Cost estimates of relocating and remeasuring permanent alpine grassland plots

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Summary

Project and Client

Terrestrial and Freshwater Biodiversity Information System (TFBIS) Programme, TFBIS Programme Project 191.

Objectives

Relocate a set of permanent Wraight alpine grassland plots, using standard relocation information, and fix plot positions with a GPS. Determine whether it is more efficient and cost effective to relocate and GPS plots in an initial, separate exercise before the actual remeasurement, or use standard relocation methods to relocate and fix plot positions during the next plot remeasurement.

Methods

Waimakariri permanent plots, established in 1961 and remeasured in 1972, were used. Archived plot map coordinates were converted to NZMS GRID coordinates and imported into TOPOMAP and upgraded based on archived plot location information. Times to collate plot information and upgrade each map coordinate were recorded.

Archived plot location information was collated for plots selected for relocation. Two teams of two experienced field staff were dropped by helicopter at adjacent plot clusters. Plots were relocated using location information and a metal detector. Plot position was fixed with a GPS. Times were recorded to locate the first peg, find all three pegs, and complete all plot tasks.

Distances between archived map coordinates, upgraded coordinates and GPS position were calculated to identify benefits of upgrading coordinates. Costs of preparation, plot relocation and vegetation remeasurement were itemised per plot and for a 30-plot dataset for three operational scenarios.

Scenario 1: relocate and fix plot position with a GPS.
Scenario 2: remeasure plot as a separate, second trip
Scenario 3: relocate, fix plot position with a GPS and remeasure plot in one trip.

Results

It took 40 minutes on average to collate information and upgrade each map coordinate. Aerial photos were the most useful information.

All 28 Waimakariri plots searched for were relocated. Relocation relied on a combination of location slides, plot description sheets, upgraded coordinates, and the metal detector. Mean time to find first and all three plot pegs was 19 and 29 minutes, respectively.

On average, upgraded map coordinates and the GPS position were within 100 m of each other, but were both c. 900 m from the archived map coordinates, although this ranged from within 50 metres to over six kilometres.

Scenario 1 is the most efficient method of relocating plots. Flying two teams of two between adjacent plots will enable 10-12 plots to be relocated per day at a cost of $470 per plot.

Remeasurement costs were calculated for a team flying to the first of three plots in a cluster or line and walking between subsequent plots. Costs varied for data types measured in the field and size of the field team.

Under Scenario 2 (remeasure only) remeasurement of species frequency data only will cost $695 per plot and a team of two will remeasure 3 plots per day. Remeasurement of all four data types (species frequency, stereophotos, tussock biomass, species inventory) will cost $885 per plot and a team of four will remeasure 4 plots per day.

Under Scenario 3 plot relocation and remeasurement of species frequency data will cost $895 per plot and a team of two will remeasure 2 plots per day. Remeasurement of all four data types will cost $1085 per plot and a team of four will remeasure 3 plots per day.

Costs of relocating and remeasuring a 30-plot dataset, accounting for wet weather and travel are as follows. Scenario 1: two teams will relocate 30 plots in 3 days, costing $15,400. Scenario 2: 13 days for a team of two to remeasure species frequency ($24,150), and 10 days for a team of four to remeasure all four data types ($40,700). Scenario 3: 20 days, in two trips, for a team of two to relocate and remeasure species frequency on 30 plots ($33,450), and 13 days, for a team of four, to relocate and remeasure all four data types ($47,700).

For relocation and remeasurement, the combination of Scenario 1 and 2 is more expensive but provide greater operational efficiency and flexibility and lower financial risk.

Conclusions

The network of alpine plots represents a set of assets that enable assessments on past and current biodiversity. It is therefore important to know the exact location of these plots.

Upgraded map coordinates are an important prerequisite for relocating plots and were much closer to the position fixed by the GPS than the original map coordinates archived in NVS.

For relocation, Scenario 1 is the best option for managing a set of permanent plots and implementing a well-designed study. A large number of plots can be relocated in a short time allowing greater flexibility with study design. The design will be based on existing plots with known locations, rather than a list of possible plots with uncertain locations (Scenario 3).

The combination of Scenarios 1 and 2 represent the most effective method of relocation and remeasurement. They enable better survey design, greater operational efficiency and flexibility, and fewer financial risks than Scenario 3.

Recommendations

Upgrade map coordinates for all alpine plots and fill in gaps for 15 key survey areas.

Locate and archive location slides for surveys that currently do not have location slides archived in NVS.

Initially relocate and fix positions of existing permanent alpine plots (Scenario 1) so that land managers know the exact location of existing plots and can manage the land appropriately.

Secondly identify key national and regional management issues and determine which existing datasets best address these issues. Design a remeasurement strategy based on these issues and select plots for remeasurement (Scenario 2).

1. Introduction

The profile of alpine grasslands in New Zealand conservation management has been raised by growing environmental issues such as climate change, increasing introduced deer numbers, and exotic weed invasion, along with the acquisition of high country land into the Conservation estate. These issues have highlighted the need to monitor alpine grasslands and provide quantitative assessments of change in biodiversity to help direct medium and long-term management strategies at regional- and national-scales (Lee et al. 2005).

There are a number approaches to assessing biodiversity in alpine grasslands. The National Vegetation Survey Databank (NVS) provides one valuable resource. NVS archives a large network of permanently marked alpine grassland plots. Permanent Wraight plots account for approximately 90% of this network. These c. 2400 plots represent c. 4300 data records from c. 70 datasets that have been collected over a 50-year period using standardised, repeatable methods. The plots represent all major alpine plant communities and are well distributed across the alpine environment (Newell & Rose 2007).

Remeasurements of permanent Wraight plots would provide valuable, standardised quantitative assessments of changes in biodiversity in response to conservation management and environmental change. Two examples include the recovery of Fiordland alpine grasslands after a reduction in deer populations (Rose & Platt 1987), and the 25-year invasion of exotic herb *Hieracium* in Harper-Avoca montane tussock grasslands (Rose et al. 1995).

Accurate plot location information is an essential prerequisite for plot relocation and remeasurement. Plot relocation is a two-step process. Archived plot location information (maps, aerial photos) position a field team within 200–300 metres of a plot. Slide transparencies, showing plot location in relation to local topographic features, enable relocation of the plot transect line and plot pegs. Relocation of permanent plots can be time-consuming, as demonstrated by the remeasurement of 44 Canterbury alpine grassland plots in 2000. On some plots it took up to 4 hours to relocate the first plot peg. In future, accurate plot positions can be obtained using a global positioning system (GPS), although traditional plot relocation methods must be used first to find each plot. GPS technology has been used on < 1% of the c. 2400 plots because most have not been remeasured in the last 15 to 20 years.

This pilot study relocated a small set of permanent alpine grassland plots, using the standard plot relocation process described above, and fixed plot positions with a GPS. The aim was to determine if it would be more efficient and cost effective to relocate and fix plots with a GPS as a separate exercise before the actual remeasurement of a set of plots, or to rely on the standard plot relocation process to relocate plots during the next plot remeasurement and update coordinates at that stage. The work was undertaken by Landcare Research under TFBIS Programme Project 191.

2. Background

The Wraight 20 x 20 m plot method was developed by the Forest Research Institute of the former New Zealand Forest Service (Wraight 1962; Wiser & Rose 1997). Plots were mostly established by the New Zealand Forest Service between 1955 and 1978 and are distributed from Stewart Island to Hawke's Bay.

Four types of data can be collected on a permanent Wraight plot (Wiser & Rose 1997). Plant species frequencies are the 'core' data collected on all plots. Species presence/absence is measured in small circular subplots regularly spaced along a 20-m or 40-m transect. This information is summed to provide species frequency per transect. Transects on plots established before about 1970 are 40-m long whereas more recently established transects are 20-m long. Species cover (using stereo-photographs) and tussock biomass are measured on a 20 x 20 m quadrat at the plot. On some plots the Reconnaissance plot method has been used to obtain a full species inventory of the 20 x 20 quadrat with an abundance value recorded for each species by height tier.

Plot location information for a Wraight plot typically consists of a marked location on an aerial photograph, imperial NZMS 1 map coordinates, location notes on the plot description sheet, and plot location slide transparencies. For 20-metre transects, location slides were taken from the bottom (0-m) and top (20-m) pegs of the transect looking, respectively, up and down the line. For 40-m transects additional location slides were taken up and down the line from the middle peg of the transect. Location slides were taken at each measurement of the plot. Sketch maps were drawn on some plot description sheets. Survey maps with marked plot locations exist for c. 10% of datasets. All this information is archived in NVS.

Plot relocation time and efficiency are influenced by a number of factors that should be considered in the planning stages. Time in the field may increase if there are gaps in the archived plot location information (e.g., no aerial photo, location slides). This information might have been lost before data transfer to the NVS archive, may not have been archived (e.g., aerial photos elsewhere) or not completed (e.g., plot description sheets not written up).

The accuracy of plot map coördinates varies and must be used in conjunction with other key supporting location information to relocate a plot. Many of the c. 2400 plots were established before topographic maps were readily available for mountainous regions of New Zealand. While plot locations were marked on aerial photographs at the time of plot establishment, map coordinates were generated at a later date for most datasets, particularly if plots were remeasured. About 20% of plots do not have full map coordinates (see Newell & Rose 2007).

Most aerial photos with marked plot locations are held in a centralised aerial photo archive in NVS. Photographs are ordered across New Zealand by photo area and run number making access to individual photographs for a specific dataset a time consuming exercise. Some plot locations are marked near the edge of the unrectified aerial photo where topographic features are distorted and interpretation may be difficult and, again, time-consuming.

Some plots have additional pegs present, marking stereophoto positions, scattered across the 20 x 20 m plot. This can be confusing and misleading for relocating the actual 20-m or 40-m transect line. Generally 20-m and 40-m transects have been marked with c. 50 cm long, c. 6 mm diameter metal pegs at the 0 m, 20 m, and 40 m positions. By contrast, stereophoto positions were typically marked with shorter, smaller-diameter aluminium pegs.

Most plots have not been visited for at least 15 to 20 years, and in some instances, particularly in subalpine grasslands, or disturbed areas, the vegetation will have changed over that period. If this has occurred the location slides may be less useful.

