INTERPINE

Forestry Innovation

# Task 4

# Operational Costing Model for FCM

Prepared for **NZ Forest Owners' Association**

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# 1 EXECUTIVE SUMMARY

Interpine has developed a cost model for the measurement of FCM variables in New Zealand radiata pine forests. The model is based on FCM variable measurement time studies performed during January 2011, and from historical time studies performed by Interpine on inventory.

The time study results showed that across all plot characteristics, age classes, terrain types and all operators, the average time to measure FCM variables was 00:01:48 per tree with a standard deviation of 00:00:44 per tree. Accounting for software management and between-tree travel, the average additional time to measure FCM variables (over and above inventory measurements) is estimated to be 00:01:23 per tree.

Interpine determined that the biggest influence on plot measurement costs is attributable to the time it takes to travel between plots. When these times are short (e.g. 15 mins), the addition of FCM variable measurement can reduce plot rates by up to 35%. If they are large (e.g. 3 hours), the addition of FCM variable measurement can reduce daily plots rates by approximately 11%.

Interpine assessed the potential costs of measuring the existing 16km by 8km nationwide LUCAS grid. The results are provided below:

| COST SUMMARY | No FCM | FCM and Inventory | FCM Only |
|---|---|---|---|
| Plot Rate | 1.7 | 1.6 | 1.7 |
| Plot Measurement Costs | $50,400.00 | $53,600.00 | $50,400.00 |
| Disbursement Costs | $77,276.00 | $80,684.00 | $77,276.00 |
| Re-measurement Costs | $- | $20,142.60 | $19,151.40 |
| Audit Costs | $12,767.60 | $13,428.40 | $- |
| Project Management Costs | $14,044.36 | $16,785.50 | $14,682.74 |
| FCM Calibration Costs | $- | $12,900.00 | $12,900.00 |
| Data Management Costs | $23,400.00 | $23,400.00 | $23,400.00 |
| **TOTAL** | **$177,887.96** | **$220,940.50** | **$197,810.14** |

Please review the attached spread sheet (FCM Cost Model.xlsx) for a workable model on FCM measurement costs.

# 2 CONTENTS

# 3 INTRODUCTION

Interpine Forestry Ltd (Interpine) was engaged by the New Zealand Forest Owners' Association (NZFOA) to provide an operational cost model for the on-going measurement of forest condition monitoring (FCM) survey plots. The information provided in this report is built on earlier work provided by Interpine to the NZFOA, which details an FCM sampling strategy approach and estimate of sampling costs.

In mid-2010 Interpine was engaged by NZFOA to conduct FCM measurements on the national LUCAS[1] plantation inventory plots. The FCM measurements coincided with the LUCAS measurement programme to both reduce costs and provide synergistic opportunities for data analysis (e.g. LiDAR correlation to FCM measurements). This was the first such survey of its type in New Zealand that focused on a systematic measurement of crown condition. In total, approximately 190 plots were assessed with the final dataset being provided to the NZFOA in October 2010.

Subsequent to the collection of FCM data from LUCAS plots, it was realised that the NZFOA would need a more comprehensive and up-to-date understanding of the costs involved with measuring FCM plots in New Zealand to continue the programme. NZFOA's plan is to implement an on-going FCM programme to provide useable long-term time-series data on the condition of the New Zealand plantation estate. While the LUCAS measurement programme provided an excellent starting point for the FCM programme, the NZ Ministry for the Environment has indicated a finite level of on-going funding for the project. This means that the NZFOA may need to continue FCM measurements without the support of the LUCAS programme. In addition, the FCM measurement survey implemented in 2010 focuses solely on reporting at a national level inventory. The NZFOA has indicated that individual forest owners/managers may wish to implement the survey at a regional level and thus are interested in the costs of doing so.

With this in mind, the analysis and costing models provided in this report have been tailored to address the mandate of the NZFOA and the intentions to identify cost structures for implementing on-going FCM measurements both nationally and regionally. The key components of the costing model developed by Interpine are based on the FCM techniques and procedures described in the FCM Data Collection Manual V2[2]. In this report, Interpine has explored FCM operational costs if they were being measured:

1. As a standalone survey;
2. As part of the LUCAS measurement programme;
3. As part of a PSP[3] measurement programme;
4. Across a national level programme; and
5. Across a regional/forest level programme.

