Re-measurement of 167 Vegetation Monitoring Plots

Molesworth Station, Marlborough

January to March 2016 Operational Report

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— New Zealand Forest Surveys —

Contents

1 Summary

A network of vegetation monitoring plots on Molesworth Station (n=167) was re-measured by New Zealand Forest Surveys from January to April 2016. Nineteen HFI (height frequency intercept) plots had been established in 1989 and re-measured 1995, 2001, 2006 (M1–M14, S1–S3, S5–S6). An additional HFI plot was established in 1995 in an ephemeral tarn to monitor threatened plant species (M15). One HFI plot had been photographed in every survey prior to the 2016 survey, and was measured for the first time in 2016 using the HFI protocol of Dickenson and Mark (S4).

In January 2007, 80 plots were established by NZ Forest Surveys on randomly selected transect lines to provide representative data. In February and March 2008, a further 66 plots were established by NZ Forest Surveys in pairs along either side of cattle exclusion fences.

Some cattle exclusion fences were poorly constructed and maintained, allowing cattle access to exclusion areas. Some fences were damaged and have provided little deterrent to cattle for many years. Even the sites with undamaged fences (Pig Trough, Leader–Dale, Serpentine, Wairau River) had evidence that stock have had access exclusion areas over recent years, suggesting fence design and establishment was inadequate. This issue needs to be addressed through fencing maintenance. It should be allowed for in any analysis and interpretation of data from these sites.

Re-measurement field work ion 2016 was incident free, with no significant problems encountered. Use of our own private helicopter operated by NZ Forest Surveys made a cost-effective survey viable. Re-measurement costs per plot were ≈$800.

2 Introduction

2.1 Management objectives

Vegetation monitoring was established at Molesworth Station between 1989–2008 to provide managers with reliable information on the outcomes of their management choices over past decades, and beyond. The monitoring system is designed to determine changes in plant species composition which has occurred at Molesworth Station between 1989 and 2016, and to make prediction for the future. These changes can to be related to the influences of cattle grazing and exclusion of cattle through fencing, and the influence of weed invasion. Important environmental influences such as altitude and location can be considered.

3 January–March 2016 Trip Overview

New Zealand Forest Surveys re-measured 167 20 m $\times$ 20 m vegetation monitoring plots from January to March 2016 with a team of five people. Each 20 m $\times$ 20 m consisted of a cluster of five smaller sub-plots and fifty Scott height frequency intercepts (HFI). Dr Sean Husheer (myself) led the team whose members were Dr Graeme Jane, Dr Betzka Ccejkova, Elizabeth Orr and Emiliana Guerra. Our average qualification was a PhD in field botany and three decades of field experience. These qualifications and experience helped us to complete work efficiently.

A week long tent-camping trip took place in the Upper Saxton Saddle (S series plots) in early January. For the remainder of January and February we were based at the hut located at the St James Homestead site. Our helicopter was used most days to access sites within a 40 km radius. This allowed us to work very efficiently. When the hut became unavailable we shifted to Sedgemere Sleepout for a fortnight, before returning in late February to St James. We moved to Lake McCrae and The Ministerial huts at Molesworth in March to complete plots in those areas. Several trips to Hamner, Christchurch and Blenheim were required to transport staff, obtain supplies and fuel, and repair damaged vehicles.

3.1 Fence Condition

Many cattle exclusion fences were in poor condition, and require repair and implementation of a scheduled maintenance programme. Fences at Cat Creek (Figure 1) and Alma River were particularly poor. Other fences allowed cattle access, but to a lesser extent. By chance, cattle have appeared to avoid most of the fenced plots at these sites, so this lack of maintenance has had no significant effect on the results of vegetation monitoring (Table 2).

Serpentine Creek Fence in very good condition. No evidence of cattle grazing within exclusion fence. ST paired plots usable.

Horse Gulley Fence in poor condition. Evidence of cattle grazing within exclusion fence. Little obvious impact on vegetation in any of the plots. HG paired plots use-able.

Lake Sedgemere - Wet Fence in very good condition. No evidence of cattle grazing within exclusion fence. SW paired plots use-able.

Lake Sedgemere - Dry Fence in good condition. Evidence of very localised cattle grazing within exclusion fence. Little obvious impact on vegetation in any of the plots. SD paired plots usable.