3. Objectives

To relocate a set of permanent alpine grassland plots, using the standard relocation process, and fix their geographic position using a GPS. Determine whether it is more efficient and cost effective to relocate and fix plot position with a GPS in an initial, separate exercise before the actual remeasurement, or to use standard relocation methods to relocate and fix plot positions during the next plot remeasurement.

4. Methods

4.1 Study area

This pilot study used permanent Wraight plots from the Waimakariri catchment, inland Canterbury. This dataset was chosen for several reasons:
- The Waimakariri survey is one of 15 key alpine survey areas with plots that have been measured at least twice.
- This is one of the early datasets established and the 46- and 35-year time span since establishment and remeasurement tests the value of using historic plot location information for plot relocation.
- Vegetation structure and species composition vary along a strong east-west rainfall gradient (Wraight 1966; MacLennan 1974) and this might influence plot relocation time.
- Most key plot location information was available in NVS.

In 1961, 179 plots were established (Wraight 1966) and 84 of these were remeasured in 1972 (MacLennan 1974). The species frequency transects were 40-m in length and ran parallel to the slope. Typically, large alpine basins/mountain slopes had clusters of three plots that were 200 to 500 m apart. Each plot was labelled with a unique identifier made up of the line and plot number. The line/plot numbering system was not consistent between 1961 and 1972.

4.2 Upgrade map coordinates

Archived Waimakariri plot map coordinates were upgraded as part of a large exercise to upgrade map coordinates of the 15 key alpine grassland survey areas archived in NVS, also funded in TFBIS Project Programme 191 (see Appendix 1). The upgrade was undertaken by a Landcare Research staff member with more than 15 years of field experience and high competency for relocating plots in the field.

The archived three-digit imperial NZMS 1 map coordinates were converted to seven-digit metric NZMS GRID coordinates on the Land Information New Zealand (LINZ) website http://www.linz.govt.nz/apps/coordinateconversions/index.html using the batch conversion programme. The metric coordinates were imported into the map programme TOPOMAP to electronically review plot locations. Archived plot location information was collated for each plot from all measurement years and used to upgrade the plot position. The position was firstly checked against the location marked on the aerial photo, as well as location notes and sketch (when present) on the plot description sheet. Location slides were also reviewed. Where necessary the plot position was manually moved in TOPOMAP and the 7 digit metric coordinates were extracted for the upgraded position. Each plot upgrade was given a precision confidence rating (1=low, 10=high) based on confidence in pinpointing the correct plot location. The times required to collate all plot location information and undertake the coordinate upgrade were noted.

4.3 Collate plots and all relevant location information

Plot location information was prepared for 33 plots. The aim was to relocate at least 25 plots and have information ready for 8 'backup' plots in case some of the former group were not found. Plots were well dispersed along the east-west rainfall gradient and represented a range of altitudes and plant communities. Plots with missing plot location information were included to determine the possibility of relocating plots without key location information.

All relevant plot location information was photocopied and collated separately per plot. This included aerial photographs with marked plot locations, as well as plot description sheets from the 1961 and 1972 measurements. Location slides from 1961 and 1972 were electronically scanned in batch loads of 50. Slides in poor condition or with poor exposure were scanned individually. Scanned images were labelled, and printed as A4-sized black and white location prints. The 1961 and 1972 species frequency plot sheets were also photocopied to use species composition information to help clarify the position of a plot peg on the transect (i.e. at 0 m, 20 m, or 40 m).

4.4 Relocate plots in the field

The field work was undertaken by two teams of two. Each team was transported between plot clusters by helicopter, which was considered the most cost-effective, efficient method. A Hughes 500 D-model was used to carry all four people plus camping gear. Most clusters were at least half a day's walk through steep forested slopes from a road end or valley floor. The teams worked on adjacent plot clusters and were moved together to minimise helicopter time.

At the cluster, camping equipment was left at the camp site and the team were flown to the plot with the highest elevation/greatest distance from the camp site. Location prints, upgraded map coordinates and aerial photographs were used in a quick 2–5 minute reconnaissance by helicopter to narrow down the search area of the plot.

On the ground all plot location information and a metal detector were used to relocate the plot. A 5-hour search limit was given to relocate the first peg on the plot, after which time the team would walk and search for the next plot. Once the first plot peg was found a 20-m tape was run up or down the slope to relocate additional pegs using the aspect angle noted on the plot description sheet and/or features on location prints. The metal detector was used when pegs could not be easily seen. If original pegs were badly bent or broken they were replaced with new steel pegs.

When all three plot pegs were found, two 20-m tapes were laid out along the transect and the transect line was photographed from the bottom and top of each 20-m segment using a digital camera. The position of the plot was fixed with a GPS at the 0-m (bottom) plot peg. Essential GPS information (make, model, 2D/3D fix, averaged/single position fix, estimate of the precision error (m)) was recorded.

The time required to complete the initial helicopter search, ground search until location of the first peg, and relocation of full 40-m transect were recorded. The time to complete additional tasks on the plot was noted to help determine the total time required at a plot during a full plot remeasurement, discounting the actual vegetation measurement. Time estimates were based on an experienced field team. The type of plant community present was categorised into 10 possible broad vegetation categories to determine whether plot relocation time varied with vegetation type and structure.

4.5 Original versus upgraded coordinates

To determine the benefits of upgrading archived map coordinates, distances between the original archived map coordinates, upgraded coordinates and the position fixed by the GPS in the field were calculated with topographic relief taken into account.

4.6 Costs of relocating and remeasuring plots

4.6.1 Per plot costs

Time and financial costs of preparatory work, plot relocation and plot remeasurement were calculated per plot for three operational scenarios. Costs were summarised for plots with and without upgraded map coordinates to itemise the costs of upgrading map coordinates for planning. The three scenarios and methods for each are as follows:

> *Scenario 1*: <u>relocate and fix plot position with a GPS</u>. Prepare archive plot location information, relocate the plot using archive plot location information, plot map coordinates and metal detector, fix plot position, and photograph transect line.
>
> *Scenario 2*: <u>remeasure plot as a separate, second trip</u>. Preparation for vegetation remeasurement, relocate plot using a GPS (position fixed in Scenario 1) and photographs taken in Scenario 1, remeasure vegetation, photograph transect line.
>
> *Scenario 3*: <u>relocate, fix plot position with a GPS and remeasure plot in one trip</u>. Preparation of archive plot location information and vegetation remeasurement, relocate the plot using archive plot location information, plot map coordinates and metal detector, fix plot position, photograph transect line, and remeasure vegetation.

Staff costs reflect generic contractor rates, including overheads, and were based on $500 per day. One person was required for the collation of plot location information, map coordinate upgrade, and vegetation measurement preparatory work before field work, and two people used for the field work. Itemised times were based on experienced staff.

Times are given for all four types of vegetation data collected on a plot. Species frequency times are given for 40-m long transects because this reflects the length of transects in most key survey areas (Appendix 1).

4.6.2 Relocating and remeasuring a dataset of 30 plots

The costs of relocating and remeasuring a dataset of 30 plots were assessed for the three operational scenarios. Costs were calculated for plots with and without upgraded map coordinates.

Estimates took account of bad weather, adding an extra day for every 5 days in the field, travel to and from the survey area, and number of trips required. The 20% down time for wet weather is less conservative than 30% averaged by the Landcare Research Carbon Monitoring System teams (M. McKay pers. comm.) that set up and remeasured forest plots between 2002 and 2006. Those teams could only measure one plot per day whereas it may be possible to remeasure one or two grassland plots per day if the weather clears. Wet days and travel days are calculated at $500 per day per person.

Travel costs assumed that the team would only drive by vehicle to and from the survey area and fly by helicopter between plot clusters/lines of plots. The assumption was made that three plots were grouped as a cluster or as a line of plots and that teams would camp near the plots.

Remeasurement times were itemised by data collection type (species frequency circular subplots, stereophoto and tussock biomass data, species inventory) and based on past experience remeasuring three of the 15 key survey areas (Harper-Avoca (C. Newell pers. obs.), Fiordland, Wairau (A. Rose pers. comm.)). Costs of remeasurement are given for species frequency only and for all four data types collectively.

5. Results

5.1 Map coordinate upgrade and collation of plot location information

Table 1. Itemised staff times per plot for Waimakariri plot map coordinate upgrade, including time to collate plot location information, complete upgrade, and undertake additional preparation (e.g., photocopy species frequency plot sheets, scan and print location slides) before field work.

Time to complete:	Average (minutes)	Range (minutes)
Collate plot location information	20	10–45
Upgrade map coordinate	20	5–35
Total upgrade time:	40	15–80
Additional preparation of location information prior to field work.	50	25–90
Total preparation time:	90	40–165

Map coordinates were upgraded for 82 Waimakariri plots remeasured in 1972. On average it took 20 minutes to collate all plot location information for a plot, 20 minutes to complete the map coordinate upgrade, and 50 minutes to complete additional preparation of location information prior to field work (Table 1). These times also applied generally for the map coordinate upgrade of the 15 key survey areas (Appendix 1).

Time-consuming tasks included matching inconsistent 1961 and 1972 line/plot numbering systems, deciphering handwriting, and interpreting plot location notes. Useful location features from the plot location notes and aerial photos were summarised for the field team.

The map upgrade involved 1) moving the plot location based on the aerial photo and 2) refining this position using plot location notes, sketches and slope aspect. Information from other plots in the cluster was helpful for some plots. In some instances the upgrade generated full metric map coordinates for plots that did not have archived imperial coordinates or only had partial map coordinates.

5.2 Waimakariri plot relocation

Twenty-eight Waimakariri plots were searched for and all were relocated. Prints from location slides, notes on plot description sheets, the metal detector, and upgraded map coordinates were the most frequently used information to relocate plots (Fig. 1). These items were not mutually exclusive. Typically the upgraded coordinates, aerial photos, notes and sketch on the plot description sheet were used to get within 50 to 100 m of a plot and then the location prints and metal detector were used to relocate the actual transect line and plot pegs.

