Accuracy of Two Ground Survey Methods for Assessing Site Disturbance

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ABSTRACT

The accuracy of successive estimates of site disturbance using two ground survey methods was evaluated. Results from the point transect and grid point intercept methods were compared with those results from an intensive 1x1 m grid survey over a 4 ha study area. The point transect method, using a transect spacing of 30 m, provided the most accurate and consistent estimate of disturbance in the study area.

Keywords: *site disturbance, harvesting, survey methods, point transect, grid point intercept.*

INTRODUCTION

Site disturbance caused during forest harvesting and mechanical site preparation may result in increased erosion, degradation of soil properties, and may cause a decline in site productivity. Assessment of disturbance can provide forest managers with information to make appropriate decisions on site rehabilitation and monitoring. In addition, disturbance assessment may also be required by regulatory bodies to assess compliance. If compliance is ascertained from a single field survey, it is important that the limitations of the method are recognized when interpreting results.

At present, there is no systematic approach to assessing site disturbance in New Zealand forestry. The study was conducted to evaluate the relative accuracy and consistency of two ground survey methods; one which had been previously used in New Zealand, and the other used extensively in Interior British Columbia.

This article provides an overview of several ground survey methods, summarizes past disturbance assessment in New Zealand, and details the field evaluation of the two methods.

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Ground Survey Methods

Three ground survey methods have been used by researchers to assess site disturbance [9]:

(1) Point Transect (PT) method

Using this method, disturbance is characterized at predetermined points along the surveyed transect. Transects may be orientated parallel to the contours, where the predominant extraction direction is downslope [5], or perpendicular to the contours [9] irrespective of the extraction directions. The distances between classification points located along the transects may range from 1 to 3m, allowing measurement of all skid trails [4,11]. Bloomberg et al. [2] developed a random method of starting point location which permitted a more statistically valid assessment of variation and sampling intensity. The coverage (%) of each disturbance class is determined from the number of points in each class and the total number of points sampled.

(2) Line Transect (LT) method

As with the PT method, disturbance along surveyed transects is classified. However, rather than classifying disturbance at specified points, the distances corresponding to changes in disturbance classes of interest are recorded. The lengths of each of the disturbance classes are summed to determine the relative coverage (%) of the net forested area.

Transects are evenly located over a site, parallel to the site contours [1,2,15] or a combination of two orientations perpendicular to each other [12]. In a variation on these, Turcotte et al. [17] used randomly orientated transects to define the disturbance within 10m x 50m plots. The minimum length of disturbance that was recorded (0.1 m) was less than that of the minimum width of disturbance (0.5 m). This ensured that all disturbance features could be recognized.

(3) Grid Point Intercept (GPI) method

A grid system is randomly orientated over a study site at a pre-defined spacing [7], and grid point located at the intercepts. At each grid point, two or four transects, 30 m in length, are established. When the study area is less than 6 ha in area, four transects are used at each grid point. For areas greater than 6 ha, only two transects are required [4]. The first transect is orientated randomly, and subsequent transects are orientated at 90°, 180°, and 270° from the original.

Disturbance Assessment in New Zealand

Only a small number of site disturbance assessments have been performed in New Zealand, with much of our information based on overseas studies [12]. These studies have included both production thinning and clear cut situations.

Firth et al. [6] evaluated the use of aerial photographs, combined with ground reconnaissance, to assess the extent of disturbance on four clear blocks. This method had several advantages over the ground survey methods, including the larger areas that could be rapidly assessed, and the ease with which deep disturbance features could be identified. However, the identification of less severe disturbance, or disturbance on sites without distinct colour differences between surface and subsoils, required the additional use of ground survey methods for validation.

In another study, Bryan et al. [3] 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 [13], in which the line transect method was used at 17 sites throughout New Zealand . The sites included clear cut and production-thinned blocks, where ground-based (skidder and tractor) or highlead cable yarder systems had been used.

METHODS

The Study Site

The study site was a 26 ha cut block in Kaingaroa Forest, in the central North Island. The soil profile comprised a succession of rhyolitic tephras, known as Kaingaroa loamy sand [14] (U.S. Taxonomy Vitruand). The site was flat to low rolling, and the soils were well-drained.

