided into different disturbance types. Additional disturbance information can be recorded by adding a clarifier suffix, which identify compaction (C), and mineral soil exposure within ruts (M). Thus, for each classification point there will be a disturbance code, with or without one of the clarifiers.

Table 2 - The classification scheme used for ground survey of disturbance.

DISTURBANCE CLASS	DISTURBANCE TYPE	CODE
Undisturbed		1
Shallow disturbance	litter in place litter removed, topsoil intact litter and topsoil mixed topsoil deposited on litter	2 3 4 5
Deep disturbance	topsoil removed, subsoil exposed erosion feature subsoil puddling 5-15cm deep rut 16-30cm deep rut >30cm deep rut subsoil/baserock deposit	6 7 8 9 10 11 12
Slash cover	10-30cm deep >30cm deep	13 14
Non-soil		15
CLARIFIER		**CODE**
Compacted Mineral/subsoil		C M

DATA RECORDING

There are several options for recording data, three of which are discussed here. How you record the data will in part dictate to what extent you can interpret it. If data for a setting or unit is recorded on a tally sheet, you are less likely to be able to identify where in the surveyed area specific types of disturbance were concentrated. When recording the codes-clarifiers in the order they were classified, you can separate data for each transect, which can then be related to the position in the surveyed area as you will know the location of that transect.

The simplest option is to record the occurrence of each disturbance code using tallies. Depending on the types disturbance likely to be seen, it may not be necessary to include all of the code-clarifier combinations on the tally sheet, making the sheet less cumbersome.

Two other alternatives are; (1) to record the disturbance codes and clarifiers into a water-proof book in the field, and then enter the data into a computer spreadsheet or data base when back in the office; or (2) enter the data directly into a field computer.

Recording into a book while in the field does have two advantages over using a computer; recorded data can be browsed, and; surveys can be completed in the rain, without risk of water or shock damage to computer equipment. The main advantage of using the computer in the field is that the data will be ready to be analysed.

If recording into a book in the field, each entry should be recorded as code - optional clarifier, such as "6C, 13, 9M, and 6".

If recording directly into a computer, or using a computer for subsequent analysis, the code-clarifier may need to be converted into a numeric code as most analysis software does not recognise the combined number and letter entry.

Each code-clarifier can be converted into a simple three digit number when entered into the computer.

The first digit indicates the clarifier (no clarifier = 0, C = 1, M = 2); and the second two digits identify the disturbance code (Figure 5). *Note that when the number "003" is entered it appears as "3".*

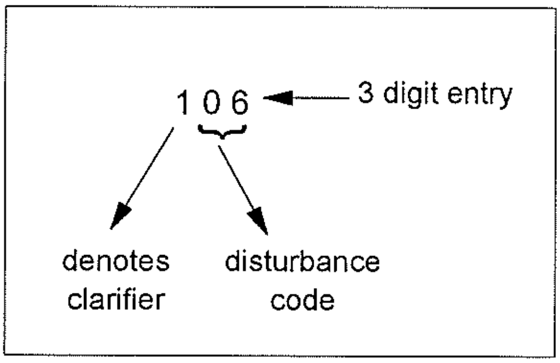


Figure 5 - The three digit numeric entry

Examples:

Disturbance codes-clarifiers "6C, 13, 9M, and 6"

would be entered as "106, 013, 209, and 006" (Figure 6)

This conversion allows the occurrence of (i) each code, (ii) each clarifier, and (iii) each code-clarifier combination to be determined.

Additional data which should be recorded includes:

- setting and sub-unit identifier
- transect number or distance from landing at beginning
- orientation of transect (bearing)
- direction of classification (i.e., east along transect)

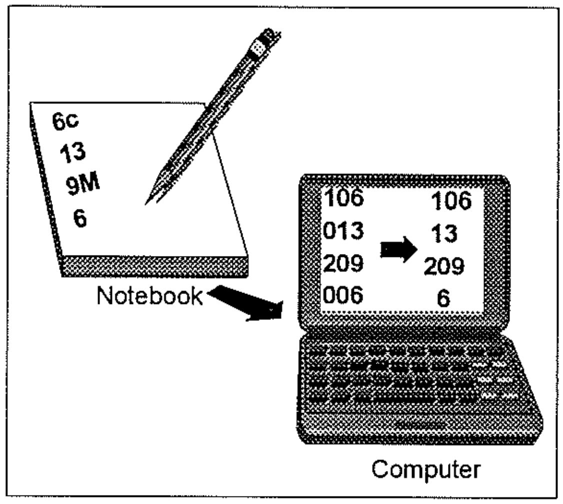


Figure 6 - Using a computer for data analysis requires data conversion to a three digit number

DATA ANALYSIS

The frequency and percentage of each disturbance code, and code-clarifier combination can be determined using a computer spreadsheet[1] (Table 3). Percentage disturbance is calculated using the following equation.