Interpine has based this cost analysis on a variety of data sources. More specifically, Interpine has focused the cost analysis from data collected during the 2010 LUCAS survey and from operational

[1] Land Use and Carbon Analysis System
[2] The FCM Data Collection Manual was developed by Interpine in 2010 according to international FCM data collection procedures and the work of Scion Research. Updates to the manual are being implemented according to lessons learned during the 2010 LUCAS measurement programme. These updates will be released in "Version 2" of the manual. At the time of writing this report, Version 2 was still being written.
[3] Permanent Sample Plots

trials implemented as part of "Task 3" of the post inventory FCM follow up work[4]. Additional information has been garnered from Interpine's extensive experience in the field and, in particular, Interpine's involvement with the LUCAS project.

The analysis in this report has been designed to provide the reader with sufficient information to make their own decisions on the potential costs of initiating an FCM programme, either standalone or in conjunction with another forest mensuration programme. Interpine has provided an accompanying spread sheet which enables the user to identify plot rate estimates and to determine and approximate operation cost depending on the size of the programme.

Please note that Interpine has a commercial sensitivity to providing actual information regarding the costs of plot measurement, particularly for PSP and LUCAS plot measurement. Because of this, Interpine has been deliberate in providing non-FCM plot measurement information at a broad level.

To build an operational cost model for forest mensuration and FCM, Interpine has separated the model into two components; direct plot measurements costs, and other indirect costs associated with plot measurements. The former costs are almost entirely dictated by the time it takes to locate and measure plots, while the latter costs will depend on the complexity of the inventory programme and the additional requirements needed to ensure crews have the adequate resources to complete their tasks (e.g. training). The following structure of this report reflects the separation in analysis, and provides a summary model in conclusion with worked examples.

[4] Task 3 involves the implementation and study of the factors that contribute to FCM measurement variability. Part of the study involves the field measurement of FCM plots by different operators enabling time series analysis of FCM measurement activities.

# 4 DIRECT PLOT MEASUREMENT TIMES

This section is focused on the time it takes to record plot measurements, with specific attention to the plot measurement information recorded by Interpine in historical inventory trials and the Task 3 FCM operator variability study. Plot measurement costs are effectively dictated by plot rates (number of plots per day) and the size of a given inventory programme. The indirect costs of plot measurement are provided in Section 5 while a summary of the plot measurement costs is provided in Section 6.

## 4.1 TASK 3 FCM OPERATOR VARIABILITY STUDY

The Task 3 FCM Operator Variability Study was designed to investigate the measurement variation that occurs between three different operators measuring the same FCM variables. The study also provided the opportunity to identify the time it takes to record FCM parameters for individual trees.

Three plots were selected from each of the three age classes 0 – 9 years, 10 – 18 years, and 19+ years. This pattern was repeated across three separate forest areas in the central north island giving a total of 27 plot locations. Each plot location was measured three times by separate operators giving a total target of 81 forest condition plot measurements.

Tree measurement times were recorded using in-built time stamp functionality in the PLOTSAFE data capture software. The time stamp would start once a tree was established (opened in the software) and stopped when the tree was finished and saved. This process provided time study information that was used to extrapolate statistical information on the average time taken to record FCM variables for trees.

The information collected from Task 3 was supplemented by interviewing the data collection manager and data collection teams about the additional time taken to record FCM variables during the 2010 LUCAS Measurement program. The objective of the time study was to determine the average time it took to measure FCM variables for each tree. This information was used to produce an FCM multiplier that can be added to other plot types (PSPs) to provide an indication of the additional cost that would be incurred for measurement of FCM.

Due to difficulties in reaching plot locations the scale of the measurement programme was reduced. In total 664 trees were assessed in 18 plots over three days by three operators. Plot information was recorded to identify any particular patterns relating to plot terrain, undergrowth, slash and age class. Plot details are provided in in Table 1.

*Table 1 – Plot Details*

| CMS Plot ID | Age Class | Undergrowth | Terrain | Slash | Road Access | Windthrow |
|---|---|---|---|---|---|---|
| CY68 | 3 | Heavy | Flat | Heavy | Good | High |
| CZ65 | 3 | Light | Flat | Light | Good | Low |
| CZ66 | 3 | Light | Flat | Light | Good | Low |
| CZ67 | 3 | Medium | Flat | Medium | Good | Low |
| DA62 | 2 | Medium | Rolling | Medium | Good | Low |
| DA64 | 1 | Light | Flat | Light | Good | Low |
| DA65 | 1 | Light | Flat | Light | Poor | Low |
| DA66 | 1 | Light | Flat | Light | Good | Low |

| | | | | | | |
|---|---|---|---|---|---|---|
| DB62 | 3 | Light | Flat | Light | Good | Low |
| DB65 | 2 | Medium | Flat | Heavy | Good | Medium |
| DB66 | 2 | Heavy | Flat | Heavy | Good | Medium |
| DC61 | 1 | Light | Flat | Light | Good | Low |
| DC63 | 2 | Heavy | Flat | Heavy | Good | Medium |
| DC64 | 3 | Medium | Flat | Light | Good | Low |
| DC65 | 1 | Light | Steep | Light | Good | Low |
| DD60 | 1 | Medium | Rolling | Medium | Poor | Medium |
| DD61 | 2 | Medium | Rolling | Light | Good | Medium |
| DD62 | 2 | Medium | Steep | Light | Good | Medium |