The site was previously stocked with *Pinus radiata* (planted in 1958) at a final stocking of 230 stems per hectare. The block was manually harvested between August and December, 1993, at age 35 years, with tree lengths being extracted to a series of landings using a Caterpillar 528 rubber-tired skidder (approximate machine weight of 14 000 kg). Trimming of stems was largely carried out in the cut block, with some being done after extraction. The maximum and average haul distances for the site, determined during planning, were 222 m and 98 m, respectively.

Field Observations

During January/February, 1994, site disturbance within a 4 ha area of the study site was characterized. The location of the study area relative to the landings, and the extraction directions, are shown schematically in Figure 1. The maximum haul distance in this area was approximately 250 m. By dividing the area into more manageable 25-m wide swaths, the disturbance was intensively assessed over the area using a 1x1 m spacing between observation points (Figure 2a). At each point, the predominant disturbance class within a 0.3 m radius was classified according to the scheme shown in Table 1. Several classification schemes have been used by researchers that recognize primary changes in physical properties by defining disturbance classes using observable features [6,11,12,16] . The classification scheme used for this study was adapted from that of Miller and Sirois [11] and Stuart and Carr [16], to include subsoil deposits and slash, and existing erosion features.

The disturbance was then assessed using the PT and GPI methods. The LT method was excluded from the method evaluation as it was considered that identification of boundaries between disturbance classes could be too subjective, and introduce excessive variation into the assessment results.

For the PT method, transect spacings of 30 m (PT30), 50 m (PT50), and 80 m (PT80) were used, as these were similar to that used by previous researchers [8,13]. The transects were orientated perpendicular to the extraction direction (Figure 2b).

The first transect was located at a randomly assigned distance from the landing, not exceeding the spacing between subsequent transects. For each transect spacing, the method was repeated three times, each with differently located transects.

In the GPI method, 11 grid points were located within the study area at 60x60 m spacings. The disturbance was classified at 1-m intervals along four 30-m-long transects originating from the grid point. The orientation for the first transect was random, with the second being 180° from the first. The third and fourth transects were orientated at 90° degrees to the first two (Figure 2c) . Where a transect crossed outside of the study area, the grid point was adjusted for the

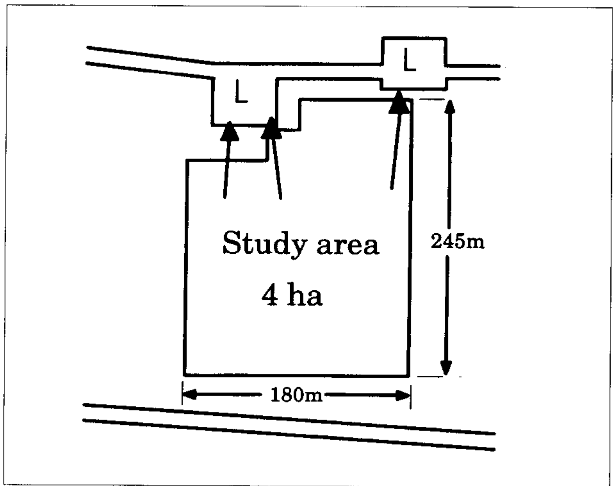

Figure 1. Study area layout. Extraction directions and entry points on to the landings (L) are indicated by the arrows (not to scale).

affected orientation. The disturbance at the grid point was excluded from the data set. The GPI method was applied three times, using different grid point and transect orientations each time.

Data Analysis

For the data sets collected during the 1x1 m PT and GPI surveys, frequency distributions were produced including all 15 disturbance classes (Table 1), and the occurrence of compaction.

The accuracy of the method was defined by how close the mean estimate for each disturbance type was to the absolute. The consistency was defined as the ability of the method to produce the same answer when repeated [10].

The accuracy of the PT and GPI methods was assessed by ANOVA, and mean disturbance estimates were compared using a Student T-test

Table 1. The disturbance classification scheme used for this study.