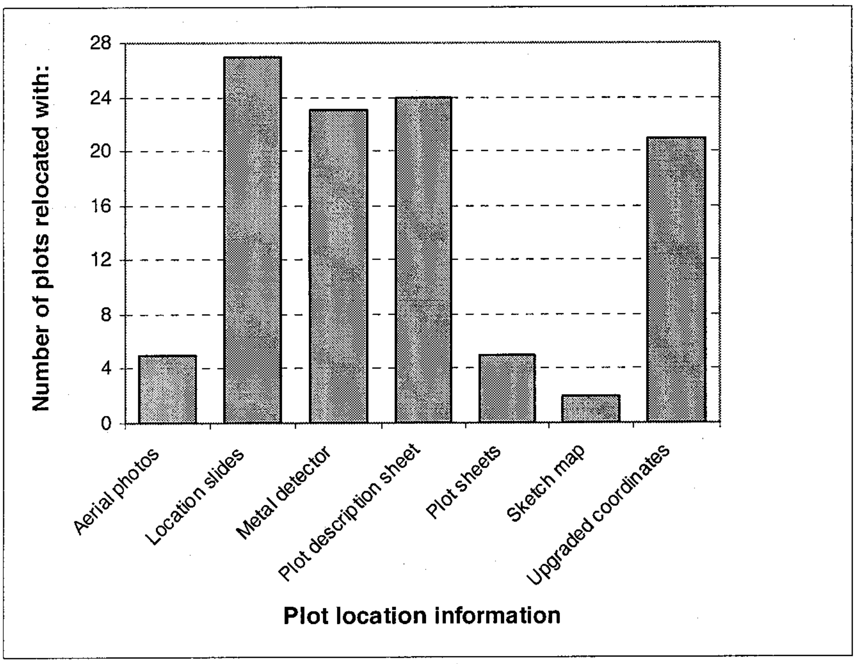

Figure 1. Plot location information used to relocate the 28 Waimakariri plots. Relocation generally relied on a combination of at least two or three of these items. Note: sketch maps were only drawn on two plot description sheets, location slides were missing for one plot. Aerial photos were used to upgrade map coordinates of 26 plots (missing for two plots) before field work.

Upgraded map coordinates: These enabled the team to find the general location of the plot.

Aerial photos: These were only used to relocate 5 plots, but were the key information used to upgrade map coordinates. Distinctive features on the photo helped identify the general location of the plot.

Notes of plot description sheets: The location notes often helped refine the search area and sometimes relocate the exact transect line. Sketch maps (when drawn) provided additional important topographic information.

Location prints: Both teams relied primarily on the location prints to pinpoint the 40-m transect. Topographic features in the prints, ranging from a subtle curved slope to a striking rock outcrop or scree slope, had changed very little in 35 or 46 years, although it was sometimes difficult to gauge the scale of these features.

Metal detector: The metal detector was often used in the essential last step of relocating plot pegs. It was used in conjunction with the location slides to search the 3 to 5-metre area around the probable location of a peg. The teams often would have struggled to relocate pegs without the detector. Some pegs were found flat on the ground under litter or buried upright under up to 20 cm of soil, litter or scree.

Average times for individual tasks on the plot were as follows: The first plot peg was found in 19 minutes and all three plot pegs of the 40-m transect were relocated in 29 minutes, although the latter ranged from 2 to 91 minutes (Table 2). Fixing the plot position and transect photography took an additional 17 minutes. A total of 46 minutes was spent at a plot, although this ranged from 16 to 122 minutes. The helicopter search was used for seven plots and was not considered very helpful. Generally features on the aerial photos were too detailed to quickly assess in the air and location prints were difficult to interpret from the air.

Table 2. Breakdown of time (mean and range) to complete all plot relocation tasks on the 28 Waimakariri plots. This excludes times for vegetation remeasurement.

Time to complete:	Average (minutes)	Range (minutes)
Ground search to find 1st plot peg	19	1–73
Relocate all 3 plot pegs	10	1–27
Total relocation time:	29	2–91
Complete other tasks on plot	17	5–33
Total for all tasks on plot	46	16–122

Relocation times did not vary greatly between the five vegetation categories sampled (Table 3), although these may have been skewed by the varying number of plots in each category. The teams did note that plot pegs were generally less engulfed and easier to find in the shorter, less dense vegetation in the eastern part of the study area.

Plots lacking photos and location prints were relocated. The two plots without aerial photos took, respectively, two and 60 minutes to relocate all three pegs, whereas the plot without location prints took 22 minutes to relocate all pegs.

Table 3. Average times to complete all tasks for plot relocation for each vegetation category represented by the Waimakariri plots. This excludes times for vegetation remeasurement. Number of plots per category is shown in parentheses.

Time to complete:	**Open low grassland-scree (4)**	**Low grassland (10)**	**Low grassland-shrubland (3)**	**Medium-tall grassland (10)**	**Tall grassland-shrubland (1)**
Search & find 1st peg	15	20	13	22	15
Find all 3 pegs	17	10	10	7	7
Total relocation:	32	30	23	31	22
Complete other tasks	18	29	15	15	10
Total for all plot tasks:	50	50	37	45	32

5.3 Relocating plots in other alpine regions

Relocation times in wetter alpine regions, such as the West Coast, North Island and Fiordland, which have denser snow tussock vegetation and greater density of subalpine shrub would take longer than the Waimakariri plots. Mean time of relocation would probably be around an hour. Recent experience relocating six permanent alpine grassland plots in the Ruahine Ranges provides some quantitative information for high rainfall areas. On average the first plot peg was found in 54 minutes (range 5 minutes to 3 hours) using upgraded map coordinates but without a metal detector (A. Hawcroft pers. comm.).

The relocation and remeasurement in 2000 of 44 alpine plots in the Harper-Avoca catchments, adjacent to the Waimakariri catchment, provides some comparison with the present study, although approximate estimates are only available. It took an experienced team of two between 5 minutes and 4 ½ hours to find all three plot pegs, averaging somewhere between 35 and 50 minutes (C. Newell pers. obs.). Relocation relied initially on aerial photos, on archived map coordinates to a lesser extent, and then location prints to identify local topographic features and pinpoint plot pegs. A metal detector was not used, which meant relocation times were longer for plots with buried pegs than times recorded on Waimakariri plots. Three additional plots in dense 1.2 m high matagouri shrubland were not relocated after one full day of searching. In each case the team was probably within 10 to 100 metres of the plot, but indistinct features on the location prints, uniformly tall vegetation obscuring topographic detail, and the absence of a metal detector prevented actual relocation.

5.4 Suggested method for plot relocation only (Scenario 1)

In this study it would be been more efficient to fly teams from plot to plot because an average of only 46 minutes was spent at a Waimakariri plot (Table 2). The methods used in this study were based on experience relocating plots in the Harper-Avoca. Teams were flown only to the first plot in the plot cluster and then walked between other plots in the cluster because it was assumed that some plots would take at least 3 to 4 hours to relocate.

If the goal is to relocate plots only (Scenario 1) it would be more efficient to hire a Robinson 44 helicopter per day (average cost of $900 per hour). One major advantage of this helicopter model is that there are no additional shut down costs. The helicopter and pilot would stay with the two teams of two all day and move them as required between adjacent plots. Based on average Waimakariri plot relocation times it should be possible for two teams to relocate a total of 12 to 18 plots per day.

5.5 Original versus upgraded map coordinates

On average, the upgraded Waimakariri plot map coordinates and fixed GPS position were c. 100 m from each other and were c. 930 and 960 metres respectively, away from the original archived map coordinates (Table 4), although there may be a discrepancy of ±200 metres in the position of each archived plot position. This can occur during the conversion of three-digit imperial coordinates to seven-digit metric coordinates.

Table 4. Average distances (metres) between the archived Waimakariri plot map coordinates (converted metric position ±200 m), upgraded map coordinates, and the position fixed with a GPS. Distance was calculated taking topographic relief in account. See Figs 2–8 for visual representation of positions.

	Average (metres)	**Range (metres)**
Archived to upgraded coordinate	961 (±200 m)	17–6240 (±200 m)
Archived to GPS position	929 (±200 m)	14–1746 (±200 m)
Upgraded to GPS position	102	7–438

The differences between upgraded and archived map coordinates demonstrate the benefits of upgrading map coordinates before field work. Distances between these three sets of coordinates varied: some upgraded coordinates and fixed positions were close to the original map coordinate (Figs 2–5); others were two to six kilometres away (Figs 6–8). The most extreme example is illustrated in Figure 7. If the original archived coordinates had been used, two of the three plots either would not have been relocated or would have required crossing a major river valley and mountain range to get to the actual plot.

Discrepancies between the original archived and upgraded map coordinate positions may vary between different datasets. The experiences relocating plots in this study indicate that upgrading should be undertaken before field work. Similarly, the Department of Conservation team relocating the six alpine plots in the Ruahine Ranges also found that upgraded map coordinates were closer to the actual plot position than the original archived positions. In that study map coordinates were upgraded using the locations marked on the archived aerial photos (A. Hawcroft pers. comm.).