Interpine could not identify any statistically discernable difference in measurement times as a result of age, hindrance, terrain, or slash debris. The major difference in measurement came from operator three, who was significantly quicker than operators one and two[5] (see Table 2).

*Table 2 – Operator Information*

| Operator | Average Time (hh:mm:ss) | Standard Deviation (hh:mm:ss) |
|---|---|---|
| 1 | 00:01:59 | 00:00:38 |
| 2 | 00:02:04 | 00:00:48 |
| 3 | 00:01:21 | 00:00:30 |

Across all plot characteristics, age classes, terrain types and all operators the average time per tree was 00:01:48 with a standard deviation of 00:00:44. Interpine has determined that approximately 25 seconds per tree is required for opening the tree in PLOTSAFE[6] and finding the appropriate tree bearing for measurement. This assumption is based on discussions with the field crews involved in the operational trials.

To determine the costs of plot measurement with standalone FCM variables, an average tree measurement time of 00:01:48 per tree was used in the cost analysis. In the case of determining the additional time for FCM measurement over and above standard inventory (PSP) measurements, 25 seconds is removed. This results in an average tree measurement time of 00:01:23. In both instances, it is assumed that the FCM measurements take place within existing plots with marked trees and no requirement for plot establishment.

### *4.1.1 Comparison to Previous Studies*

Productivity figures published by Bulman (2008) state that on average it takes 9.8 minutes per plot to assess and record all variables for one plot of 25 young trees (23.52 seconds per tree). Mid rotation stands take 11.3 minutes per plot (27.12 seconds per tree) and final-crop stands only took 9.2 minutes per plot (22.08 seconds per tree). This time study was carried out on only one assessor but over a period of two years of monthly measurements.

The variables measured Bulman (2008) include: crown transparency, shoot dieback, general health, colour, stem visibility, resin bleeding, *Dothistroma*, *Cyclaneusma*, yellowing and crown depth. These measurements were similar to the Task 3 trial, as defined by the FCM Data Collection Manual V2.

[5] Confirmed by a simple t-test investigating the difference between two means at the 95% confidence level.
[6] PLOTSAFE is a field data capture software developed specifically for forest inventory.

The main difference is that the Task 3 trial included defoliation[7] measurements and also a measure of the height of the assessable crown included in the defoliation assessment.

The results show the Task 3 measurement times to be considerably higher than the figures published by Bulman (2008) when measuring similar variables. While the Bulman figures are much lower, the processes and training that lead to the collection of the data was considerably different. At the time of measurement, Bulman was a highly experienced measurer of the FCM variables who revisited the plots on a regular basis. Interpine believes the methodology employed as part of Task 3 is more representative of the time it takes to record FCM variables given the commercial nature of the measurement methods.

The figures provided by Bulman (2008) and Interpine are in stark contrast to the 8.0 minutes per tree taken in the British FCM systems to assess 28 different forest condition variables.

## 4.2 Standard Inventory Measurement Times

Interpine has conducted internal studies on the time taken to measure trees in standard inventory plots. Depending on the variables required, it is expected that the measurement of plots takes between 00:18:50 and 00:35:03 per plot of between 00:01:15 and 00:02:23 per tree (average 00:01:47 per tree). The measurement times are based on basic PHI inventory measurement techniques for repeat measurement plots with a target number of trees between 10 and 20. Interpine notes that the measurement times per tree in PHI inventory are similar to those for PSPs.

Based on the information collected in Task 3, and from information collected in earlier studies by Interpine, the inclusion of FCM measured variables into a standard plot measurement programme would increase average tree measurement times by approximate one 00:01:23 or 00:27:40 per plot. When considering the time taken to measure inventory plots, the estimated time taken to measure inventory plots with the inclusion of FCM variables would be between 00:02:38 and 00:03:46 per tree (average of 00:03:10 per tree). The total plot measurement time for a plot of 20 trees is estimated to be between 00:52:34 and 01:15:15 (average of 01:03:20).