Percentage occurrence is defined as:

$$\% = \frac{\text{frequency}}{\text{total no. of classification points}}$$

From this frequency information, the percentage of classification points which exhibit different disturbance classes can be determined (Table 4). As can be seen, the percentage results for the same code-clarifier entry can be used to determine different disturbance classes.

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[1] A Mircosoft Excel template to calculate frequencies and percentage disturbance is available from LIRO.

Table 3 - Example of a frequency table, showing the percentage of each code, and code-clarifier combination

Numeric entry	Frequency	%
1	23	1
2	529	31
3	90	5
4	341	20
.	.	.
.	.	.
14	30	2
15	27	2
203	15	1
206	45	3
Total	1100	100

Table 4 - Using the percentage data for each individual disturbance code-clarifier combination from Table 3, the percentage of each disturbance class can be determined by summing the percentages for the appropriate code-clarifier entries

Disturbance class	Indicated by the following data..
No disturbance	1
Shallow (topsoil present)	2 - 5, 102 - 105
Deep (topsoil removed)	06 - 12, 106, 112, 108, 209 - 211
Slash	13, 14, 113
Non soil	15
Compaction	102 - 106, 108, 113
Erosion feature	7
Rutting - within topsoil - into subsoil	 9 -11 209 - 211
Slash beds on skid trails	113, 114

PERSONNEL AND EQUIPMENT REQUIREMENTS FOR THE SURVEY

The following equipment is needed:

- compass
- tape measure (with 1m intervals clearly marked)
- map of the setting
- field notebook or pad (preferably waterproof)
- the classification scheme (waterproofed)
- spray paint
- hip chain and spare cotton

The assessment procedure can be easily performed by one person, with some knowledge of the soils, and the harvesting systems or site preparation treatments employed at the site.

Before starting the assessment, it is a good idea to walk over the site to get a feel for identifying the different disturbance types. Most of all, make sure the classification is consistent.

The time taken for an assessment to be completed will depend on the nature of the site (for example, slope and depth of slash), the abilities of the surveyor, and the size and complexity of the setting and subdivided units. Nevertheless, it is likely that an area of three to 10 ha could be subdivided and assessed in a seven hour period, depending on the number of classification points required.

SUMMARY

A survey method has been presented to assess site disturbance caused by production thinning, harvesting and mechanical site preparation. The method is simple and quick to perform, providing information on the types and extent of disturbance within an area. This information can be used by forest managers and workers to measure the impacts of specific practices, help identify the potential for detrimental on-site or off-site impacts, and provide a measure of machine and system performance at achieving environmental goals. As our understanding of the impacts of site disturbance increases (for instance, erosion, reduced soil quality and crop productivity), the measurement of disturbance is likely to be important in identifying pactises to reduce or mitigate detrimental impacts.

EXAMPLE OF DISTURBANCE ASSESSMENT

Presented below is an example of setting subdivision and transect location for a ground-based setting. Also included is an example of data analysis.

The results presented here are fictitious, intended only to illustrate the survey method.

Example - Ground-Based Setting

The setting which was surveyed had a total area of 6.9 ha. The landing area was 0.4 ha.

Extraction was to a single roadside landing, through which there was a permanent road (Figure 7a). There were no unstocked areas within the setting, therefore the net stocked area was 6.5 ha.

The first step was to subdivide the setting to create two units within which the extraction directions were relatively uniform (Figure7b). If this was not done, the survey was likely to produce inconsistent results, as it was possible that the transects could have been located along the length of the skid trails.

For this setting, an absolute error of 3% was nominated for the disturbance results. Therefore, a total of 1111 classification points (Table 1) were required for the whole setting.

Using the equation shown on page 5, the transect spacing was calculated:

Transect spacing
= (6.4 / 1111) x 10,000
= 58 m.