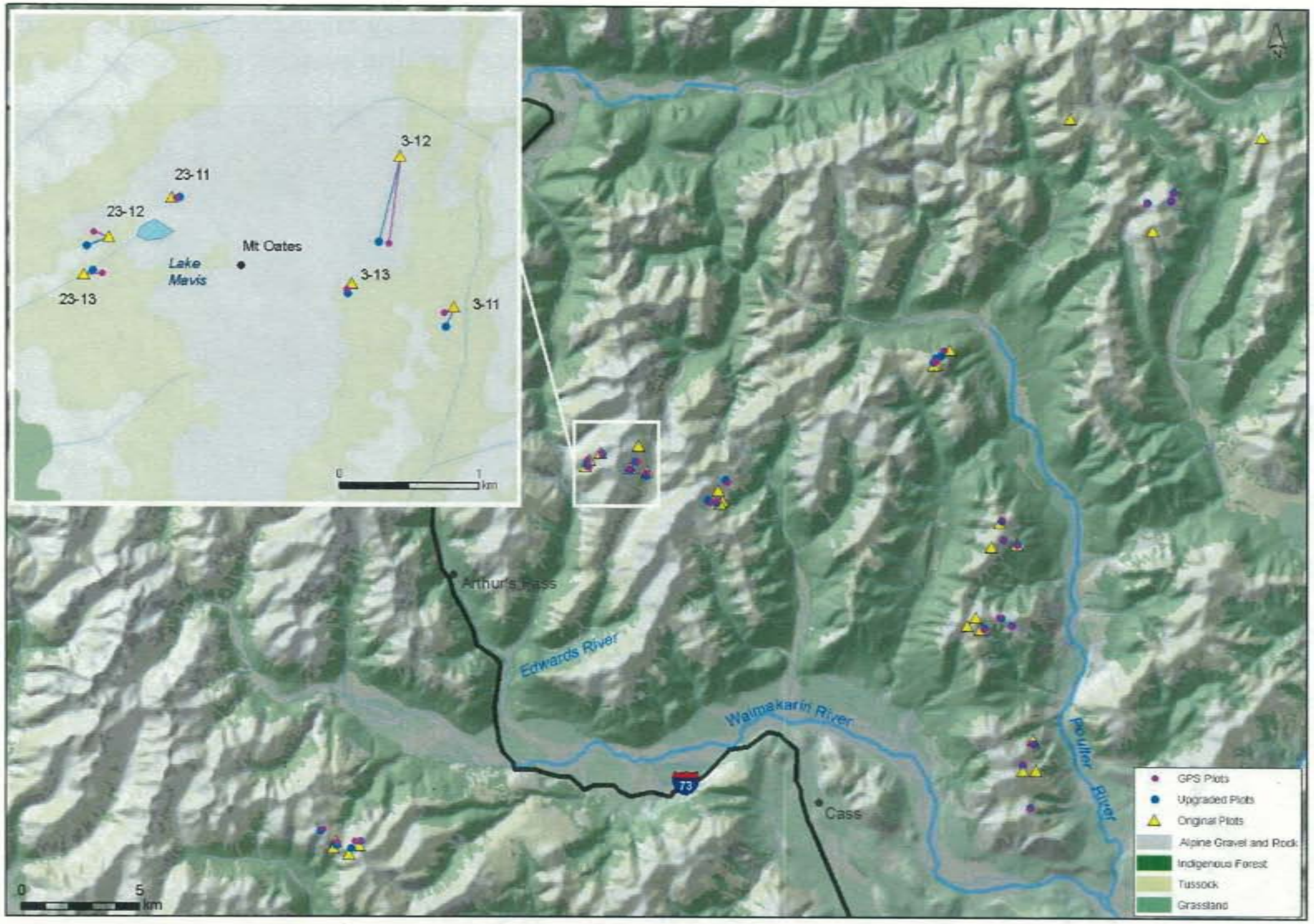

Figure 2. Positions of archived map coordinates, upgraded map coordinates and GPS fixed location for the plot clusters near Mt Oates, Edwards and Minga River catchments, Arthur's Pass National Park, Waimakariri Area. For each plot the lines connect the upgraded coordinates and fixed position with the archived map coordinates. Plots are numbered using the 1972 line/plot system.

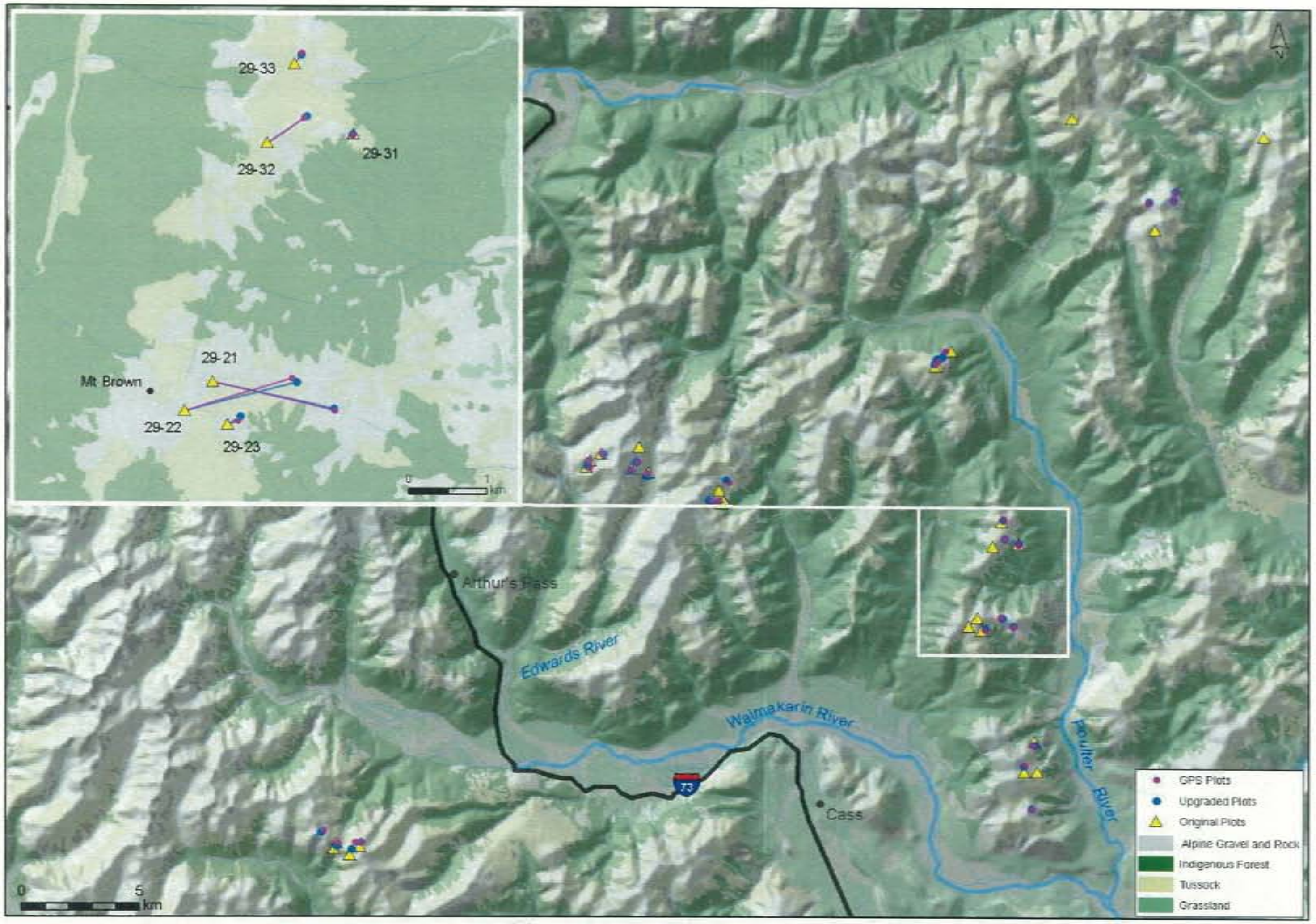

Figure 3. Positions of archived map coordinates, upgraded map coordinates and GPS fixed location for the plot clusters on the range between Andrews Stream and the Poulter River, Arthur's Pass National Park, Waimakariri Area. See Figure 2 for details.

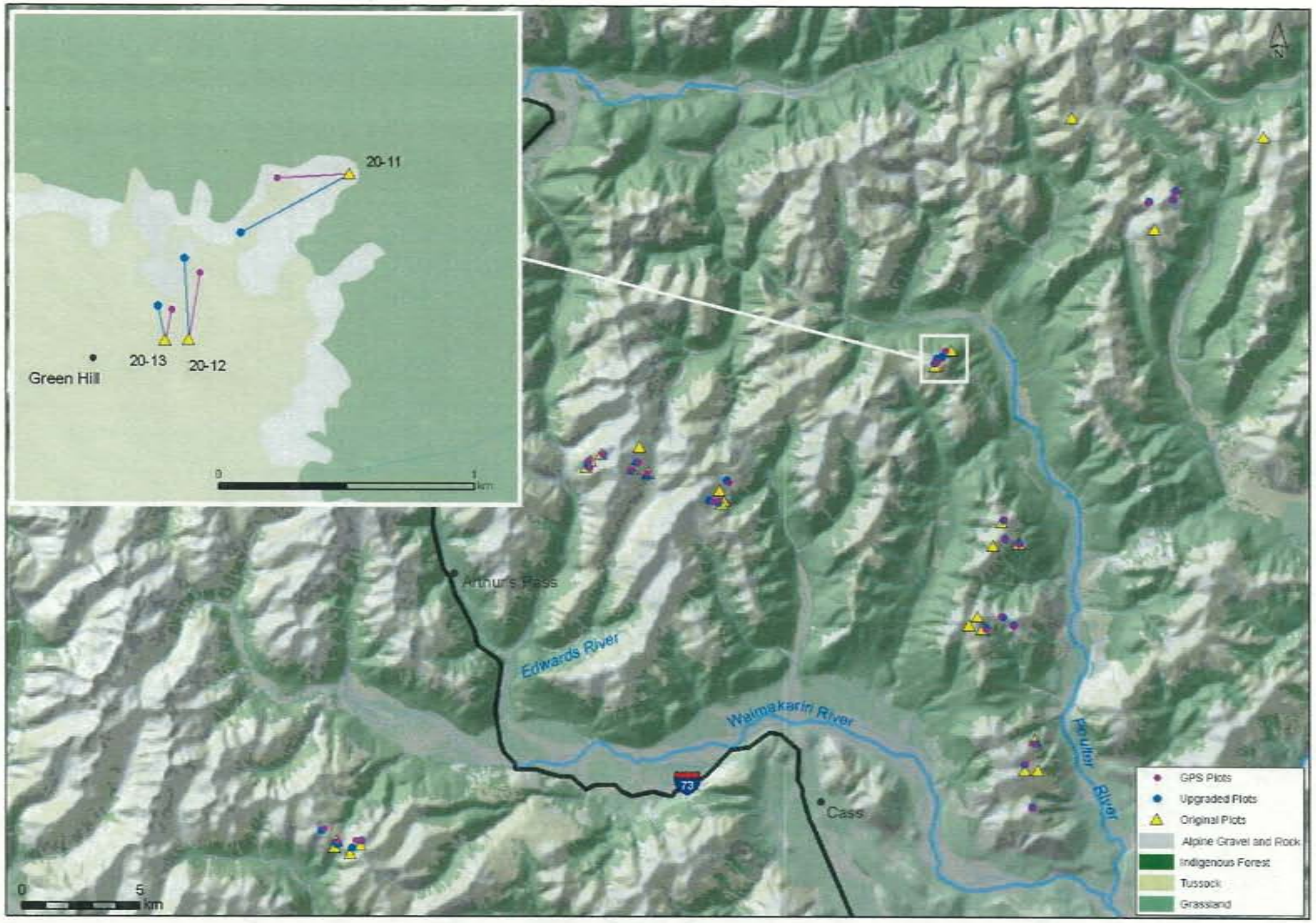

Figure 4. Positions of archived map coordinates, upgraded map coordinates and GPS fixed location for the plot cluster near Green Hill, Poulter River, Arthur's Pass National Park, Waimakariri Area. See Figure 2 for details.