## 4.3 Travel Time Between Plots

The largest variation in the total day rates for plot measurement is the time taken to travel between plots. This is a difficult variable to estimate as it depends on the forest type, topography, roading, undergrowth, slash (i.e. thinnings), and (most importantly) distance. The trials conducted by Interpine on standard PHI measurements show an approximate 25 minute interval between plots. This is based on a walking distance of between 150 and 200 metres and includes locating of the plot centre.

The chart provided in Figure 1 shows the effect of increased travel time on the plot rate calculation. This assumes a nine hour working day, 20 minutes set- up and pack up time, a tree stocking of 20 stems per hectare, and average plot measurement times discussed in 4.1 and 4.2.

As the chart is for illustration purposes, the calculation does not round the plot rate down to the nearest whole number. Please note however; it is not common practice for measurement crew to leave an unfinished plot at the end of a work day, nor is it common practice to start a new plot if it is known that the plot will not be finished.

[7] Defoliation is described as the amount of needle loss in the assessable crown as compared to a reference tree. It differs slightly to Crown Transparency providing an alternative measurement of crown health.

As expected, when the time travelled between plots increases, the number of plots per day for each measurement type converges. This is because the fixed time associated with between-plot travel becomes so large reducing the influence of the actual within-plot measurement time on the day rate.

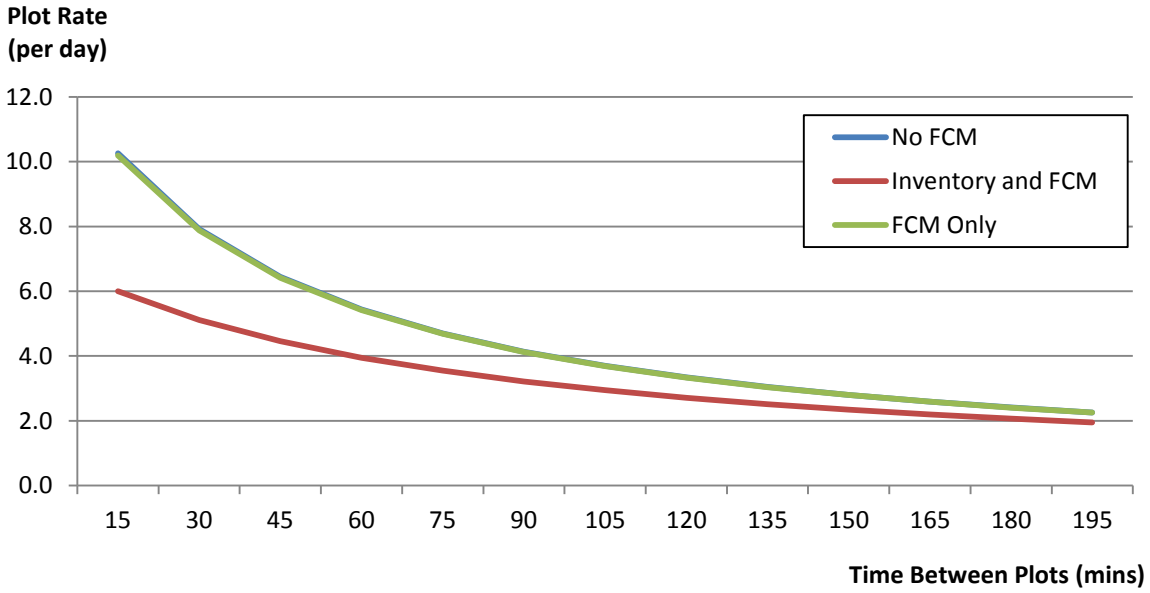


*Figure 1 – Effect of travel times on plot rate calculation*

The time taken to travel between plots also has a significant effect on the influence that the measurement of FCM variables has on standard plot measurement times (FCM multiplier). In this instance, the FCM multiplier is represented by the percentage reduction in plot rate that results from introducing FCM variables into an inventory programme.

The effect of travel times between plots on the FCM multiplier is illustrated in Figure 2. As expected, the FCM multiplier has a much reduced impact on plot rates when there is considerable travel time between plots. This shows that for large inventories with long travel distances (such as the LUCAS project), the impact of measuring FCM variables would result in an approximate 11% reduction in daily plot rates.