DISTURBANCE TYPE DESCRIPTION	CODE
Undisturbed	
No evidence of machine or log passage, litter and understorey intact	1
Shallow disturbance	
Litter still in place, evidence of minor disruption	2
Litter removed, topsoil exposed	3
Litter and topsoil mixed	4
>5 cm topsoil on litter	5
Deep disturbance	
Topsoil removed	6
Erosion feature	7
Topsoil puddled	8
Rutted — 5-15 cm deep	9
16-30 cm deep	10
>30 cm deep	11
Unconsolidated subsoil or base rock deposit	12
Slash/understorey residue	
10-30 cm	13
>30 cm	14
Non-soil (stumps, rocks)	15
CLARIFIER	**CODE**
Compacted	
Evidence of tire, track and/or log passage	C

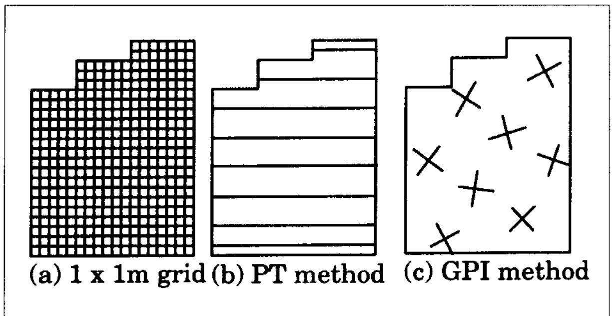

Figure 2. Illustration of the three types of survey used in the study. For the 1x1 m method, observations were made at the intercept of the grid lines, and for the PT and GPI methods, observations were made every 1 m along the transects.

procedure. Method consistency was assessed from the magnitude of the 95% confidence intervals, which reflected the range of survey results produced when the method was repeated.

RESULTS

Accuracy

The results of the 1x1 m grid survey were assumed to represent the absolute disturbance within the study area, and thus were considered the standard by which the other methods would be assessed. Using this method, a total of 40 375 observations were made in the study area compared to 504 - 1358 observations for the PT and GPI surveys (Table 2). The potential for sampling error within this absolute measure was recognized.

For the purpose of illustration, only selected results have been presented here. Results for the 15 individual classes were combined to represent three types of disturbance: (1) undisturbed and shallow disturbance, (2) deep disturbance, and (3) compaction. The percentage estimates for slash cover and non-soil have been omitted. Individual percentages of undisturbed, shallow disturbance, and deep disturbance (presented), and slash and non-soil (not presented) add up to 100%. All results are expressed as a percentage of the total number of observations made for each individual assessment.

Results from each of the methods are shown graphically in Figure 3 and summarized in Table 2.

Variation in estimates from the PT and GPI methods are evident in Figure 3. For the undisturbed