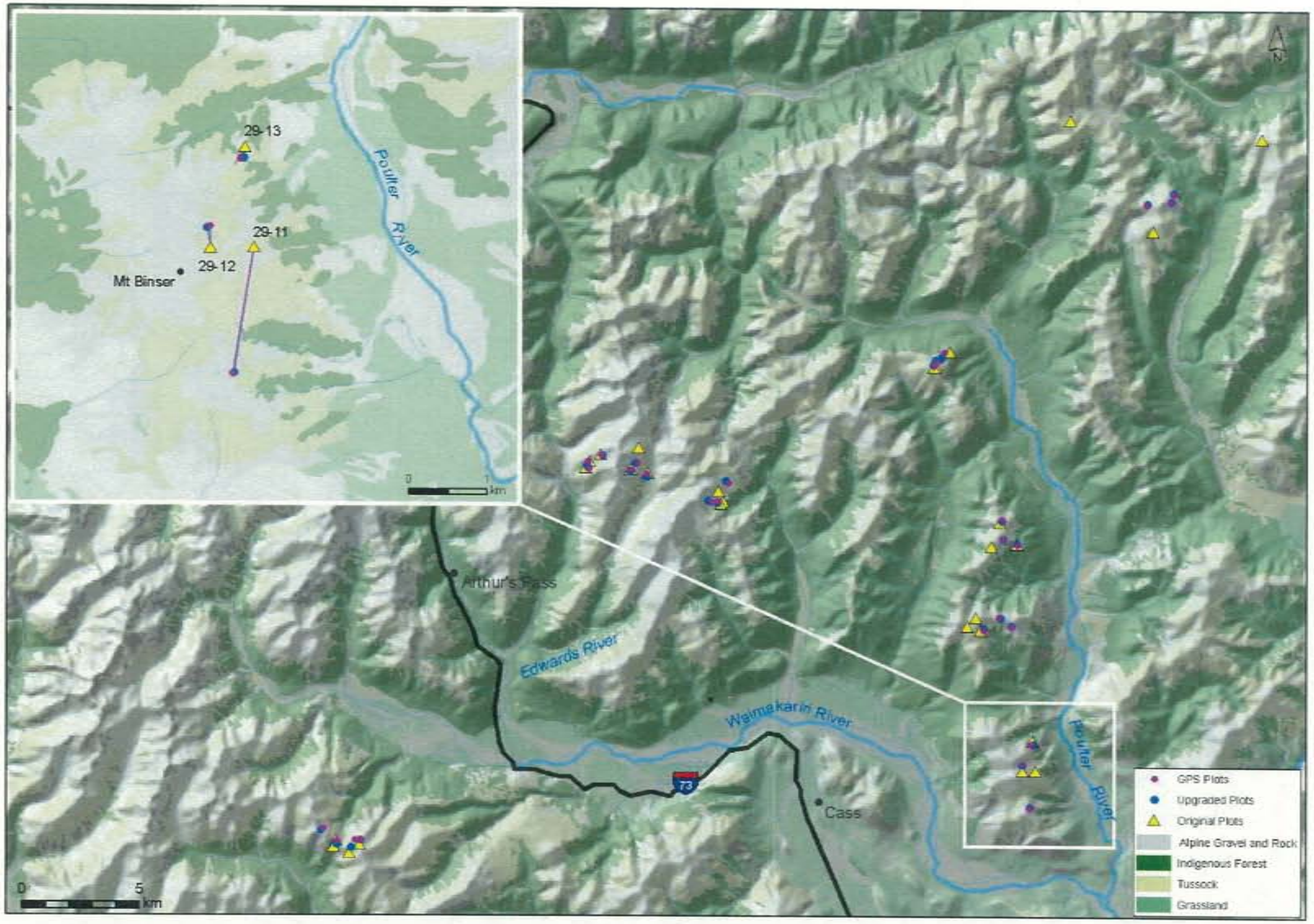

Figure 5. Positions of archived map coordinates, upgraded map coordinates and GPS fixed location for the plot cluster near Mount Binser, Poulter River, Arthur's Pass National Park, Waimakariri Area. See Figure 2 for details.

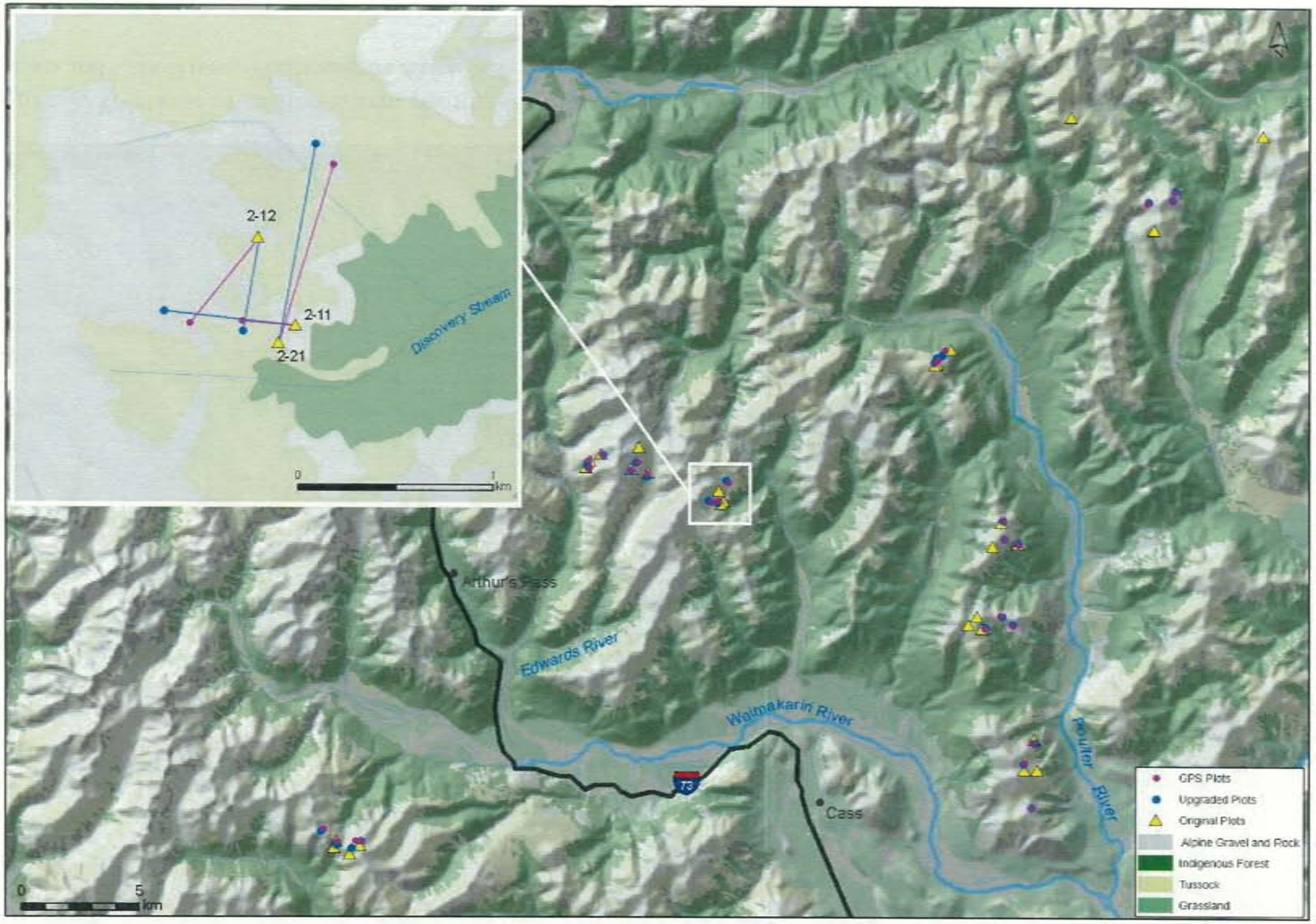

Figure 6. Positions of archived map coordinates, upgraded map coordinates and GPS fixed location for the plot cluster near Discovery Stream, Hawdon River, Arthur's Pass National Park, Waimakariri Area. See Figure 2 for details.