Upper Wairau River Fence in good condition. Evidence of very localised cattle grazing within exclusion fence, which appeared to have had no effect on plots. WR paired plots usable.

Sedgemere Tarn Fence in very good condition. No evidence of cattle grazing within exclusion fence. M15 usable.

Cat Creek Fence in very poor condition. Evidence of localised cattle grazing within exclusion fence which appeared to effect plot. CC-1 and CC-3 useable. Caution required for CC-2 fenced

Alma River Fence in very poor condition. Evidence of localised cattle grazing within exclusion fence which appeared to effect plot.AR-2 and AR-3 usable. Caution required for AR-1 fenced.

Leader–Dale Fence in good condition, but cattle observed within fence, which appeared to have had no effect on plots. LD paired plots usable.

Pig Trough Fence in very good condition. No evidence of cattle grazing within exclusion fence. PT paired plots usable.

Upper Saxton Fence in good condition. Evidence of very localised cattle grazing within exclusion fence. Little obvious impact on vegetation in any of the plots. S2, S3, S4 paired plots usable.

Figure 1: Cat Creek cattle exclusion fence in poor condition in March 2016

4 Methods

In all three series of plots (HFI established in 1989, random plots in 2007 and paired plots in 2008), vegetation was assessed using the height frequency intercept (HFI) method described in (Dickinson et al., 1992) that is a modification of Scott's (1965) method. Cover of individual species was also estimated in fixed-area quadrats in 2007 and 2008. This is a widely used approach for monitoring grasslands (Mueller-Dombois & Ellenberg, 1974; Chiarucci et al., 1999). Each 20 m × 20 m plot contains 5 smaller cover quadrat plots (10 m × 10 m , 5 m × 5 m, 2 m × 2 m, 1 m × 1 m, 0.5 m × 0.5 m, Figure 2).
Random plots were established on 20 north-south orientated plots, and paired plots the following summer. Groups of paired plots were established at sites at Molesworth Station where cattle had been excluded from valleys with high conservation values. These sites were at Horse Gulley, Alma River, Cat Creek, western Lake Sedgemere (Sedgemere Wet), eastern Lake Sedgemere (Sedgemere Dry) and Pig Trough Stream. Six pairs of plots were established at Serpentine Stream and in the Leader–Dale River. Exact locations are provided on field sheets using GPS co-ordinates in NZMS 260 series map grids. Iterative GPS locations were recorded for every plot at the A corner using Garmin 60csx. Plot sites were selected to provide a range of vegetation types at each fence location. Paired plots were selected in similar vegetation type as close as possible to the same altitude.

4.1 Plot Layout

To provide a representative monitoring system, twenty randomly located lines were selected for plot establishment throughout all of Molesworth Station in January 2007. Four plots were established at 200 m intervals on each randomly selected magnetic north orientated line. Fifty height frequency intercepts were established at each plot, along with five nested quadrat plots from 0.5 m × 0.5 m to 20 x 20 m in size. Plots were not established at two transects dominated by rock and scree, instead two further random transects were established (Z transects). Each plot took approximately one person day to establish including walking, helicopter or four wheel drive access. A further 66 paired fenced and unfenced plots were established in March 2008 along either side of cattle exclusion fences. These fences were established between 1989 and February 2008, and the same plot protocol was used in both the 2007 and 2008 surveys. In five valleys (Wairau River, Pig Trough Stream, Horse Gully Stream, Cat Creek, Alma River) three pairs of plots were established. In three other valleys, six pairs of plots were established (Sedgemere, Serpentine Stream and Leader-Dale).
The origin of each plot is located at corner A, with corner B lying along the transect bearing. Corners C and D are located counter-clockwise thereafter. Corner A is marked by a 1 m high aluminium stake with the transect name, plot number and corner scribed. Corners B, C, and D are marked by 600 mm stakes. The internal corner of the 5 m