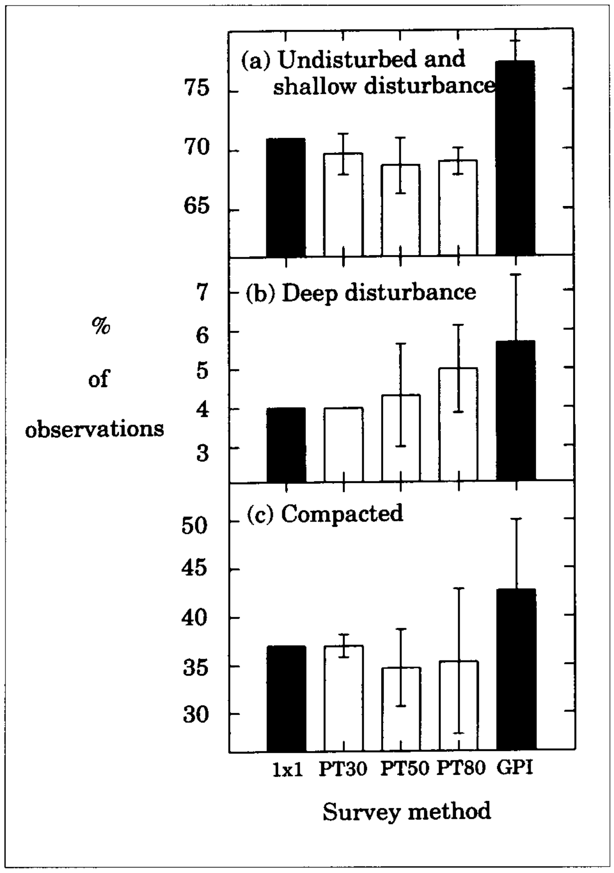

Figure 3. Selected disturbance results using the 1x1 m survey, mean results and 95% confidence intervals for the PT and GPI methods. Note that the PT30 method provided the same result for deep disturbance when repeated three times.

and shallow disturbance, and compaction, the mean estimates deviated approximately 7% and 5%, respectively, from that of the 1x1 m survey.

By comparing the mean estimates with that of the 1 x 1 m survey, it appeared that the PT30 method consistently provided the most accurate estimates of disturbance. In contrast, results in Figure 3 show that the GPI method tended to overestimate the disturbance, also producing estimates higher than that of the PT methods. Only in the case of the undisturbed and shallow disturbance was the difference in mean estimates by the GPI method significantly higher ($P<0.05$) than the assumed absolute or PT estimates. In this case, the GPI estimate was approximately 7% greater than the other methods. The overestimation of this disturbance type is reflected in an underestimation of the percentage slash cover and non-soils.

Consistency

The consistency of the PT and GPI methods was indicated by the magnitude of the 95% confidence intervals attached to the respective mean estimates shown in Figure 3.

For the three types of disturbance there were no clear trends as to which of the two methods was the most consistent. For undisturbed and shallow disturbance, the most consistent method was the PT80 (Figure 3 (a)).

For deep disturbance, the PT30 method provided the most consistent result, with each of the three successive assessments providing the same answer of 4% (Figure 3 (b)).

For compaction, the level of consistency of the PT methods decreased as the transect spacing increased from 30 m to 80 m. The GPI displayed a consistency similar to that of the PT80 method.

DISCUSSION

Effect of Sample Size on Accuracy

It appeared that accuracy did not consistently reflect sample sizes. Although statistically similar, there was variation between the mean estimates provided by the three transect spacings for the PT method (Table 2). Increasing the transect spacing from 30 m to 80 m, and thereby decreasing the sample size, did not result in progressive reduction in accuracy. However, the larger sample size of the PT30 method did appear to provide the most accurate estimate relative to the other PT methods.

The mean estimates from both the PT30 and the GPI methods were based on similar sample sizes (1320 and 1358, respectively). Despite this similarity, it appeared that the GPI method was less accurate than the PT method, consistently overestimating the assumed absolute level.

Effect of Sample Size on Consistency

It appeared that sample size did have some effect on method consistency. For two of the three disturbance types, the PT30 provided a more consistent estimate than the PT50 and PT80 methods. Also, the PT30 method provided more consistent estimates than the GPI method, which had a similar sample size.

Effects of Sampling Strategy

As has been discussed, the sample size did not seem to fully explain the differences in the accuracy and consistency of the PT and GPI methods. It is possible that differences in sampling strategies may also have contributed to method performance. The PT and GPI methods involved contrasting approaches to the location of the observation or sampling points. A systematic approach was used for the PT method, based on transects orientated perpendicular to the dominant extraction direction. In contrast, the GPI method involved the random location of the grid point pattern and random orientation of transects.

The random approach employed by the GPI method is likely to result in less consistent estimates of disturbance types which were systematically orientated, parallel to the extraction direction. This is illustrated in Figure 4. Skid trail orientations usually reflect the dominant extraction direction, and may be continuous over distances of tens of metres. At smaller transect spacings, the systematic approach of the PT method is less likely to miss disturbance features relative to the GPI method. In the three successive surveys shown in Figure 4, it could be expected that the consistency of deep disturbance estimates would be lower for the GPI method. This was the case of the results of this study shown in Figure 3.

In the case of less continuous and systematic disturbance types, such as slash or woody residue, and undisturbed and shallow disturbed areas, three successive applications of the two methods may be expected to provide estimates of similar consistency, as was the case for this study.