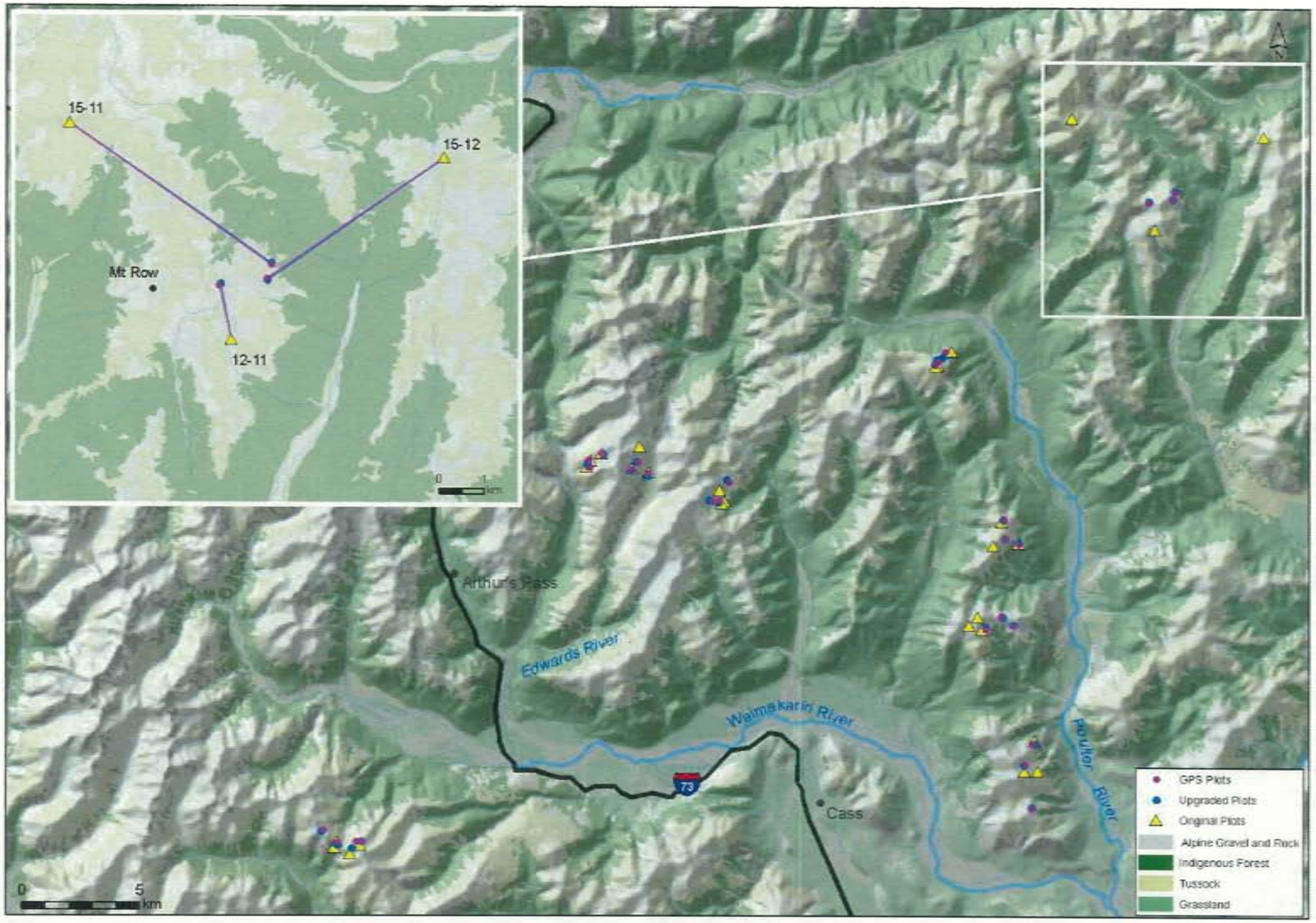

Figure 7. Positions of archived map coordinates, upgraded map coordinates and GPS fixed location for the plot cluster near Mount Row, Row Stream and Cox River, Waimakariri Area. See Figure 2 for details.

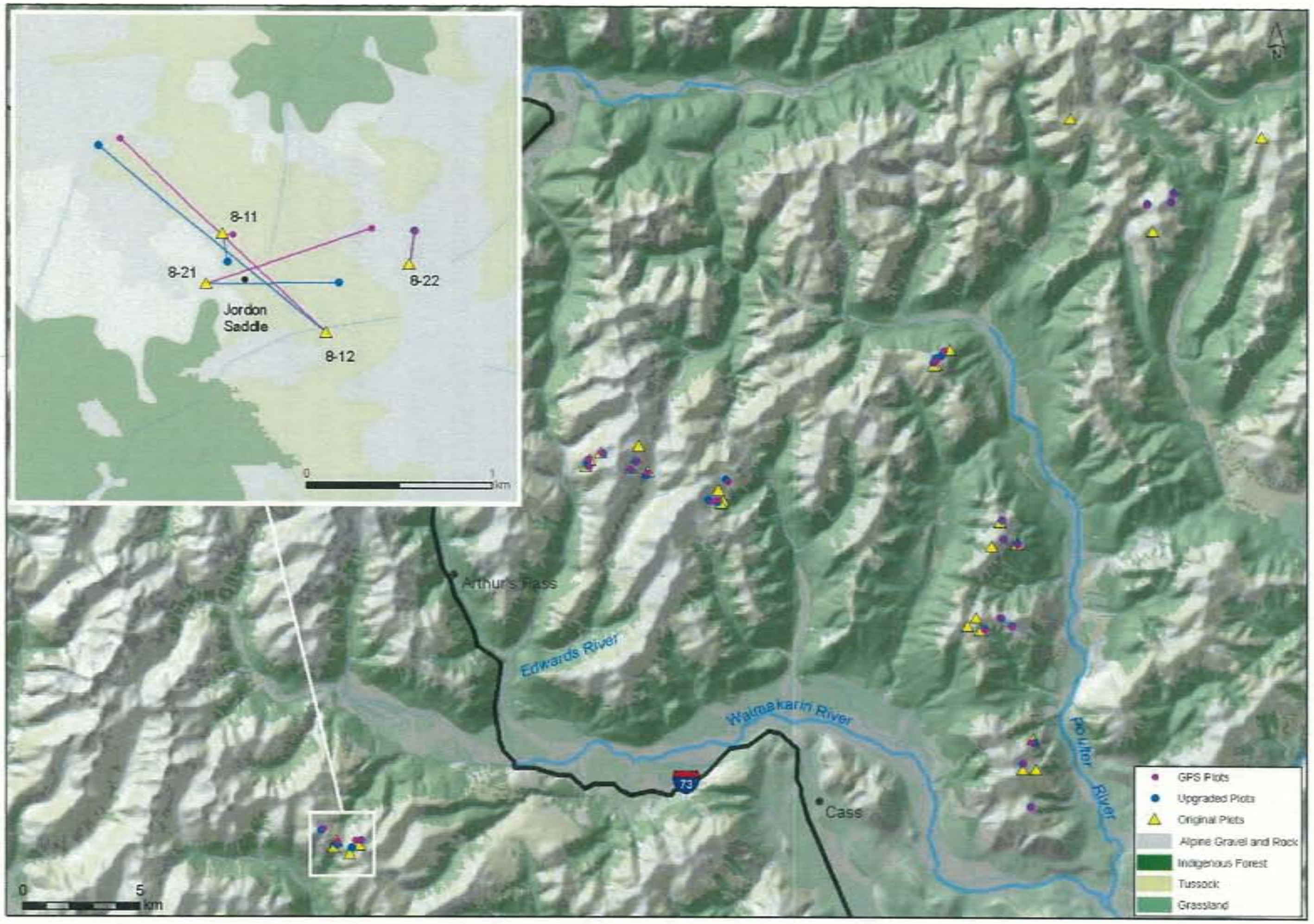

Figure 8. Positions of archived map coordinates, upgraded map coordinates and GPS fixed location for the plot cluster near Jordon Saddle, upper Waimakariri River, Arthur's Pass National Park, Waimakariri Area. See Figure 2 for details.

5.6 Costs of relocating and remeasuring plots

5.6.1 Breakdown of costs per plot

The time and financial costs of relocating and remeasuring a plot were broken down into four different components (map coordinate upgrade, GPS the plot position, travel to/between plots, remeasure plot; Table 5). Plot relocation time was increased from 29 minutes (Waimakariri plots) to one hour to accommodate relocation in denser vegetation in wetter regions. Travel time and costs were given separately for Scenario 1 (fly to each plot to relocate only using a Robinson 44: see Section 5.4) and Scenarios 2 and 3 (fly only to first plot in plot cluster or line and walk 60 minutes between plots).

Average costs are: $42.00 in time for the map coordinate upgrade, $219.00 in time for additional preparation and field relocation to fix the plot position with a GPS, as well as $250.00 for travel time to each plot under Scenario 1 and $404.00 for travel time to and between plots for Scenarios 2 and 3. Costs of the actual plot remeasurement range from $287.00, to remeasure species frequency data only, and $475.00 to remeasure all four data types.

It must be emphasised that these costings do not include other costs associated with plot remeasurement, such as liaising with the Department of Conservation for access permission, team management and employment, plant identification preparation for remeasurement, field allowances, equipment and post-field work on plant identification and dataset management.

5.6.2 Costs per plot for operational Scenarios 1–3

Average costs per Scenario for plots that, respectively, have and have not had map coordinates upgraded (latter in parentheses) are as follows (see Table 6):

(a) To relocate plots only:
Scenario 1 (relocate and fix plot position with a GPS) will cost $470.00 ($510.00).

(b) To remeasure plots only as a second trip:
Scenario 2 (remeasure plot as a separate, second trip) will cost a minimum of $695.00 to relocate the plot using the GPS and remeasure species frequency data only, and $885 to measure all four types of vegetation data.

(c) To relocate and remeasure plots:
Scenario 1 and 2 combined will cost $1165.00 ($1205.00) to remeasure species frequency data only and $1355.00 ($1395.00) to measure all four types of vegetation data.

Scenario 3 (relocate, fix plot position with a GPS and remeasure plot as one trip) will cost $895.00 ($935.00) to relocate the plot and remeasure species frequency data only, and $1085.00 ($1125.00) to relocate the plot and remeasure all four types of vegetation data.

Table 5. Average time and financial costs of the four different components required to relocate and remeasure a plot. [*]Required if undertaking plot remeasurement as a second trip (Scenario 2). [$]Plot remeasurement times were generalised to accommodate denser grasslands and are itemised by data collection type. [&]Times are given for remeasuring species frequency on a 40-m transect. Times and costs based on one experienced staff member for the map upgrade and field preparation, and two experienced staff for field work, each @ $500 per day.

	Time:	**Total Cost:**	**Cost in field:**
Map upgrade:			
Map upgrade	40 minutes	$42.00	
TOTAL		$42.00	
GPS plot:			
Additional field prep.	50 minutes	$52.00	
Relocate & GPS plot, photo transect	1 hour 20 minutes	$167.00	$167.00
TOTAL		$219.00	$167.00
Travel to/between plots:			
Scenario 1:			
Helicopter to each plot		$250.00	$250.00
TOTAL		$250.00	$250.00
Scenario 2 and 3:			
Helicopter to cluster/line		$320.00	$320.00
Walk between plots	40 minutes	$84.00	$84.00
TOTAL		$404.00	$404.00
Remeasure plot[$]:			
Prep. for vegetation remeasurement	15 minutes	$16.00	
(Relocate plot with GPS)[*]	10 minutes	$21.00	$21.00
(a) Species frequency[&]	2 hours	$250.00	$250.00
(b) Stereophotos & tussock biomass	1 hour	$125.00	$125.00
(c) Species inventory	30 minutes	$63.00	$63.00
TOTAL		$475.00	$459.00

Table 6. Financial costs per plot for operational Scenarios 1–3, showing costs where a plot has and has not had the map coordinates upgraded. See Table 5 for breakdown of costs per plot. Costs were rounded up or down to nearest $5.00. *Includes costs for preparation for vegetation remeasurement, [&]includes relocation time with a GPS.