× 5 m plot is marked with a 600 mm stake (Fig 2). A colour photograph of the full extent of the 20 m × 20 m plot was taken from 1–3 m from corner A towards the plot center. Each photograph contains the survey, transect and plot number either on a photographed whiteboard.
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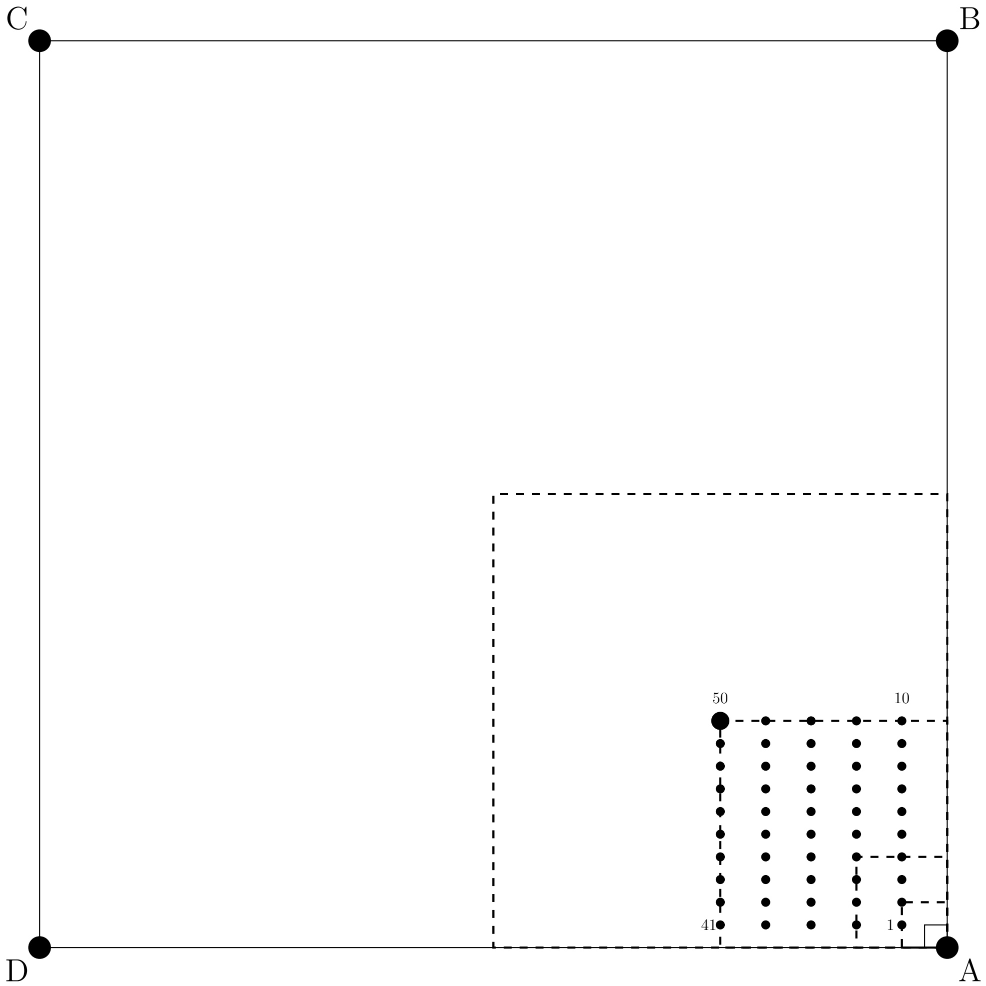


Figure 2: Layout of 20 m × 20 m plots, showing sub-plots and the location of the 50 Scott Height Frequency intercepts located within the 5 m × 5 m qaudrat (•). Five aluminium angle extrusions marking each corner (A – 1000 mm long, other four pegs 600 mm long) are marked with: ●. HFI intercept 1 is located nearest to the A corner, intercepts 10, 41 and 50 are also labeled.