The reasons the GPI method overestimated the level of disturbance is less apparent. As no rational explanation could be found, it is conceded that this maybe the result of the low number of replicates. It was beyond the scope of this study to further investigate this possibility.

Interpretation and Application of Disturbance Estimates

This study has highlighted that disturbance assessment only provides an estimate of actual disturbance levels. The poor consistency of the PT and GPI methods requires replication of surveys to provide

Table 2. Summary of disturbance assessment results for the three types of disturbance.

Survey method	Mean no. of observations	Mean % disturbance[1] Undisturbed and Shallow	Deep	Compacted
1x1 m	40 375[2]	71.0	4.0	37.0
PT 30	1320	69.7a	4.0a	37.0a
PT 50	804	68.7a	4.3a	34.7a
PT 80	504	69.0a	5.0a	35.3a
GPI	1358	77.3b	5.7a	42.7a

1 - mean estimates which are significantly different (P<0,05) are assigned different letters.
2 - actual numbers of observations

accurate estimates. In operational situations, where single ground surveys are being used to assess site disturbance, it is necessary to recognize the inherent variability in estimated results. This is particularly important when using the assessment results to determine compliance with a quantitative standard. For instance, if statutory regulations stipulate specific limits on allowed disturbance, then a result which exceeds the limit by several percent may not truly reflect the level of disturbance but may actually reflect the extent of method consistency. The same also applies to estimates that are several percent less than the limit value. Thus, it is recommended that the accuracy and consistency of the method being used are known, and that interpretations and regulatory standards recognize method limitations.

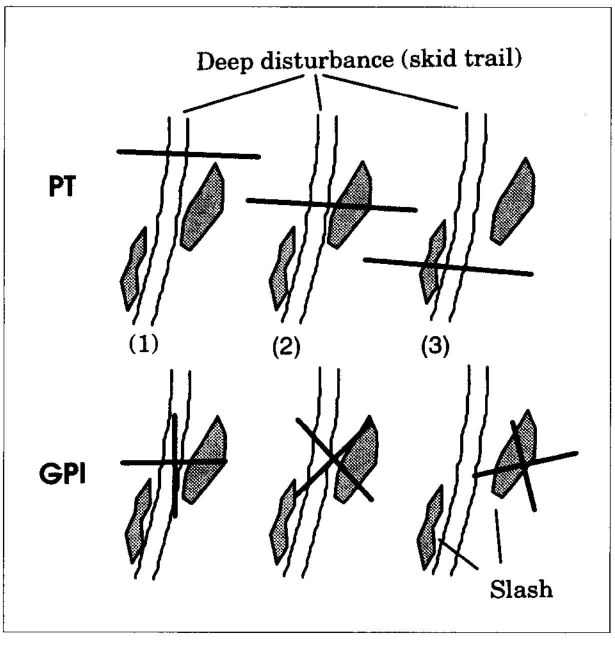

Figure 4. Examples of causes in variation in estimates between three successive applications of the GPI and PT methods.

CONCLUSIONS

A field evaluation of two methods of site disturbance assessment was conducted to determine the accuracy and consistency of two ground survey methods. The two methods were the point transect method, using three different transect spacings, and the grid point intercept method. The methods were applied to a 4-ha cut block which was manually harvested and within which extraction was done by a rubber-tired skidder. The accuracy of the two methods was assessed by comparing mean disturbance estimates with results of an intensive 1x1 m grid survey over the study area. Method consistency was determined by independently applying the assessment methods three times to the same area. The main findings of this study were:

1. The point transect method, with 30 m spaced transects, provided the most accurate estimate of the disturbance. In contrast, the grid point intercept method provided the least accurate estimates, consistently overestimating the level of disturbance.

2. The point transect method, with 30 m spaced transects, appeared to be more consistent than the other methods.

The poor accuracy and consistency of the point transect and grid point intercept methods highlight the need to recognize method limitations when assessing compliance using single survey results, and also establishing specific allowable levels of disturbance.

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