		Map upgrade to be completed:	Map upgrade completed:
Scenario 1:	Map upgrade:	$40	
relocate & fix plot position with a GPS in an initial trip	GPS plot:	$220	$220
	Travel to plots:	$250	$250
TOTAL		$510	$470
Scenario 2:	Remeasure plot:		
remeasure plot as a separate, second trip	(a) Species frequency*[&]	$290	$290
	(b) Stereophotos & tussock biomass	$125	$125
	(c) Species inventory	$65	$65
	Travel to/between plots:	$405	$405
TOTAL		$885	$885
Scenario 3:	Map upgrade:	$40	
relocate, fix plot position with a GPS & remeasure plot as one trip	GPS plot:	$220	$220
	Remeasure plot:		
	(a) Species frequency*	$270	$270
	(b) Stereophotos & tussock biomass	$125	$125
	(c) Species inventory	$65	$65
	Travel to/between plots:	$405	$405
TOTAL		$1125	$1085

5.6.3 Average number of plots relocated and/or remeasured per day

Average times are given for a team of two to relocate a plot and remeasure (i) species frequency and (ii) species frequency, stereophotos, tussock biomass, and the species inventory. For ii) times are also given for a team of four people, as this would halve the remeasurement time per plot and increase the number of plots remeasured in a day. Note that travel costs would increase per plot for a team of four people.

(a) To relocate plots only (Scenario 1):

The recommended method for relocating plots only is hiring a Robinson 44 helicopter on a daily basis to fly two teams between plots. Teams would work on adjacent plots and would be flown on to the next plot once a plot had been relocated (see Section 5.4). Based on the time of 1 hour 20 minutes to relocate all three plot pegs, GPS the plot position and photograph the transect line, plus 5 to 15 minutes of flying time between plots, it should be possible for two teams to relocate a total of 10 to 12 plots per day. By comparison only 6 plots would be relocated if two teams are each flown only to the first plot in a cluster/line of three plots.

(b) To remeasure plots only as a second trip (Scenario 2):

(i) Species frequency only: With plot position already fixed by GPS during a previous Scenario 1 trip, it will take 2 hours 50 minutes to find and remeasure species frequency data per plot (including 40 minutes walk between plots; Tables 5, 6). It should be possible to remeasure three plots per day.

(ii) Species frequency, stereophotos, tussock biomass, and the species inventory combined: A team of two could remeasure all four types of data on a plot in 4 hours 20 minutes and will remeasure one to two plots per day. A team of four could remeasure three to four plots (2 hours 5 minutes per plot) per day.

(c) To relocate and remeasure plots as one trip (Scenario 3):
(i) Species frequency only: A plot will take 3 hours 45 minutes to relocate, using standard plot location information, and remeasure species frequency data only which means it should be possible to remeasure two plots per day.

(ii) Species frequency, stereophotos, tussock biomass, and the species inventory combined: It would take 5 hours 15 minutes for a team of two to relocate a plot and remeasure all four data types. A team of two will average only one plot per day whereas a team of four could relocate and remeasure two to three plots (2 hours 50 minutes per plot) per day.

5.6.4 Relocating and measuring a dataset of 30 plots

Average costs and days are given per Scenario to relocate and remeasure a set of 30 plots (Table 7) based on per plot costs shown in Table 6. Costs and time for relocation only are calculated for two teams of two. Remeasurement costs are itemised for (i) a team of two to remeasure species frequency only and (ii) a team of four to remeasure species frequency, stereophotos, tussock biomass, and the species inventory, with extra travel expenses to cover four people flying between plot clusters and walking between plots (an additional $250/plot and $45/plot respectively). Costs for 30 plots that require a map coordinate upgrade are shown in parentheses.

(a) To relocate 30 plots only (Scenario 1):
It will take 3 days for two teams of two to relocate and fix the position of 30 plots at a total cost of $15,400 ($16,600; Table 7).

(b) To remeasure 30 plots only as a second trip (Scenario 2):
(i) Species frequency only: One team of two will remeasure 30 plots in 13 days, including 2 days of wet weather and 1 day of travel, at a cost of $24,150.

(ii) Species frequency, stereophotos, tussock biomass, and the species inventory combined: One team of four will take 10 days to remeasure 30 plots, including 1.5 wet days and 1 day of travel, at a cost of $40,700.

(c) To relocate and remeasure 30 plots as one exercise (Scenario 3):

(i) Species frequency only: One team of two will take two trips and a total of 20 days to relocate, GPS and remeasure 30 plots, including 3 days of wet weather and 2 days of travel. The cost of $32,450 ($33,650) includes $1,000 for additional helicopter costs to move the team out of trip 1 and back in for trip 2.

(ii) Species frequency, stereophotos, tussock biomass, and the species inventory combined: One team of four will take one trip of 13 days, including 2 wet days and 1 travel day to relocate, GPS and remeasure 30 plots at a cost of $47,700 ($48,900).

These are average estimates. The number of plots measured per day and ratio of wet to fine days may be, respectively, over- and under-estimated for areas of high rainfall.

An additional $18,000 minimum will be necessary to cover other tasks associated with relocating and remeasuring a dataset of 30 plots. These tasks include liaising with the Department of Conservation for access permission, team management and employment, plant identification and plot preparation for remeasurement, field allowances, equipment and post-field work on plant identification, and dataset management/post-processing.

5.6.5 Advantages and disadvantages of each operational Scenario

(a) Relocating plots – Scenario 1 versus Scenario 3:
Scenario 1 provides the best option for managing a set of permanent grassland plots and implementing a well-designed study (Table 8). Under this scenario it will be possible to relocate a large number of plots in a short amount of time to catalogue which plots still exist and exactly where they are located. This is important for the general management of an area. Scenario 1 also enables much greater flexibility with study design and plot selection for remeasurement than Scenario 3, because plot selection will be based on the exact locations of all existing plots, rather than a list of possible plots with uncertain locations. For these reasons the design and implementation of regional and national-scale studies will be more efficient and successful under Scenario 1. This scenario provides greater assurance than Scenario 3 that the number of plots to be remeasured will be large enough to meet statistical assumptions.

(b) Relocating and measuring plots - Scenario 1 and 2 versus Scenario 3:
For Scenarios 1 and 2 the benefits of implementing a well-designed survey, from a list of plots that are known to exist, outweigh the disadvantages of higher total costs and organising two different types of field trips (Tables 7, 8). In addition, the Scenario 1 and 2 combination uses staff skills more efficiently, enables greater operational efficiency and flexibility, and has fewer financial risks than Scenario 3 (Table 8). The list of uncertain factors, such as whether a plot will be found and how much time to allocate per plot, is greater under Scenario 3 and this will make it more challenging to run an efficient field trip.

In areas of high rainfall it may be more practical to time two shorter trips (Scenarios 1 and 2) in windows of fine weather than one longer trip under Scenario 3. During marginal weather it will be easier to relocate plots by GPS in Scenario 2 than in Scenario 3 where relocation will require good visibility to match topographic features in location prints with the surrounding landscape.

Table 7. Costs of relocating and remeasuring 30 plots with upgraded map coordinates for Scenarios 1–3 (price including map upgrade in parentheses). Costs of remeasurement are itemised for (i) species frequency only and (ii) all four types of data. See Table 6 for per plot costs. Mileage reflects a *400 km return trip from base (@70c/km). Teams travel by helicopter to each plot in Scenario 1 and between plot clusters/lines in Scenarios 2 and 3. There is #additional helicopter time for two trips in Scenario 3(i) and additional per plot costs of $\$250 helicopter time and **$45 walking time to cover a team of four remeasuring all four data types.

	Days	Cost	Days	Cost
Two teams of two	**Scenario 1** (relocate only)			
Relocation days:	3 days	$14,100		
	10-12 plots/day			
	$470 per plot			
Travel to/from area		$1,000		
Mileage		$300		
TOTAL		$15,400 ($16,600)		
i) species frequency:	**Scenario 2**		**Scenario 3**	
Team of two	(remeasure only)		(relocate and remeasure)	
Remeasurement days:	10 days	$20,850	15 days	$26,850
	3 plots/day		2 plots/day	
	$695/plot		$895/plot	
Wet days (1 in 5 days):	2 days @$1000/day	$2,000	3 days	$3,000
Travel to/from area:	1 day @$1000/day	$1,000	2 days	$1,000
Mileage*:		$300		$600
Extra helicopter time:				$2,000#
Number of trips:	1		2	
TOTAL		$24,150		$33,450 ($34,650)
ii) all four data types:	**Scenario 2**		**Scenario 3**	
Team of four	(remeasure only)		(relocate and remeasure)	
Remeasurement days:	7.5 days	$26,550	10 days	$32,550
	4 plots/day		3 plots/day	
	$885/plot		$1085/plot	
Extra helicopter time:	$250/plot$	$7,500	$250/plot$	$7,500
Extra walking time:	$45/plot**	$1,350	$45/plot**	$1,350
Wet days (1 in 5 days):	1.5 days @$2000/day	$3,000	2 days	$4,000
Travel to/from area:	1 day @$2000/day	$2,000	1 day	$2,000
Mileage:		$300		$300
Number of trips:	1		1	
TOTAL		$40,700		$47,700 ($48,900)

Table 8. The advantages (adv) and disadvantages (dis) of Scenario 1 versus Scenario 3 for relocating, and Scenarios 1 and 2 versus Scenario 3 for remeasuring a set of alpine plots.