This spacing was checked for the two units using a simple overlay, and it was found that because of the shape of Unit B, the transect spacing had to be reduced to 55m to fit in the required number of points (Figure 7c).

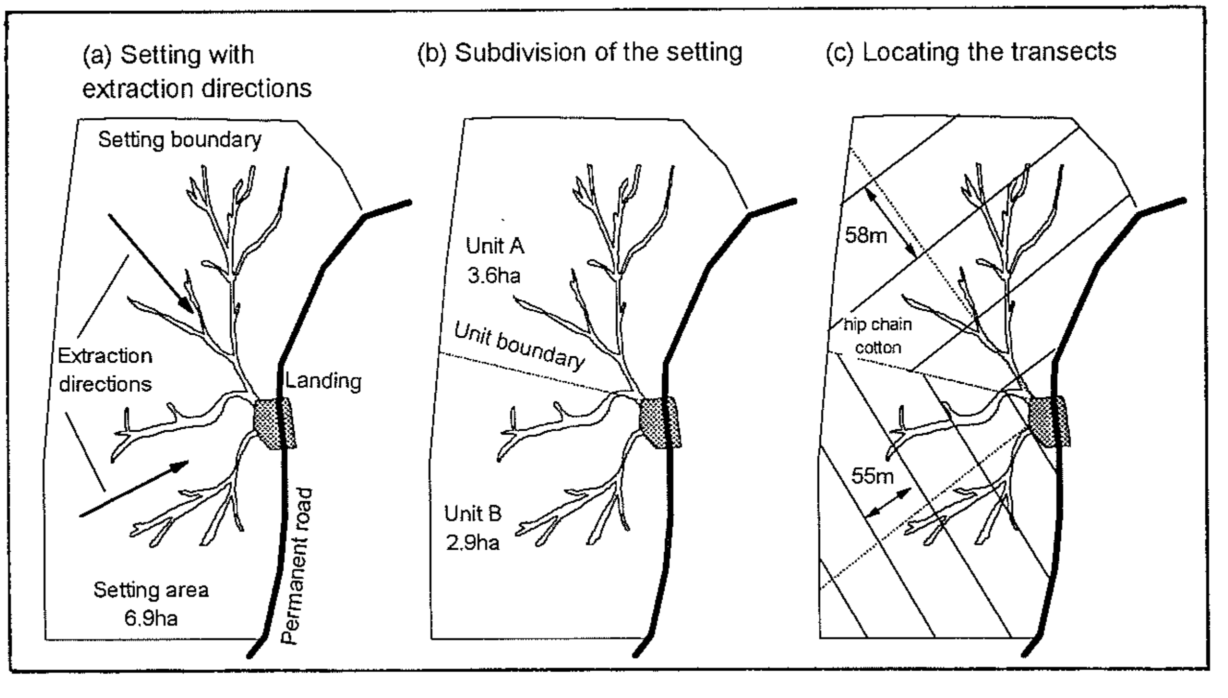

Figure 7 - Subdividing a ground-based setting for assessment, locating the transects for each unit

The disturbance assessment was performed in each of the units. Hip chain cotton was laid along the boundary of the two units to provide a clear boundary to survey up to. Again, using the hip chain, a line out through the centre of each unit from the landing was walked, and spots were painted to mark the transect spacings (every 58 and 55 m in each unit, respectively). The bearing of this line was noted. At each painted spot, the transects were established at right angles to the centre line, extending to the unit boundary. Disturbance was classified at one metre intervals along the transects. Once back in the office, the data was entered on to a computer spreadsheet for analysis and the frequency table shown in Table 5 was produced.

In total, 1112 points were classified in the 6.9 ha example setting. From the data shown in Table 5, the percentages of selected disturbance classes were determined (Table 6). Absolute errors in each disturbance class result were also calculated using:

$$\%\text{occurrence} \pm 2\sqrt{\frac{\%(100-\%)}{n}}$$

where n = the total number of observations made in the two units.