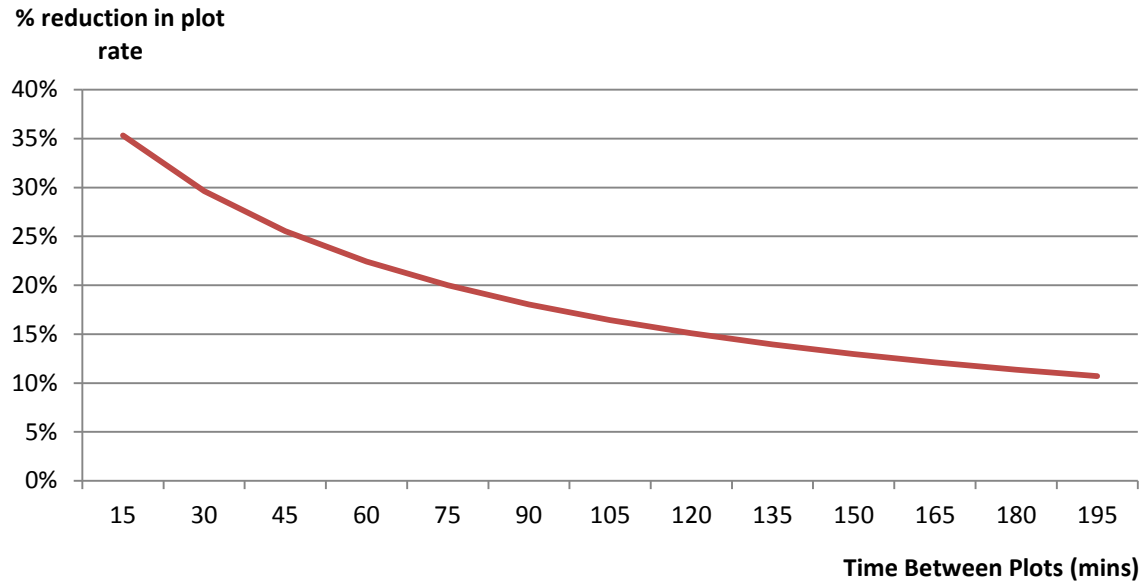


*Figure 2 – Effect of travel times on FCM multiplier*

# 5 INDIRECT PLOT MEASUREMENT COSTS

In addition to plot measurement costs, this section provides an indication of the additional costs involved with implementing an FCM programme. To run a measurement programme such as the one discussed in this report the following cost components need to be considered when developing a budget:

- Disbursement Expenses;
- Training and Calibration;
- Plot Re-measurement
- Reporting;
- Data Management and Hosting; and
- Project Management.

## 5.1 DISBURSEMENT EXPENSES

Disbursement expenses will vary considerably depending on the scale and location of the project. Things to consider are flights, vehicle hire (at destination), vehicle running, accommodation and away allowances.

## 5.2 TRAINING

Annual training and calibration of field assessors is widely regarded as an extremely important exercise for reducing "between-assessor" variability. It is recommended that each assessor of FCM variables undertake at least one week of training prior to the commencement of any FCM programme (Bulman, 2008). The costs of training would include crew costs (approximately $700 per day) and trainer costs (approximately 1,500 per day).

## 5.3 PLOT RE-MEASUREMENT COSTS

The independent re-measurement of a plot subset is important to the success of any FCM programme being undertaken. Re-measurement information is integral to providing an understanding of the FCM information quality (between operator variability), proving an understanding of whether more calibration is required on future measuring programmes. Re-measurement work would need to be undertaken by a crew that is different from the one that carried out the primary assessment. In previous reports it was advised that at least 18 plots of a national system should be "blindly" re-measured. If the same productivity and daily costs are assumed for re-measurement, then the cost of the repeat measurement programme would increase measurement and disbursement costs by approximately 15%.

## 5.4 REPORTING

Specifying the exact reporting requirements for an FCM programme is beyond the scope of this report. However for completeness of this costing analysis it has been estimated that NZFOA should budget around $10,000 per year for an annual report on the findings of the program. It is important for the long term success of this program that results are communicated to all shareholders annually. NZFOA may also want to publish results internationally.

## 5.5 DATA MANAGEMENT AND HOSTING

A long term monitoring programme would require a database for data warehousing. This database would need to be hosted in manner that would allow users to access and analyse the data. Although calculating the exact cost of data management and hosting for a FCM database is outside the scope of this report, Interpine estimates (based on its experience of hosting similar databases for several clients), that the cost would likely be around $1,500 to $2,000 per month. This would include hiring and hosting of server space for a Microsoft SQL database and 10-15 hours data management per month.

## 5.6 PROJECT MANAGEMENT

A measurement programme would require some degree of the project management; this cost would be in the order of the 10% of the annual cost.