Relocating plots:	**Scenario 1**		**Scenario 3**	
Relocation efficiency	Relocate a lot of plots in a few days	adv	Fewer plots relocated in same time period	dis
Plot management	Know which plots exist & their exact location	adv	Same, but probably for a smaller number of plots	dis
Survey design	Can design a study knowing which plots exist, therefore can efficiently design & implement a large-scale study	adv	Study designed before know which plots still exist and where they are, therefore difficult to undertake a large-scale study	dis
	Plot sampling design flexible because have accurate locations for existing plots		Less flexible sampling design because don't know which plots still exist	
	Greater assurance that number of plots sampled will meet statistical assumptions		Can't guarantee will relocate enough plots	
Land management	Know exact location of plots and can manage land accordingly	adv	Know exact location of plots and can manage land accordingly	adv

Relocating and measuring plots:	**Scenario 1 and 2**		**Scenario 3**	
Overall cost	More expensive	dis	Cheaper	adv
Overall organisation	2 trips to organise	dis	1 trip to organise	adv
Use of expertise	2 trips with different expertise	adv	1 or 2 trips with all skills	dis
	trip 1- plot relocation skills			
	trip 2- species identification skills			
Operational efficiency	Very efficient use of staff skills	adv	Less efficient use of staff skills	dis
	Better planning for Scenario 2 as exact plot locations known		Hard to plan efficiently because don't which plots exist or their exact location	
	Go straight to plot to remeasure in Scenario 2		Team have to find plot first before remeasurement begins	
Operational flexibility	Highly flexible	adv	Less flexible	dis
	Less time at a plot and between plots for Scenario 2		Unknown time required per plot	
			Potentially less efficient use of staff	
	Efficient use of staff expertise			
Financial risks	Less likely to lose $ in travel and staff time	adv	Lose more $ if plots hard to find/not found, location not where thought	dis
Wet weather	2 shorter trips in 2 windows of fine weather	adv	Longer trip – more likely to encounter bad weather	dis
	Easy to relocate plots with GPS in marginal weather		Difficult to relocate plots in marginal weather – views of surrounding landscape required	
Fixed funds per year	Year 1: Relocate more plots with Scenario 1	adv	Years 1 & 2: fewer plots relocated and remeasured per year, less efficient as don't know which plots can be found & their exact location	dis
	Year 2: Well-organised trip to selected plots			

6. Conclusions

- The network of permanent alpine plots across New Zealand represents a set of fixed assets that provide information on past and current biodiversity. It is important that land managers know the exact location of these assets and can manage them appropriately.
- It is important to obtain accurate locations for all existing permanent plots.
- Key factors for **plot relocation** include: upgraded map coordinates, experienced staff, efficient use of helicopters, historic archived plot location information and a metal detector.
- **Accurate map coordinates** are essential for plot relocation and future assessments of biodiversity on grassland plots. Large discrepancies between original map coordinates archived in NVS and GPS positions highlight the practical difficulties of relying on original map coordinates to relocate plots.
- All archived map coordinates should be upgraded before plot relocation to maximise field efficiency. Upgraded map coordinates were much closer to the GPS position than archived map coordinates. The extra $42 cost per plot to cover the coordinate upgrade would be much lower than extra costs of relocating plots using archive coordinates.
- The most useful **plot location information** for relocating the 28 Waimakariri plots were aerial photos (for map coordinate upgrade), and combination of prints from location slides, plot description sheet notes and sketches (the latter where present), and upgraded coordinates. It was possible to relocate plots without aerial photos or location slides.
- Average time to relocate the first plot peg on the 28 Waimakariri plots was 19 minutes, an additional 10 minutes to find all three pegs, and 17 minutes to complete other tasks.
- Time and costs were itemised per plot and per day for three operational scenarios.

  Scenario 1: <u>relocate and fix plot position with a GPS</u>. Prepare archive plot location information, relocate plot using archive plot location information, map coordinates, and metal detector, fix plot position, and photograph transect line.

  Scenario 2: <u>remeasure plot as a separate, second trip</u>. Prepare for vegetation remeasurement, relocate plot using a GPS and photos (both obtained in Scenario 1), remeasure vegetation, photograph transect line.

  Scenario 3: <u>relocate, fix plot position with a GPS and remeasure plot in one trip</u>. Prepare archive plot location information and vegetation remeasurement, relocate the plot using archive plot location information, plot map coordinates, and metal detector, fix plot position, photograph transect line, and remeasure vegetation.
- **Relocation only (Scenario 1)** for plots with upgraded map coordinates: the most efficient method will be to hire a Robinson 44 helicopter on a daily basis to fly two teams between adjacent plots. Average estimated cost of $470 per plot, including helicopter expenses. Two teams of two should be able to relocate 10-12 plots per day.
- **Remeasurement costs** were calculated for a team flying to the first of three plots in a cluster or line and walking between subsequent plots. Costs depended on which data types were measured in the field and the size of the field team.
- **Remeasurement only (Scenario 2)** for plots with upgraded map coordinates:
  - i) <u>species frequency only:</u> Average cost of $695 per plot. A team of two will take 2 hours 50 minutes to remeasure one plot and will remeasure 3 plots per day.

  - ii) species frequency, stereophotos, tussock biomass, species inventory: Average cost of $885 per plot. A team of four will take 2 hours and 5 minutes to remeasure one plot and will remeasure 4 plots per day.
- **Relocate and measure (Scenario 3)** for plots with upgraded map coordinates:
  - i) species frequency only: Average cost of $895 per plot. A team of two will take 3 hours and 45 minutes to relocate the plot using standard archived plot information, GPS and remeasure vegetation. They will remeasure 2 plots per day.
  - ii) species frequency, stereophotos, tussock biomass, species inventory: Average cost of $1085 per plot. A team of four will take 2 hours and 50 minutes per plot and will remeasure 3 plots per day.
- The average number of plots per day may decrease in areas of high rainfall.
- **Estimated costs for relocating and remeasuring a dataset of 30 plots** with upgraded map coordinates are as follows:
  - **Relocate only (Scenario 1):** It will take 3 days for two teams of two to relocate and fix the position of 30 plots at a total cost of $15,400.
  - **Relocate only (Scenario 2):**
    - i) species frequency only: A team of two will take 13 days to remeasure 30 plots, including 2 days of wet weather and 1 day of travel, at a cost of $24,150.
    - ii) species frequency, stereophotos, tussock biomass, species inventory: A team of four will take 10 days in total to remeasure 30 plots, including 1.5 wet days and 1 day of travel, at a cost of $40,700.
  - **Relocate and remeasure (Scenario 3):**
    - i) species frequency only: A team of two will take 20 days, as two trips, to relocate, GPS and remeasure 30 plots, including 3 days of wet weather and 2 days of travel, at a cost of $32,450.
    - ii) species frequency, stereophotos, tussock biomass, species inventory: A team of four will take one trip of 13 days, including 2 wet days and 1 travel day to relocate, GPS and remeasure 30 plots at a cost of $47,700.
- **Plot relocation**: Scenario 1 is the best option for managing a set of permanent grassland plots and implementing a well-designed, remeasurement study. A large number of plots can be relocated in a short time enabling survey design to be based on existing plots with a known location, rather than a list of possible plots with uncertain locations (Scenario 3). Accordingly, Scenario 1 allows greater flexibility with study design and plot selection for remeasurement than Scenario 3.
- **Plot relocation and remeasurement combined**: Scenarios 1 and 2 will have better survey design, greater operational efficiency and flexibility, and fewer financial risks than Scenario 3.
- Times and costs in this report are quoted for plots with 40-m transects. Relocation costs would be similar for plots with 20-m transects. Remeasurement times would remain the same for stereophotos, tussock biomass, and species inventory data but would be c. 20–30 minutes less per plot for measuring species frequency data.

7. Recommendations

- Upgrade map coordinates for all alpine grassland plots, particularly fill gaps in the 15 key alpine survey areas (see Appendix 1).
- Locate and archive location slides for surveys that currently do not have location slides archived in NVS.
- In preparation of plot relocation, locate and archive location slides for surveys that currently do not have location slides archived in NVS.
- Initially relocate and fix positions of existing permanent alpine plots (Scenario 1) so that land managers know the exact location of existing plots and can manage the land accordingly.
- Secondly, identify key national and regional management issues and determine which existing datasets best address these issues. Design a remeasurement strategy based on these issues and select existing plots to remeasure (Scenario 2).
- At a minimum species frequency should be remeasured on each plot. The remeasurement of the three other data types will depend on the study objectives.

8. Acknowledgements

Thanks to Chris Morse for painstakingly upgrading c. 600 alpine grassland plot locations, Dean Richards for collating plot location information and help with field logistics, and Dean Richards, Ellen Cieraad, Kate Ladley, and Mike Perry for relocating the Waimakariri plots. This report benefited from discussions with Rob Allen, Amy Hawcroft, Jim Henderson, Meredith McKay, and Alan Rose. Anne Austin, Larry Burrows, and Meredith McKay reviewed the report.

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Appendix 1

Summary of map coordinate upgrade of 15 key alpine survey areas and status at end of current upgrade. All datasets have been measured at least twice. The upgrade concentrated on plots that had been remeasured. Aerial photos were missing for over half the Hokitika plots and all of the Taramakau plots. Plots from the Kaimanawa and Waitaki datasets were not upgraded due to time constraints. The length of species frequency transects used in each data is also given. *Some Ruahine map coordinates upgraded by Department of Conservation, Wanganui Conservancy.

Region	Survey Area	Total no. of plots	No. of plots remeasured	No. of plots upgraded	Transect length (m)	Datasets and years measured
North Island						
Hawke's Bay	Ngaruroro/Kaweka	77	43	41	40	1960, *p*1980
	Ruahine	166	107	0*	40	1961, *p*1970, 1975
	Tutaekuri/Kaweka	7	7	7	40	1960, 1965, 1981
Tongariro	Kaimanawa	48	9	0	40	1981, *p*1989
Wellington	Tararua	18	18	18	40	1959, 1964, 1974, 1984
South Island						
Canterbury	Ashley	71	60	26	40	1962, *p*1978
	Harper-Avoca	89	85	79	40	1955, 1960, 1965, 1975, 1980, 1985, 1990, 1995, 2000, 2005
	Hurunui/Hope/Jollybrook	79	12*	41	40	1962/63,1975/76
	Waimakariri	179	84	82	40	1961, *p*1972
	Waitaki	476	292	0	20	1973, *p*1985

Region	Survey Area	Total no. of plots	No. of plots remeasured	No. of plots upgraded	Transect length (m)	Datasets and years measured
Nelson/Marlborough	Wairau/Branch/Leatham	121	120	78	40	1959/60, *p*1971/72, *p*1985, *p*1995/96
Southland	North Fiordland	201	182	185	20	1969, *p*1975, *p*1984
	Takitimu	38	27	17	40	1961, 1968
Westland	Hokitika	45	45	16	40	1957, 1963, 1971
	Taramakau	59	59	0	20	1968, 1973

* Relationship between different datasets in this region still needs to be clarified.