Bin (codes)	Frequency Unit A	Unit B	Total	Total %
1	20	16	36	3
2	71	60	131	12
3	26	20	46	4
4	160	114	274	26
5	4	0	4	0
6	48	31	79	7
7	0	0	0	0
8	29	27	56	5
9	7	5	12	1
10	1	0	1	0
11	0	0	0	0
12	10	12	22	2
13	112	82	194	17
14	18	11	29	3
15	17	27	44	4
102	6	0	6	1
104	13	16	29	3
106	43	38	81	7
112	28	33	61	5
209	4	0	4	0
	617	495	1112	100

$$\% = \left(\text{frequency}/_{1112}\right)\text{x}100$$

Table 5 - Frequency for the two units, and percentages of disturbance for the whole setting. Percentage disturbance was calculated on the total frequency for the setting

The absolute errors shown for each disturbance class in Table 6 confirmed that the maximum error of 3% was achieved.

Table 6 - Summarised disturbance class results for the example, using definitions in Table 4

Disturbance class	Percentage ± absolute error
Undisturbed	3 ± 1
Shallow	46 ± 3
Deep	27 ± 3
Slash	20 ± 2
Non soil	4 ± 1
	100%
Compacted	16 ± 2

The results from this example can be summarised as follows:

1. The setting area was 6.9 ha
2. The landing area was 0.4 ha
3. The net stocked area was 6.5 ha
4. Within the NSA:
   - the dominant disturbance class was shallow disturbance (46%)
   - deep disturbance accounted for 27% of the observations
   - slash cover accounted for 20% of the observations
   - 16% of the observations exhibited compaction.

To assess an area similar to that described above, it would be expected that approximately four hours would be spent in the field, with analysis taking a further two to four hours.

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APPENDIX - DISTURBANCE CODE DEFINITIONS

Codes

Code 1 - Undisturbed

- no evidence of machine or log passage
- original litter in place
- understorey intact
- no slash residue present

Code 2 - Litter in place

- evidence that the surface has been traversed
- minor disruption of the litter layer which is still in place
- understorey vegetation is disturbed

Code 3 - Litter removed

- litter has been either entirely or partially removed exposing the topsoil
- topsoil is still intact
- in the absence of compaction this disturbance is likely to be caused by the dragging of trees or rope

Code 4 - Litter and topsoil mixed

- minor "scuffing" of the soil surface
- some original soil structure remains (not under saturated conditions)

Code 5 - Topsoil is deposited on top of the litter

- topsoil is loose
- often either bladed or from overturned stumps

Code 6 - Topsoil removed revealing the mineral/subsoil

- may occur where there has been blade use and stem drag on extraction tracks

Code 7 - Erosion feature

- natural features
- cannot relate directly to harvesting or site preparation
- examples include slips, surface or rill erosion and slumps

Code 8 - Mineral/Subsoil puddling

- under wet conditions
- associated with repeated machine/log passage on trails or extraction corridors
- no litter layer evident
- slash may be incorporated
- unlike compaction, soils may turn to a slurry and appear pugged when wet

Codes 9, 10, 11 - Ruts

- formed by wheels, tracks, ropes or by logs/branches
- considered potential runoff channels
- some discretion is needed in their classification as short discontinuous ruts may not constitute a runoff problem
- no litter layer
- rut depth relative to rut walls (Figure 8)
- if bottom of rut is into mineral subsoil, then the M clarifier can be added

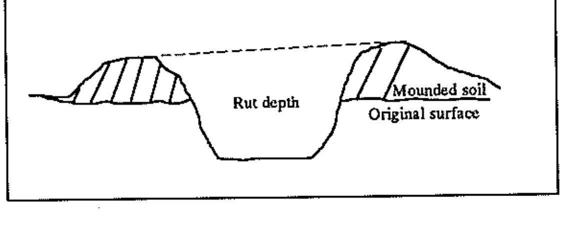

Figure 8 - Measure rut depth from the height of the rut walls. This alleviates problems with identifying the original surface

Code 12 - Subsoil, base rock deposit

- deposited on the soil surface
- deposit is unconsolidated

Codes 13, 14 - Slash

- ground surface cannot be seen
- likely to be an impediment to planting
- tree ferns and waste logs are also included
- can have a C clarifier added to Code 13 if compacted, indicating vehicle passage over the slash.

Code 15 - Non soil

- non-productive areas
- tree stumps
- soil or rock banks or batters
- rock outcrops
- swamps

Clarifiers

Clarifier C - Compacted

- evidence of wheel or track passage
- tyre lug or track impressions in litter or soil surface
- note, that no measure of the degree of compaction is made as this requires lengthy quantification

Clarifier M - Mineral/subsoil exposed

- used to indicate mineral soil exposure in the bottom of ruts (Codes 9 to 11)