# 6 SUMMARY OF MEASUREMENT COSTS

Interpine's studies show that the measurement of FCM variables will increase (on average) the time it takes to measure a tree by approximately 00:01:23. However, the most significant factor impacting on plot measurement costs is the time it takes to travel between plots. As Interpine has shown, this also impacts on the significance that additional FCM measurements can have on overall plot measurement costs. As Table 3 shows, once the travel time between plots increases to over two hours, the plot rates between measurement of inventory only, inventory and FCM, and FCM only become very similar.

*Table 3 – Plot rate summary based on travel time between plots*

| Time B/W Plot (min) | Plots Per Day | | | FCM Multiplier |
|---|---|---|---|---|
| | Inventory Only | Inventory and FCM | FCM Only | |
| **15** | 10.3 | 6.6 | 10.2 | 35% |
| **30** | 7.9 | 5.6 | 7.9 | 30% |
| **45** | 6.4 | 4.8 | 6.4 | 26% |
| **60** | 5.4 | 4.2 | 5.4 | 22% |
| **75** | 4.7 | 3.8 | 4.7 | 20% |
| **90** | 4.1 | 3.4 | 4.1 | 18% |
| **105** | 3.7 | 3.1 | 3.7 | 16% |
| **120** | 3.3 | 2.8 | 3.3 | 15% |
| **135** | 3.0 | 2.6 | 3.0 | 14% |
| **150** | 2.8 | 2.4 | 2.8 | 13% |
| **165** | 2.6 | 2.3 | 2.6 | 12% |
| **180** | 2.4 | 2.1 | 2.4 | 11% |
| **195** | 2.3 | 2.0 | 2.3 | 11% |

Interpine has provided a spread sheet summarising the information provided in this report (FCM Cost Model.xlsx). The sheet allows the user to simulate the costs of their own programme. The plot rate calculation sheet should be used to estimate the plot rate based on the estimated time taken to travel between plots. The plot rates can then be used in the Inventory_Cost_Calc worksheet to estimate the costs of the inventory.

## 6.1 CREW DAY RATES

The day rate for inventory crews depends on a number of factors including the location of the plot, amount of auxiliary information collected and the skill level required. At the time of writing, the day rate for data collection is approximately $700 - $800 per crew. This rate includes two crew members, handheld data capture computer, and GPS unit; it does not include vehicle costs. A limited amount of project management and internal audit is also included in these rates.

## 6.2 WORKED EXAMPLES FOR COST OF FCM MEASUREMENT

The following worked examples provide an indication of the expected costs for measuring FCM and inventory programmes across New Zealand radiata pine forests. The information provided in this section is supplementary to the spread sheet costing model that accompanies this report.

The worked examples present the costs for three scenarios. Some important factors to note are:

- Plot rates are based on the plot rate calculations provided in Table 3;
- Input parameters for operational costs are broadly based on Interpine's experience. It is advised that the user of this model conduct their own analysis to verify these costs;
- Crew number are based on completing the programme over a three-four week period;
- Non FCM programmes exclude training and re-measurement costs;
- An audit cost of 10% of plotting costs has been introduced for the auditing of inventory measurements. FCM only plots exclude the costs of audit; and
- The costs shown represent annual costs of repeat measurement on existing plot network. The costs of plot establishment will be higher, particularly for inventory.

Please note that the information presented in this section is designed as a guide to understanding the costs of implementing an FCM programme in New Zealand. It does not represent a quote, nor does it imply the maximum or minimum costs that would be expected to implement such a programme.

### *6.2.1 LUCAS 16x8 km GRID Inventory Programme (106 plots)*

*Table 4 – Plot Measurement Assumptions – LUCAS Inventory Programme Example*

| PLOT MEASUREMENT | Rate | Unit |
|---|---|---|
| Number of crew members | 8 | People |
| Crews | 4 | Full crews |
| Time between Plots | 270 | Minutes |
| Plot Rate | 1.7 | Average plots per day per crew |
| Size of programme | 106 | Plots |
| Basic Crew Rate | $800.00 | Per day (includes equipment, no vehicle) |
| Re- measurement | 15% | % of Plot and Disbursement Costs |
| Audit Costs | 10% | % of Plot and Disbursement Costs |
| Project Management | 10% | % of All Costs Excluding Training and Data |