4.2 Scott Height Intercept Methods

In 1989, 19 HFI plots were established at subjectively located sites in the upper Wairau, Clarence and Saxton valleys. Another HFI plot was established in the upper Wairau Valley in 1995 to monitor a site where an undescribed variant of *Craspedia uniflora* occurs (*Craspedia* “tarn”). All 20 HFI plots were remeasured in 1995, 2001 and 2006. An additional HFI was established at a photopoint site in 2016, so that a total of 21 HFI intercepts were measured. These plots consist of 100 intercepts along 50 m long transect lines. HFI plots were permanently marked with 1.8 m angled aluminium stakes (3 cm × 3 cm), placed 25.1 m apart.
The HFI method assesses vertical structure of vegetation and provides estimates of biomass (Scott, 1965), which is particularly important when assessing impacts that may affect vegetation height, such as retirement from grazing or burning. In the plots established as part of the 1989 series, 100 HF intercepts were measured along a 50 m long transect line. In the 2007 and 2008 surveys, 50 HF intercepts were measured along 5 parallel 5 m long lines located within a permanently marked 5 m × 5 m quadrat cover plot. In the 2016 all HF intercepts were re-measured following establishment protocols. All live vegetative material (excluding flowering/seeding parts) that intruded into the measurement column were recorded within each height tier. Intercepts in all surveys consisted of 4.47 cm x 4.47 cm sized vertical columns (or intercepts) spaced at 0.5 m intervals. These columns were divided up into 5 cm height tiers and the presence of all vascular plant species occurring in each height tier was recorded. Thus, each 100 cm high column is divided up into twenty 100 cm^3 cubes. Husheer (2006) showed that 100 intercepts were more than necessary to show changes in species composition of commonly occurring plants. Rare plants are unlikely to be recorded using the HFI method even with several hundred intercepts, because the Scott height-frequency plot (often called a transect) with 100 intercepts covers only the same surface area as a single 0.5 m × 0.5 m quadrat plot (0.25 m^2). The number of intercepts used during the January 2007 and 2008 Molesworth surveys was restricted to 50 to reduce field effort.

Prior to the establishement of an additional 80 random plots in 2007, an exhaustive data search was undertaken to determine what plot data was available. Unfortunately, an entire data set had been hidden from access and appeared lost. These plot sites might have been included in the 2007 survey had they been known about. There are ten plots in the upper catchment of the Wairau Valley in Molesworth established by NZ Forest Service in February 1960 and re-measured in January and February 1973, (3, Wraight, 1963). Data from these surveys is now publicly available. Data from a re-measurement by Landcare Research staff in 1995–96 (Rose et al., 2004) is still restricted.

While the small Scott intercepts of 100 cm^3 are probably best for grass and herb fields, the larger intercepts of Wraight (884 cm^3 if used in 5 cm height tiers) are probably better for larger plants such as found in scrub. The Wraight method is a widely used (>2000 plots in alpine shrub- and grass-lands), but infrequently reported method (but see Wraight, 1960, 1962, 1963, 1966; Holloway et al., 1963; Rogers, 1991; Husheer, 2005; Tanentzap et al., 2009). The former New Zealand Forest Service established several thousand of these plots from the 1950s until its demise in 1987. Fifty 6" ($\approx$15.2 cm) diameter circular intercept points are spaced at two link ($\approx$15.8", $\approx$40.2 cm) intervals along a one chain length transect ($\approx$20.1 m, although early plots used 100 intercepts along a two chain transect). The presence of all vascular plant species rooted within the intercept is recorded. Wraight plots were established in the upper Wairau catchment of Molesworth and used 50–100 intercepts (one–two chain long) and additionally recorded plants overhanging the 6 inch ring, but have not distinguished height tiers. This limits the usefulness of the classic NZ Forest Service method for assessing biomass or height structure.

Scott 4.47 cm $\times$ 4.47 cm Height Frequency Intercept (HFI) details:

1. Fifty HFI intercepts are measured along 5 parallel lines located within the 5 m $\times$ 5 m quadrat cover plot. These HFI lines run parallel to the A–B boundary of the 20 m $\times$ 20 m plot with 10 HFI intercepts/line. The first line is located 1 m inside the plot boundary line and subsequent lines at 1 m intervals thereafter along the A-D boundary.

2. Intercept No. 1 located at 0.5 m from the A–D boundary of the 20 m $\times$ 20 m plot. Intercepts are placed at 0.5 m intervals.

3. Intercept 11 is located at the start of the second line (i.e. adjacent to Intercept No. 1). Intercepts 21, 31, and 41 are located similarly. Intercept 50 is located at the internal corner (marked by a aluminium peg) of the 5 m $\times$ 5 m plot.

4. The recording cube is placed at the north-west quadrant from the HFI height gauge.

5. In order to minimise disturbance, intercepts are measured from the uppermost height intercepts towards ground level.

6. All vegetative material (excluding flowering/seeding parts) that intrudes into the measurement column is recorded within each height tier on the SHF data field sheet.

7. Dead vegetative material is not recorded. Where there is a gradient or imprecision of live–dead, (e.g. browning leaf-tips of grasses and tussocks as apart of a live plant) then these should be treated as "live" and recorded.

8. Moss, litter and lichen were not recorded

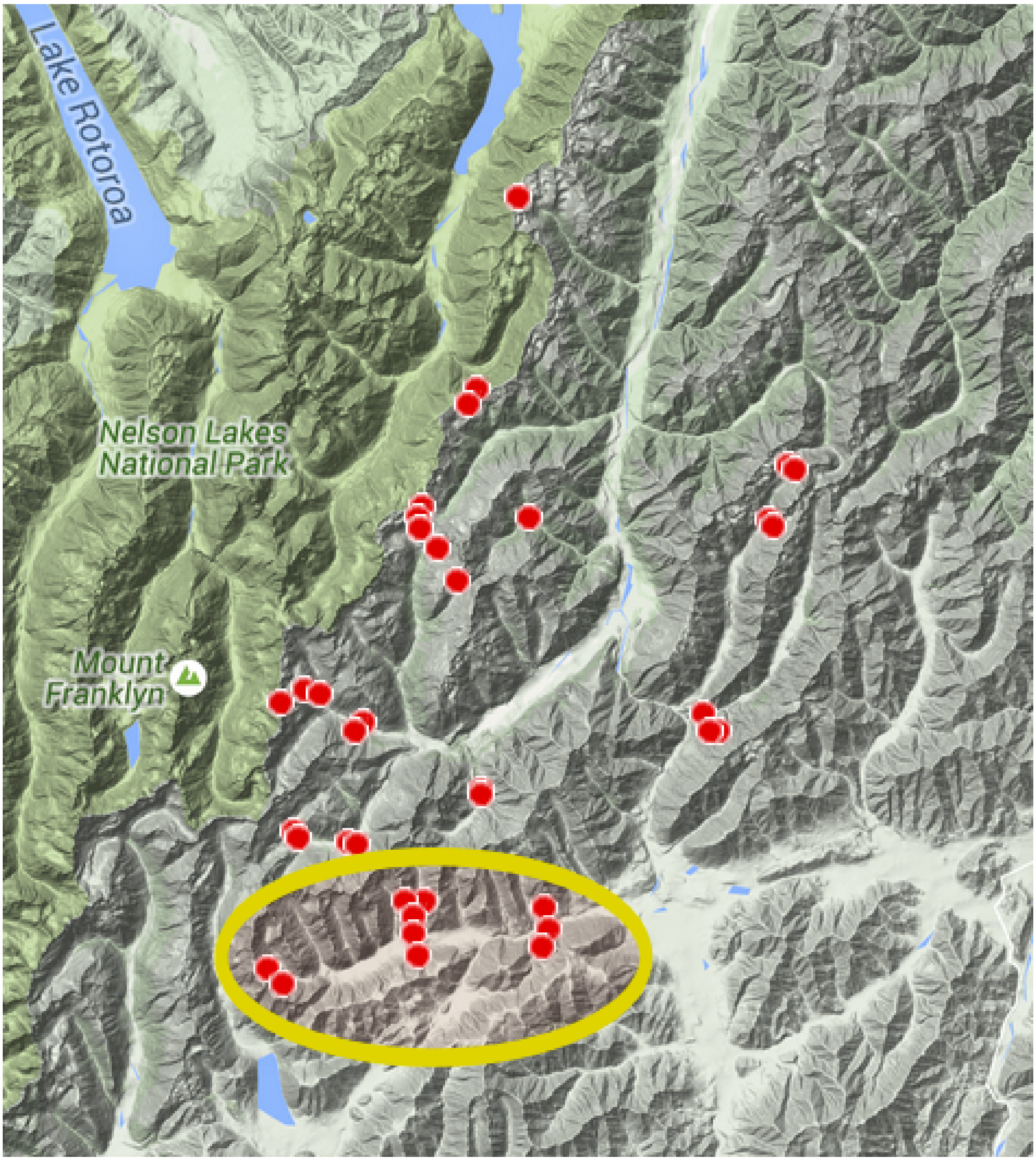


Figure 3: Locations of Wraight grassland plots in upper Wairau Catchment established in 1960. Plots on Molesworth are circled. Screenshot from National Vegetation Surveys meta data search website (https://nvs.landcareresearch.co.nz/).