*Table 5 – Disbursement Assumptions – LUCAS Inventory Programme Example*

| DISBURSEMENT EXPENSES | Rate | Unit |
|---|---|---|
| Total Flight Costs | $2,000.00 | Estimated for programme |
| Vehicle Costs | $0.71 | per km |
| Estimated kms | 300 | per day per crew |
| Accommodation | $70.00 | per person per night |
| Nights Away | 10 | Estimated total nights away per person |
| Away Allowance | $60.00 | Per person per night away |
| Travel Rate | $350.00 | Per person |
| Travel days | 4 | Estimated per person |

*Table 6 – Estimated Costs – LUCAS Inventory Programme Example*

| COST SUMMARY | No FCM | FCM and Inventory | FCM Only |
|---|---|---|---|
| Plot Rate | 1.7 | 1.6 | 1.7 |
| Plot Measurement Costs | $50,400.00 | $53,600.00 | $50,400.00 |

| | | | |
|---|---|---|---|
| Disbursement Costs | $77,276.00 | $80,684.00 | $77,276.00 |
| Re-measurement Costs | $- | $20,142.60 | $19,151.40 |
| Audit Costs | $12,767.60 | $13,428.40 | $- |
| Project Management Costs | $14,044.36 | $16,785.50 | $14,682.74 |
| FCM Calibration Costs | $- | $12,900.00 | $12,900.00 |
| Data Management Costs | $23,400.00 | $23,400.00 | $23,400.00 |
| **TOTAL** | **$177,887.96** | **$220,940.50** | **$197,810.14** |

### *6.2.2 Nationwide Inventory Programme (300 plots)*

*Table 7 – Plot Measurement Assumptions – Nationwide Inventory Programme Example*

| PLOT MEASUREMENT | Rate | Unit |
|---|---|---|
| Number of crew members | 16 | People |
| Crews | 8 | Full crews |
| Time between Plots | 150 | Minutes |
| Plot Rate | 2.4 | Average plots per day per crew |
| Size of programme | 300 | Plots |
| Basic Crew Rate | $800.00 | Per day (includes equipment, no vehicle) |
| Re- measurement | 15% | % of Plot and Disbursement Costs |
| Audit Costs | 10% | % of Plot and Disbursement Costs |
| Project Management | 10% | % of All Costs Excluding Training and Data |

*Table 8 – Disbursement Assumptions – Nationwide Inventory Programme Example*

| DISBURSEMENT EXPENSES | Rate | Unit |
|---|---|---|
| Total Flight Costs | $2,000.00 | Estimated for programme |
| Vehicle Costs | $0.71 | per km |
| Estimated kms | 250 | per day per crew |
| Accommodation | $70.00 | per person per night |
| Nights Away | 8 | Estimated total nights away per person |
| Away Allowance | $60.00 | Per person per night away |
| Travel Rate | $350.00 | Per person |
| Travel days | 2 | Estimated per person |

*Table 9 – Estimated Costs – Nationwide Inventory Programme Example*

| COST SUMMARY | No FCM | FCM and Inventory | FCM Only |
|---|---|---|---|
| Plot Rate | 2.8 | 2.4 | 2.8 |
| Plot Measurement Costs | $86,400.00 | $100,000.00 | $86,400.00 |
| Disbursement Costs | $183,200.00 | $207,340.00 | $183,200.00 |
| Re-measurement Costs | $- | $46,101.00 | $40,440.00 |
| Audit Costs | $26,960.00 | $30,734.00 | $- |
| Project Management Costs | $29,656.00 | $38,417.50 | $31,004.00 |
| FCM Calibration Costs | $- | $21,300.00 | $21,300.00 |
| Data Management Costs | $23,400.00 | $23,400.00 | $23,400.00 |
| **TOTAL** | **$349,616.00** | **$467,292.50** | **$385,744.00** |

### 6.2.3 Regional Measurement Programme (150 plots)

*Table 10 – Plot Measurement Assumptions – Regional Inventory Programme Example*

| PLOT MEASUREMENT | Rate | Unit |
|---|---|---|
| Number of crew members | 8 | People |
| Crews | 4 | Full crews |
| Time between Plots | 90 | Minutes |
| Plot Rate | 4.1 | Average plots per day per crew |
| Size of programme | 150 | Plots |
| Basic Crew Rate | $800.00 | Per day (includes equipment, no vehicle) |
| Re- measurement | 15% | % of Plot and Disbursement Costs |
| Audit Costs | 10% | % of Plot and Disbursement Costs |
| Project Management | 10% | % of All Costs Excluding Training and Data |