4.3 Quadrat Plots

To provide data from a variety of plot sizes on Molesworth, six nested quadrat plots (0.5 m × 0.5 m, 1 m × 1 m, 2 m × 2 m, 5 m × 5 m, 10 m × 10 m, 20 m × 20 m) were established at each of 80 monitoring plots, and all vascular plants were identified by species and their cover assessed within 6 height tiers (<0.1 m, 0.1-0.3 m, 0.3 -1 m, 1 -2 m, 2 -5 m, >5m). This allows comparisons with data obtained from other eastern dry tussock grassland plot surveys (e.g Meurk et al., 2002; Duncan et al., 2001; Beets & Brandon, 2011), none of which seem to use a consistent plot size.
Environmental variables were estimated for the 20 m × 20 m plot. Altitude (m), aspect (°), slope (°), landform type (ridge, gulley, face, terrace), Dalryumple's physiographic class (1–9) were estimated for each plot (Allen, 1992). The shape of slope was ascribed as linear, convex or concave. Soil depth was measured at each corner of the 20 m × 20 m plot with a 50 cm probe at plot establishment, and drainage classified as good (freely draining), medium (ponding after rain) and poor (prolonged ponding). The presence of animal pellets and browse in plots was recorded. The presence of any evidence of cattle grazing within 100 m of the plot was also recorded (presence of cattle, hoof prints, dung or browse). Plots with evidence of grazing were classified as grazed, plots with no evidence of grazing within 100 m were classified ungrazed, and fenced plots were those with cattle exclusion fences established across a valley. Location was recorded using GPS in New Zealand Map Grid (NZMS260). Angle to the horizon was measured at 360°, 45°, 90°, 135°, 180°, 225°, 270° and 315° magnetic using an inclinometer. The presence of human induced change such as road, tracks, fences or grazing was recorded.

Unlike quadrat plot size, an attempt has been made to standardise height classes in New Zealand's grassland plots (<0.1, 0.1–<0.3, 0.3–<1.0, 1.0–<2.0, 2.0–<5.0, ≥5.0 m), and these standardised height tiers were used for the 2007 and 2008 Molesworth surveys. Standardised scores for cover were also used (Hurst & Allen, 2007, 1 = <2% cover, 2=2–5%, 3=6–25%, 4=26–50%, 5=51–75%, 6=76–100%).
Our impression of the methods used for plot measurement was favourable. Visual estimates of cover are not the most accurate way of showing cover (Archaux et al., 2006, 2007) because of their subjectivity (Wilson, 2010), but are a efficient method for showing species composition. Summing cover scores for multiple species in multiple tiers (i.e total cover) is not ideal as an index of biomass. Frequency occurrence in sub-plots are better (Wraight1960, Wraight1963, Scott1965). So Scott HFI intercepts were employed, but in the end they are only an index of biomass, cover or structure. Scott HFI intercepts have more than eight times smaller area than Wraight intercept methods (20 cm^2 vs. 176 cm^2), so are best at sampling small plants. Point intercept methods show cover by definition and were developed in New Zealand (Levy, 1927; Levy & Madden, 1933), but take longer. Recent work has shown how well they work when used properly (Jonasson, 1988). e.g sample 100 points in five-ten 1 m^2 sub-plots, record species occurrence on

intercepts, and maybe (if intercepts are spaced on a 10 cm × 10 cm grid) the occurrence of each species in 100 cm^2 sub-sub-plots as recommended by Wilson (2010). Individual species could be recorded on just the highest intercept (cover) or number of interceptions all the way to the ground (biomass) (Fehmi, 2010). We collected faecal pellet data at all plots, but they are very prone to various sorts of errors and often provide surprising and erratic results (Husheer & Robertson, 2005). Pellet-recording techniques have been widely used to index animal abundance in New Zealand and elsewhere (Bennett et al., 1940; Riney, 1957; Batcheler, 1975; Forsyth et al., 2011), but the potential for variability in decomposition rates between seasons (Aulak & Babińska-Werka, 1990), between areas (Bayliss & Giles, 1985) or amongst operators (Van Etten & Bennett Jr, 1965; Caughley et al., 1976) will affect estimates to the point that the method will only detect very large differences in abundance (Forsyth et al., 2007). They are not a reliable index of ungulate abundance, so data probably should not be collected, let alone used.

Despite a very long field season we have really enjoyed this work, the challenge of working in remote locations while increasing the precision of our measurements. Once again thank you very much to DOC East coast staff for allowing us to do this work, and even paying for it too. We appreciate it very much. Thank you.

5 Recommendations

1. Enter plot data into a digital database.

2. Undertake thorough statistical analysis and reporting of HFI and 20 m × 20 m plots data during winter 2016. Use modern spatial–temporal modelling techniques to handle the complexity of the survey design. These results should be used to underpin management decisions.

3. Review the network of 167 HFI and 20 m × 20 m plots on Molesworth Station in a context of future management information requirements.

4. Re-measure vegetation plots within two decades, or sooner if management action changes.

7 Helicopter useage

New Zealand Forest Surveys was allowed to operate our own Hu300C helicopter, without the standard requirement of DOC contractors to only use aircraft operating under CAA Rule Part 135 "Air Operator Certificate or equivalent, as required by the Civil Aviation Rules". This was because our private operations are undertaken under CAA Rule Part 91, which does not require certification. CAA Rules only require certification for aircraft operators who are in the business of transporting fare paying passengers. Certification is not at all appropriate nor required for NZFS plotting operations. We were not paid by DOC for the use of our aircraft. Our aircraft are used to get to our place of work only, and explicitly not undertake Air Transport Operations. The contract had several special clauses to allow for the use of our aircraft. These clauses were included after consultation with CAA staff, DOC aircraft administration specialists and contract administrators. The clauses are:

1. The contractor will source their own aircraft services if required.
2. Any aircraft operated by the contractor for access will undertake flying following CAA rules in particular:
   (a) The pilot will not be flying for hire or reward.
   (b) The aircraft will not transport Department of Conservation staff.
   (c) The aircraft will not be used for aerial survey work unless licensed under part 137 Agricultural Aircraft Operations.

8 Photopoints

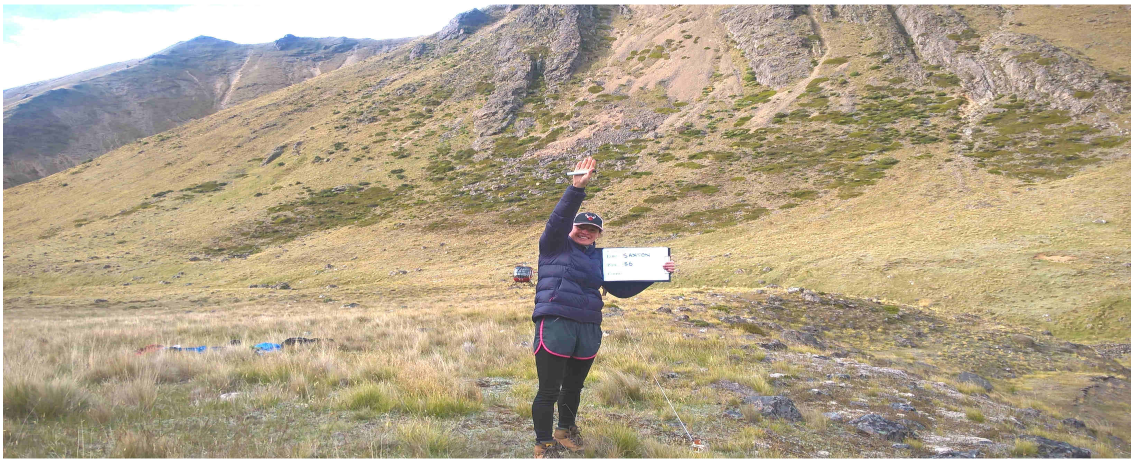
Digital photographs were taken from 1–3m from the A corner of each plot, facing the plots center. Although photopoints took little time to collect, and can in some instances be useful to demonstrate visually obvious vegetation change to the public or managers (e.g. Mark, 1989), their usefulness at Molesworth is dubious. It is difficult to get accurate measures of change from photopoints, the identity of individual species may be obscured, and they cannot determine the causes of observed changes (Figure 4e). Any statistical analysis should rely on the quantitative data collected such as HFI or species cover abundance scores. At a low productivity site such as Molesworth small incremental changes can be important, but may not be easily recognised by photographs. Photopoints are difficult to summarise quantitatively, unless an unexpected future breakthrough is made with image analysis. For that reason photopoint information should be stored.

(a) 1990

(b) 1995

(c) 2001

(d) 2006



(e) Lizzie and Izzie (ZK-HIZ). Saxton Plot 6, Oyster Stream. January 2016. Any compositional or structural changs in vegetation are hidden by changes in light and tussock flowering.

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