*Table 11 – Disbursement Assumptions – Regional Inventory Programme Example*

| DISBURSEMENT EXPENSES | Rate | Unit |
|---|---|---|
| Total Flight Costs | $- | Estimated for programme |
| Vehicle Costs | $0.71 | per km |
| Estimated kms | 200 | per day per crew |
| Accommodation | $70.00 | per person per night |
| Nights Away | 2 | Estimated total nights away per person |
| Away Allowance | $60.00 | Per person per night away |
| Travel Rate | $350.00 | Per person |
| Travel days | 2 | Estimated per person |

*Table 12 – Estimated Costs – Regional Inventory Programme Example*

| COST SUMMARY | No FCM | FCM and Inventory | FCM Only |
|---|---|---|---|
| Plot Rate | 4.1 | 3.4 | 4.1 |
| Plot Measurement Costs | $29,600.00 | $29,600.00 | $29,600.00 |
| Disbursement Costs | $28,696.00 | $28,696.00 | $28,696.00 |
| Re-measurement Costs | $- | $8,744.40 | $8,744.40 |
| Audit Costs | $5,829.60 | $5,829.60 | $- |
| Project Management Costs | $6,412.56 | $7,287.00 | $6,704.04 |
| FCM Calibration Costs | $- | $12,900.00 | $12,900.00 |
| Data Management Costs | $23,400.00 | $23,400.00 | $23,400.00 |
| **TOTAL** | **$93,938.16** | **$116,457.00** | **$110,044.44** |

### 6.2.4 Small-Scale Localised Inventory Programme (100 plots)

*Table 13 – Plot Measurement Assumptions – Localised Inventory Programme Example*

| PLOT MEASUREMENT | Rate | Unit |
|---|---|---|
| Number of crew members | 6 | People |
| Crews | 3 | Full crews |
| Time between Plots | 30 | Minutes |
| Plot Rate | 5.6 | Average plots per day per crew |

| | | |
|---|---|---|
| Size of programme | 100 | Plots |
| Basic Crew Rate | $800.00 | Per day (includes equipment, no vehicle) |
| Re- measurement | 15% | % of Plot and Disbursement Costs |
| Audit Costs | 10% | % of Plot and Disbursement Costs |
| Project Management | 10% | % of All Costs Excluding Training and Data |

*Table 14 – Disbursement Assumptions – Localised Inventory Programme Example*

| DISBURSEMENT EXPENSES | Rate | Unit |
|---|---|---|
| Total Flight Costs | $- | Estimated for programme |
| Vehicle Costs | $0.71 | per km |
| Estimated kms | 150 | per day per crew |
| Accommodation | $70.00 | per person per night |
| Nights Away | 0 | Estimated total nights away per person |
| Away Allowance | $60.00 | Per person per night away |
| Travel Rate | $350.00 | Per person |
| Travel days | 0 | Estimated per person |

*Table 15 – Estimated Costs – Localised Inventory Programme Example*

| COST SUMMARY | No FCM | FCM and Inventory | FCM Only |
|---|---|---|---|
| Plot Rate | 7.9 | 5.6 | 7.9 |
| Plot Measurement Costs | $10,400.00 | $14,400.00 | $10,400.00 |
| Disbursement Costs | $4,153.50 | $5,751.00 | $4,153.50 |
| Re-measurement Costs | $- | $3,022.65 | $2,183.03 |
| Audit Costs | $1,455.35 | $2,015.10 | $- |
| Project Management Costs | $1,600.89 | $2,518.88 | $1,673.65 |
| FCM Calibration Costs | $- | $10,800.00 | $10,800.00 |
| Data Management Costs | $23,400.00 | $23,400.00 | $23,400.00 |
| **TOTAL** | **$41,009.74** | **$61,907.63** | **$52,610.18** |

# 7 CONTACT

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***About Interpine Forestry***

This report was prepared by Interpine Forestry Limited. Interpine Forestry is an industry leading organisation providing technical and consulting services for a wide range of forestry-related companies. Interpine's success is underpinned by a committed management team of professional foresters backed by qualified field technicians and data analysts.

Interpine has three main divisions: Forestry Services, IT & Research, and Consulting. Its key services relate to forest mensuration, value chain improvement, value recovery auditing, log scaling, and carbon accounting.

Since 1980 Interpine has been providing New Zealand forestry with innovative ideas and solutions for an ever-changing forest industry. Today, Interpine's head office in Rotorua is nestled in the hub of New Zealand forestry working with a wide range of companies from large corporate entities to generalist farm foresters. Whatever the needs of the client, Interpine will always strive to find quality solutions at a competitive price. If you would like to know more about Interpine and its dedicated team please contact us on the details provided. Further information about Interpine can also be found by visiting www.interpine.com.

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